International Journal of Agricultural Sciences
Volume **20** | Issue 1 | January, 2024 | 68-74 ■ ISSN : 0973-130X
DOI:10.15740/HAS/IJAS/20.1/68-74
Visit us : *www.researchjournal.co.in*

RESEARCH PAPER

Importance of sensor-based nitrogen application and effect of growth parameters in wheat crop

Mustkim A. Patel*, Manjeet Singh, P. K. Singh, Mahesh Kothari **and** Brij Gopal Chhipa
Soil and Water Engineering, College of Technology and Engineering, Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan) India (Email: mustkimp7@gmail.com)

Abstract : An experiment of sensor-based nitrogen application and effect of growth parameters in wheat crop was conducted during the *Rabi* season of 2022 at the Technology Park, CTAE campus, MPUAT, Udaipur. This study examined the impact of various fertilizer treatments, including a crop sensor-based approach, on wheat crop growth. The results showed that the crop sensor-based treatment demonstrated significant improvements in plant height and tiller density as compared to the 100% Recommended Dose of Fertilizer (RDF) treatment.”

Key Words : Importance of sensor-based nitrogen application, Effect of growth parameters, Wheat crop

View Point Article : Patel, Mustkim A., Singh, Manjeet, Singh, P. K., Kothari, Mahesh and Chhipa, Brij Gopal (2024). Importance of sensor-based nitrogen application and effect of growth parameters in wheat crop. *Internat. J. agric. Sci.*, **20** (1) : 68-74, **DOI:10.15740/HAS/IJAS/20.1/68-74.** Copyright@2024: Hind Agri-Horticultural Society.

Article History : Received : 05.07.2023; **Revised :** 08.08.2023; **Accepted :** 11.09.2023

INTRODUCTION

Wheat (*Triticum aestivum* L.) stands as a pivotal cereal crop globally, occupying a central role in addressing food security concerns. As the staple food for approximately one-third of the world’s population, wheat cultivation is crucial for sustaining productivity and meeting the dietary needs of billions. In this context, India emerges as a significant contributor to the global wheat landscape, ranking second in both area and production. Despite a commendable global wheat production of 781.31 million metrictons in 2021 (Anonymous, 2022), India faces the ongoing challenge of securing even higher yields to feed its burgeoning population.

The quest for increased wheat production reveals a notable yield gap within the country’s wheat-growing regions, emphasizing the need for improved nutrient management. One of the primary contributors to this yield gap is the inappropriate management of nutrients, as highlighted by Majumdar *et al.* (2012).

India’s extensive wheat cultivation spans 31,868.26 hectares, with the state of Rajasthan alone dedicating 2,964.70 hectares, yielding 3,676.00 kg/ha. The Green Revolution of 1970 played a transformative role in India’s agricultural landscape, relying on high-yielding varieties responsive to inorganic fertilizers like Urea, DAP, and MOP. However, the nation’s heavy dependence on imported fertilizers has led to rising input costs, prompting

---

***Author for correspondence:**

reductions in subsidies to conserve foreign exchange and boost the country's GDP.

Fertilizer nitrogen (N) emerges as a key input for crop production, particularly for cereals like rice, wheat, and maize, accounting for over half of the global fertilizer N consumption. With estimates suggesting a 50-70% increase in cereal grain demand by 2050 to sustain a population exceeding 9 billion (Singh *et al*., 2011), the demand for fertilizer N is poised to rise significantly. However, the current efficiency of fertilizer N recovery in wheat stands at a modest 30-50%, primarily due to inefficient splitting of N doses and applications exceeding crop requirements.

Conventional approaches, characterized by blanket recommendations for fixed-time application of fertilizer N doses, fail to consider dynamic soil N supply and crop N requirements. This leads to excessive fertilizer N application, causing nutrient imbalances, increased susceptibility to diseases and pests, higher production costs, and environmental pollution. In response, site-specific nitrogen management emerges as a promising approach to enhance fertilizer use efficiency and grain yield in farmers' fields (Nath *et al.,* 2013).

MATERIAL AND METHODS

This study, titled "Importance of sensor-based nitrogen application and effect of growth parameters in wheat crop." employed a comprehensive methodology encompassing field experiments, data collection, and rigorous statistical analysis. The following sections detail the materials used, the experimental site, climatic conditions, data collection procedures, soil characteristics, and the experimental layout.

Fig. A : Location map of the study area

Experimental site :

The field experiment transpired during the *Rabi* season in 2022-23 at the Technology Park, College of Technology and Engineering (CTAE), Maharana Pratap University of Agriculture and Technology (MPUAT) in Udaipur. The site is situated at 24°35' North latitude, 73°44' East longitude, with an elevation of 582.17 meters above mean sea level.

Climate and weather :

Udaipur falls under Rajasthan agro-climatic zone IV, characterized by a sub-humid climate with an annual rainfall of 637 mm. Temperature variations, ranging from 39°C in summer to 1°C in winter, are conducive to the phenological stages of wheat (October to April).

Data collection :

Soil characteristics :

Soil samples from two depths (0-15 cm) were collected, air-dried, processed, and analysed for mechanical, physical, and chemical properties. These analyses included parameters such as sand, silt, clay percentages, pH, electrical conductivity, organic carbon, and availability of nitrogen, phosphorus, and potassium.

Experimental and treatment details :

The experiment utilized a Randomized Block Design (RBD) with five treatments and four replications during the *Rabi* season. The Raj-4238 wheat variety was sown, and specific treatments were applied based on a detailed schedule. The given details are shown in Table A.

Table A : Treatments details of the experiment

Treatment	Dose (kg N ha^{-1})	Details of application
T_1	Control	Absolute control (N, P, or K)
T_2	75 % of RDF	37.5% at Basal +37.5% CRI
T_3	100 % of RDF	50% at Basal +50% CRI
T_4	125 % of RDF	62.5% at Basal +62.5% CRI
T_5	Based On Crop Sensor	75% N in two splits as basal and at CRI + NDVI sensor

Detail of field cultural operations :

Cultural operations, including field preparation, layout, sowing, irrigation, nitrogen application, intercultural operations, harvesting, and threshing, were conducted according to a pre-defined calendar.

Field preparations :

The field under went initial preparation using tractor-drawn implements, followed by deep ploughing, cross-harrowing, levelling, and manual preparation of plots.

Crop water requirement :

The base period for wheat was 120 days, and irrigation was carried out at critical stages, with a total water depth of 7.5 cm applied at 25-day intervals.

Nitrogen application :

Nitrogen application, based on treatment specifications, was performed using urea and single super phosphate (SSP) at rates of 75, 100, and 125 kg/ha. Sensor-based nitrogen application was determined during each irrigation.

Sowing :

Seeds were sown at a depth of 3 cm in furrows spaced 20 cm apart, with a seeding rate of 100-125 kg/ha.

Irrigation :

The field received pre-sowing and subsequent irrigations based on crop-specific requirements.

Harvesting and threshing :

Harvesting was conducted manually in late March, followed by manual threshing and winnowing in early April.

Observations recorded :

Growth studies :

Five randomly selected plants per plot underwent growth parameter assessments at 30-day intervals.

Plant height and number of Tillers/m² :

Plant height was measured at 30, 60, and 90 days after sowing, and the total number of tillers per meter row length was recorded at 60 days and harvest.

Yield and yield attributes :

Number of spike/m² and number of grains/Per spike:

The count of spikes per meter row length was recorded at maturity, and the number of grains per spike was determined from randomly selected spikes.

1000-Grain weight and grain yield :

One thousand grains from each plot were weighed, and grain yield was recorded in kg/ha.

Nutrient status of soil :

Post-harvest, soil samples were collected for available nitrogen, phosphorus, and potassium determination.

Plate 1 : Measured nitrogen in wheat crop

Economic studies :

Cost of cultivation, gross returns, net returns, and benefit-cost ratios were calculated for each treatment.

Plate 2: Available nitrogen in wheat crop

Statistical analysis :

Statistical analyses involved ANOVA, standard errors, and critical differences at a 5% significance level.

RESULTS AND DISCUSSION

This chapter presents the outcomes of the study, focusing on the performance of sensor-based nitrogen application in wheat crops compared to conventional methods. The investigation involved three nitrogen application levels, including a control group, and the results are analysed comprehensively.

Growth studies :

Plant height at 30, 60 DAS and at harvest :

Plant height is a crucial indicator of crop growth, representing structural progression. Measurements at different growth stages revealed interesting patterns. At 30 days after sowing (DAS), there was no significant variation among treatments. However, at 60 DAS, the Crop Sensor treatment exhibited significantly greater plant height measuring 41.93 cm, comparable to the 100% RDF treatment, which measured 40.89 cm. Similar trends persisted at 90 DAS and harvest. Growth parameters, including plant height and tiller count, consistently favoured sensor-based nitrogen applications. The recommended 100% RDF and 75% RDF treatments guided by the crop sensor resulted in superior growth parameters. These findings align with previous research, indicating improved yield-related characteristics with site-specific crop management. crop studies are presented in Table 1 and Fig. 1.

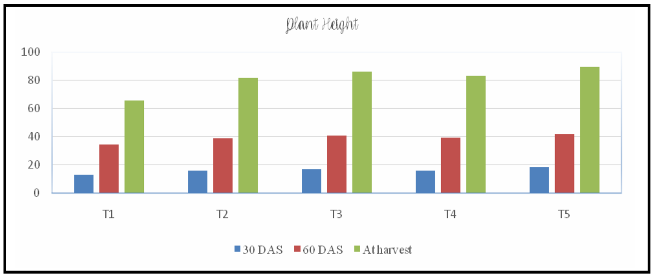

Fig. 1: Plant height 30,60, at harvest DAS in wheat crop

Sensor-based analysis of wheat crop :

The N-Sensing System, utilizing the GreenSeeker handheld sensor, provided NDVI values reflecting plant health and growth. NDVI peaked at 0.79 during the "Maturity" stage, indicating maximum vegetative growth and grain development. This data aids decision-making in wheat cultivation, potentially enhancing yields and quality during the *Rabi* season are presented in Table 2 and Fig. 2.

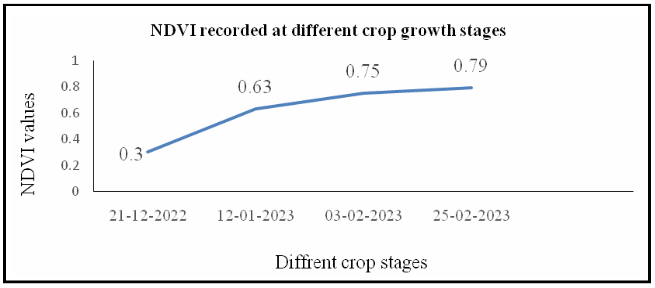

Fig. 2 : NDVI curve of wheat crop during *Rabi* 2022-23

Fertigation application :

During the cropping period, fertilizer was applied as per the methodology adopted in treatment T_1 no fertilizer has been applied as a control plot. In treatment, T_2 75% RDF has been applied in two splits 37.5% as

Table 1 : Plant height

Treatment		30 DAS	60 DAS	At harvest
T_1	Control	12.96	34.83	65.71
T_2	75% Recommended dose of fertilizer (RDF)	16.21	38.83	81.75
T_3	100% Recommended dose of fertilizer (RDF)	16.84	40.89	86.21
T_4	125% Recommended dose of fertilizer (RDF)	16.3	39.62	83.27
T_5	Based on Crop Sensor	18.3	41.93	89.81
S.E.±		NS	1.85	4.25
C.D. (P=0.05)		NS	5.70	11.13

Table 2 : Field data of wheat crop collected during *Rabi* 2022-23

Sr. No.	Date	NDVI	Crop stage
1.	21-12-2023	0.30	Tillering
2.	14-1-2023	0.63	Shooting
3.	03-2-2023	0.75	Heading
4.	25-2-2023	0.79	Maturity

basal and 37.5% at the CRI stage. In treatment T_3 100% RDF has been applied in two splits 50% as basal and 50% at the CRI stage. In treatment T_4 125% RDF has been applied in two splits 62.5% as basal and 62.5% at the CRI stage and treatment T_5 nitrogen has been applied at 37.5% as basal and 37.5% at the CRI stage and tillering and shooting stage as per NDVI value of the crop sensor. The details of nitrogen application at various growth stages under different treatments are shown in Table 3.

Number of tillers at harvest :

The sensor-based nitrogen application treatment and the 100% RDF, showed a count of 443 per m². treatment recorded the highest number of tillers per square meter at harvest, statistically similar and significantly higher than the control. The Crop Sensor's ability to guide nitrogen application at critical growth stages contributed to increased tiller count, a crucial factor in wheat productivity.

Yield attributes :

Data about yield attributes, including the number of spikes/m², number of grains per spike, and 1000-grain weight (g), influenced by various sensor-based nitrogen applications in wheat crops, the detailed yield attributes are presented in Table 4 and Fig. 3.

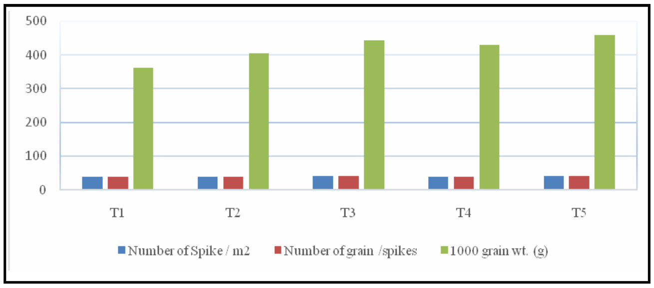

Fig. 3:Number of spike, number of grain /spikes, 1000 grain wt

Number of spikes per m² :

Sensor-based nitrogen applications significantly influenced the number of spikes/m², yielding the highest countreaching 459 spikes/m², statistically similar to the 100% RDF treatment, which yielded 443. The control group recorded the lowest count, emphasizing the positive impact of sensor-guided nitrogen application on wheat spike formation.

Number of grains per spike :

Sensor-based nitrogen application treatments significantly impacted the number of grains per spikereaching 40.07, with the Crop Sensor treatment resulting in the highest count. This aligns with the notion that precise nitrogen application positively influences wheat yield attributes.

The 1000-grain weight was highest in the Crop Sensor treatment totalling 40.70 grams, statistically similar

Table 3 : Nitrogen application at various growth stages under different treatments

Treatment	N application (kg ha^{-1})				
	Basal	21 DAS	42 DAS	65 DAS	Total
T_1	0	0	0	0	0
T_2	37.5	37.5	0	0	75
T_3	50	50	0	0	100
T_4	62.5	62.5	0	0	125
T_5	37.5	37.5	33	8	116

Table 4 : Yield attributes

Treatment		Number of spike / m^2	Number of grain /spikes	1000 grain wt. (g)
T_1	Control	37.73	37.36	362
T_2	75% Recommended dose of fertilizer (RDF)	38.95	39.13	406
T_3	100% Recommended dose of fertilizer (RDF)	39.86	39.76	443
T_4	125% Recommended dose of fertilizer (RDF)	39.41	38.44	429
T_5	Based on the crop sensor	40.07	40.70	459
S.E.±		9.59	2.31	1.83
C.D. (P=0.05)		29.56	7.13	5.63

to the 100% RDF treatment which resulted in a 1000-grain weight of 39.76 grams. This indicates that sensor-based nitrogen application not only enhances the quantity but also the individual weight of grains, contributing to overall yield improvement.

Grain yield (t/ha) :

Sensor-based nitrogen application treatments significantly influenced grain yield, with the Crop Sensor treatment recording the highest yield totalling 5.61 t per ha, statistically similar to the 100% RDF treatmentwhich produced a grain yield of 5.27 t per ha. This highlights the efficacy of sensor-based nitrogen application in optimizing wheat productivity. Grain yield is presented in Table 6 Fig. 4.

Straw yield (t/ha) :

Straw yield also showed significant improvements with sensor-based nitrogen applications. The Crop Sensor treatment recorded the highest straw yieldof 11.54 t per ha, emphasizing the holistic benefits of precision nitrogen management. Straw yield is presented in Table 6 Fig. 4.

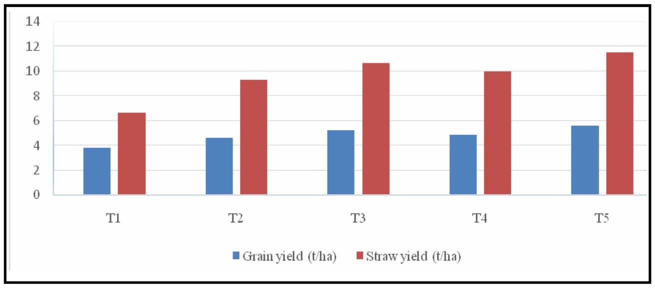

Fig. 4: Grain yield and straw yield

Available nutrients in soil :

Available N in soil :

Different sensor-based nitrogen application treatments did not significantly impact available nitrogen levels. The crop sensor treatment recorded the highest nitrogen content, suggesting that precision nitrogen management does not adversely affect soil nitrogen levels

Table 6 : Grain yield and straw yield

Treatment		Number of Spike / m^2	Number of grain /spikes	1000 grain wt. (g)
T$_1$	Control	37.73	37.36	362
T$_2$	75% Recommended dose of fertilizer (RDF)	38.95	39.13	406
T$_3$	100% Recommended dose of fertilizer (RDF)	39.86	39.76	443
T$_4$	125% Recommended dose of fertilizer (RDF)	39.41	38.44	429
T$_5$	Based on the crop sensor	40.07	40.70	459
S.E.±		9.59	2.31	1.83
C.D. (P=0.5)		29.56	7.13	5.63

Table 7: N, P and K status of soil at harvest level in wheat crop

Treatment		Nitrogen	Phosphorus	Potassium
T$_2$	75% Recommended dose of fertilizer (RDF)	208.33	21.01	210.0
T$_3$	100% Recommended dose of fertilizer (RDF)	238.33	21.99	227.0
T$_4$	125% Recommended dose of fertilizer (RDF)	242.67	22.26	234.5
T$_5$	Based on crop sensor	245.33	22.70	246.5
S.E.±		162.66	1.90	10.19
C.D. (P=0.05)		NS	NS	NS

NS= Non-significant

Table 8 : Effect of sensor-based nitrogen application on relative economics in wheat crop

Treatment		Cost of cultivation	Gross returns	Net returns	B:C
T$_1$	Control	30689.00	94680.33	63991.33	2.09
T$_2$	75% Recommended dose of fertilizer (RDF)	31621.36	102837.01	71216.01	2.25
T$_3$	100% Recommended dose of fertilizer (RDF)	31933.04	118646.65	86713.65	2.72
T$_4$	125% Recommended dose of fertilizer (RDF)	32243.29	110455.35	78212.35	2.43
T$_5$	Based on crop sensor	33718.60	114039.93	80321.93	2.38

(Subbiah *et al*.,1956).

Available P in Soil :

Available phosphorus levels were not significantly affected by sensor-based nitrogen applications. The crop sensor treatment recorded the highest phosphorus content, showcasing the compatibility of sensor-based nitrogen management with soil phosphorus levels (Olsen *et al.,*1954).

Potassium (K) uptake by the soil :

Sensor-based nitrogen application treatments did not significantly impact available potassium levels. The Crop Sensor treatment recorded the highest potassium content, indicating that precision nitrogen management is compatible with soil potassium levels (Jackson *et al*., 2005).

Economics in wheat :

Economic considerations play a vital role in technology adoption. Net returns and benefit-cost ratios were used to assess the economic viability of different treatments. The 100% RDF treatment emerged as the most economically favourable, followed by the 125% RDF treatment. This aligns with the notion that precision nitrogen management contributes not only to enhanced yields but also to economic profitability. The given details are shown in Table 8.

Conclusion :

In conclusion, the study demonstrates the positive impact of sensor-based nitrogen applications on wheat growth, yield attributes, and overall economic viability. The crop sensor treatment consistently outperformed other treatments, showcasing its efficacy in optimizing nitrogen use and improving wheat productivity. The findings support the integration of precision nitrogen management, guided by advanced sensor technology, into wheat cultivation practices for sustainable and economically viable outcomes. Future research may delve into the long-term effects and scalability of sensor-based nitrogen applications across diverse agro-climatic conditions.

REFERENCES

Anonymous (2022). Annual Report-2017-18. Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare Government of India, 3.

Jackson, M. L. (2005). *Soil chemical analysis: advanced course.* UW-Madison Libraries Parallel Press.

Majumdar, K., Jat, M. L., Pampolino, M., Satyanarayana, T., Dutta, S. and Kumar, A. (2012). Nutrient management in wheat: current scenario, improved strategies and future research needs in India. *Journal of Wheat Research*, 4.

Nath, D. K., Haque, F., Amin, F., Islam, M. S. and Saleque, M. A. (2013). Farmers participatory site specific nutrient management in gangetic tidal flood plain soil for high yielding boro rice (*Oryza sativa* L.). *The Agriculturists,* **11** : 8-14.

Olsen, S. R. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate US Department of Agriculture 939.

Singh, S. and Singh, J. P. (2012). Effect of organic and inorganic nutrient sources on some soil properties and wheat yield. *Journal of the Indian Society of Soil Science,* **60** : 237-240.

Subbiah, B. V. and Asija, G. L. (1956). A rapid procedure for the determination of available nitrogen in soils.*Current Sciences,* **25** : 259-268.