

Research Article	Pak-Euro Journal of Medical and Life Sciences	
DOI: 10.31580/pjmls.v6i3.3159	Copyright © 2025 All rights are reserved by Corresponding Author	
Vol. 6 No. 3, 2023: pp. 387xiii-387xx		
www.readersinsight.net/pjmls	Revised: August 26, 2023	Accepted: September 05, 2023
Submission: July 16, 2023	Published Online: September 10, 2023	

YIELD PERFORMANCE OF WHEAT UNDER VARIOUS NITROGEN LEVELS IN DIFFERENT GROWTH STAGES

Zahid Hussain^{1*}, Sefat Ullah¹, Wajid Ali Shah¹, Roohul Amin¹, Arbab Hamid Ullah¹, Muhammad Farooq^{2*}



¹Department of Agriculture, Bacha Khan University, Charsadda, KPK, Pakistan

²College of Food Science and Engineering, Northwest A and F University, Yangling, Shaanxi 712100, PR China

***Corresponding Authors:** Muhammad Farooq and Zahid Hussain.

E. mails: farooq.fst28@gmail.com and drzahid97@gmail.com

Abstract

This field experiment investigated wheat's response to nitrogen application rates (0-120 kg/ha) and combined soil-foliar nitrogen application methods (soil application, 95%+5% foliar, 90%+10% foliar, 85%+15% foliar). Results showed that 120 kg N/ha significantly improved grains/spike (55.4), thousand grain weight (43.6g), biological yield (10977 kg/ha), grain yield (4265 kg/ha), harvest index (39.75%), grain protein (11.3%), and straw protein (2.8%). Meanwhile, 85% soil + 15% foliar application outperformed other methods, yielding grains/spike (59.2), thousand grain weight (43.1g), biological yield (9947 kg/ha), grain yield (4129 kg/ha), harvest index (42.30%), grain protein (11.5%), and straw protein (2.6%). The interaction between nitrogen rates and application methods significantly affected various yield parameters. The study recommends 120 kg N/ha with 85% soil + 15% foliar application for maximum wheat productivity.

Keywords: Foliar application, Grain yield, Growth stages, Nitrogen application, Wheat

INTRODUCTION

Wheat is a fundamental staple crop worldwide, contributing significantly to global food security. Enhancing wheat yield is vital to address the increasing food demands. Nitrogen (N) plays a pivotal role in regulating wheat growth and productivity. Sufficient nitrogen availability promotes photosynthesis, biomass accumulation, and grain yield (1). However, over-application of nitrogen may result in environmental degradation and diminished economic efficiency.

Recent research underscores the necessity of precision nitrogen management, which involves tailoring application based on variables such as developmental stage, soil characteristics, and climatic conditions (2, 3). Evidence suggests that both the timing and the rate of nitrogen application are critical determinants of wheat yield and grain quality (4).

While appropriate nitrogen levels facilitate optimal physiological processes and yield formation, excessive input can lead to adverse environmental impacts, economic inefficiencies, and elevated greenhouse gas emissions (5). Hence, adopting site-specific nitrogen management practices is crucial for sustainable wheat cultivation. Effective nitrogen management strategies are essential to optimize yield potential, maintain grain quality, and minimize environmental consequences. Contemporary studies recommend the implementation of optimized nitrogen rates—generally in the range of 100–150 kg N/ha—split applications and the use of enhanced-efficiency fertilizers such as slow-release formulations and nitrification inhibitors to improve nitrogen use efficiency and reduce nitrogen losses (6-8). Moreover, precision agriculture technologies, including crop sensors and unmanned aerial vehicles (UAVs), enable real-time monitoring and accurate application of nitrogen, thereby minimizing waste and environmental impact (9). Decision support systems further aid growers by integrating data on weather patterns, soil properties, and crop phenology to



guide nitrogen management decisions (10). Collectively, these advanced approaches contribute to improved wheat productivity and quality while supporting environmental sustainability.

MATERIALS AND METHODS

A field experiment entitled “Yield performance of wheat under various nitrogen levels in different growth stages” The experiment was conducted at Bacha Khan Agricultural Research Farm Charsadda (BARF), Bacha Khan University, Charsadda during winter season. The experiment was designed in a RCB design having three replication. Plot size will be 1.8m x 3m and all other agronomic and cultural practices were uniformly maintained.

The experiment consisted of two factors: nitrogen application and growth stages. For nitrogen application, there were five levels: 80 kg ha⁻¹ (N1), 100 kg ha⁻¹ (N2), 120 kg ha⁻¹ (N3), 140 kg ha⁻¹ (N4), and 160 kg ha⁻¹ (N5). The second factor involved different growth stages for nitrogen application, which included: applying 100% of nitrogen at sowing time (S1); splitting nitrogen into 50% at sowing and 50% at the second irrigation, 50 days after sowing (S2); applying 50% of nitrogen at sowing and 50% at tillering (S3); and splitting nitrogen into four equal parts, applied at sowing, second irrigation, booting, and after anthesis (S4).

The study measured various parameters, including protein concentrations in grains and straw, as well as several growth and development metrics. These metrics included grains spikes⁻¹, thousand grains weight (g), biological and grain yield (kg ha⁻¹) and harvest index (%).

Grain protein content was determined using near-infrared reflectance spectroscopy (NIRS) (11) at NIFA Peshawar's oilseed quality lab. Straw protein content was analyzed via near-infrared reflectance spectroscopy (NIRS) (11) at NIFA Peshawar.

STATISTICAL ANALYSIS

Data was analyzed using Randomized Complete Block Design (RCBD) and means were compared using Least Significant Difference (LSD) test at 5% significance level (5).

RESULTS AND DISCUSSION

GRAINS SPIKE⁻¹

Nitrogen application significantly impacted grains per spike, with the highest value (50 grains) observed at 160 kg N/ha and the lowest (42 grains) at 80 kg N/ha (Table I and Fig. 1). Split nitrogen application (25% each at sowing, second irrigation, booting, and after anthesis) yielded more grains per spike (49 grains) than single application at sowing (44 grains). The interaction between nitrogen rate and application timing was significant, with the highest grains per spike (53 grains) recorded at 160 kg N/ha with split application, supporting previous findings (12, 13).

Table I. Grains per spike of wheat as influenced by nitrogen levels and application timing

Nitrogen at different growth (DGS) stages (kg ha ⁻¹)	Levels of Nitrogen (kg ha ⁻¹)					Means
	80	100	120	140	160	
100% ST	38	41	43	53	46	44d
50% ST 50% SI 50 days	40	42	47	51	48	46c
50% ST 50% T	42	45	48	51	52	47b
25% ST 25% SI 25% B 25% AA	47	51	53	42	53	49a
Means	42d	45c	48b	49a	50a	

*LSD for Nitrogen = 0.169; LSD for different growth stages = 0.151; LSD for N x DGS = 0.339

THOUSAND GRAINS WEIGHT (g)

Nitrogen application significantly affected thousand grain weight (TGW), with the highest value (41g) observed at 140 kg N/ha and the lowest (36g) at 80 kg N/ha (Table II and Fig. 2). Split nitrogen application resulted in higher TGW (41g) compared to single application at sowing (37g). The interaction

between nitrogen rate and timing was significant, with the highest TGW (42g) recorded at 160 kg N/ha with split application, supporting previous research on nitrogen's positive impact on wheat growth and yield components (14, 15).

Table II. Thousand grains weight (g) in wheat as influenced by nitrogen levels and application timing

Nitrogen at different growth (DGS) stages (kg ha ⁻¹)	Levels of Nitrogen (kg ha ⁻¹)					Means
	80	100	120	140	160	
100% ST	32	36	40	41	38	37d
50% ST 50% SI 50 days	35	35	38	43	41	38c
50% ST 50% T	37	38	40	41	42	40b
25% ST 25% SI 25% B 25% AA	40	41	42	40	42	41a
Means	36d	37c	40b	41a	41a	

* ST = Sowing Time; SI = Second Irrigation; T = Tillering; AA = After Anthesis; LSD for Nitrogen = 0.569; LSD for different growth stages = 0.508; LSD for N × DGS = 1.138

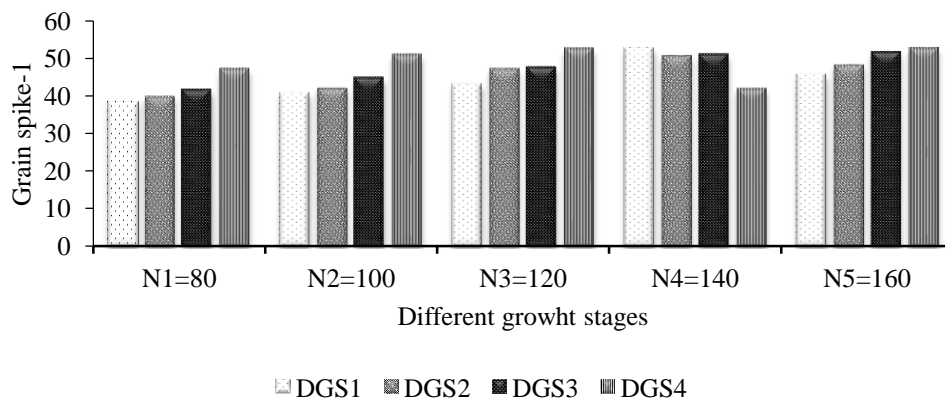


Fig.1. Nitrogen levels and application timing impact on wheat grain spike-1

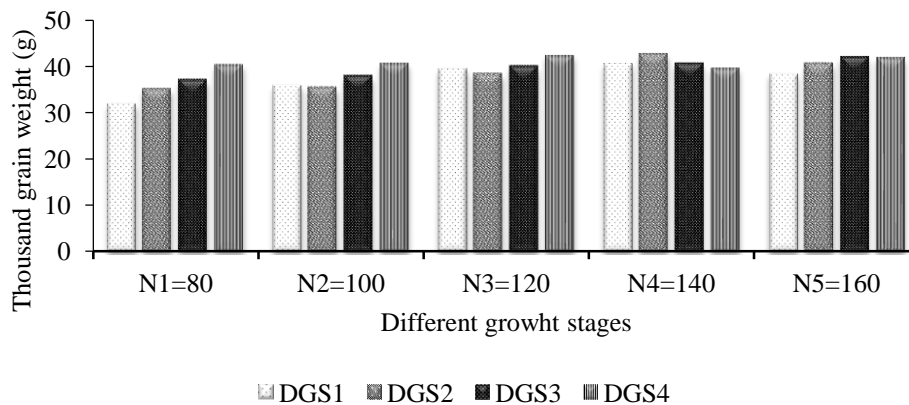


Fig. 2. Nitrogen levels and application timing impact on wheat thousand grain weights (g)

BIOLOGICAL YIELD (kg ha⁻¹)

Nitrogen application significantly impacted biological yield, with the highest value (11640 kg/ha) observed at 160 kg N/ha and the lowest (8364 kg/ha) at 80 kg N/ha (Table III and Fig. 3). Split nitrogen application resulted in higher biological yield (10203 kg/ha) compared to single application at sowing (9371 kg/ha). The interaction between nitrogen rate and timing was significant, with the highest biological yield (12769 kg/ha) recorded at 160 kg N/ha with 50% application at sowing and 50% at second irrigation, supporting previous research on nitrogen's positive impact on wheat productivity (16, 17).

GRAINS YIELD (kg ha⁻¹)

Nitrogen application significantly affected grain yield, with the highest value (4004 kg/ha) at 160 kg N/ha and the lowest (2989 kg/ha) at 80 kg N/ha (Table IV and Figure 4). Split nitrogen application resulted in higher grain yield (3709 kg/ha) compared to single application at sowing (3249 kg/ha). The interaction

between nitrogen rate and timing was significant, with the highest grain yield (4347 kg/ha) recorded at 160 kg N/ha with 50% application at sowing and 50% at second irrigation, supporting previous findings on nitrogen's positive impact on wheat yield (18,19).

Table III. Biological yield (kg ha⁻¹) in wheat as influenced by nitrogen levels and application timing

Nitrogen at different growth (DGS) stages (kg ha ⁻¹)	Levels of Nitrogen (kg ha ⁻¹)					Means
	80	100	120	140	160	
100% ST	7910	8239	8650	10277	11777	9371d
50% ST 50% SI 50 days	8034	8627	9128	10774	12769	9866c
50% ST 50% T	8279	8964	9555	10981	12433	10042b
25% ST 25% SI 25% B 25% AA	9234	9756	11459	10985	9582	10203a
Means	8364e	8896d	9698c	10754b	11640a	

* LSD for Nitrogen = 96.34; LSD for different growth stages = 86.17; LSD for N x DGS = 192.69

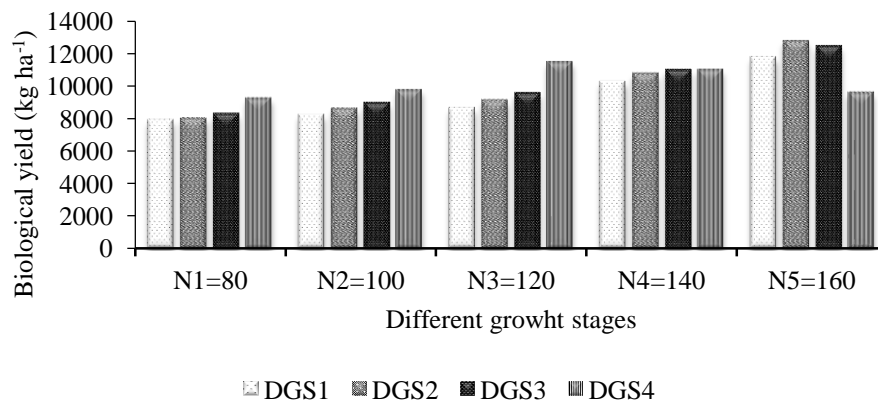


Fig. 3. Nitrogen levels and application timing impact on wheat biological yield (kg ha⁻¹)

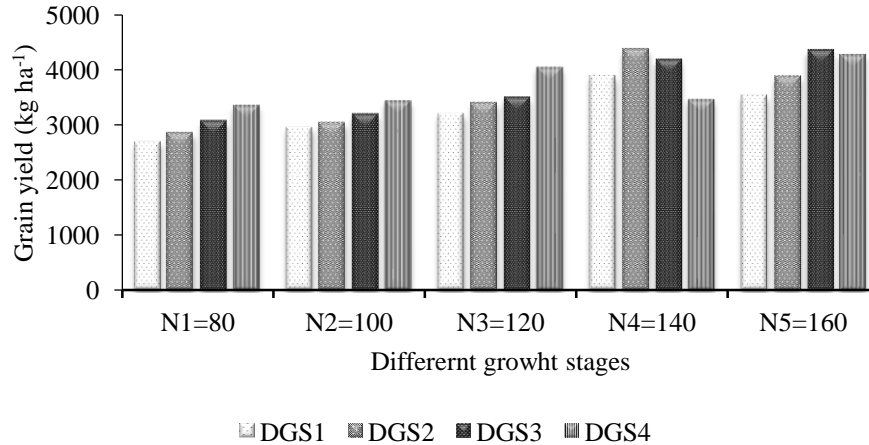


Fig. 4. Nitrogen levels and application timing impact on wheat grain yield (kg ha⁻¹)

HARVEST INDEX (%)

Significant observation was observed for harvest index by the application of nitrogen, nitrogen at different growth stages and their interaction N x DGS as shown in Table V and Fig. 5. Maximum (37%) harvest index were noted in plots treated with 140 kg N ha⁻¹, while minimum (35%) harvest index were noted in plots treated with 80 kg N ha⁻¹. Same observation was recorded by Sarwar *et al.*, 2019 (20). Among different growth stages maximum grain yield (37%) was observed in plots treated with the application of nitrogen with 25% sowing 25% second irrigation 25% booting 25% after anthesis growth stages while minimum (35%) was observed with 100% at sowing stages. In case of interaction harvest index (41%) were counted in plots treated with the application of nitrogen at the rate of 140 kg N ha⁻¹ with 50% sowing 50% second irrigation as compare with all others possible interaction as shown in Fig. 5. Same observations were in previous studies (21).

Table IV. Grain yield (kg ha^{-1}) in wheat as influenced by nitrogen levels and application timing

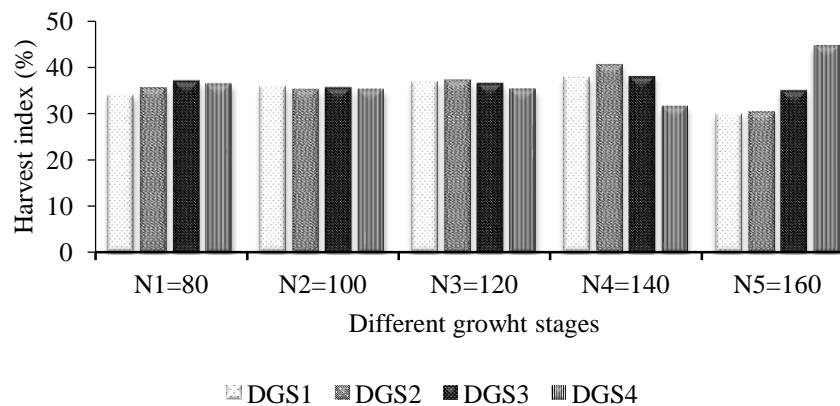
Nitrogen at different growth (DGS) stages (kg ha^{-1})	Levels of Nitrogen (kg ha^{-1})					Means
	80	100	120	140	160	
100% ST	2685	2952	3197	3880	3531	3249d
50% ST 50% SI 50 days	2852	3031	3390	4365	3869	3501c
50% ST 50% T	3065	3191	3488	4172	4347	3653b
25% ST 25% SI 25% B 25% AA	3353	3432	4035	3456	4269	3709a
Means	2989e	3151d	3528c	3968b	4004a	

*ST = Sowing Time; SI = Second Irrigation; T = Tillering; AA = After Anthesis; LSD for Nitrogen = 98.20; LSD for different growth stages = 87.83; LSD for N x DGS = 196.41

Table V. Harvest index (%) in wheat as influenced by nitrogen levels and application timing

Nitrogen at different growth (DGS) stages (kg ha^{-1})	Levels of Nitrogen (kg ha^{-1})					Means
	80	100	120	140	160	
100% ST	34	36	37	38	30	35b
50% ST 50% SI 50 days	36	35	37	41	30	36ab
50% ST 50% T	37	36	37	38	35	36ba
25% ST 25% SI 25% B 25% AA	36	35	35	31	45	37a
Means	36bc	35bc	36ab	37a	35c	

*LSD for Nitrogen = 1.077; LSD for different growth stages = 0.963; LSD for N x DGS = 2.155

**Fig. 5.** Nitrogen levels and application timing impact on wheat harvest index (%)

PROTEIN CONTENT IN STRAW (%)

Nitrogen application significantly impacted harvest index, with the highest value (37%) observed at 140 kg N/ha and the lowest (35%) at 80 kg N/ha (Table VI and Fig. 6), consistent with previous research (20). Split nitrogen application resulted in a higher harvest index (37%) compared to single application at sowing (35%). The interaction between nitrogen rate and timing was significant, with the highest harvest index (41%) recorded at 140 kg N/ha with 50% application at sowing and 50% at second irrigation, supporting similar findings (21).

Table VI. Protein content in straw (%) in wheat as influenced by nitrogen levels and application timing

Nitrogen at different growth (DGS) stages (kg ha^{-1})	Levels of Nitrogen (kg ha^{-1})					Means
	80	100	120	140	160	
100% ST	1.7	1.8	1.9	2.2	2.3	2.0a
50% ST 50% SI 50 days	1.8	2.0	2.0	2.3	2.2	2.1b
50% ST 50% T	2.0	2.1	2.2	2.5	2.7	2.3c
25% ST 25% SI 25% B 25% AA	2.2	2.3	2.5	2.6	2.9	2.5d
Means	1.9e	2.1d	2.2c	2.4b	2.5a	

*LSD for Nitrogen = 0.052; LSD for different growth stages = 0.046; LSD for N x DGS = 0.0104

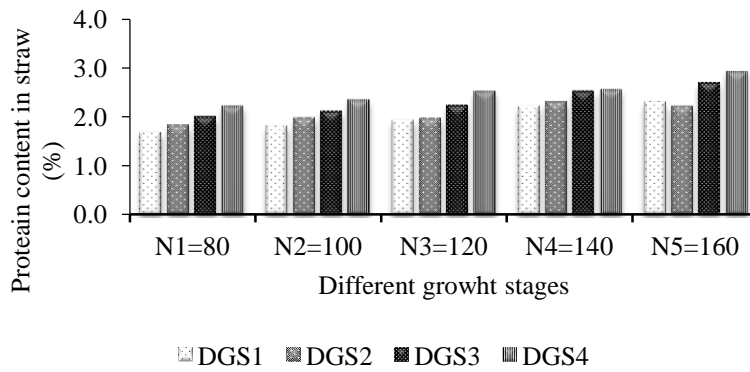


Fig. 6. Nitrogen levels and application timing impact on wheat protein content in straw (%)

PROTEIN CONTENT IN GRAIN (%)

Significant observation was observed for P content in grains by the application of nitrogen, nitrogen at different growth stages and their interaction N x DGS as shown in Table VII and Fig. 7. Maximum (12%) P content in grains was noted in plots treated with up to 160 kg N ha⁻¹, while minimum (10%) P content in grains was noted in plots treated with 80 kg N ha⁻¹. Same observation was recorded by Khan *et al.*, 2020 (22). Among different growth stages maximum P content in grains (12%) was observed in plots treated with the application of nitrogen with 25% sowing 25% second irrigation 25% booting 25% after anthesis growth stages while minimum (9%) was observed with 100% at sowing stages. In case of interaction P content in grains (13%) were counted in plots treated with the application of nitrogen at the rate of 160 kg N ha⁻¹ with 50% sowing 50% second irrigation 25% sowing 25% second irrigation 25% booting 25% after anthesis growth stages as compare with all others possible interaction as shown in Fig. 7. Means of the same category followed by different letters are significantly different at 5% level of probability using LSD test.

Table VII. Effect of nitrogen levels and application timings on Nitrogen content in straw (%) of wheat

Nitrogen at different growth (DGS) stages (kg ha ⁻¹)	Levels of Nitrogen (kg ha ⁻¹)					Means
	80	100	120	140	160	
100% ST	8	9	10	10	10	9d
50% ST 50% SI 50 days	9	10	11	11	12	11b
50% ST 50% T	10	10	11	12	13	11b
25% ST 25% SI 25% B 25% AA	11	12	12	12	13	12a
Means	10c	10c	11b	11b	12a	

*ST = Sowing Time; SI = Second Irrigation; T = Tillering; AA = After Anthesis; LSD for Nitrogen = 0.199; LSD for different growth stages = 0.178; LSD for N x DGS = 0.399

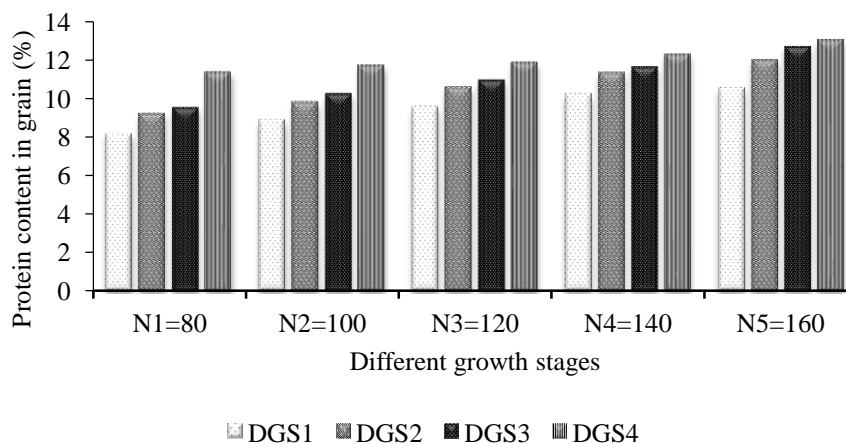


Fig. 7. Nitrogen levels and application timing impact on wheat grain protein content

CONCLUSION

The application of nitrogen at rates of 120-160 kg ha⁻¹ resulted in maximum wheat yield and protein content. Split nitrogen application, with 25% each at sowing, second irrigation, booting, and after anthesis

stages, also performed better in producing higher yields. Based on these findings, applying 120-160 kg N ha⁻¹ and using the split application method could be recommended for achieving higher grain yields and protein content in wheat crops.

Acknowledgement:

The authors highly appreciate Department of Agriculture, Bacha Khan University, Charsadda, Pakistan for providing experimental materials and facilities needed for the research.

Conflict of interest:

There is no conflict of interest among authors regarding this article.

Authors' contribution:

ZH, SU, WAS Concept; ZH, WAS Research methodology; RA, SU, AH, MF Data analysis; ZH, WAS, RA, SU, MF Writing, review and editing. All authors have reviewed and consented to the final version of the manuscript for publication.

References:

- Hawkesford MJ. Reducing the reliance on nitrogen fertilizer for wheat production. *J Cereal Sci.* 2014;59(3):276–83.
- Liu X, Zhang Y, Chen J, Wang H, Zhao S. Optimizing nitrogen application for wheat production in different regions of China. *Agric Sci.* 2020;11(12):1740.
- Wang Y, Li Q, Chen L, Zhang H, Sun J. Effects of nitrogen application rate and timing on wheat yield and quality. *J Agric Sci.* 2022;160(3):249–60.
- Khan A, Khan MA, Javed MT, Ahmad A, Ullah A. Analysis of wheat genotypes and N application on yield and protein content. *Pure Appl Biol.* 2020;9(1):229–39.
- Guo C, Liu J, Zhang F, Sun L, Wu Y. Effects of split nitrogen application on wheat yield and nitrogen use efficiency. *J Agric Sci.* 2020;158(3):342–53.
- Li Y, Wang Z, Chen X, Liu Y, Yang T. Effects of slow-release nitrogen fertilizers on wheat yield and nitrogen use efficiency. *Agric Sci.* 2021;12(10):1410.
- Zhao B, Hu Y, Liu K, Gao J, Zhang M. Optimizing nitrogen application rates for wheat production in different regions of China. *Agric Sci.* 2022;13(5):701.
- Yang G, Xu B, Shang J, Liu T, Wu D. Precision nitrogen management for wheat production using UAV-based remote sensing. *Precis Agric.* 2022;23(3):748–66.
- Liu X, Wang Y, Zhao H, Zhang X, Chen Z. Development of a decision support system for nitrogen management in wheat production. *Comput Electron Agric.* 2022;194:106755.
- Daun JK, Clear KM, Williams P. Comparison of three whole seed near infrared analyzers for measuring quality components of canola seed. *J Amer O Chm Soc.* 1994; 71:1063-8.
- Steel RGD, Torrie JH. Principles and procedure of statistics 2nd Ed Mc, Graw, Hill, New York. 1984.
- Naz G, Akmal M. Yield and yield contributing traits of wheat varieties as affected by nitrogen rates. *Sar J Agri.* 2016; 32(3):212-7.
- Iqbal B, Shazma A, Farjad I, Wajid A, Mohammad I, Shehryar KH. Response of Wheat crop to humic acid and nitrogen levels. *Ec Agri.* 2016; 3(1):558-65.
- Pandey KA, Ghosh A, Agrawal M, Agrawal SB. Effect of elevated ozone and varying levels of soil nitrogen in two wheat (*Triticumaestivum* L.) cultivars Growth, gas-exchange, antioxidant status, grain yield and quality. *Ecot & Envi Saf.* 2018; 158:59-68.
- Leghari SJ, Wahocho NA, Laghari GM, Laghari AH, Bhabhan GM, Talpur KH, Bhutto TA, Wahocho SA, Lashari AA. Role of nitrogen for plant growth and development: A review. *Adv Envi Biol.* 2016; 10(9):209-19.
- Khandare RN, Chandra R, Pareek N, Raverkar KP. Carrier-based and liquid bioinoculants of Azotobacter and PSB saved chemical fertilizers in wheat (*Triticumaestivum* L.) and enhanced soil biological properties in Mollisols. *J Plt Nut.* 2020; 43(1):36-50.
- Jamali A, Sohrabi Y, Mardeh AS, Hoseinpanahi F. Morphological and yield responses of 20 genotypes of bread wheat to drought stress. *Arch Bio Sci.* 2020; 3(4):1-1.
- Ali AM, Ibrahim SM. Wheat grain yield and nitrogen uptake prediction using at Leaf and GreenSeeker portable optical sensors at jointing growth stage. *In Pro in Agri.* 2019.

19. Mueller SM, Carlos D, Messina J, Vyn JT. Simultaneous gains in grain yield and nitrogen efficiency over 70 years of maize genetic improvement. *Sci Re.* 2019; 9(1):1-8.
20. Sarwar N, Wasaya A, Saliq S, Reham A, Farooq O, Mubeen K, Shehzad M, Zahoor MU, Ghani A. Use of Natural Nitrogen Stabilizers to Improve Nitrogen use Efficiency and Wheat Crop Yield. *Cer Agro in Mol.* 2019; 52(2):107-15.
21. Khan FA, Mohammad F, Ahmad M, Adil M, Rehman NU, Iqbal A. Identification of traits for the improvement of grain yield in bread wheat under nitrogen stress and non-stress conditions. *Pre & App Bio.* 2019; 8(1):698-705.
22. Khan A, Shah WA, Hussain Z, Ahmad M, Amin R, Uddin S, Ishaq M. Analysis of wheat genotypes and N application on the yield in response to protein and nitrogen content in grains and straw. *Pre & App Bio.* 2020; 9(1):229-39.