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# Performance of Wheat (*Triticum aestivum* L.) under Need based Nitrogen Management Strategies and Different Tillage Options

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**A B S T R A C T**

Sensor based smart technologies can lead a way in increasing wheat production for small and marginal farmers with the save guard of sustainable environment using adequate synthetic fertilizer. Field plot experiment was conducted having conventional tillage (CT) and zero tillage (ZT) in main plots and five nutrient management *viz.*, $N_1$ and $N_2$ with top dressing after and before irrigation, respectively having similar recommended dose, $N_3$ based on Nutrient Expert tool, $N_4$ using nutrient expert tool in combination with Green Seeker and $N_5$ (nutrient enriched plot) in sub plots. The experiment was laid out in split plot design with three replications during the dry season of 2014-15 and 2015-16. Results indicated that across the two tillage options, the nutrient expert tool with green seeker based N application could save the N fertilizer by 30% without affecting the grain yield of wheat crop. This smart technology ($N_4$) also increased the net return by Rs. 4643 and Rs. 10574 over the 100% and 150% recommended dose of N, respectively. Research findings strongly suggest the need of revision in current nutrient recommendations for wheat crop and aiming that nutrient expert tool and green seeker can be the viable option for higher productivity and profitability of wheat crop.

## Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cereals in the human diet in different countries of the world since time immemorial. The national productivity of wheat is not quite enough and the rising population poses the unrivaled pressure on agricultural production system. Despite of smart technologies the wheat grain production per unit application of nutrient has been decreased continuously (Lpez-Bellido *et al.*, 2005; Ghosh *et al.*, 2017) resulting poor Nutrient use efficiency (40-50% for N and 20-40% for P) and partial factor productivity. Hence, there is an urgent need to increase the nutrient use efficiency from the view point of sustainability. Site specific need based nitrogen management strategies are very dynamic to bridge the gap between supply and demand. The large variation in soil N status and blanket fertilizer application following improper general recommendation by the farmers lead to over application of N fertilizer. The main reason for poor N use efficiency is inefficient splitting of N dose coupled with excess N application leads to low N use efficiency in wheat (Singh *et al.*, 2010).

Increment of N use efficiency can be obtained only when the application will coincide with most hungry stages with adequate amount that reduce the losses (Diacono *et al.,* 2013). From sustainable point of view, the N management in wheat needs to be refined for improving N use efficiency, crop productivity and profitability, and minimizing fertilizer N loss to the environment. The blanket N dose varying from 100 to 180 kg N $ha^{-1}$ indicates huge spatial variation and farmers are often apply in more than two splits. In fact farmers often apply an extra dose of N to avoid the risk of deficiency as it is linked with irrigation events. In many regions farmers are applying N fertilizer at levels that exceed the dose suggested by the government extension services (Takebe *et al.,* 2006; Singh *et al.,* 2011). The hand held Greenseeker (Trimble Navigation Limited, Sunnyvale, CA, USA) is an active optical crop canopy sensor with a red (650±10nm) and a NIR (770±15nm) is commercially available and used widely. By measuring the strength of the reflected light, the sensor shows a numeric reading of NDVI (Normalized Difference Vegetation Index) between 0.00 and 0.99. Raun *et al.,* (2001) noted expected yield as determined from NDVI has strong relationship with the actual grain yield in winter wheat. Using NDVI measurements of wheat at different times during crop growth period, Raun *et al.,* (2001, 2002) developed concepts of response index and potential yield, to define a fertilizer nitrogen algorithm for the N requirement in winter wheat based on expected yields as well as achievable greenness of the leaves. Raun *et al.,* (2002) showed that prediction of wheat response to N applications guided by optical sensor was positively correlated to measured N response and increased N-use efficiency. Under need based management strategy Nutrient Expert (NE) developed International Plant Nutrition Institute, USA) is also good option, computer based decision support software for wheat and smallholder farmers. NE is a nutrient decision support software that uses the principles of site-specific nutrient management (Dobermann and Witt, 2004; Witt *et al.,* 2009) and enables farm advisors to develop fertilizer recommendations tailored to a specific field or growing environment. NE uses a systematic approach of capturing information from farmers' field, which is important for developing a location-specific recommendation. As a computer-based decision support tool, NE combines all the steps and guidelines in site specific nutrient management into simple software tailored for farm advisors. Nutrient Expert allows the users to draw required information from their own experience, farmers' knowledge of the local region and farmers' practices. With NE, parameters can be estimated using proxy information, which allows farm advisors to develop fertilizer guidelines for a location without data from field trials. Excessive tillage operation in conventional farming also has the negative environmental impacts such as soil erosion, groundwater pollution and atmosphere contamination. Jat *et al.,* (2009) reported that direct seeding or zero tillage is alternative option, as the researchers suggested its wide applicability in many crops around the world and this technology has potential to allow saving in time, energy, water and labour during crop establishment. The major objective of the present investigation was to test whether Nutrient Expert tool or Greenseeker based N fertilizer management in wheat was appropriate under zero/conventional tillage for managing fertilizer N in irrigated wheat.

## Materials and Methods

### Experimental site

Field experiment was conducted during *rabi* season of 2014-15 and 2015-16 in the research farm of Bihar Agricultural University, Sabour, Bhagalpur (25$^{o}$15′40″ N latitude, 87$^{o}$2′42″E longitude and an elevation of 37.0 m a.s.l.), India for precision N management in wheat using green seeker and nutrient expert tool under zero and conventional tillage. The soil of the experimental plot was sandy loam in texture, low in nitrogen (179 kg/ha) and organic carbon (0.55) and medium in available $P_2O_5$ (23 kg/ha) and $K_2O$ (183 kg/ha), neutral in reaction (soil pH 7.05) and non-saline in nature. The climate of Sabour is characterized by hot and humid during summer (April and May), rainy during June to September, moderately hot and dry during autumn (October and November), cool and dry during winter (December and January) and moderate in spring (February and March). The site receives annual average rainfall of 1200 mm of which 70-75% occurred in the monsoon months (June to October). The average temperature varies from 19°C in December/January to 29.6°C in May/June.

## Experimental details and treatments

The experiment was laid out in split plot design with three replications consisting of two tillage options i.e., conventional tillage (CT) and zero tillage (ZT) in main plots and five nutrient (N) management *viz*., recommended dose (150:60:40 kg $N:P_2O_5:K_2O$ $ha^{-1}$) with top dressing after irrigation ($N_1$), recommended dose with top dressing before irrigation ($N_2$), nutrient management based on Nutrient Expert tool ($N_3$; 125:63:105 kg $N:P_2O_5:K_2O$ $ha^{-1}$), nutrient management based on nutrient expert tool (70% N) + remaining N as guided by Green Seeker ($N_4$; 105:63:105 kg $N:P_2O_5:K_2O$ $ha^{-1}$) and nutrient enriched plot having 150% N and $P_2O_5$ & $K_2O$ (225:60:40 kg $N:P_2O_5:K_2Oha^{-1}$) as per recommendation ($N_5$) in sub plots. All the treatments received 50% N and full dose of $P_2O_5$ and $K_2O$ during final land preparation except $N_3$ and $N_4$. The N was top dressed in the form of urea at 25% each at CRI and jointing stages of wheat crop. The sources of chemical fertilizers were urea, single super phosphate and muriate of potash.

## Crop management

Wheat variety 'HD 2733' was used for this investigation. It was the most popular variety of wheat grown in India for several decades and provides good yield. It takes about 130-135 days to mature in Bihar, India. Basal dose of fertilizer as per the treatments was applied and incorporated in each plot at one day before sowing of wheat. Wheat crop was sown on 25th November in the year 2014 and 2015 at spacing of 20 cm between rows.

## Observations recorded

An area 5 $m^2$ from each plot was ear-marked for destructive sampling and the rest of the plot was used for biological yield estimation. Various biometric data were recorded at different growth stages of the crop from the ear–marked area of each plot and economic yield was estimated at final harvest. The number of earhead $m^{-2}$, number of grains earhead$^{-1}$ and test weight of grain were recorded from each plot at maturity. The crop was harvested from 5 $m^2$ area for yield estimation in each plot. After threshing the grain and straw were dried in the sun for 3-4 days and corrected to 12% moisture content. The economics of wheat cultivation was calculated on the basis of government approved rate and prevailing market price of various inputs and outputs in the local markets. The cost of different cultural operations was computed on the basis of fixed cost and variable cost. The cost of cultural operations common for all the treatments such as sowing seeds, weeding and irrigation are put under fixed cost and those vary with treatments like the field preparation, fertilizers and their application, harvesting and processing costs are put under variable cost. The cost per unit yield for harvest and processing was calculated using measured mean yield under various treatments tested in consultation with the published standard costs for harvesting and processing of the crop. The net return was calculated by deducting the production cost from the gross value of the produce, including by-product value (gross return) and the benefit: cost ratio was measured on net return basis.

## Statistical analysis

The data were analyzed statistically by applying "Analysis of Variance" (ANOVA) technique of RCBD (Cochran and Cox 1985). The significance of different sources of variations was tested by Error mean square of Fisher Snedecor's 'F' test at probability level 0.05. Least significant difference (LSD) at 5% level of significance was worked out for each character of the experiment.

## Results and Discussion

The yield attributes and economic yield of wheat crop did not vary significantly between the two tillage options, however significant variation has been observed among the nutrient management practices. The mean grain yield of wheat in conventional tillage yielded non significantly higher mean grain yield (44.76 qha$^{-1}$) than that of the zero-tillage (44.0 qha$^{-1}$) and it was due to the yield attributes did not vary significantly among the main plots (Table 1). This showed that wheat sown either in zero tillage or conventional tillage provided similar wheat yield (Jat *et al.*, 2009). Among the different N management practices, Nutrient Expert tool (70% N) + remaining N as guided by Green Seeker recorded higher mean grain of 49.44 q ha$^{-1}$and was statistically at par with the mean grain yield of recorded from Nutrient Expert tool (45.24q$^{-1}$) and intern were significantly superior to the mean grain yield obtained in other nutrient management practices. In our study, nutrient expert tool ($N_3$) and nutrient expert Tool with green seeker guided ($N_4$) nutrient management practices received lower dose of N rate as compared to that of $N_1$, $N_2$ and $N_5$ i.e. 100 to 150% N dose and were found most encouraging N management in increasing yield and yield attributes of wheat crop. The result indicated that 105 kg N for wheat through nutrient expert and green seeker guided tool lead to good nutrient supply throughout the growing periods of wheat and may able to save about 45 kg N ha$^{-1}$ (30%) when compared with normal recommendation practices ($N_1$ and $N_2$) without affecting the grain yield of the crop. The treatment $N_5$ received highest dose of N (225 kg ha$^{-1}$) and able to facilitate high vegetative growth rather than reproductive output. Sui *et al.,* (2013) and Ghosh *et al.*, (2017) noticed that biomass production under high N fertilized fields was faster and higher than that of optimized N treatments at vegetative stages but not at the reproductive stages.

The maximum earhead and grains were also observed in Green Seeker guided N treatment, whereas the test weight did not differ significantly among the treatments. The high N fertilizer ($N_5$) did not affect the yield attributes and may lead to poor N use efficiency and environment degradation. The nutrient expert tool evaluated the potassium dose and it was >2.5 times than the existing dose of K. The further study and survey is very needful in this area for a concrete conclusion in recommended dose of K for wheat cultivation. From the economic point of view, the net return and B:C ratio were found significantly higher in nutrient expert with green seeker guided treatment ($N_4$) than that of other nutrient management practices. The treatment $N_4$ recorded 50.5% higher net return and 19% more benefit: cost ratio when compared with the $N_5$ having the highest fertilizer dose (Table 1).

**Table.1** Yield attributing characters, yield, and economics as influenced by varying tillage options and different N management practices in wheat

| Treatments | No of ear head/m $^2$ | Grains/Ear head | Test weight (g) | Yield (q/ha) | Net Return (Rs.) | B:C Ratio |
|---|---|---|---|---|---|---|
| **Main Plot** | | | | | | |
| **Zero tillage** | 263 | 40.66 | 41.17 | 44.00 | 68404 | 1.99 |
| **Conventional Tillage** | 267 | 40.57 | 41.25 | 44.76 | 65436 | 1.87 |
| **CD (0.05)** | NS | NS | NS | NS | NS | NS |
| **Sub Plot** | | | | | | |
| **N1* (150:60:40 kg ha$^{-1}$)** | 266 | 40.52 | 41.37 | 44.57 | 27357 | 2.02 |
| **N2 (150:60:40 kg ha$^{-1}$)** | 262 | 41.01 | 41.33 | 43.79 | 26405 | 2.00 |
| **N3 (125:63:105 kg ha$^{-1}$)** | 268 | 40.91 | 41.42 | 45.24 | 27605 | 2.01 |
| **N4 (105: 63:105 kg ha$^{-1}$)** | 273 | 41.80 | 42.64 | 49.44 | 31524 | 2.13 |
| **N5 (225:60:40 kg ha$^{-1}$)** | 259 | 39.31 | 39.32 | 39.73 | 20950 | 1.79 |
| **CD (0.05)** | 8 | 1.08 | NS | 5.12 | 1978 | 0.09 |

*The numbers indicate the nutrient dose of N: $P_2O_5$: $K_2O$; CD = Critical difference

The increase in economics in $N_4$ was associated with increase in grain yield with less use of N fertilizer over that of higher recommended dose in $N_1$, $N_2$ and $N_5$ (Diacono *et al.*, 2013; Peng *et al.*, 2012; Ghosh *et al.*, 2017). The result indicated that the Nutrient Expert in combination with green seeker may be the best option for higher productivity of wheat crop at lowest cost leading to more profitability and sustainability.

The nutrient expert tool with green seeker based N application can be used for sustainable wheat production. Herein, significant increment in grain yield was observed with the saving of considerable amount of N in using nutrient expert tool in combination with green seeker guided N management strategy.

This smart technology increased net return by Rs. 4643 over 100% recommended dose of nutrient and by Rs. 10574 over 150% recommended dose of N. Our findings indicated that revision of current recommendations of nutrient for wheat cultivation and aiming to using nutrient expert tool and green seeker for higher productivity and profitability of wheat crop.

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