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Effect of different nitrogen management and Tillage options on soil, nutrient content, uptake and yield of wheat (*Triticum aestivum* L.) using under active crop canopy sensor

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Abstract

A field experiment was conducted during *Rabi* at BAC, Research Farm Sabour to access the effect of precession nitrogen management and tillage practices on growth parameter of wheat. The experiment was carried two tillage practices (conventional tillage, CT and Zero tillage, ZT) in main-plots and six different nutrient management practices [*viz.* N1-Recommended dose of nutrients (150:60:40 kg NPK/ha, full P & K and ½ N at basal +1/2N in two splitting at 1st & 2nd irrigation- Top dressing after irrigation, N2-Recommended dose of nutrients (150:60:40kg NPK/ ha, full P & K and ½ N at basal +½ N in two splitting at 1st & 2nd irrigation-Top dressing before irrigation, N3-SSNM Based on Nutrient Expert (NE), N4-70% N of SSNM based on NE+ remaining N as guided by Green Seeker, N5 Nitrogen enriched plots (225:60:40Kg. NPK/ha.) and N6-SPAD based nutrient management, (75Kg. N as basal +25Kg. N as 1st top dress +25Kg. N at 42 SPAD reading) in sub plots with 3 replications. the conventional tillage recorded slightly higher grain yield than that of the zero tillage during both years of experimentation The maximum grain yield (45.5 and 49.4 q ha⁻¹ in 1st year and 2nd year, respectively) was recorded from the plots received 70% N of SSNM based on nutrient expert system +remaining N guided by Green Seeker treatment and was significantly superior to the rest of the nutrient management practices.

Keywords: Nitrogen, nutrient, uptake, quality, wheat, tillage and sensor

Introduction

Wheat (*Triticum aestivum* L.) is one of the leading food crops of world farming and occupies significant position among the cultivated cereals. Wheat production has increased significantly from 6.5 million tonnes (1950-51) to more than 106.21 million tonnes (2019-20). Wheat is the second largest important grain crop after rice and contributed significantly to the food security of the nation. India is the second largest producer of wheat next to China and occupying an area of about 30 million hectare and producing 94 million tonnes with a productivity of 31q/ha, which contributes to 37% of the country's food grain production.

Conventional farming has led to extensive use of chemicals and, in turn, to negative environmental impacts such as soil erosion, groundwater pollution and atmosphere contamination. Farming systems should be more sustainable to reach economical and social profitability as well as environmental preservation. A possible solution is to adopt precision agriculture, a win-win option for sustaining food production without degrading the environment. Precision technologies are used for gathering information about spatial and temporal differences within the field in order to match inputs to site-specific field conditions. Here we review reports on the precision N management of wheat crop. The aims are to perform an investigation both on approaches and results of site-specific N management of wheat and to analyse performance and sustainability of this agricultural practice.

Research in India on zero tillage (ZT) wheat started in the 1970s but was soon abandoned due to technical constraints. However, with the involvement of the Consultative Group for International Agricultural Development (CGIAR) in the South Asia region under the Rice-Wheat Consortium (RWC) programme of the IGP (Indo Gangetic plain zone), ZT technology gained momentum in the late 1990s in NW Indian states.

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Here, after the initial spread, the area under the technology stabilised at 20-25%.

Nitrogen limits the growth of crops in many production systems and N management is the most serious nutritional challenges in wheat production which helps in carbohydrate accumulation in culms, leaf sheath and grain of wheat. Farmers are routinely applying more N fertilizer than a crop can use is due to the common perception that the general fertilizer recommendations are not appropriate for their location and/or climatic conditions. Several pathways for N loss resulting in low recover efficiency, which creates a problem in crop production system. A blanket recommended N rate without considering the nutrient supply capacity of the soil and crop need often does not increase the crop productivity. On the other hand, it results in lower N use efficiency and may cause the deterioration of soil health.

The chlorophyll content in leaves can indirectly measure the N status of the crop and thus helps in-season fertilizer N topdressing in accordance with need of the crop (Peng *et al.*, 1996) [9]. Minolta Camera Company developed a portable chlorophyll meter or SPAD (Soil-Plant Analyses Development) meter which can be used to estimate chlorophyll levels non-destructively in leaves. Nitrogen is the key element in chlorophyll molecules that capture sunlight used in photosynthesis. Thus chlorophyll meter provides instant crop nitrogen status as SPAD value in a non-destructive manner. Recent advances in the development of precision nutrient management tools like Nutrient Expert (NE), a decision support system, Green Seeker (GS) hand held sensors, and SPAD or Chlorophyll metre have shown promise in increasing factor productivity and nutrient use efficiency of crops and minimizing environmental foot prints

Materials and Methods

The experiment was conducted in the experimental plot, situated in the Southern Section New Area (SSNA) of Research Farm Bihar Agricultural University, Sabour, during *rabi* season of two consecutive years 2014-15 and 2015-16, respectively. The Bihar Agricultural University, Research Farm, Sabour is located in south of the river Ganges, beyond the natural levees. It is situated at latitude of 25°15' 4" N and longitude 78°2' 45" E with an altitude of 37.19 meter above the mean sea level in Bhagalpur district of Bihar state under Gangetic plains of India. The experimental plots were provided with assured irrigation facility having uniform topography and proper drainage. Sabour, Bhagalpur has sub-tropical climate, characterized with hot and dry summer, cold winter and moderate annual rainfall. The experiment was carried in split plot design with two tillage practices (conventional tillage, CT and Zero tillage, ZT) in main-plots and six different nutrient management practices [*viz.* N1-Recommended dose of nutrients (150:60:40 kg NPK/ha, full P & K and ½ N at basal +1/2 N in two splitting at 1st & 2nd irrigation- Top dressing after irrigation, N2-Recommended dose of nutrients (150:60:40kg NPK/ ha, full P & K and ½ N at basal +½ N in two splitting at 1st & 2nd irrigation-Top dressing before irrigation, N3-SSNM Based on Nutrient Expert (NE), N4-70% N of SSNM based on NE+ remaining N as guided by Green Seeker, N5 Nitrogen enriched plots (225:60:40Kg. NPK/ha.) and N6-SPAD based nutrient management, (75Kg. N as basal +25Kg. N as 1st top dress +25Kg. N at 42 SPAD reading) in sub plots with 3 replications. The soil samples were collected at random from the experimental field with the help of soil auger up to a depth of 15 cm prior to application of fertilizers. The soil samples

were mixed properly and a composite sample was obtained for analysis. The soil was sandy loam in texture (47.4% sand, 32.6% silt and 19.6% clay, Piper 1950), with Soil pH, CEC, Organic Carbon values of 7.1, 10.2 cmol (+) kg⁻¹ and 0.55% respectively. It was low in available nitrogen (176 kg ha⁻¹), while the availability of phosphorus (23 kg ha⁻¹) and potassium (185.67 kg ha⁻¹) is medium. Several parameters were measured separately in soils like pH and Electrical conductivity (Jackson, 1973) [6], Organic Carbon (Walkley and Black's, 1934) [13], Nitrogen (Subbiah and Asija, 1956) [12], Phosphorus (Olsen *et al.*, 1954) [8] and Potassium (Jackson, 1973) [6]. The SPAD measurement was started from 25DAS in wheat and was continued up to the first flowering (85 DAS) at 10days interval for all treatments and replication. A mean of 15 reading per plots was taken as the measured SPAD value. Correlation graph between SPAD values at different crop growth stages and growth yield was made for all the treatments. The SPAD value corresponding to optimum grain yield was considered as optimum. SPAD value particular growth stage. Green seeker hand optical sensor (Fig.4) was used as a tool that provides precision measurement and data logging of the Normalized difference vegetative index (NDVI) and a ratio of reflectance of red to near infrared (NIR) radiation for a crop canopy.

Results and Discussion

The result and discussion of the preceding are hereby discussed briefly. An attempt has been made to interpret and explain the results with a view to understand the 'causes' and 'effect' relationship among nutrient content, uptake, and yield of wheat crop observed according to different nitrogen management and tillage options.

Soil parameters

The pH, electrical conductivity (EC), Organic carbon, available Nitrogen, Phosphorus and potassium were measured at 0-15 cm depth of soil at maturity and statistically analysed and presented in table 1. The pH and EC did not vary significantly among the main and sub plots and the interaction effect was remained also non-significant during the study. The soil showed here slightly alkali condition considering the pH of the soil. The EC of soil also indict the alkali status as it was ranged from 0.22-0.24 during study. From the two years of field experiment it was observed that the soil fertility status did not vary significantly under the tillage options, but the nutrient management practices exerted significant effect on soil fertility. In the first year the highest organic carbon was noted in N₅ which was significantly higher than N₁ and N₄, whereas in the second year the organic carbon remained non-significant among the nutrient management practices. The main plots and interaction effects remained non-significant for organic carbon content in both the years of the study. The available nitrogen status was recorded maximum in the treatments N₅ (194 kg ha⁻¹, averaged over two years) in both the years which was significantly superior to the others during the study. The interaction effect was found during non-significant in both the years study. Likewise other soil parameters the soil available P₂O₅ and K₂O were also not varied between the tillage options, whereas among the N management practices these parameters differed significantly. Treatment N₅ recorded the highest P₂O₅ and K₂O which were significantly superior to N₄ and N₆ during both the years. Treatments N₁, N₂ and N₃ remained non-significant with each other. The interaction was found both the years non-significant. Singh *et al.*, (2017) [11] recorded substantial

improvement was recorded in organic carbon, available nitrogen, phosphorus and potassium where significantly higher in case of plots which had received either organic in combination with chemical fertilizers then the plots which had

received chemical fertilizers only. Kalhapure *et al.*, (2014)^[7] reported that deep tillage along with integration of organic and inorganic sources of nutrients help to improve soil environment for increasing the growth of wheat.

Table 1: Effect of tillage and nitrogen management practices on soil pH, EC, OC, N, P₂O₅ and K₂O of post-harvest of soil

Treatment	pH		EC (dSm ¹)		OC (%)		N (kg ha ⁻¹)		P ₂ O ₅ (kg ha ⁻¹)		K ₂ O (kg ha ⁻¹)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Tillage practices												
ZT	7.28	7.22	0.23	0.23	0.55	0.57	172.7	168.0	22.5	23.6	193.0	196.0
CT	7.25	7.23	0.22	0.22	0.55	0.54	168.7	165.8	22.8	21.6	185.0	181.8
S.Em(±)	0.04	0.06	0.01	0.01	0.01	0.01	2.13	2.25	0.48	0.53	2.03	2.3
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Nitrogen management												
N ₁	7.22	7.27	0.23	0.23	0.52	0.55	168.5	171.3	23.5	23.5	193.6	193.6
N ₂	7.29	7.24	0.22	0.22	0.55	0.55	167.1	170.1	22.5	23.0	197.0	194.8
N ₃	7.25	7.15	0.22	0.22	0.55	0.55	166.0	166.6	21.1	22.1	193.0	192.8
N ₄	7.28	7.22	0.23	0.23	0.54	0.56	162.5	152.8	20.6	20.3	163.0	166.0
N ₅	7.22	7.23	0.23	0.24	0.58	0.55	194.3	194.6	25.8	25.5	201.0	198.3
N ₆	7.30	7.21	0.23	0.23	0.56	0.56	164.3	151.8	20.8	21.3	188.6	187.8
S.Em(±)	0.14	0.09	0.01	0.01	0.01	0.01	2.49	2.94	0.85	0.63	2.88	3.23
CD (P=0.05)	NS	NS	NS	NS	0.04	NS	7.83	9.27	2.69	1.99	9.08	10.19
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

ZT= Zero tillage; CT= Conventional tillage; N₁= 150 kg N (after irrigation); N₂= 150 kg N (before irrigation); N₃= 125 kg N (Nutrient expert); N₄= SSNM & Greenseeker; N₅= 225 kg N; N₆= 150 kg N (SPAD based); DAS= Days after sowing; SEm (±)= Standard error of mean; CD= Critical difference

Nutrients uptake and Nitrogen use efficiency

The total nitrogen, phosphorus and potassium, uptake and nitrogen use efficiency of wheat were measured by multiply nutrient content of the dry mass of respective plant at maturity and it presented in (Table 2). The total nitrogen, uptake differed significantly between the tillage options in the first year, whereas, in the second year the conventional tillage marked significantly higher over the zero tillage. The total phosphorus, potassium uptake and nitrogen use efficiency are found comparable between the tillage options in both the years of the study. Among nitrogen management practices then highest nitrogen uptake was observed in the treatment N₄ which was significantly superior to all other treatments and the lowest one recorded in the N enrich plot (N₅) during the study. The phosphorus and potassium uptake were also followed the same trend as in total nitrogen uptake. The nitrogen enriched plot recorded the lowest uptake and it was due to less grain fragmentation spikelet against the higher nitrogen application. The interaction was found non-significantly for all nutrients management uptake. The

agronomic nitrogen use efficiency (NUE) did not vary significantly between the tillage options during the study. Among the sub plots it was found higher in the treatment N₄ having the lowest N recommendation using green seeker. From the two year field experimentation it was noted that NUE was 38.2% higher (22.0-61.7%) and found significantly superior to all other nitrogen management treatments. The nitrogen enriched plot (N₅) recorded lowest nitrogen use efficiency (17.3 & 17.2 kg in 2014-15 & 2015-16 respectively) it was due to less production of grain yield against the higher application of nitrogen. The interaction effect was found non-significant for both the years during the study. One of the main reasons for the low uptake and efficiency of N is that many farmers in the wheat belt apply 150 kg N ha⁻¹ or even more (Cassman *et al.* 1998; Prasad 1999)^[2, 10]. Banerjee *et al.*, (2014)^[1] it was found that the highest values for agronomic efficiency, physiological efficiency and recovery efficiency were also found where fertilizer was applied on the basis of Nutrient Expert recommendation.

Table 2: Effect of tillage and nitrogen management practices on uptake of nitrogen phosphorus, potassium and agronomic nitrogen use efficiency (NUE) (kg ha⁻¹) by wheat crop

Treatment	Nitrogen uptake		Phosphorus uptake		Potassium uptake		NUE	
	2014	2015	2014	2015	2014	2015	2014	2015
Tillage Practices								
ZT	102.4	105.1	24.2	23.5	31.1	30.0	29.9	31.8
CT	106.2	106.8	24.0	24.4	31.4	30.9	30.0	31.3
S.Em(±)	1.5	0.2	0.3	0.4	0.8	0.4	0.2	0.1
CD (P=0.05)	NS	1.5	NS	NS	NS	NS	NS	NS
Nitrogen Management								
N ₁	103.0	102.9	21.8	21.8	28.2	28.0	28.3	29.5
N ₂	98.9	100.8	21.9	21.6	28.5	28.0	27.2	28.9
N ₃	103.8	106.7	23.4	22.8	29.4	29.2	34.1	36.3
N ₄	115.3	120.6	27.5	29.3	36.0	36.5	43.3	47.0
N ₅	98.1	93.5	26.6	21.8	29.8	27.6	17.3	17.2
N ₆	108.0	111.1	27.2	26.3	35.6	33.4	29.5	30.5
S.Em(±)	2.0	1.3	0.8	1.0	1.3	0.7	0.5	0.5
CD (P=0.05)	6.5	4.2	2.5	3.2	4.3	2.2	1.6	1.1
Interaction	NS	NS	NS	NS	NS	NS	NS	NS

Grain yield

The grain yield of wheat did not differ significantly between the different tillage options. However, the conventional tillage show slightly higher grain yield than that of zero tillage in both the years during the study (Table 3). The SSNM with green seeker based nitrogen management practices recorded the highest grain yield (45.5 qha^{-1} and 49.44 qha^{-1}) which was significantly superior to the treatments N_2 and N_5 in the first year and in second year N_4 was statistically superior than all the other treatments. Application of excess nitrogen (225 kgha^{-1}) nitrogen in nitrogen enrich plots reduced the yield quantity around 10-15% than other nitrogen management practices during the study. Therefore SSNM based nutrient expert tool with green seeker guided nitrogen management not only produced the considerable amount of grain yield, but also increase the nitrogen efficiency of crop. The interaction effect was found non-significant in both the years. Ghosh *et al.*, (2017) [4] suggested that the SPAD based precision N management concept has been demonstrated promising agronomic potential with increased wheat yield and N use efficiency.

Straw yield

The straw yield wheat crop recorded at maturity where statically analysed and presented in table 3. Likewise grain yield the straw yield remained non-significantly under different tillage option however, among the nitrogen management practices the treatment N_4 recorded the maximum straw yield and significantly superior to that of N_1 , N_2 and N_5 in both the years of the study. The SPAD based N management practice (N_6) also recorded a considerable amount of straw yield which was statistically at par with N_4 wherein, the N_4 has the lower application of nitrogen fertilizer with higher nitrogen use efficiency than N_6 during the study. The minimum straw yield was found in treatment N_5 (nitrogen enrich plots) both the years study. This indicated that judicious and timely application of nitrogen fertilizer can maintained good amount of straw yield in wheat without affecting the grain yield. The interaction was found in the non-significant in both the years during the study. Proper management of nutrients in wheat cultivation can improve crop yield while reducing fertilizer nitrogen use (Dobermann and Fairhurst, 2000) [3].

Table 3: Effect of tillage and nitrogen management practices on grain yield (q ha^{-1}), straw yield (q ha^{-1}) and harvest index in wheat crop

Treatment	Grain yield (q ha^{-1})		Straw yield (q ha^{-1})		Harvest index	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Tillage Practices						
ZT	41.5	44.3	61.1	58.8	41.0	42.5
CT	43.4	45.0	62.3	61.9	41.7	43.0
S.Em(\pm)	0.47	0.15	1.84	1.20	1.15	0.83
CD(P=0.05)	NS	NS	NS	NS	NS	NS
Nitrogen management						
N_1	42.5	44.3	61.5	59.1	40.6	42.4
N_2	40.8	43.4	59.5	57.3	39.4	40.6
N_3	42.6	45.3	63.5	59.2	41.9	43.1
N_4	45.5	49.4	65.8	66.4	44.6	45.8
N_5	39.0	38.8	56.4	59.3	38.7	39.9
N_6	44.3	45.5	63.6	63.9	43.1	44.6
S.Em(\pm)	1.10	0.85	1.15	2.00	1.07	1.01
CD(P=0.05)	3.45	2.69	3.63	6.31	3.36	3.18
Interaction	NS	NS	NS	NS	NS	NS

Harvest index

The harvest index calculated from grain yield and straw yield was statistically analysed and presented in table 3. Likewise economic yield the harvest index did not vary significantly within the different tillage practices. However, the nitrogen management practices exerted significant effect on harvest index. The treatment N_4 recorded the highest harvest index which was statistically at par with N_6 and significantly superior to the N_1 , N_2 and N_5 in both the years during the study. Like was grain yield and straw yield. The lower harvest index recorded treatment N_5 in both the years. The interaction was found in the non-significant. Iqbal *et al.*, (2012) [5] reported that yield attributing traits such as grain yield (kg/ha) and harvest index were maximum at seeding rate of 150 kgha^{-1} and minimum at seeding rate of 125 kgha^{-1} .

Conclusion

Based on the result obtained during both years of experimentation, it may be concluded that the performance of timely sown irrigation wheat crop under conventional and zero tillage conditions were found to be statically alike in obtained grain yield of wheat but for economic point of view cultivation of wheat under zero tillage condition was found to be the most economic method of wheat cultivation. Among the different nutrients management practices the 70% N of

SSNM based on NE along with Green-Seeker guided N application may prove to be the effective and efficient management practices for resource efficient and cost efficient production of wheat. The result of the present study are promising to suggest that precision N management based on Nutrient Expert tool and Green-Seeker guided N management can potentially improve agronomic nitrogen use efficiency and economic return from irrigated wheat production system.

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