Faculty of Agriculture, University of Poonch Rawalakot
Jammu Kashmir Journal of Agriculture
ISSN: 2312-9344 (Online), 2313-1241 (Print)
https://jkjagri.com/index.php/journal
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IMPACT OF BASAL AND FOLIAR SPRAY OF NITROGEN ON WHEAT CROP AND ITS EFFECTS ON NUTRITIONAL QUALITY

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A B S T R A C T

Nitrogen deficiency is a widespread problem in wheat crops in Pakistan, primarily due to factors such as insufficient soil fertility, improper fertilizer application, and limited availability of high-quality inputs. As wheat is a crucial staple crop in Pakistan and a vital source of nutrients and energy for millions of people, the impact of nitrogen deficiency on wheat crops is substantial. Field experiments were conducted to evaluate the effects of foliar application of nitrogen on the growth, yield, and nutritional quality of Triple Dwarf (TD-1) wheat variety. Different doses of basal and foliar nitrogen concentrations were applied to the wheat plants. Experiment Analysis of Variance (ANOVA) revealed a noteworthy distinction ($P<0.05$) for all yield and growth characteristics appropriate to treatments. The experimental treatments included T1 (non-treated plots), T2 (1.0% of foliar applied nitrogen), T3 (Recommended dose of nitrogen (168kg ha^{-1}), and T4 (recommended dose (168kg ha^{-1}) + 1.0% foliar nitrogen) at the booting growth stage. The results of the study indicated that the recommended dose of nitrogen combined with foliar application significantly influenced wheat growth and nutritional quality. Moreover, the findings suggested that timely foliar sprays during appropriate growth stages can maximize crop yield and improve nutritional quality in the field. Overall, this research highlights the importance of addressing nitrogen deficiency in wheat crops through optimized nutrient management practices, such as appropriate fertilizer application and timely foliar sprays, to enhance crop productivity and nutritional value.

Keywords: Foliar application; Nitrogen; Protein; Wheat

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Article history
Received: July 02nd, 2023
Revised: July 29th, 2023
Accepted: August 06th, 2023

INTRODUCTION

Nutrient deficiency is a global challenge that hinders crop production and impacts the nutritional characteristics of wheat crops. Wheat is a widely cultivated cereal crop globally and serves as a primary food source in Pakistan, with a cultivated area of 9.2 million hectares in 2019-2020. Pakistan ranks third in wheat production in Asia and eighth in the world (GoP., 2015). Nitrogen is a crucial component for plant growth and seed protein synthesis, and its availability, whether through soil or foliar application, significantly influences crop growth (Grant et al., 1991). Among the micronutrients, nitrogen (N) is the most deficient nutrient in crops in Pakistan (Shah et al., 2011). Insufficient nitrogen utilization efficiency remains a major limiting factor for crop productivity in the country. Cereal crops like wheat are highly responsive to nitrogen fertilizers and vulnerable to nitrogen application.

Applying nitrogen as a foliar spray on wheat has proven to be practical for improving both nutritional quality and yield (Wilhelm et al., 2002). Foliar application of nitrogen to wheat tillers is more efficient compared to soil application, as it helps control various pathways of nitrogen loss (Adesemoye et al., 2008). Numerous experiments have been conducted to study the relationship between fertilization intervals and crop quality, revealing that foliar application of nitrogen significantly affects qualitative and quantitative traits of wheat crops (Gooding and Davies, 1992). Notably, foliar application of nitrogen during the booting stage is particularly beneficial, as it facilitates rapid absorption (up to 50% within six hours) and efficient transport of nitrogen to the grains (Gooding and Davies, 1992). The protein content in wheat grains is a critical quality factor that can have a significant impact on the global market (Foca et al., 2007).

Protein content in grains plays a crucial role in determining wheat's baking quality, and market adjustments are established worldwide based on protein content (Woolfolk et al., 2002). Studies have demonstrated that spraying wheat with 10 kg ha^{-1} urea increased seed protein content from 9.9% to 10.8% (Johnson and Prince, 2002). The protein content of food products is often determined based on total nitrogen content, which is then multiplied by a factor to estimate the protein content. Studies, such as those by Dekov (2004), have shown that foliar application of nitrogen on the leaves two to three weeks after flowering increases seed protein content without adversely affecting quantity traits. Through foliar spray, grain protein content can be maximized from 11% to 12.2%, with the foliar-applied nitrogen primarily incorporated into storage proteins responsible for bread-making quality (Johnson et al., 1988). Foliar nitrogen spray not only influences protein content but also increases grain yield (Zečević et al., 2004). The application of foliar nitrogen during the early vegetative stage, particularly at the boot growth stages, has the potential to enhance yield and is commonly used to increase grain protein content (Orloff et al., 2012). With this context in mind, the primary objective of this research was to assess the impact of nitrogen fertilization applied solely through foliar spraying on winter wheat. This evaluation involved a comparison of various nitrogen dosage levels and was conducted in contrast to traditional soil fertilization methods. The ultimate goal was to identify the most suitable nitrogen dosage that would promote optimal growth and enhance the nutritional quality of the winter wheat crop.

MATERIALS AND METHODS

Site description, experimental design, sampling, and measurement

A two-year field experiment was conducted at the "Student's Experimental Farm" of the Department of Agronomy, Sindh Agriculture University, Tandojam, with coordinates of Latitude 25.42° N and Longitude 68.53° E. The experiment took place during the growing seasons of 2015-16 and 2016-2017, focusing on a commercial wheat variety called "TD-1". The experimental design employed a randomized complete block design (RCBD) with three replications. Each plot had a size of 4m x 3m ($12m^2$).The study involved four different treatments of nitrogen application. The treatments were as follows: T1: Non-treated plots (no foliar application of nitrogen), T2: Foliar application of 1.0% nitrogen, T3: Recommended dose of nitrogen (168 kg/ha), T4: Recommended dose of nitrogen (168 kg/ha) + 1.0% foliar application at the booting growth stage.

The seedbed was well-prepared for wheat cultivation, and a recommended dose of P: K (phosphorus: potassium) at a ratio of 84:60 kg/ha was applied to all treatments, except for the control plot, based on soil testing. The wheat crop received six timely irrigations, and measures were taken to control diseases, weeds, and pests at the experimental sites.

Observations were recorded on five randomly selected plants from each plot. The following parameters were measured: Plant height: Recorded in centimeters at crop maturity, Spike length: Measured in centimeters at crop maturity, Tillers (m^{-2}): Counted before 3rd irrigation, Number of grains per spike: Counted and averaged Grain yield: Weighed based on the grain yield per plot and calculated in kilograms per hectare (kg/ha).

To evaluate quality parameters, wheat samples were analyzed using a NIR (near-infrared) analyzer (PERTEN) following standard routine and NIR-based methods. Five hundred grams of wheat grain sample were fed into the NIR analyzer, and within 5 minutes, the readings for starch and protein concentrations appeared on the digital screen of the Infratec Grain Analyzer. These values were reported on a dry basis and calibrated against traditional chemistry methods for prediction. Through these experimental procedures, the study aimed to assess the effects of different foliar nitrogen treatments on various growth parameters, yield, and quality characteristics of the TD-1 wheat variety.

Statistical analysis

The data were subjected to analysis of variance and figures were drawn by using the software Python. Two-way ANOVAs were used the analysis the difference between treatments, years, and parameters.

RESULTS

Plant height

The results of the study indicate that the application of various foliar sprays had an impact on plant height. As shown in Figure 1A, the highest mean maximum plant height of 69.5 cm was observed in the treatment where the recommended dose of N + 1.0% foliar of Nitrogen (T4) was

DOI: 10.56810/jkjagri.003.02.0071

applied. This height was significantly greater compared to the other treatments. In contrast, the non-treatment plot (T1) and the treatment with 1.0% Nitrogen foliar (T2) resulted in lower plant heights of 42.5 and 67.0 cm, respectively, compared to T4. Notably, the plant height in the non-treated plot (T1) was even lower than in T2.Additionally, a plant height of 68.0 cm was observed in the treatment where the recommended dose of Nitrogen was applied. Analysis of variance showed that 2015 -2016 had slightly high plant height. These findings suggest that the recommended dose of N + 1.0% foliar of Nitrogen (T4) had a significant positive effect on plant height. Conversely, the non-treatment plot and the treatment with 1.0% Nitrogen foliar (T2) resulted in lower plant heights.

Tillers m^{-2}

As presented in Figure 2, the number of tillers m^{-2}in wheat cropswas significantly influenced by the foliar application during the booting stage. In the non-treated plot (T1), the wheat plants had the lowest number of tillers (m^{-2}), with only 221 tillers m^{-2}. At T2 and T4 the tiller m^{-2}wasrecorded 261 and 314, while in T3, the tiller m^{-2} was 318 which was the highest as compared to other treatments. As shown in Figure 2B in the year of 2015- 2016 had maximum numbers of tillers (m^{-2}).

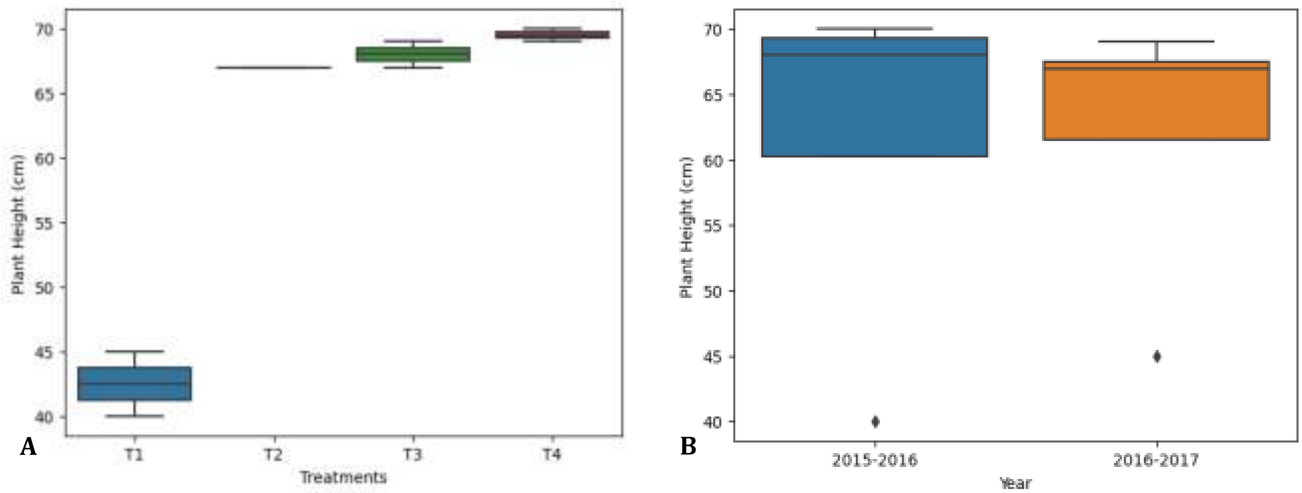

Figure 1. A) Effect of foliar spray of Nitrogen (Treatment (T1): non-treated plots, T2: 1.0% of foliar spray, T3: Recommended Dose of N, T4: Recommended Dose+ 1.0% of foliar spray) on plant height (cm) wheat. Whereas T stands for Treatment; B) Effect of year on plant height (cm) wheat.

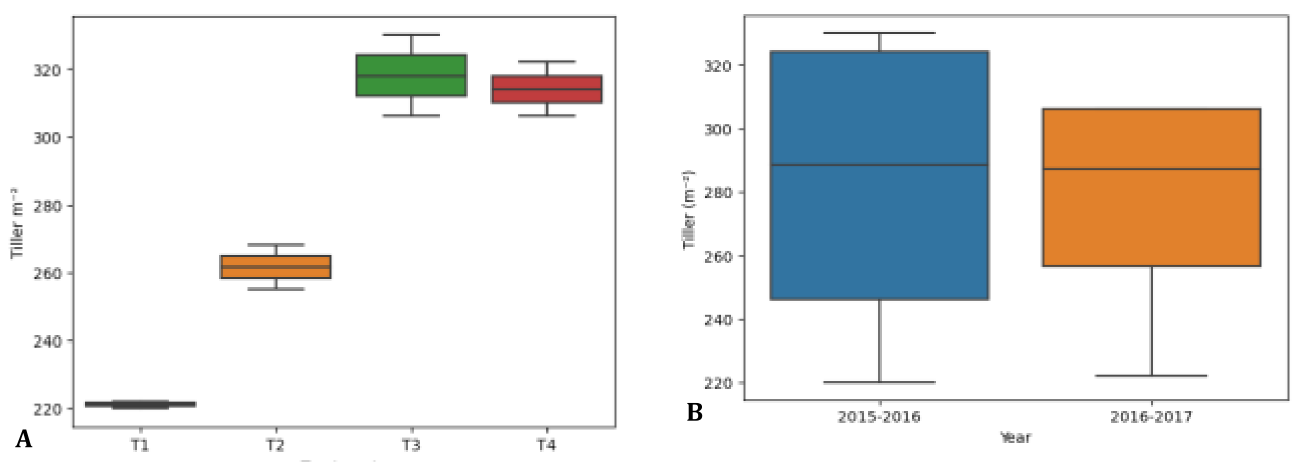

Figure 2. A) Effect of foliar spray of Nitrogen (Treatment (T1): non-treated plots, T2: 1.0% of foliar spray, T3: Recommended Dose of N, T4: Recommended Dose+ 1.0% of foliar spray) on Tiller (m-2) wheat. Whereas T stands for Treatment; B) Effect of year on plant height (cm) wheat.

 DOI: 10.56810/jkjagri.003.02.0071

Spike length

Spike length is a crucial factor affecting wheat grain formation. Figure 3A shows the variation in spike length (cm) of the wheat cultivar TD-1 due to different foliar applications. Our research findings indicate that the highest average spike length (9.21 cm) was observed in T4, where the recommended dose of nitrogen was combined with a 1.0% foliar spray of nitrogen was applied. Following closely, T3 with the recommended dose of nitrogen exhibited a spike length of 9.21 cm. In contrast, the control plots (non-treated) at T1 showed the shortest spike length, measuring 6.4 cm. additionally, a spike length of 7.4 cm was recorded at T2, where only a 1.0% foliar spray was applied. These results highlight the positive impact of foliar applications, particularly when the recommended dose of nitrogen was supplemented with a 1.0% foliar spray, on achieving maximum spike lengths in the wheat cultivar TD-1. As shown in the Figure 3B 1st year of sown had maximum spike length as compare to second year.

Grain per spike

The statistical analysis for grains spike^{-1}was affected by the various concentration of foliar application of Nitrogen, shown in Fig 4A. Our research findings indicate that the highest average grains per spike (50.5 and 55.5 grains/spike) were observed in T3 and T4. In contrast, T2, where only 0.1% nitrogen was applied in a different manner, exhibited slightly lower grains per spike. The lowest grains per spike found (42.5 grains per spike) was recorded in the non-treated plot (T1), which served as the control plot and received no nitrogen application. These results suggest that the grains per spike were maximized when basal and sprays of nitrogen were applied.

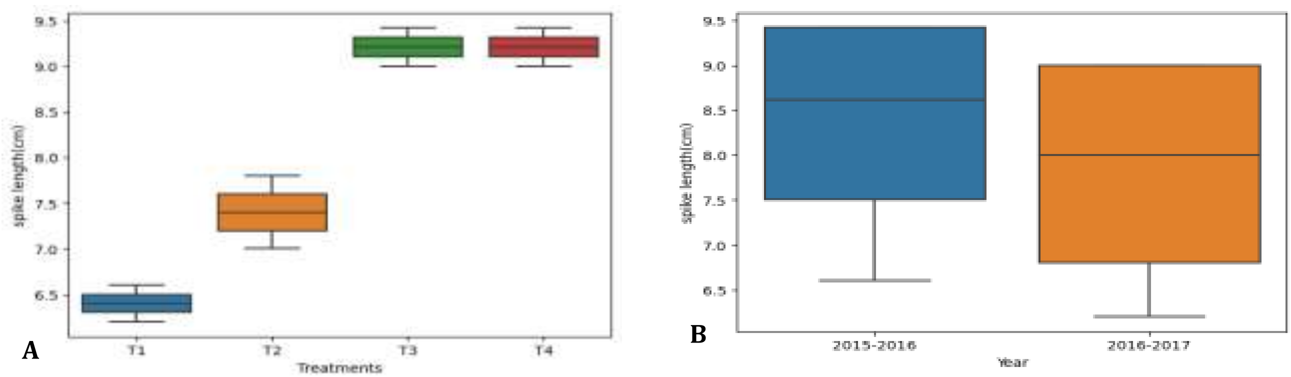

Figure 3. A) Effect of foliar spray of Nitrogen (Treatment (T1): non-treated plots, T2: 1.0% of foliar spray, T3: Recommended Dose of N, T4: Recommended Dose+ 1.0% of foliar spray) on spike length (cm) wheat. Whereas T stands for treatment. B) Effect of the year on spike height (cm) wheat.

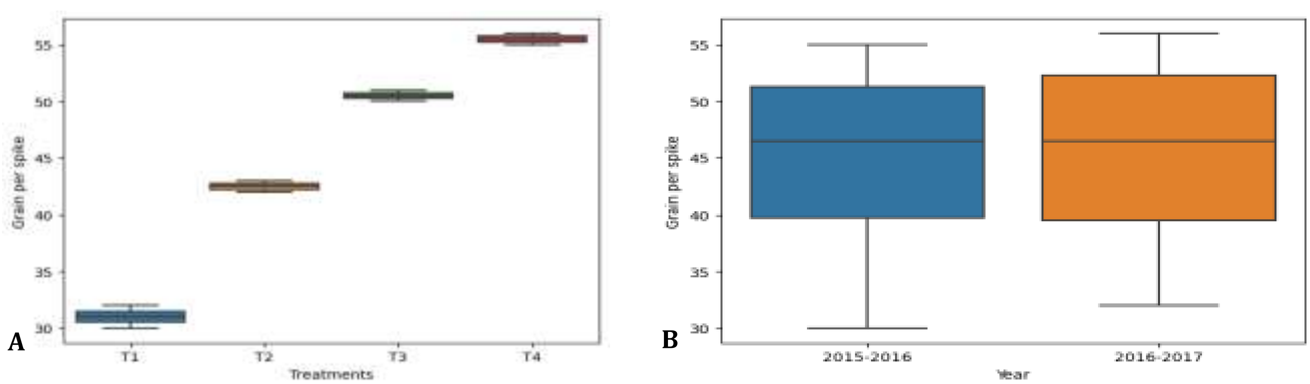

Figure 4. A) Effect of foliar spray of Nitrogen (Treatment (T1): non-treated plots, T2: 1.0% of foliar spray, T3: Recommended Dose of N, T4: Recommended Dose+ 1.0% of foliar spray) on grain per spike wheat. Whereas T stands for Treatment. B) Effect of year on grain per spike wheat.

This highlights the significance of nitrogen supplementation through foliar applications in enhancing the development and productivity of wheat spikes, resulting in a higher number of grains per spike. Analysis of variance shows in the year of 2016- 2017 had maximum grain per spike.

Grain yield (kg/ha)

The analysis of variance for grain yield (kg ha^{-1}) showed a significant response to the foliar application of Nitrogen as illustrated in Figure 5A. Our research findings revealed that the highest grain yield (5081 and 5231 kg/ha) resulting from nitrogen foliar spray was observed in T3 and T4, respectively. In contrast, the non-treated control plots exhibited the lowest grain yield (3210 kg/ha), while T2 showed a grain yield of 4196 kg/ha.

These results indicate that the foliar application of nitrogen, specifically when combined with the recommended dose along with a 0.1% nitrogen spray (T4), positively influenced grain yield. The grain yields obtained in these treatment groups were significantly higher compared to the non-treated control plots.

Grain protein

Analysis of grain protein (%) showed a significant response to the foliar concentration of Nitrogen, which is presented in Figure 6A.

Our finding shows that the maximum mean grain protein (Dry basis) (12 % and 13%) was obtained at T3 and T4 of nitrogen foliar spray and minimum protein content (9%) at non-treated control plots. While 11% were found at T2. By comparing the two growing seasons, 2015-2016 had slightly low grain protein content. While in the 2nd year, while it was the opposite for grain protein.

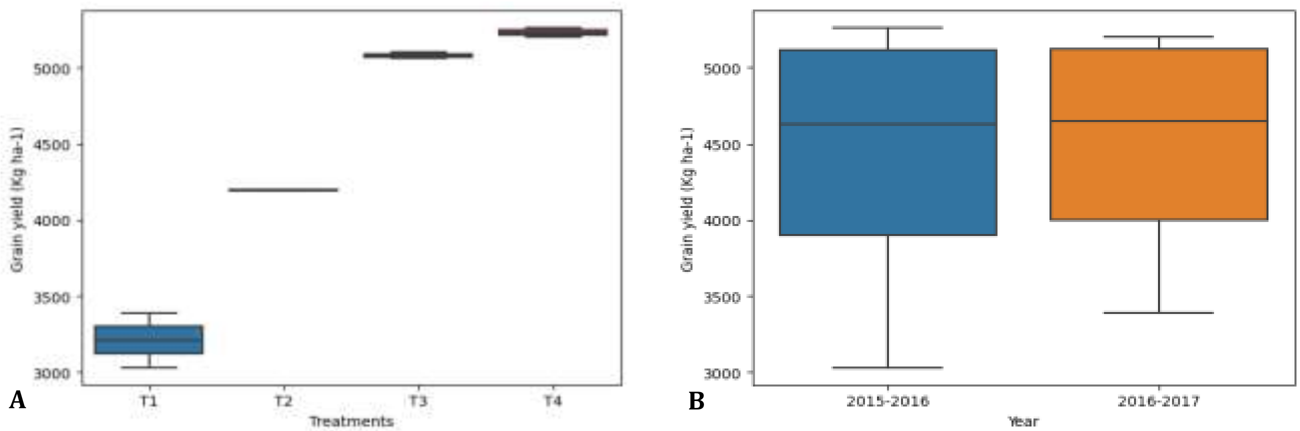

Figure 5. A) Effect of foliar spray of Nitrogen (Treatment (T1): non-treated plots, T2: 1.0% of foliar spray, T3: Recommended Dose of N, T4: Recommended Dose+ 1.0% of foliar spray) on grain yield (kg-1) wheat. Whereas T stands for Treatment; B) Effect of year on grain yield (kg ha-1) wheat.

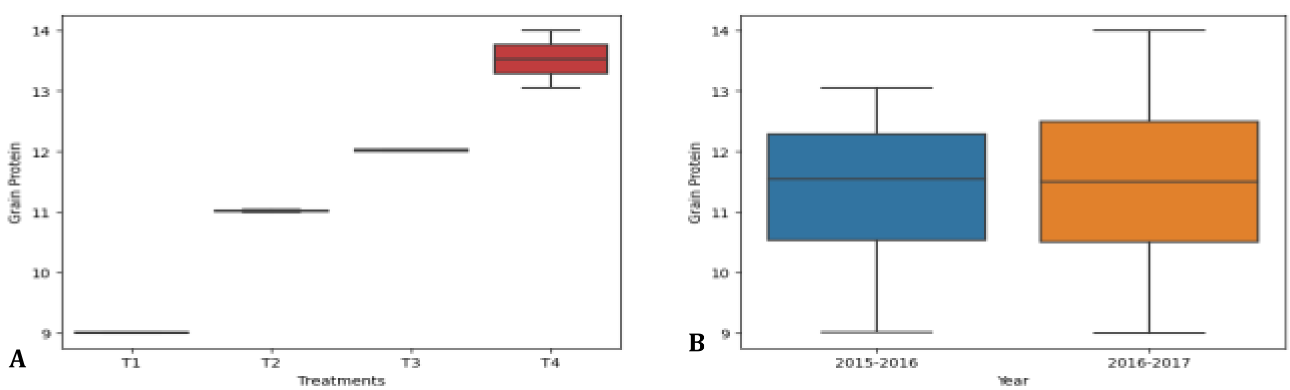

Figure 6. A) Effect of foliar spray of Nitrogen (Treatment (T1): non-treated plots, T2: 1.0% of foliar spray, T3: Recommended Dose of N, T4: Recommended Dose+ 1.0% of foliar spray) on grain Protein (%) wheat. Whereas T stands for Treatment. B) Effect of year on grain Protein wheat.

In Table 1, the results of a comprehensive statistical analysis investigating the relationship between various plant characteristics, including plant height (cm), tiller (m^{-2}), spike length (cm), grain per spike, yield, and grain protein, are presented. The analysis aimed to assess the impact of the variables 'Treatments' and 'Year' on these plant characteristics. The findings from the analysis indicate that the 'Treatments' factor has a significant effect on plant height, tiller, spike length, grain per spike, yield, and grain protein. This implies that the different treatments applied to the plants have led to noticeable variations in these plant characteristics. The statistical significance of the 'Treatments' factor, as indicated by the low p-value, strengthens the evidence for its influence on the studied variables. Further examination of the results reveals that the treatment associated with the recommended dose of N + 1.0% foliar of Nitrogen (T4) resulted in the highest mean plant height. This height was significantly greater than those observed in the other treatments, indicating the effectiveness of this specific treatment in promoting plant growth.

Table 1. The results of a comprehensive statistical analysis between treatment and years on growth, yield, and nutritional quality of wheat*, significant at $p < 0.05$.

Parameters	Source	Df	Mean_sq	F	PR(>F)
Plant Height (cm)	C (Treatment)	3.0	331.50	68.58	0.002
	C (year)	1.0	10103	0.103	0.768
Tillers m^{-2}	C (Treatment)	3.0	4277.12	30.23	0.009
	C (year	1.0	78.125	0.552	0.511
Spike Length (cm)	C (Treatment)	3.0	3.890	207.69	0.0005
	C (year	1.0	0.5202	27.768	0.0133
Grain $spike^{-1}$	C (Treatment)	3.0	228.45	288.57	0.0003
	C (year	1.0	1.125	1.4210	0.3189
Yield (Kg ha^{-1})	C (Treatment)	3.0	1.739	98.631	0.0017
	C (year	1.0	1.468	0.832	0.4288
Grain Protein (%)	C (Treatment)	3.0	7.156	58.003	0.003
	C (year	1.0	0.092	0.7492	0.450

In contrast, the 'Year' factor does not demonstrate a significant effect on the plant characteristics analyzed in this study. This suggests that year-to-year variations, within the scope of the study, did not have a statistically significant impact on plant height, tiller density, spike length, grain per spike, yield, and grain protein. The statistical insignificance of the 'Year' factor, as supported by the high p-value, suggests that the observed differences in these plant characteristics across the studied years are likely due to random fluctuations or other unexamined factors.

Based on the statistical analysis presented in Table 1, the 'Treatments' factor shows a significant effect on plant height, tiller, spike length, grain per spike, yield, and grain protein. In contrast, the 'Year' factor does not demonstrate a significant effect on these plant characteristics. These findings underscore the importance of the specific treatments applied to the plants in influencing their growth and yield-related attributes. The results contribute to our understanding of the factors influencing these plant characteristics in the context of the study, providing valuable insights for agricultural practices and further research in crop improvement.

In contrast, the 'Year' factor does not demonstrate a significant effect on the plant characteristics analyzed in this study. This suggests that year-to-year variations, within the scope of the study, did not have a statistically significant impact on plant height, tiller, spike length, grain per spike, yield, and grain protein.

These findings highlight the significance of the specific treatments applied to the plants in influencing their heights and other plant characteristics, such as tiller, spike length, grain per spike, yield, and grain protein. The results contribute to our understanding of the factors influencing these plant characteristics within the context of the study. They provide valuable insights for agricultural practices aiming to optimize plant growth, improve yield, and enhance grain quality.

DISCUSSION

Nitrogen is a primary macronutrient that significantly impacts the growth and development of wheat. A foliar application of fertilizer can supply nutrients for crops more rapidly than soil application, especially during late sowing (Fageria et al., 2009; Zhang et al., 2010). Implementing the foliar application of nitrogen help reduces the losses due to leaching, denitrification, and immobilization (Gooding and Davies, 1992). Previous researchers also studied that foliar application of Nitrogen is helpful for wheat growth and yield (Blandino et al., 2015; Wang et al., 2021).

The present study showed wheat plant height, tillers (m^{-2}), spike length (cm), grains spike$^{-1,}$ grain yield (kg ha^{-1}), and grain protein (%) were influenced by foliar application of Nitrogen. These results suggest that wheat crops rapidly absorb Nitrogen due to the foliar application of Nitrogen. These findings are similar to the previous studies (Alston, 1979; Arif et al., 2006; Kenbaev and Sade, 2002; Rogalski, 1994; Shah and Saeed, 1989; Strong, 1982; Veesar et al., 2017).

Recent studies support the notion that the dose of foliar fertilization plays a crucial role. Late-season supply, at booting, has proven to be more effective in increasing yields and nutritional quality and improving bread-making properties compared to the control plot, as observed in our T3 treatment (Arif et al., 2006; Woolfolk et al., 2002). It is believed that recommended dose + 1.0% foliar spray early foliar application increases the yield and nutritional quality. However, at the booting stage, the absorbed nitrogen primarily goes toward the developing kernels. Additionally, we propose that small amounts of foliar nitrogen applied at booting, as seen in our treatment 2, are insufficient to significantly enhance grain quality, likely due to a cumulative deficiency from earlier growth stages.

In this study, among the three treatments, the quality of protein in grain is directly related to the absorption and accumulation of Nitrogen in wheat. The protein content in grain was significantly affected by the absorption of Nitrogen. Enhancement in grain protein was more noticeable when Nitrogen was sprayed with higher concentrations at the booting stages. Our findings show that results had that the booting stage is primarily used to increase protein; these findings are similar to the previous works of scientists (Abdi et al., 2002; Mahajan et al., 2004).Several studies have reported an increase in grain protein content (GPC) under different doses of nitrogen (Johansson et al., 2003; Rao et al., 1993).

In general, our study revealed that Recommended dose (168 kg/ha) +1.0% Nitrogen as a foliar spray is superior over other treatments of nitrogen applications to enhance wheat yield and quality. Moreover, the growing season had a no significant effect on different parameters. The foliar fertilization along with the basal fertilization technique is eco-friendly and better for nutrient enhancement in wheat crops.

CONCLUSIONS

It was concluded that the recommended dose of nitrogen combined with foliar application significantly influenced wheat growth and nutritional quality. Moreover, the findings suggested that timely foliar sprays during appropriate growth stages can maximize crop yield and improve nutritional quality in the field.

STATEMENTS AND DECLARATIONS

This research paper contributes to the growing body of literature on the effects of human and soil health. Understanding the relationship between fertilizer and wheat usage can inform interventions and strategies to promote a positive effect of foliar fertilization

FUNDING

We thank the cooperation of the Department of Agronomy (Sindh Agriculture University Tandojam) for providing materials and experimental fields. We are also thankful to the field staff of the Sindh Agriculture.

CONFLICTS OF INTEREST

The authors declare that they have no known competing financial interest or personal relationships that could have appeared to influence the work reported in this paper.

AUTHORS' CONTRIBUTION

All authors contributed and supported in this manuscript.

REFERENCES

Abdi, M., Nour Mohammadi, G., Golchin, A., 2002. The influence of foliar nutrition of urea and potassium chloride on grain yield, grain protein content, yield components and leaf relative water content of Sardari wheat under rainfed condition. Journal of Agricultural and Food Sciences 8, 29-38.

Adesemoye, A., Torbert, H., Kloepper, J., 2008. Enhanced plant nutrient use efficiency with PGPR and AMF in an integrated nutrient management system. Canadian Journal of Microbiology 54, 876-886.

Alston, A., 1979. Effects of soil water content and foliar fertilization with nitrogen and phosphorus in late season on the yield and composition of wheat. Australian Journal of Agricultural Research 30, 577-585.

Arif, M., Chohan, M.A., Ali, S., Gul, R., Khan, S., 2006. Response of wheat to foliar application of nutrients. Journal of Agriculture and Biological Sciences 1, 30-34.

Blandino, M., Vaccino, P., Reyneri, A., 2015. Late-season nitrogen increases improver common and durum wheat quality. Agronomy Journal 107, 680-690.

Dekov, D., 2004. Effect of late foliar application of Nitrogen on grain yield and quality of soft and durum wheats. Rasteniev" dni-Nauki 25, 7-17.

Fageria, N., Filho, M.B., Moreira, A., Guimarães, C., 2009. Foliar fertilization of crop plants. Journal of Plant Nutrition 32, 1044-1064.

Foca, G., Ulrici, A., Corbellini, M., Pagani, M.A., Lucisano, M., Franchini, G.C., Tassi, L., 2007. Reproducibility of the Italian ISQ method for quality classification of bread wheats: An evaluation by expert assessors. Journal of the Science of Food and Agriculture 87, 839-846.

Gooding, M., Davies, W., 1992. Foliar urea fertilization of cereals: A review. Fertilizer Research 32, 209-222.

Grant, C., Gauer, L., Bailey, L., Gehl, D., 1991. Protein production and nitrogen utilization by barley cultivars in response to nitrogen fertilizer under varying moisture conditions. Canadian Journal of Plant Science 71, 997-1009.

Johansson, E., Prieto-Linde, M., Svensson, G., Jönsson, J., 2003. Influences of cultivar, cultivation year and fertilizer rate on amount of protein groups and amount and size distribution of mono-and polymeric proteins in wheat. The Journal of Agricultural Science 140, 275-284.

Johnson, A., Dahnke, W., Swenson, L., 1988. The effect of foliar application of urea ammonium nitrate on yield and protein content of wheat. Farm Research 46, 20-23.

Johnson, A., Prince, J., 2002. Effect of adding sulphur to urea sprays at milky ripe on protein content of winter wheat. Annals of Applied Biology 15, 371-372.

Kenbaev, B., Sade, B., 2002. Response of field-grown barley cultivars grown on zinc-deficient soil to zinc application. Communications in Soil Science and Plant Analysis 33, 533-544.

Mahajan, G., Singh, G., Sekhon, G., 2004. Effect of phosphorus and foliar application of urea on the growth and yield of summer urdbean genotypes, 10th International Congress of Soil Science. Soil Science Society of Pakistan, Tandojam.

Orloff, S., Wright, S., Ottman, M., 2012. Nitrogen management impacts on wheat yield and protein, Proceedings, California Alfalfa & Grains Symposium, Sacramento, CA,, pp. 11-12.

Rao, A., Smith, J.L., Jandhyala, V., Papendick, R., Parr, J., 1993. Cultivar and climatic effects on the protein content of soft white winter wheat. Agronomy Journal 85, 1023-1028.

Rogalski, L., 1994. Influence of supplementary foliar spray nutrition with plant protection on yield of winter wheat. Acta Academia Agri Tech Olsteninsis 57, 111-118.

Shah, K., Saeed, M., 1989. Effect of combination of soil and foliar application of urea on three wheat genotypes. Pakistan Journal of Scientific and Industrial Research 9, 112-123.

Shah, Z., Ahmad, S.R., Rahman, H.U., Shah, M., 2011. Sustaining rice-wheat system through management of legumes. II Effect of green manure legumes and N fertilizer on wheat yield. Pakistan Journal of Botany 43, 2093-2097.

Strong, W., 1982. Effect of late application of nitrogen on the yield and protein content of wheat. Australian Journal of Experimental Agriculture 22, 54-61.

Veesar, S.A., Laghari, G.M., Ansari, M.A., Oad, F., Soomro, A.A., 2017. Effect of foliar application of urea on different growth stages of wheat. LIFE: International Journal of Health and Life-Sciences 3, 1-11.

Wang, S., Sun, N., Yang, S., Tian, X., Liu, Q., 2021. The effectiveness of foliar applications of different zinc source and urea to increase grain zinc of wheat grown under reduced soil nitrogen supply. Journal of Plant Nutrition 44, 644-659.

Wilhelm, W., McMaster, G., Harrell, D.M., 2002. Nitrogen and dry matter distribution by culm and leaf position at two stages of vegetative growth in winter wheat. Agronomy Journal 94, 1078-1086.

Woolfolk, C.W., Raun, W.R., Johnson, G.V., Thomason, W.E., Mullen, R.W., Wynn, K.J., Freeman, K.W., 2002. Influence of late-season foliar nitrogen applications on yield and grain nitrogen in winter wheat. Agronomy Journal 94, 429-434.

Zečević, V., Đokić, D., Knežević, D., Mićanović, D., 2004. The influence of nitrogen foliar application on yield and bread making quality parameters of wheat. Kragujevac Journal of Science 26, 85-90.

Zhang, Y., Shi, R., Rezaul, K.M., Zhang, F., Zou, C., 2010. Iron and zinc concentrations in grain and flour of winter wheat as affected by foliar application. Journal of Agricultural and Food Chemistry 58, 12268-12274.