Biological and Clinical Sciences Research Journal
eISSN: 2708-2261; pISSN: 2958-4728
www.bcsrj.com
DOI: https://doi.org/10.54112/bcsrj.v2024i1.1196
*Biol. Clin. Sci. Res. J., Volume, **2024**: 1196*
Original Research Article

IMPACT OF VARIED AMOUNTS OF NITROGENOUS FERTILIZERS ON GRAIN YIELD AND RELATED AGRO-PHYSIOLOGICAL TRAITS IN SPRING WHEAT (*TRITICUM AESTIVUM L.*)

FAROOQ MR[1], NAZAR MZK[2], AKBAR MZ[3], GHAFOOR T[4], SHABIR MA[5], RAFIQUE HM[6], QAMAR MJ[*1], QAZI MA[7], ASLAM Z[8], HAFEEZ Z[9], MANZOOR N[10], HASSAN W[6], KHALIQ A[6], MURTAZA G[11], REHMAN SU[6], MUBASHIR M[12], BASHIR MA[13], ARIF M[14], ASIF M[2], IMRAN M[15], KHALID M[16], HUSSAIN S[10]

[1]*Soil Fertility (Field), Bahawalpur, Pakistan*
[2]*Soil and Water Testing Laboratory, Bahawalnagar, Punjab-Pakistan*
[3]*Department of Plant Breeding and Genetics, Faculty of Agriculture Sciences and Technology, BZU Multan, Pakistan*
[4]*Department of Agronomy, University of Agriculture, Faisalabad, Pakistan*
[5]*Cotton Research Sub-Station, Rajanpur, Pakistan*
[6]*Soil and Water Testing Laboratory for Research, Bahawalpur, Punjab-Pakistan*
[7]*Soil Fertility Research Institute, Lahore, Punjab-Pakistan.*
[8]*Soil and Water Testing Laboratory for Research, Lahore, Punjab-Pakistan*
[9]*Oilseed Research Station, Bahawalpur, Punjab-Pakistan*
[10]*Regional Agricultural Research Institute Bahawalpur, Punjab-Pakistan*
[11]*Pesticide Quality Control Laboratory Bahawalpur Research Bahawalpur Punjab-Pakistan*
[12]*Soil Fertility Zinc Multan, Agriculture Department, Government of Punjab, Pakistan*
[13]*Department of Soil Science, Faculty of Agriculture and Environment, the Islamia University of Bahawalpur, Pakistan.*
[14]*Fodder Research Institute Sargodha, Pakistan*
[15]*Soil and Water Testing Laboratory for Research, Rahim Yar Khan, Punjab-Pakistan*
[16]*Soil Fertility (Field), Multan, Pakistan*
**Corresponding author`s email address: javedqamarswt@gmail.com*

(Received, 24th July 2024, Revised 05th September 2024, Published 25th September 2024)

Abstract: *The application of nitrogen (N) is a critical factor influencing grain yield and agro-physiological traits in spring wheat (Triticum aestivum L.). This study aimed to evaluate the impact of varied nitrogen levels on grain yield and associated traits under field conditions. The study was conducted in Chak No. 136 / 6.R Haroonabad, District Bahawalnagar under the supervision of the Institute of Soil Fertility (Field) during the crop year 2022-23. A randomized complete block design (RCBD) was used, with five N treatments (160, 145, 131, 117 and 103 kg ha⁻¹) applied across three replicates. Key parameters, including flag leaf area, thousand-grain weight, spikelets per spike, number of grains per spike, chlorophyll a, stomatal conductance, net photosynthetic rate, biological yield and gain yield, were measured. The results showed a significant increase in flag leaf area, thousand-grain weight, spikelets per spike, number of grains per spike, chlorophyll a, stomatal conductance, net photosynthetic rate, biological yield and gain yield with increasing nitrogen application, with the highest yield observed at 160 kg ha⁻¹. The results unveiled the presence of highly significant variations among nitrogen treatments in wheat variety based on the agro-physiological parameters including flag leaf area, thousand-grain weight, number of spikelets per spike, number of grains per spike, chlorophyll a, stomatal conductance, net photosynthetic rate, biological yield and gain yield. Furthermore, the results also unveiled that treatments with higher nitrogen dosage produce better results for almost all the study parameters including grain yield. The correlation coefficient analysis also confirmed the results and suggested that any wheat breeding program aimed at improving wheat yield must select its parental genotypes based on traits having the highest correlation with yield i.e., flag leaf area, thousand-grain weight, number of grains per spike, chlorophyll a, stomatal conductance and net photosynthetic rate except the number of spikelets per spike and biological yield for which the correlation was positive but non-significant. The results suggest that nitrogen in higher amounts up to a certain level is necessary for obtaining maximum output from wheat crops under semi-arid conditions.*

Keywords: Wheat; Correlation; Bar Graph; Grain Yield; Plant Physiology, Fertilizers

Introduction

Wheat (*Triticum aestivum L.*) holds a pivotal role in global food security, being one of the most extensively cultivated and consumed crops worldwide. As a staple food for over 35% of the global population, wheat provides essential calories and proteins to billions of people, particularly in developing nations (1). The crop contributes significantly to daily caloric intake, playing a crucial role in reducing hunger and malnutrition. Wheat's adaptability to various climates and its wide use in producing flour for bread, pasta, and other food products make it an irreplaceable component of the global food system (2). In Pakistan, wheat is a vital crop that plays a central role in the country's agriculture-based economy. It is the principal staple food, accounting for nearly 60% of daily caloric intake for the population. The crop occupies the largest cultivated area in the country,

[Citation Farooq, M.R., Nazar, M.Z.K., Akbar, M.Z., Ghafoor, T., Shabir, M.A., Rafique, H.M., Qamar, M.J., Qazi, M.A., Aslam, Z., Hafeez, Z., Manzoor, N., Hassan, W., Khaliq, A., Murtaza, G., Rehman, S.U., Mubashir, M., Bashir, M.A., Arif, M., Asif, M., Imran, M., Khalid, M., Hussain, S. (2024). Impact of varied amounts of nitrogenous fertilizers on grain yield and related agro-physiological traits in spring wheat (*Triticum aestivum L.*). *Biol. Clin. Sci. Res. J.*, **2024***: 1196*. doi: https://doi.org/10.54112/bcsrj.v2024i1.1196]

with approximately 9 million hectares under wheat cultivation annually (3). Wheat production in Pakistan has steadily increased over the years, reaching around 31.4 million metric tons in 2023-24 (4). This makes Pakistan one of the top wheat-producing countries globally, ranking among the top 10 producers. However, despite significant domestic production, the country's growing population often outstrips supply, leading to reliance on wheat imports to meet national demand.

Globally, wheat production was estimated at around 780 million metric tons in 2023, with the European Union, China, India, Russia, and the United States being the top producers (5). This crop's importance in the global trade market is reflected by its significant share in agricultural exports, with major exporters such as Russia, Canada, and the U.S. supplying wheat to wheat-deficient regions like Africa and the Middle East (6). The ever-increasing global demand for wheat, coupled with concerns about climate change and shrinking arable land, underscores the critical need for sustainable practices and enhanced production efficiency (7). Hence, improving wheat yields through better management practices, such as optimized nitrogen application, is a priority for researchers and policymakers to ensure both national and global food security (8). Pakistan's reliance on wheat extends beyond food security, as it supports millions of livelihoods across rural areas, where smallholder farmers depend on the crop for their income. The government plays an active role in wheat production by subsidizing inputs, managing strategic wheat reserves, and regulating prices to ensure affordability. The strategic importance of wheat for Pakistan extends beyond its economic value, as food security challenges linked to fluctuating production and climate stressors make the crop crucial for social stability (9).

Nitrogen (N) is one of the most essential macronutrients required for the growth and development of wheat and other crops. As a key component of chlorophyll, nucleic acids, and proteins, nitrogen plays a critical role in photosynthesis, cell division, and overall plant metabolism (10). It influences both vegetative and reproductive stages of crop growth, making it a determining factor in achieving optimal grain yield and quality. During the vegetative growth phase, nitrogen is indispensable for promoting the development of leaves, stems, and roots. In wheat, adequate nitrogen application supports vigorous plant growth by enhancing chlorophyll content, which is necessary for efficient light capture during photosynthesis (11). As nitrogen aids in the synthesis of amino acids and proteins, it directly contributes to the expansion of leaf area and biomass accumulation. Well-nourished crops with sufficient nitrogen levels exhibit greater tillering (production of additional shoots), leading to increased canopy cover and improved interception of sunlight (12). This ultimately boosts the plant's capacity to assimilate carbon and sustain healthy growth throughout the vegetative period.

As wheat transitions from the vegetative to the reproductive phase, nitrogen continues to play a pivotal role in the formation and development of reproductive structures, such as spikes and grains. Adequate nitrogen during this phase ensures that the crop can produce a sufficient number of spikelets and grains per spike, which are critical determinants of final yield (13). Additionally, nitrogen availability during the reproductive stage promotes grain filling by supplying the necessary proteins and enzymes required for starch synthesis. This leads to heavier and more nutrient-dense grains, enhancing both yield and grain quality. While nitrogen is crucial for crop growth, excessive nitrogen application can have detrimental effects on both crop development and the environment (14). Over-application of nitrogen during the vegetative stage can lead to excessive foliage growth, often resulting in a lush canopy with an overabundance of leaves. While this may initially appear beneficial, it can cause the plant to divert resources away from reproductive development, leading to a delayed or uneven transition to the reproductive stage. This imbalance between vegetative and reproductive growth can result in lower grain yield and quality, as the plant fails to allocate sufficient resources for grain filling (15). Moreover, nitrogen overapplication poses significant environmental risks and could leach into groundwater, contaminating drinking water sources, while the volatilization of nitrogen as ammonia contributes to air pollution. Furthermore, excessive nitrogen application increases the emission of nitrous oxide (N_2O), a potent greenhouse gas that contributes to climate change.

Evaluation of nitrogen use efficiency in existing cultivated germplasm is a prerequisite for wheat breeding programs aiming to develop nitrogen-efficient wheat cultivars as it provides the genetic diversity needed to identify and exploit traits associated with improved nitrogen use efficiency (NUE). Nitrogen-efficient varieties are capable of producing higher yields with reduced nitrogen input, enhancing both economic and environmental sustainability. These strategies can contribute to sustainable agricultural systems where nitrogen inputs are minimized, yet wheat productivity is maintained, ensuring food security amid challenges like climate change. Therefore, the current study was designed to evaluate the efficiency of nitrogen use in modern wheat cultivars.

Methodology

The current study was conducted in Chak No. 136 / 6.R Haroonabad, District Bahawalnagar under the supervision of the Institute of Soil Fertility (Field) during the crop year 2022-23 to evaluate the impact of different dosages of Nitrogen, keeping the other macronutrients same. The experimental material consisted of wheat variety (Nawab-2021), developed by the Regional Agricultural Research Institute (RARI), Bahawalpur while five different levels of nitrogen fertilizers were used as treatments. Those levels included (i) 160 kg ha^{-1}, (ii) 145 kg ha^{-1}, (iii) 131 kg ha^{-1}, (iv) 117 kg ha^{-1} and (v) 103 kg ha^{-1}, while the levels of Phosphorus and Potassium were kept as same as standard (60 kg ha^{-1}, 114 kg ha^{-1}), respectively. The sowing was done on 11th November 2022 with the help of a dibbler. The net plot size for each treatment was 800 m^2 and the experiment was laid out under a randomized complete block design in three replicates. The standard agronomic, cultural and plant protection practices were carried out in all five treatments across three replications. The data regarding key agro-physiological and yield-related traits including flag leaf area

[Citation Farooq, M.R., Nazar, M.Z.K., Akbar, M.Z., Ghafoor, T., Shabir, M.A., Rafique, H.M., Qamar, M.J., Qazi, M.A., Aslam, Z., Hafeez, Z., Manzoor, N., Hassan, W., Khaliq, A., Murtaza, G., Rehman, S.U., Mubashir, M., Bashir, M.A., Arif, M., Asif, M., Imran, M., Khalid, M., Hussain, S. (2024). Impact of varied amounts of nitrogenous fertilizers on grain yield and related agro-physiological traits in spring wheat (*Triticum aestivum L.*). *Biol. Clin. Sci. Res. J.,* **2024***: 1196*. doi: https://doi.org/10.54112/bcsrj.v2024i1.1196]

(FLA), thousand-grain weight (TGW), spikelets per spike (SPS), number of grains per spike (GPS), chlorophyll a (Chl a), net photosynthetic rate (Pn), stomatal conductance (C), biological yield (BY) and grain yield (GY) were measured to evaluate the impact of different dosages of nitrogen on wheat crop. The physiological data including net photosynthetic rate, and stomatal conductance were measured using an infrared gas analyzer i.e., CI-340 handheld photosynthetic system. Moreover, the data regarding physiological traits were measured from 10:00 a.m. to 12:30 p.m.

The data was recorded for soil macro and micronutrients including electric conductivity (EC), pH organic matter percentage (OM%), soil phosphorus (P ppm), soil potassium (K ppm) and soil nitrogen percentage (N %) as pre-sowing and post-sowing of treatments to compare the leaching and uptake of nutrients by the plants (Table 1). The soil parameters data were recorded from 0 to 15 cm and 15 to 30 cm for each treatment before and after harvesting the recorded data were then subjected to analysis of variance and other post hoc analyses (16, 17). To compare the performance of the wheat genotype for each trait under a given nitrogen dosage bar plots were drawn using Microsoft Excel and OriginPro packages.

Table 1: Soil analysis report for key soil parameters (Pre- and Post-Harvest)

SOIL ANALYSIS (Pre-Sowing)								
Treatments	Soil Parameters	EC (dS m^{-1})	pH	OM%	P (ppm)	N (%)	K (ppm)	Texture
	Depth (0 - 15) cm	0.6	8.1	0.7	6.4	0.0373	136	Loam
	Depth (15-30) cm	0.7	8.2	0.67	7	0.0335	120	-
SOIL ANALYSIS (Post Harvest)								
Treatments	Soil Parameters	EC (dS m^{-1})	pH	OM%	P (ppm)	N (%)	K (ppm)	Texture
1	Depth (0 - 15) cm	0.64	8.14	0.88	6.23	0.0460	128	Loam
	Depth (15-30) cm	0.82	8.26	0.69	6.67	0.0349	116	-
2	Depth (0 - 15) cm	0.67	8.13	0.74	6.36	0.0374	131	
	Depth (15-30) cm	0.72	8.22	0.69	6.87	0.0345	114	
3	Depth (0 - 15) cm	0.87	8.17	0.64	6.46	0.0319	132	
	Depth (15-30) cm	0.73	8.27	0.62	7.31	0.0317	122	
4	Depth (0 - 15) cm	0.69	8.13	0.61	6.46	0.0311	138	
	Depth (15-30) cm	0.71	8.22	0.56	7.32	0.0289	125	
5	Depth (0 - 15) cm	0.78	8.18	0.60	6.48	0.0312	138	
	Depth (15-30) cm	0.69	8.27	0.53	7.34	0.0271	126	

Results and Discussion

The data obtained from five treatments and three replications were subjected to analysis of variance and the results revealed that significant variations exist between these treatments of nitrogen in wheat variety nawab-2021 for studied plant traits including flag leaf area (FLA), thousand-grain weight (TGW), number of spikelets per spike (SPS), number of grain per spike (GPS), chlorophyll a (Chl a), net photosynthetic rate (Pn), stomatal conductance (C), biological yield (BY) and grain yield per hectare (GY) (Table 2). Our results were in complete line with the findings reported by (18-20), who showed that wheat responds differently to the different amounts of nitrogen applications and significant differences present between yield and related traits under different nitrogen dosages.

Table 2: Mean Square (MS) of key plant traits in Nawab-2021 under varying amounts of nitrogen

SOV	Df	FLA	TGW	SPS	GPS	Chl a	Pn	C	GY	BY
Replication	2	0.133	0.516	0.722	0.398	252.75	1.64	44.4	354	0.0006
Treatments	4	1.891**	1.08**	1.81**	1.19**	500.7**	4.7**	2153.2**	168586**	0.939**
Error	8	0.048	0.035	0.655	0.158	21.79	0.058	81.2	519	0.004

The mean data for all the study trades were used to compute the relationship between different nitrogen treatments in the Nawab - 2021 2 bar graph representation. The data showed that significant variations were present for nitrogen treatments in Nawab – 2021 (Figure 1a). The highest flag leaf area was given by nawab-2021 in treatment-1 (30.6 cm^2) followed by treatment-2 (30.2 cm^2) while the lowest flag leaf area was observed in treatment-5 (28.5 cm^2) followed by treatment-4 (29.4 cm^2). This suggests that higher nitrogen dosage has a significant impact on grain filling rate, source-sink relationship, and accumulation of carbohydrates in the endospermic part of grains in cereals (21, 22).

A similar pattern was observed in thousand-grain weight where the highest thousand-grain weight was obtained in treatment-1 (46.6 g) followed by treatment-2 (46.3 g) while the lowest thousand-grain weight was observed in treatment-5 (45.0 g), followed by treatment-4 (45.8 g) (Figure 1b). The number of spikelets per spike, which is a key shield contributing trait, showed some deviation from the previous parameters. In Nawab – 2021, the highest number of spikelets per spike our observed in treatment-1

[Citation Farooq, M.R., Nazar, M.Z.K., Akbar, M.Z., Ghafoor, T., Shabir, M.A., Rafique, H.M., Qamar, M.J., Qazi, M.A., Aslam, Z., Hafeez, Z., Manzoor, N., Hassan, W., Khaliq, A., Murtaza, G., Rehman, S.U., Mubashir, M., Bashir, M.A., Arif, M., Asif, M., Imran, M., Khalid, M., Hussain, S. (2024). Impact of varied amounts of nitrogenous fertilizers on grain yield and related agro-physiological traits in spring wheat (*Triticum aestivum L.*). *Biol. Clin. Sci. Res. J.,* **2024***: 1196*. doi: https://doi.org/10.54112/bcsrj.v2024i1.1196]

(19.5) followed by treatment-3 (18.3) while the lowest number of spikelets per spike was observed in treatment-5 (17.4) followed by treatment-4 (17.9) (Figure 2c). The data regarding the number of grains per spike depicted that treatment-1 was the most productive treatment with respect to the number of grains per spike which produces 55.1 grains per spike on average followed by treatment-2 (54.6) and treatment-4 (54.3) while the lowest number of grains per spike was produced under treatment-5 (53.4) followed by treatment-3 (54.2) (Figure 2d). Similar to flag leaf area, thousand-grain weight and number of spikelets per spike higher nitrogen levels produced higher results by improving plant growth and development, accumulation of carbohydrates in seed, source-sink relationship, maintenance and assimilate partitioning which resulted in the larger flag leaf area, higher thousand-grain weight and number of grains per spike in higher nitrogen dosage (23, 24).

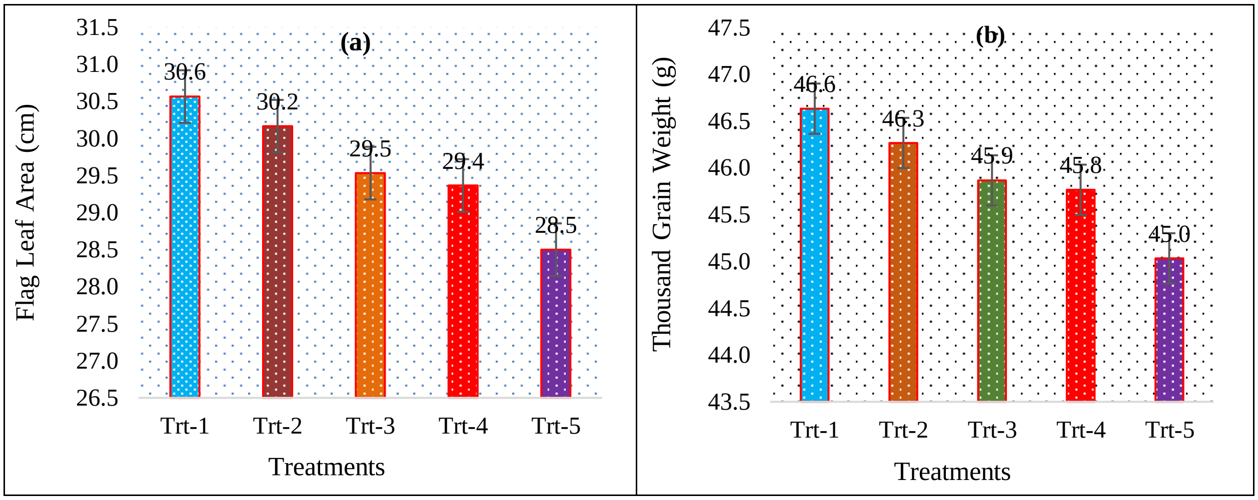

FIGURE 1 | Performance of wheat variety Nawab-2021 under different nitrogen dosages based on (a) Flag Leaf Area (b) Thousand Grain Weight

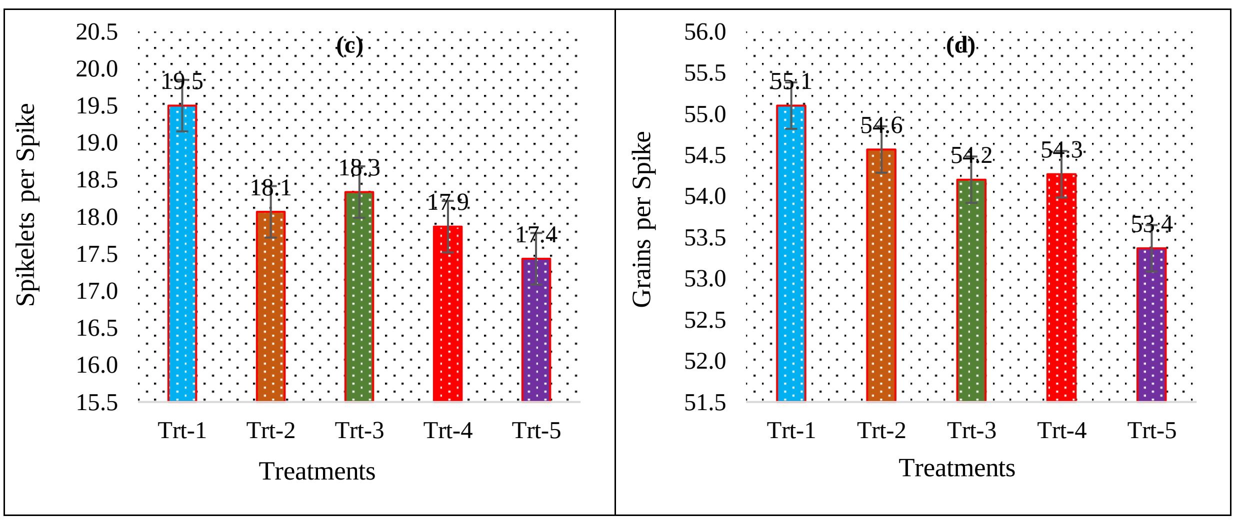

FIGURE 2 | Performance of wheat variety Nawab-2021 under different nitrogen dosages based on (c) Spikelets per Spike (d) Grains per Spike

Plant physiological parameters play an important role in the determination of the performance of a crop plant under different treatments. The chlorophyll content was observed to be the highest under treatment-1 (375.2 ug/g FW) followed by treatment-2 (363.1 ug/g FW) and 3 (361.3 ug/g FW) while the lowest chlorophyll a contains were observed in treatment-5 (341.2 ug/g FW) followed by treatment-4 (350.9 ug/g FW) (Figure 3e). The similar patterns over also observed for the remaining two physiological traits including net photosynthetic rate and stomatal conductance where treatment-1 (31.7 µmole m^{-2} s^{-1}; 434.6 mmoles m^{-2} s^{-1}) showed the highest values in Nawab-2021 followed by treatment-2 (30.4 µmole m^{-2} s^{-1}; 426.5 mmoles m^{-2} s^{-1}) and 3 (29.6 µmole m^{-2} s^{-1}; 402.7 mmoles m^{-2} s^{-1}) while treatment-5 (28.5 µmole m^{-2} s^{-1}; 370.8 mmoles m^{-2} s^{-1}) showed minimum value for these dates followed by treatment-4 (29.1 µmole m^{-2} s^{-1} ; 385.9 mmoles m^{-2} s^{-1}) (Figure 3f & Figure 4g).

[Citation Farooq, M.R., Nazar, M.Z.K., Akbar, M.Z., Ghafoor, T., Shabir, M.A., Rafique, H.M., Qamar, M.J., Qazi, M.A., Aslam, Z., Hafeez, Z., Manzoor, N., Hassan, W., Khaliq, A., Murtaza, G., Rehman, S.U., Mubashir, M., Bashir, M.A., Arif, M., Asif, M., Imran, M., Khalid, M., Hussain, S. (2024). Impact of varied amounts of nitrogenous fertilizers on grain yield and related agro-physiological traits in spring wheat (*Triticum aestivum L.*). *Biol. Clin. Sci. Res. J.,* **2024***: 1196*. doi: https://doi.org/10.54112/bcsrj.v2024i1.1196]

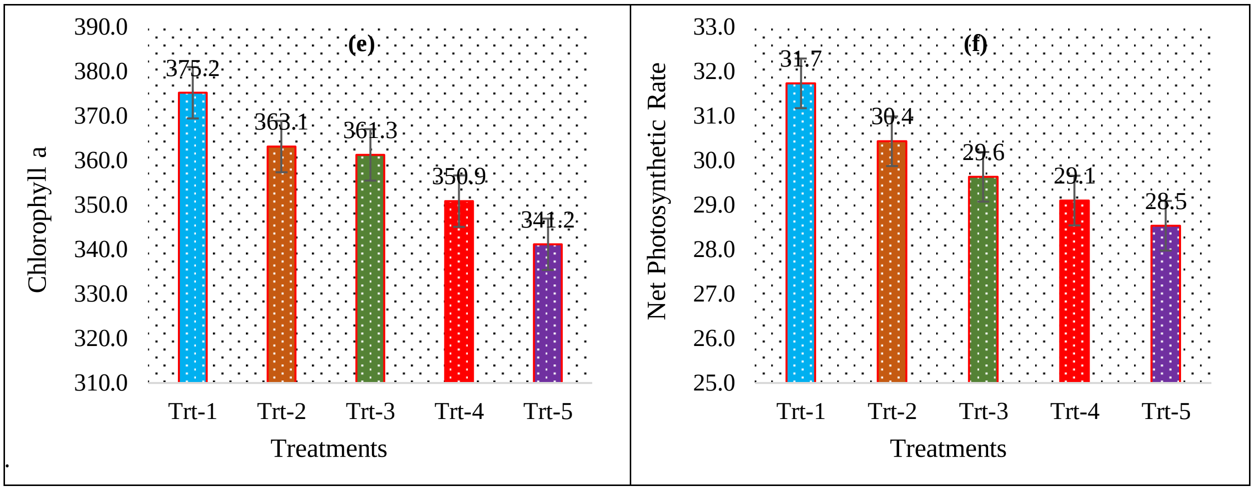

FIGURE 3 | Performance of wheat variety Nawab-2021 under different nitrogen dosages based on (e) Net Photosynthetic Rate (f) Stomatal Conductance

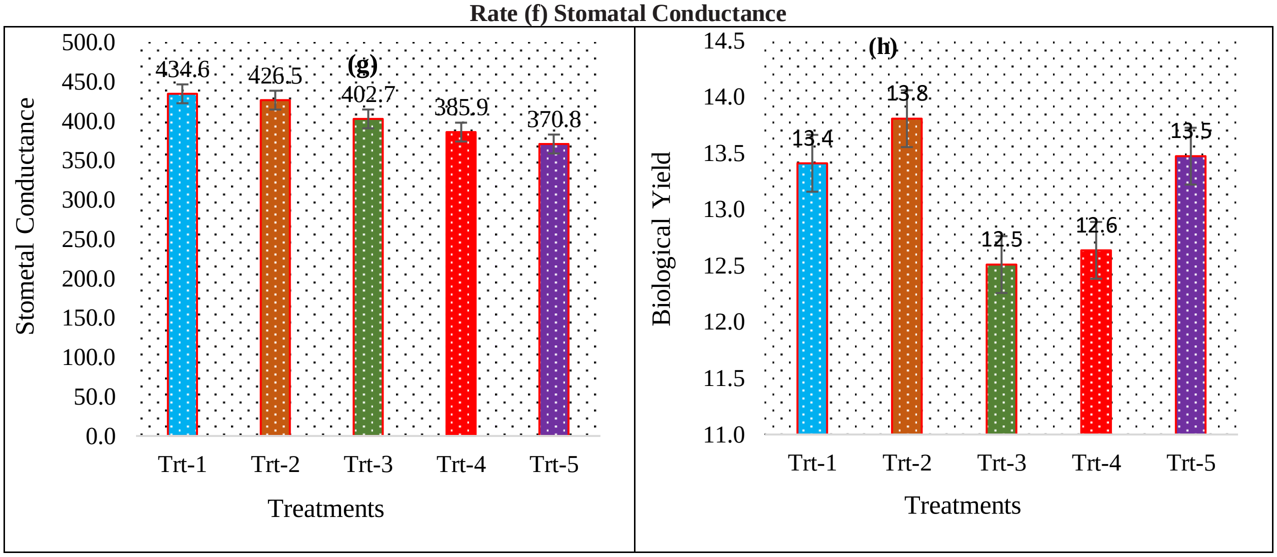

FIGURE 4 | Performance of wheat variety Nawab-2021 under different nitrogen dosages based on (g) Biological Yield (h) Grain Yield

This might be because under higher nitrogen availability plant chlorophyll contents increase with the increase in nitrogen application as nitrogen is an essential component in their structure. More chlorophyll-a means more light absorption during photosynthesis, which leads to improved plant growth. Since chlorophyll-a plays a central role in light absorption, increased nitrogen allows for enhanced photosynthetic efficiency and overall plant productivity (25, 26, 27). Nitrogen application significantly impacts stomatal conductance, which refers to the rate at which gases (like water vapour and CO_2) pass through the stomata of plant leaves (28). Studies revealed that with the increased application of nitrogen, the photosynthesis of plants is boosted since nitrogen is a vital nutrient for their chlorophyll production which will ultimately increase photosynthesis (29). To meet the need for higher photosynthesis, carbon dioxide movement will also increase, prompting the stomata to open wider and increase the stomatal conductance (30). Moreover, nitrogen also promotes the growth of larger, healthier leaves with more stomata, which can further contribute to higher stomatal conductance.

There are several studies which show that the biological yield of wheat plants has a direct relationship with grain yield for any variety (31). The studies also showed that the higher the biomass of a variety, the higher will be the food resources developed through photosynthesis processes, which strengthen the sink and ultimately increase the grain yield. Plant biological yield is one of the major traits to be considered in the evaluation of yield and yield-related performance in wheat genotypes. In the current study, treatment-2 produces the highest biological yield (13.8 kg) followed by treatment-1 (13.4 kg) and treatment-5 (13.5 kg) while treatment-3 (12.5 kg) produces the lowest yield followed by treatment-4 (12.6 kg) (Figure 4h). Improvement of grain yield is of prime importance in any breeding program.

[Citation Farooq, M.R., Nazar, M.Z.K., Akbar, M.Z., Ghafoor, T., Shabir, M.A., Rafique, H.M., Qamar, M.J., Qazi, M.A., Aslam, Z., Hafeez, Z., Manzoor, N., Hassan, W., Khaliq, A., Murtaza, G., Rehman, S.U., Mubashir, M., Bashir, M.A., Arif, M., Asif, M., Imran, M., Khalid, M., Hussain, S. (2024). Impact of varied amounts of nitrogenous fertilizers on grain yield and related agro-physiological traits in spring wheat (*Triticum aestivum L.*). *Biol. Clin. Sci. Res. J.*, **2024***: 1196*. doi: https://doi.org/10.54112/bcsrj.v2024i1.1196]

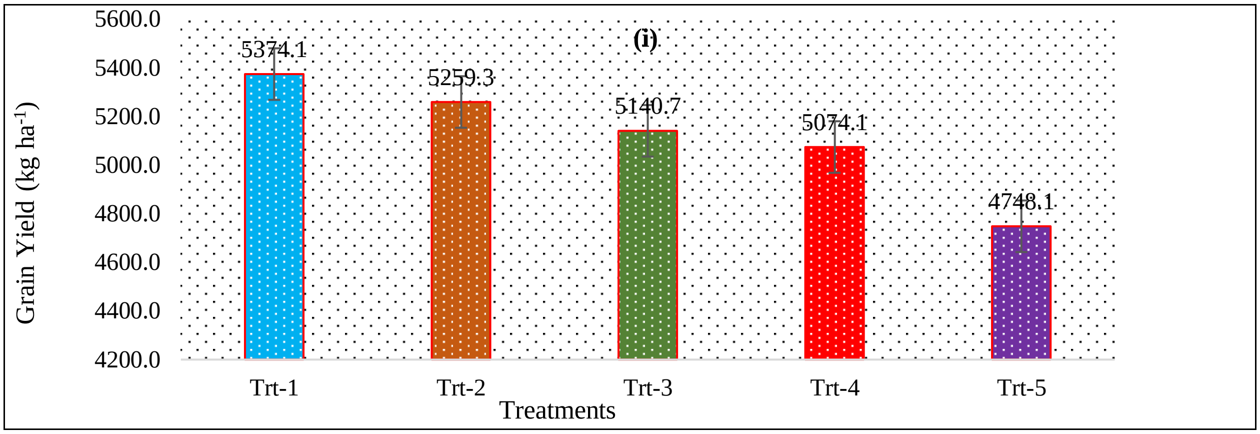

FIGURE 4 | Performance of wheat variety Nawab-2021 under different nitrogen dosages based on (g) Biological Yield (h) Grain Yield

The grain yield, being the multigenic trait and one of the most vulnerable to environmental changes, is a tough task for plant scientists to make it improve with respect to different conditions and stresses. In the current study, the highest grain yield was observed in treatment-1 (5374.1 kg ha^{-1}) followed by treatment-2 (5259.3 kg ha^{-1}) and 3 (5140.7 kg ha^{-1}) while the lowest yield was observed in treatment-5 (4748.1 kg ha^{-1}) followed by treatment-4 (5074.1 kg ha^{-1}) (Figure 5). The grain yields associated traits like flag leaf area, thousand-grain weight, grains per spike, number of spikelets per spike, chlorophyll a, net photosynthetic rate, stomatal conductance, and biological yield showed a similar behaviour that was associated with higher nitrogen demands (32-36).

The correlation coefficient analysis is one of the most commonly used statistical procedures to drive our relationship between two parameters their direction and magnitude. The data obtained during the study was subjected to the correlation coefficient analysis and results revealed that green yield has a highly significant and positive association with flag leaf area thousand grain weight number of grains per spike chlorophyll a net photosynthetic rate stomatal conductance. however, grain yield has a positive but non-significant correlation with the number of sparklers per spike and the biological yield of the plant (Figure 6). These results show that these days having the highest correlation with grain yield must be considered in the process of parental selection in any breeding program aimed at improving weed yield, especially under nitrogen-varying conditions. The findings of this study were in complete line with the previous findings of other researchers who showed that flag leaf area, thousand-grain weight, number of grains for the spike, chlorophyll a, net photosynthetic rate and stomatal conductance had a significant association with grain yield in wheat under different nitrogen dosages (37-39).

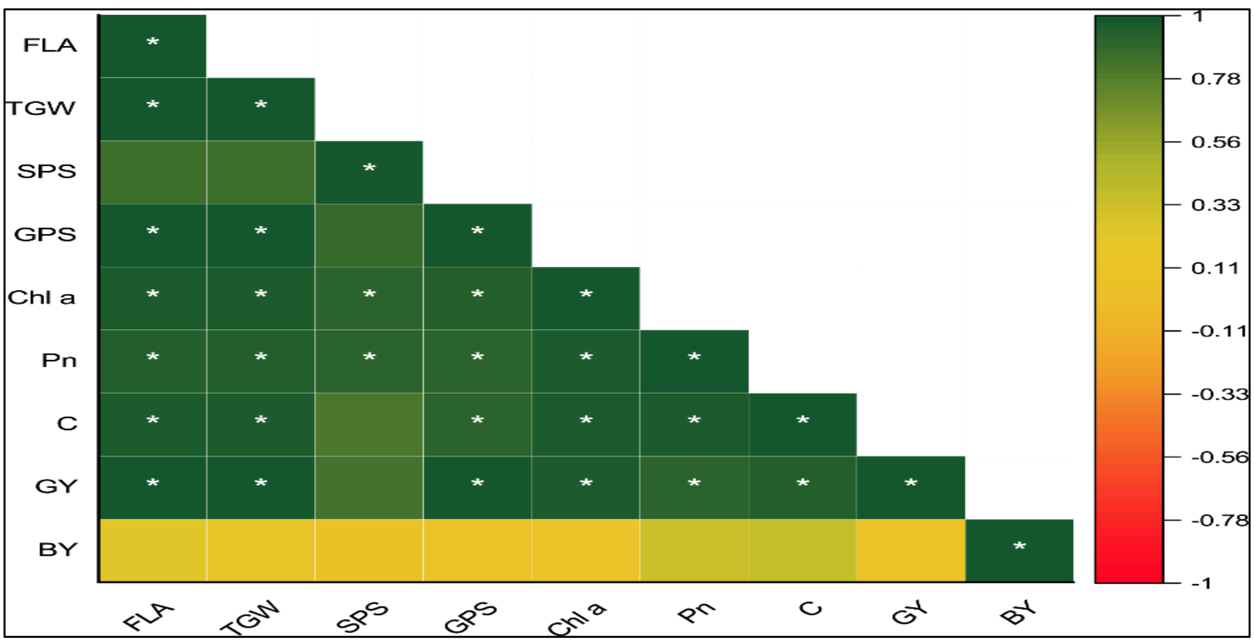

FIGURE 6: Correlation coefficients between studied plant traits in wheat variety Nawab-2021 under varying amounts of nitrogen dosages *(* shows the significant relationship)*

[Citation Farooq, M.R., Nazar, M.Z.K., Akbar, M.Z., Ghafoor, T., Shabir, M.A., Rafique, H.M., Qamar, M.J., Qazi, M.A., Aslam, Z., Hafeez, Z., Manzoor, N., Hassan, W., Khaliq, A., Murtaza, G., Rehman, S.U., Mubashir, M., Bashir, M.A., Arif, M., Asif, M., Imran, M., Khalid, M., Hussain, S. (2024). Impact of varied amounts of nitrogenous fertilizers on grain yield and related agro-physiological traits in spring wheat (*Triticum aestivum L.*). *Biol. Clin. Sci. Res. J.*, **2024***: 1196*. doi: https://doi.org/10.54112/bcsrj.v2024i1.1196]

Conclusion

The current experimental research was conducted at Chak No. 136 / 6.R Haroonabad, District Bahawalnagar under the supervision of the Institute of Soil Fertility (Field) during the crop year 2022-23 to evaluate the impact of different dosages of Nitrogen, keeping the other macronutrients same. The results unveiled the presence of significant variations among studied traits i.e., flag leaf area, thousand-grain weight, number of spikelets per spike; number of grains per spike, chlorophyll a, stomatal conductance, net photosynthetic rate, biological yield and grain yield across all five nitrogen treatments. A similar pattern was observed for all the traits under study where higher nitrogen application responded towards the higher grain yield and associated traits. The results were also confirmed through correlation coefficient analysis, which unveiled the presence of a highly significant and positive correlation of grain yield with flag leaf area, thousand-grain weight, grains per spike, chlorophyll a, stomatal
Conductance and net photosynthetic rate. The correlation of grain yield with the number of spikelets per spike and biological yield was also positive yet non-significant.

Declarations

Data Availability statement
All data generated or analyzed during the study are included in the manuscript.
Ethics approval and consent to participate
Approved by the department Concerned.
Consent for publication
Approved
Funding
Not applicable

Conflict of interest

The authors declared absence of conflict of interest.

Author Contribution

References

1. Acevedo, M., J. D., Zurn, G., Molero, P., Singh, X., He, M., Aoun, ... and L. McCandless. 2018. The role of wheat in global food security. In Agricultural development and sustainable intensification (pp. 81-110). Routledge.
2. Láng, L., M., Rakszegi and Z. Bedő. 2013. Cereal production and its characteristics. Engineering aspects of cereal and cereal-based products.
3. Singh, S. K., S., Kumar, P. L., Kashyap, R., Sendhil and O.P. Gupta. 2023. Wheat. In Trajectory of 75 years of Indian agriculture after independence (pp. 137-162). Singapore: Springer Nature Singapore.
4. ESP (2024). Economic Survey of Pakistan. 2023-24, Ministry of Finance, Govt. of Pakistan. Available online at Accessed on April 3, 2022. https://www.finance.gov.pk/survey/chapters_24/02-Agriculture.pdf
5. Soofizada, Q. 2023. Evaluation of the effects of nutrient management on grain yield, quality, and rheological properties of common wheat varieties (Triticum aestivum L.). Thesis for Doctor of Philosophy (Ph.D)
6. Yin, Z., J. Hu, J. Zhang, X. Zhou, L. Li, and J. Wu. 2024. Temporal and spatial evolution of global major grain trade patterns. Journal of Integrative Agriculture, 23(3), 1075-1086.
7. Grover, D., A. K., Mishra, P., Rani, N., Kalonia, A., Chaudhary and S., Sharma. 2024. Soil Management in Sustainable Agriculture: Principles and Techniques. In Technological Approaches for Climate Smart Agriculture (pp. 41-77). Cham: Springer International Publishing.
8. He, G., X., Liu and Z. Cui. 2021. Achieving global food security by focusing on nitrogen efficiency potentials and local production. Global Food Security, 29: 100536.
9. Grote, U., A., Fasse, T. T., Nguyen and O., Erenstein. 2021. Food security and the dynamics of wheat and maize value chains in Africa and Asia. Frontiers in Sustainable Food Systems, 4: 617009.
10. Fathi, A. 2022. Role of nitrogen (N) in plant growth, photosynthesis pigments, and N use efficiency: a. Agrisost, 28: 1-8.
11. Reynolds, M., J., Foulkes, R., Furbank, S., Griffiths, J., King, E., Murchie ... and G. Slafer. 2012. Achieving yield gains in wheat. Plant, cell & environment, 35(10): 1799-1823.
12. Wibberley, E. J. 2006. Fertilising small-grain cereals for sustainable yield and high quality (No. 17). International Potash Institute.
13. Pilbeam, D. J. 2011. The utilization of nitrogen by plants: a whole plant perspective. Annual plant reviews, nitrogen metabolism in plants in the post-genomic era. Wiley, New York.
14. Leghari, S. J., N. A., Wahocho, G. M., Laghari, A., Hafeez Laghari, G., Mustafa Bhabhan, K., Hussain Talpur, ... and A.A. Lashari. 2016. Role of nitrogen for plant growth and development: A review. Advances in Environmental Biology, 10(9), 209-219.
15. Bennett, E., J. A., Roberts, and C. Wagstaff. 2012. Manipulating resource allocation in plants. Journal of Experimental Botany, 63(9), 3391-3400.
16. Steel, R.G.D., J.H. Torrie and D.A. Dickey. 1997. Principles and Procedures of Statistics: A Biometrical Approach, 3rd Ed. McGraw Hill Book Co., New York.
17. Dewey, D. R. and K. Lu. 1959. A correlation and path-coefficient analysis of components of crested wheatgrass seed production. Agronomy Journal, 51: 515-518.
18. Oral, E. 2018. Effect of nitrogen fertilization levels on grain yield and yield components in triticale based on AMMI and GGE biplot analysis. Applied Ecology & Environmental Research, 16(4).
19. Zhang, Y., J., Wang, S., Gong, D., Xu and J. Sui. 2017. Nitrogen fertigation effect on photosynthesis, grain yield and water use efficiency of winter wheat. Agricultural Water Management, 179, 277-287.
20. Fan, X., F., Li, F., Liu and D., Kumar. 2004. Fertilization with a new type of coated urea: Evaluation for nitrogen efficiency and yield in winter wheat. Journal of plant nutrition, 27(5): 853-865.
21. Guo, C., X., Yuan, F., Yan, K., Xiang, Y., Wu, Q., Zhang, ... and J. Ma. 2022. Nitrogen application rate

[Citation Farooq, M.R., Nazar, M.Z.K., Akbar, M.Z., Ghafoor, T., Shabir, M.A., Rafique, H.M., Qamar, M.J., Qazi, M.A., Aslam, Z., Hafeez, Z., Manzoor, N., Hassan, W., Khaliq, A., Murtaza, G., Rehman, S.U., Mubashir, M., Bashir, M.A., Arif, M., Asif, M., Imran, M., Khalid, M., Hussain, S. (2024). Impact of varied amounts of nitrogenous fertilizers on grain yield and related agro-physiological traits in spring wheat (*Triticum aestivum L.*). *Biol. Clin. Sci. Res. J.,* **2024***: 1196*. doi: https://doi.org/10.54112/bcsrj.v2024i1.1196]

affects the accumulation of carbohydrates in functional leaves and grains to improve grain filling and reduce the occurrence of chalkiness. Frontiers in Plant Science, 13, 921130.
22. Yue, K., L., Li, J., Xie, Y., Liu, J., Xie, S., Anwar and S. K. Fudjoe. 2022. Nitrogen supply affects yield and grain filling of maize by regulating starch metabolizing enzyme activities and endogenous hormone contents. Frontiers in Plant Science, 12: 798119.
23. Zhou, B., M. D., Serret, J. B., Pie, S. S., Shah and Z. Li. 2018. Relative contribution of nitrogen absorption, remobilization, and partitioning to the ear during grain filling in Chinese winter wheat. Frontiers in Plant Science, 9, 1351.
24. Wei, J., Q., Yu, J., Ding, C., Li, X., Zhu, W., Guo and M. Zhu. 2022. Physiological and agronomic mechanisms involved in 'Source–Sink relationship in the high-yield population of Weak-Gluten Wheat. Agronomy, 13(1): 91.
25. Burkholder, P. R. 1936. The role of light in the life of plants. I. Light and physiological processes. The Botanical Review, 1-52.
26. Walter, J., and J. Kromdijk. 2022. Here comes the sun: How optimization of photosynthetic light reactions can boost crop yields. Journal of Integrative Plant Biology, 64(2), 564-591.
27. Givnish, T. J. 1988. Adaptation to sun and shade: a whole-plant perspective. Functional Plant Biology, 15(2): 63-92.
28. Waraich, E. A., R., Ahmad, R., Saifullah and A. Ahmad. 2011. Water stress and nitrogen management effects on gas exchange, water relations, and water use efficiency in wheat. Journal of plant nutrition, 34(12): 1867-1882.
29. Kubar, M. S., Q., Zhang, M., Feng, C., Wang, W., Yang, K.A., Kubar, ... and M.A., Asghar. 2022. Growth, yield and photosynthetic performance of winter wheat as affected by co-application of nitrogen fertilizer and organic manures. Life, 12(7): 1000.
30. Buckley, T. N., and S.J., Schymanski. 2014. Stomatal optimisation in relation to atmospheric CO2. New Phytologist, 201(2): 372-377.
31. Tripathi, S. N., S., Marker, P., Pandey, K. K., Jaiswal and D. K. Tiwari. 2011. Relationship between some morphological and physiological traits with grain yield in bread wheat (Triticum aestivum L. em. Thell.). Trends in Applied Sciences Research, 6(9): 1037.
32. Pennacchi, J. P., E., Carmo-Silva, P. J., Andralojc, D., Feuerhelm, S. J., Powers and M. A. Parry. 2018. Dissecting wheat grain yield drivers in a mapping population in the UK. Agronomy, 8(6): 94.
33. Vicente, R., O., S., Vergara-Díaz, F., Medina, S. C., Chairi, J., Kefauver, Bort... and J. L. Araus. 2018. Durum wheat ears perform better than the flag leaves under water stress: gene expression and physiological evidence. Environmental and Experimental Botany, 153: 271-285.
34. Li, Y., F., Tao, Y., Hao, J., Tong, Y., Xiao, Z., He and M. Reynolds. 2023. Variations in phenological, physiological, plant architectural and yield-related traits, their associations with grain yield and genetic basis. Annals of Botany, 131(3): 503-519.
35. Yousaf, M. I., M.H. Bhatti, M.A. Maqbool, A. Ghani, M. Akram, I. Ibrar, A. Khan, R.A.H. Khan, S.A. Kohli, M.A.B. Saddiq and M.U. Khalid. 2021. Heat stress-induced responses in local and exotic maize hybrids for morphophysiological and grain quality traits. Pakistan J. Agric. Sci. 58: 1511– 1521. doi: 10.21162/PAKJAS/21.424
36. Yousaf, M. I., K. Hussain, S. Hussain, A. Ghani, M.H. Bhatti, A. Mumtaz, M.U. Khalid, A. Mehboob, G. Murtaza and M. Akram. 2022. Characterization of maize (Zea Mays L.) hybrids for physiological attributes and grain quality traits under heat stress. Iranian Journal of Plant Physiology 12: 4075- 4087.
37. Jańczak-Pieniążek, M. 2023. The influence of cropping systems on photosynthesis, yield, and grain quality of selected winter triticale cultivars. Sustainability, 15(14), 11075.
38. Farhad, M., U., Kumar, V., Tomar, P. K., Bhati, J, N., V., Krishnan Barek, ... and A. Hossain. 2023. Heat stress in wheat: a global challenge to feed billions in the current era of the changing climate. Frontiers in Sustainable Food Systems, 7: 1203721.
39. Ghani, A., M.I. Yousaf, K. Hussain, S. Hussain, A. Razaq, N. Akhtar, I. Ibrar, N. Kamal, B. Ali, A.M. Khan, S.W.H. Shah, S. Khanum and R.M. Hassan. 2023. Relationship between high-temperature stress and key physio-chemical, reactive oxygen species and antioxidants in spring maize hybrids under semi-arid conditions. Biol. Clin. Sci. Res. J.: 199.

[Citation Farooq, M.R., Nazar, M.Z.K., Akbar, M.Z., Ghafoor, T., Shabir, M.A., Rafique, H.M., Qamar, M.J., Qazi, M.A., Aslam, Z., Hafeez, Z., Manzoor, N., Hassan, W., Khaliq, A., Murtaza, G., Rehman, S.U., Mubashir, M., Bashir, M.A., Arif, M., Asif, M., Imran, M., Khalid, M., Hussain, S. (2024). Impact of varied amounts of nitrogenous fertilizers on grain yield and related agro-physiological traits in spring wheat (*Triticum aestivum L.*). *Biol. Clin. Sci. Res. J.*, **2024***: 1196*. doi: https://doi.org/10.54112/bcsrj.v2024i1.1196]