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RESEARCH NOTE

Precision nitrogen management in irrigated wheat (*Triticum dicoccum* L.) using optical sensor

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Remote sensing based nitrogen managenent is a new strategy having relationship between NDVI value derived from satellite data or Green Seeker optical sensor with biomass index. The objective was to study the sensor based precision management on growth, yield and efficiencies of applied nitrogen in wheat. A field experiment was conducted to study the Precision nitrogen management in irrigated Wheat using optical sensor at University of Agricultural Sciences, Dharwad, Karnataka on medium deep soil during *rabi* 2018-19. Treatments comprised of nitrogen management practices with rich plot where higher dose of 100 kg nitrogen was applied and absolute control, four Green Seeker guided treatments where recommended N was applied in two and three splits. Higher N use efficiency was recorded with Green Seeker guided N management with N fertilizer saving to the extent of 46 % over N rich plot, 10 % over RDF and 40 % over 90 kg N. Higher grain yield and net returns was recorded by application of 20 kg N as basal + 20 kg N at CRI + Green Seeker guided N management(43.45 q/ha)and (₹ 52794/ha) respectively.

Keywords: Green Seeker, Nitrogen use efficiency, Split application

Wheat is a feeding bowl to human race occupies a leading place of all the staple food grain crops.It is grown across a wide range of environmental condition around the world. In India it contribute 37 per cent of the food grain and occupied 24 per cent of the total cropped area. Nitrogen (N) is one of the most crucial input factors for growth and development of plants and the most limiting nutrient in crop production especially under irrigated cereal based cropping systems. Blanket recommendation, most prevailing nitrogen management strategy in India could not help in increasing the nutrient use efficiency beyond a certain limit (Singh, 2008) due to temporal and spatial variability is not considered in blanket recommendation.

Traditional crop and soil diagnostic tools like soil testing, plant tissue analysis and long-term field trials have limited use due to the large time gap between sampling and ultimate results. Hence, real time N management practices which are non-destructive, quick, reduce spatial and temporal variability to greater extent and match needs and supply. Alternatively tools like chlorophyll meter (SPAD), leaf color chart (LCC), optical sensors are being used to measure leaf and canopy N status. A pre set dose of N is applied using SPAD and LCC when a critical value or critical colour shade is obtained (*Swamy et al*. 2016.) These methods gave an excellent option in terms of evolving real-time N management strategies but they do not consider photosynthetic rates or the biomass production and expected yields for working out fertilizer N requirements (Singh *et al.,* 2011). Hence, Remote sensing based nitrogen management is a new strategy, which is having better relationship between NDVI and crop condition. In turn it is derived from satellite data or GreenSeeker optical sensor with biomass index as revealed in the progress report of rice–wheat consortium. The hypothesis of the experiment was sensor based N management provides higher yield and N use efficiency than the blanket recommendation. The objective of the experiment includes to study the effect of sensor based precision management on growth yield, Agronomic efficiency, Recovery efficiency and Physiologic efficiency in wheat.

A field experiment was conducted to study precision N management in irrigated wheat using optical sensor at Main Agricultural Research Station Dharwad during *rabi* 2018-19.The total rainfall received during cropping season was 34.4 mm in November and 38.4 mm in December month during crop growth stage. However, there was no rainfall during January, February and March months.The soil of the experimental site was clay soil with pH (7.78), electrical conductivity (0.26 dS m^{-1}), organic carbon (0.53 %), available N (252.54 kg ha^{-1}), P_2O_5 (35.76 kg ha^{-1}), K_2O (332.4 kg ha^{-1}). The experiment was laid out in a randomized complete block design (RCBD) involving ten treatments in three replications. Treatments comprised of rich plot with higher dose of N was applied , an absolute control, four Green Seeker guided treatments, RDN in two and three splits. Green Seeker guided N application was combined with fixed N rate @10 and 20 kg ha^{-1} anan time at basal and at crown root initiation (CRI). Green Seeker optical sensor was used at 47 and 65 DAS. Wheat variety 'DDK-1029'was used. The row spacing of 20 cm and the net plot size of 2.8 m x 5.0 m was followed in the study. Recommended dose of fertilizers at 60: 30: 20 N, P_2O_5 and K_2O kg ha^{-1} FYM @ 6.0 t ha^{-1} were applied during the crop period. The nutrients were applied in the form of urea, diammonium phosphate and muriate of potash. The nitrogen doses were applied at basal and top dressed at CRI, maximum tillering, 47 DAS and 65 DAS. The entire dose of P and K were applied as basal. The other management operations were done as per recommended package of practices for the region.

Green Seeker based N fertilizers requirement were calculated by using CIMMYT, Mexico developed mobile app for wheat urea calculator. It requires information like NDVI values of the rich plot and treatment plot, NDVI value of each crop stage and information on experimental site. Based on the NDVI values of rich plot and treatment plot it provide the precise N recommendation in the form of urea. Crop N concentration was estimated by modified micro kjeldhal's method (Tandon, 1998) expressed in kg ha^{-1}. Data on grain yield, amount of N applied and N uptake were used to work out N efficiency indices are as follows.

Agronomic efficiency N (AE_N)

Agronomic efficiency of added N (AEN) was calculated as suggested by Cass man *et al.* (1998).

$$AE_N = \frac{\text{(Grain yield in N fertilized plot – Grain yield in absolute plot)}}{\text{(Quantity of N fertilizer applied in N fertilized plot)}}$$

Recovery efficiency (RE_N)

Recovery efficiency of added N (RE_N) was calculated as per the formula given by Cassman *et al.* (1998).

$$RE_N = \frac{\text{(Total N uptake in N fertilized plot - Total N in absolute plot)}}{\text{(Quantity of N fertilizer applied in N fertilized plot)}} \times 100$$

Physiological efficiency (PE)

Physiological efficiency of N (PE) was worked out as suggested by Baligar *et al.* (2001).

$$PE_N = \frac{\text{(Grain yield in N fertilized plot – Grain yield in absolute plot)}}{\text{(Total N uptake in N fertilized plot - Total N in absolute plot}}$$

The net returns were calculated treatment wise by subtracting the total cost of cultivation from gross returns and expressed in rupees per hectare. The statistical analysis for the the data recorded on various parameters were subjected to Fisher's method of analysis of variance and interpretation of the data was made as given by Gomez and Gomez (1984).The level of significance used in 'F' and 't' test was P = 0.05. Critical difference (CD) values were calculated where the 'F' test was found significant. In case of non-significant effects, value of standard error of means alone is presented in tables.

Growth and yield attributes

Results indicated that among N schedules, N rich plot recorded significantly greater grain yield (45.02 q) as compared RDF and found on par with 30 kg N as basal + 30 kg N at CRI+30 kg N at tillering and Green Seeker guided treatment. It was mainly due to higher rate of N application in two splits which in turn increased yield attributes *viz.*, effective tillers per m^{-2} (315), and grain weight per spike(1.84 g) (Table 2). Further, yield parameters of wheat was mainly due to improved growth parameters *viz.* the table on plant height, total dry matter production per meter row length, leaf area, leaf area index and number of tillers per meter row length (Table 1)

Grain yield depends on production of photosynthesis and their distribution among various plant parts. The plant parts, the synthesis, accumulation and translocation of photosynthates depend upon efficient photosynthetic structure as well as the as the extent of translocation into (grains) and also on plant growth and development during early stages of crop growth. The production and translocation of synthesized photosynthates depend upon mineral nutrition supplied either by soil or through foliar application. Most of photosynthetic pathways are dependent on enzymes and co-enzymes which are synthesized by mineral element such as nitrogen, phosphorus and potassium.

Among Greeen Seeker guided treatments higher grain yield was obtained by application of 20 N ha^{-1} each at sowing and CRI stage, as fixed dose and 13 and 4 kg N ha^{-1} at 47 and 65 DAS, respectively, as guided by Green Seeker this was mainly due to the increased growth and yield attributes by adequate nitrogen supply in right amount and at right time that enabled the wheat

Table 1. Plant height, total dry matter, leaf area, leaf area Index and number of tillers at harvest as influenced by split application of nitrogen in wheat

	Treatment details	Plant height (cm)	Total dry matter (g/mt length)	Leaf area (dm^2)	Leaf area Index	Number of tillers (per meter row length)
T_1	Absolute control	66.7	281.7	38.3	1.92	70.7
T_2	30 kg N basal + 30 kg N at CRI + 30 kg N at Tillering	91.7	382.0	64.4	3.22	163
T_3	30 kg N basal + 15 kg N at CRI + 15 kg N at Tillering	85.9	333.3	57.5	2.87	134.7
T_4	20 kg N basal + 10 kg N at CRI + GS (13 kg N at 47 DAS + 4 kg N at 65 DAS)	90.5	362.0	61.2	3.06	154.0
T_5	20 kg N basal + 20 kg N at CRI + GS (8 kg N at 47 DAS + 6 kg N at 65 DAS)	91.4	377.0	63.4	3.17	158.7
T_6	10 kg N basal + 10 kg N at CRI + GS (18 kg N at 47 DAS + 6 kg N at 65 DAS)	90.0	357.0	60.3	3.02	152.3
T_7	10 kg N basal + 20 kg N at CRI + GS (16 kg N at 47 DAS + 6 kg N at 65 DAS)	91.1	370.7	62.8	3.14	155.7
T_8	30 kg N basal + 30 kg N at 30 DAS	82.6	329.3	55.6	2.78	125.0
T_9	20 kg N basal + 20 kg N at CRI + 20 kg N at Tillering	86.5	334.7	57.9	2.90	135.3
T_{10}	Rich plot (50 kg N basal + 50 kg N at CRI)	93.1	394.3	66.3	3.32	165.3
	S.Em.±.	1.33	16.9	2.03	0.10	4.52
	C.D. (P = 0.05)	3.90	49.4	5.91	0.30	13.21

Table 2. Yield attributes, yield and economics as influenced by split application of nitrogen in wheat

	Treatment details	No. of effective tillers per m²	No of grains per spike	Grain weight per spike (g)	1000 grain weight (g)	Grain yield (q ha^{-1})	Net return (₹ ha^{-1})
T_1	Absolute control	176.0	35.27	1.18	40.26	25.38	28253
T_2	30 kg N basal + 30 kg N at CRI + 30 kg N at Tillering	312.3	42.03	1.82	43.32	44.85	56944
T_3	30 kg N basal + 15 kg N at CRI + 15 kg N at Tillering	267.0	37.53	1.40	41.94	38.02	42836
T_4	20 kg N basal + 10 kg N at CRI + GS (13kg N at 47 DAS + 4 kg N at 65 DAS)	295.0	39.30	1.68	42.87	42.15	51490
T_5	20 kg N basal + 20 kg N at CRI + GS (8 kg N at 47 DAS + 6 kg N at 65 DAS)	302.7	41.43	1.80	43.17	43.45	54206
T_6	10 kg N basal + 10 kg N at CRI + GS (18 kg N at 47 DAS + 6 kg N at 65 DAS)	293.7	38.50	1.66	42.23	41.61	50347
T_7	10 kg N basal + 20 kg N at CRI + GS (16 kg N at 47 DAS + 6 kg N at 65 DAS)	300.0	40.97	1.76	43.11	43.19	53646
T_8	30 kg N basal + 30 kg N at 30 DAS	269.3	37.40	1.37	41.71	37.72	42516
T_9	20 kg N basal + 20 kg N at CRI + 20 kg N at Tillering	271.0	37.60	1.42	42.19	38.64	44118
T_{10}	Rich plot (50 kg N basal + 50 kg N at CRI)	315.0	42.90	1.84	47.98	45.02	57526
	S.Em.±.	12.5	2.76	0.10	2.78	1.33	2794.01
	C.D. (P = 0.05)	36.5	NS	0.30	NS	3.89	8155.53

CRI = Crown root initiation stage, DAS = Days after sowing, GS = GreenSeeker, NS = Non significant

plant to produce higher yield. The results are similar with findings of Kaur (2017) who reported that N rich plot recorded significantly higher growth and yield attributes which were on par with site specific nutrient management (SSNM)+ nutrient expert, SSNM+ nutrient expert+ Green Seeker and all these treatments were significantly better than N_{120} before or after irrigation and no N control. Swamy *et al.* (2016) also reported NDVI threshold 0.8 based N recommended has saved N fertilizers, enchanced yield and economic returns in sweet corn

Nitrogen use efficiency (NUE)

Different N schedules had imposed a significant effect on N uptake. N rich soil recorded the greater N uptake (114.68 kg ha^{-1}) which was statistically similar to 30 kg N as basal + 30 kg N at CRI and+ 30 kg N at tillering Green Seeker guided treatments were significantly superior over RDF and absolute control (54.44 kg ha^{-1}). Higher N uptake in N rich plot might be due to higher dry matter accumulation and higher yields under increased N levels. (Chittapur *et al.* (2015) and Vikram *et al.* (2015)

Among Green Seeker guided treatments recorded higher when N was applied in combination *i.e.,* 20 kg N ha^{-1} each at basal and CRI stages, as fixed dose and Green Seeker based 13 and 4 kg N ha^{-1} at 47 and 65 DAS, respectively .This might be due to better timing and splitting of fertilizer N application during the season led to increased and uniform availability of total N throughout the growth period which resulted in enhanced biomass and led to higher N accumulation in plants. The enhanced nutrition led to improved N uptake in crop. The uptake of nutrients usually follows the yield pattern the amount of nutrient taken up per unit amount of biomass production determine the yields, since the essential nutrients are involved in the metabolism of the plants. Similar results were reported by Khurana *et al.* (2008). observed the effect of late-season N application on higher N content and uptake. Nitrogen use efficiency for the wheat was estimated in terms of recovery efficiency (RE), agronomic efficiency (AE) and physiological efficiency (PE). Both recovery efficiency (RE) and agronomic efficiency (AE) were significantly higher under Green Seeker guided treatments when compared to other treatments.

Agronomic efficiency (AE) was found higher by application of 10 kg N each at basal and CRI later Green Seeker based 18 kg N at 47 DAS and 6 kg N at 65 DAS (36.89 kg/kg N applied) compared to rest of the treatments. However, it was statistically on par with other Green Seeker guided treatments (T_4, T_7 and T_5) superior over RDF and absolute control (Table 2). Recovery efficiency (RE) was also greater by application of 10 kg N each at basal and CRI later Green Seeker based 18 kg at 47 DAS and 6 kg N at 65 DAS(115.2%) However it was found on par with other GS guided treatments (T_4, T_7 and T_5). Physiological efficiency (PE) found higher in 30 kg N as basal + 30 kg N at 30 DAS , however it was found on par with other treatments except T_4, T_5 and T_7. When fertilizer N was applied in right quantity and right time where crop could convert it efficiently into grain yield through which higher fertilizer N use efficiency could be expected. Ratanoo *et al.* (2016) and Singh *et al.* (2011) have reported the same result *i.e.,* Green Seeker technology ensures higher nitrogen use efficiency. Because of the AE being numerator and RE being denominator physiological efficiency followed unusual trend.

Economic Returns

Data revealed that higher net return (₹ 57526 ha^{-1})was recorded in rich plot however it was found on par with 30 kg N basal + 30 kg N at CRI + 30 kg N at tillering and Green Seeker guided treatments (T_5, T_7, T_4 and T_8) Higher net returns in higher N doses treatment might be due to higher grain and straw yield

Table 3. Nitrogen uptake, agronomic (AE_N), recovery (RE_N)and physiological effenciencies (PE_N) of wheat as influenced by split application of nitrogen

	Treatment	N uptake at maturity	AE_N (kg grain/kg N)	RE_N (%)	PE_N (kg grain/ kg N uptake)
T_1	Absolute control	54.44	-	-	-
T_2	30 kg N basal + 30 kg N at CRI + 30 kg N at tillering	114.2	21.63	66.36	32.78
T_3	30 kg N basal + 15 kg N at CRI + 15 kg N at Tillering	88.1	21.08	56.01	37.45
T_4	20 kg N basal + 10 kg N at CRI + GS (13 kg N at 47 DAS + 4 kg N at 65 DAS)	106.4	35.69	111.07	32.18
T_5	20 kg N basal + 20 kg N at CRI + GS (8 kg N at 47 DAS + 6 kg N at 65 DAS)	110.7	34.09	106.06	32.31
T_6	10 kg N basal + 10 kg N at CRI + GS (18 kg N at 47 DAS + 6 kg N at 65 DAS)	105.1	36.89	115.12	32.61
T_7	10 kg N basal + 20 kg N at CRI +GS (16 kg N at 47 DAS + 6 kg N at 65 DAS)	109.8	34.25	106.49	32.31
T_8	30 kg N basal + 30 kg N at 30 DAS	83.9	20.57	49.10	44.42
T_9	20 kg N basal + 20 kg N at CRI + 20 kg N at Tillering	89.4	22.11	58.33	38.87
T_{10}	Rich plot (50 kg N basal + 50 kg N at CRI)	114.7	19.64	60.24	32.76
	S.Em. ±	3.1	2.40	6.82	4.12
	C.D. (P = 0.05)	9.1	7.02	19.91	12.01

CRI = Crown root initiation stage, DAS = Days after sowing, GS = Green Seeker, NS = Non significant

under these treatments as compared to absolute control treatment. The higher grain yield due to Green Seeker application was responsible for net return in GS guided treatments. Among GS guided treatments 20 kg N basal + 20 kg N at CRI + GS (8 kg N at 47 DAS + 6 kg N at 65 DAS) recorded higher net return (Table 1). These results were found similar with Kaur (2017). Sapkota *et al.* (2014) has also reported higher returns from Nutrient expert or Nutrient expert + Green Seeker in comparison to recommended practices.

Conclusion

Higher grain yield, net returns and nitrogen efficiency was recorded with the application of 20 kg N as basal + 20 kg N at CRI + Green Seeker (8 kg N at 47 DAS +6 kg N at 65 DAS) guided N management.

References

Cassman K G, Peng S, Olk D C, Ladha J K, Reichardt W, Dobermann A and Singh U, 1998, Opportunities for increased nitrogen use efficiency from improved resources management in irrigated lowland rice systems. *Field Crop Research.,* 56: 7-38.

Chittapur B M, Umesh M R and Biradar D P, 2015, Decision support tools for nitrogen in cereals. A Review. *Karnataka Journal Agricultural Sciences,* 28 (4): 446-453

Gomez K A and Gomez A A, 1984, *Statistical Procedures for Agricultural Research,* 2nd Ed. John Willy and Sons, New York (USA), p. 639.

Kaur J, 2017, Precision nutrient management in wheat (*Triticum aestivum* L.) using nutrient expert and Green-Seeker. *M. Sc. (Agri.) Thesis.* Punjab Agricultural University., Ludhiana.

Khurana H S, Philips S B, Singh B, Alley M M Doberman A, Sindhu A S, Singh Y and Preng S, 2008, Agronomic and economic evaluation of site specific nutrient management for irrigated wheat in northwest India. *Nutrient Cycling Agro Ecosystem.,* 82: 15-31.

Ratanoo R, Kumar S, Dhaka A K and Singh B, 2016, Nitrogen management in irrigated wheat (*Triticum aestivum* L,) using optical sensor Green–Seeker, *Indian Journal of Agronomy,* 61 (1):105-108.

Sapkota T B, Majumdar K, Jat M L, Kumar A, Bishnoi D K, McDonald A J and Pampolino M, 2014, Precision nutrient management in conservation agriculture based wheat production of Northwest India: probability, nutrient use efficiency and environmental footprint. *Field Crops Research,* 155: 233-244

Singh B, 2008, Crop demand driven site specific nitrogen application in rice (*Oryza sativa*) and wheat (*Triticum aestivum*): some recent advances. *Indian Journal of Agronomy,* 53 (3):157-166.

Singh B, Sharma R K, Kaur J, Jat M L, Martin K L, Singh Y, Singh V, Chandna P, Choudhary O P, Gupta R K, Thind H S, Singh J, Uppal H S, Khurana H S, Kumar A, Uppal R K, Vashistha M, Raun W R and Gupta R, 2011, Assessment of the nitrogen management strategy using an optical sensor for irrigated wheat. *Agronomy of Sustainable. Development*, 31:589-603.

Swamy M, Umesh M R, Ananda N, Shanwad U K, Amaregowda A and Manjunath N, 2016, Precision nitrogen management for *rabi* sweet corn (*Zea mays saccharata* L.) through decision support tools. *Journal of Farm Sciences*, 29(1): (14-18) 2016

Vikram A P, Biradar D P, Umesh M R, Basavaneppa M A and Narayana Rao K, 2015, Effect of nutrient management techniques on growth, yield and economics of hybrid maize (*Zea mays* L.) in vertisol. *Karnataka Journal of Agricultural Sciences,* 28 (4): 477-481.