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Original Research Article

RESPONSE OF FOLIAR APPLIED UREA ON GROWTH, YIELD AND QUALITY OF WHEAT (*TRITICUM AESTIVUM* L.) AT DIFFERENT GROWTH STAGES

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Abstract *The cost of fertilizer manufacturing and the current energy crisis have increased, affecting the market supply. The situation gets acute when the availability of nitrogen fertilizer, particularly urea, is decreased during the wheat sowing season. As documented in the literature, when applied to plants through foliar, Urea fertilizer reduces the yellowing of lower leaves in wheat. The current research trial was designed to address these issues and reduce production losses caused by urea non-availability in wheat through foliar treatment at various growth stages. A field study was conducted in 2023-24 at the Wheat Program, National Agricultural Research Centre, Islamabad. The experiment consisted of two variables: a) different crop growth stages in the main plot (tilling, booting, and heading) and b) foliar urea application in subplots (control, 2%, 4%, 6%, 8%, and 10%). Yield components, grain yield data, nitrogen content in grain, and absorption were determined. The findings showed that foliar urea application significantly increased yield components and grain yield (grains per spike, productive tillers, 1000-grain weight, and grain yield), spike growth (spike length, spikelet per spike), biomass accumulation (biological yield, harvest index, and plant height) and quality attributes (nitrogen contents and grain crude protein). When applied at the heading stage, a foliar spray of 4 and 6% urea solution was the most effective at improving quantitative and qualitative traits. Applying 4% urea foliar spray is the most effective solution that increases grain yield by 30 per cent. Further increases in urea spray doses were shown to be inefficient due to its toxicity, which reduced grain yield.*

Keywords: Foliar spray; Urea; Wheat; Growth Stages; Yield components

Introduction

Wheat is a staple grain in Pakistan, accounting for a large portion of the crop during the rabi season. Wheat accounts for around 45% of total human nutrition in Pakistan (Rizwan *et al*., 2017). Wheat is grown globally in diverse nations and climates (Aghanejad *et al*., 2015). The involvement of macro and micronutrients in crop nutrition is critical for increasing yields (Leghari *et al*., 2016). Pakistan's soils are nitrogen deficient, and chemical fertilizer is used to increase crop production and reduce the yellowing of lower leaves in wheat grown in irrigated and barani areas (Akram *et al*., 2010). Nitrogenous fertilizers are essential in modern farm technology. However, only 20-50% of the applied nitrogen is retrieved by annual crops (Veesar *et al*., 2017). Denitrification, volatilisation, and leaching remove the remaining nitrogen from the soil system. It is vital to have nitrogen available throughout critical stages (tillering, booting, and heading). Crop yields are reduced when nitrogen is used inefficiently. One of the primary barriers to increasing crop economic yield is the current price increase in fertilizers. Thus, efforts must be made to reduce losses and maximise financial value. Foliar fertilisation, or nutrient supplementation through leaves, is an effective fertilisation strategy that increases the availability of nutrients directly into the crop plant (Khan *et al*., 2009). Fertilizers, particularly urea, are less effective when delivered through soil than when applied through leaves and increase productivity (Pampolino *et al*., 2012). Foliar urea applications enhanced grain yield, mainly when applied before flag leaf emergence and when nitrogen supply was limited (Veesar *et al*., 2017). Applying N near flowering boosted post-flowering N uptake, grain protein content, and grain protein concentration. Increases in grain N content were generally more significant when N fertilizer inputs to the soil were reduced, and the urea solution was sprayed during anthesis (Babar *et al*., 2011). Several studies have shown that applying a small amount of NPK fertilizers via foliar spraying significantly boosts crop productivity (Lenka and Singh, 2011). Several researchers supported the hypothesis that nutrients (such as nitrogen) can be absorbed by roots and leaves and disseminated throughout the plant (Ahmed and Ahmed, 2005). Foliar nitrogen application significantly impacts wheat yield and yield components because it is more effective and causes fewer losses than foliar spray (Seifu *et al*., 2022). However, the effectiveness of nitrogen uptake through leaves is determined by several parameters, including varieties or genotypes. The study was initiated to explore the efficacy of foliar urea spray for wheat yield and yield components at various growth stages.

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Foliar fertiliser spray increases crop yields while reducing the amount of fertiliser applied through the soil. Foliar application can help shorten the interval between application and plant uptake (Ahmad and Jabeen, 2005). As the crop grows in the spring, its nitrogen (N) needs to increase. N insufficiency is typical, mainly when temperatures are low, and little N is mineralised from soil organic matter. Nitrogen deficit causes the plant to turn yellow throughout, with lower leaves wilting and withering from the leaf tips inward (Figure 1). Nitrogen deficit also causes decreased tillering, top growth, and root growth. The principal reasons for nitrogen deficit are insufficient fertiliser rates, application issues, too late nitrogen application, leaching from severe rains, denitrification from saturated soils, and large amounts of crop residue that immobilize nitrogen. So keeping in view the above facts, this study was planned to see the effects of foliar application of urea at different growth stages of wheat to optimize the dose of foliar application of urea for wheat crop, to identify the suitable stage of wheat crop for exogenous application of urea, to minimize the yellowing of leaves, lesser use of urea in case of urea shortage and to minimize the production cost of wheat.

Materials and Methods

Plant material

Wheat variety Wafaq-2023 was collected from the Wheat Program, Crop Sciences Institute, NARC Islamabad for this experiment.

Experimental site

The experimental work was conducted at a field area allocated to the national coordinated wheat program at the National Agricultural Research Centre Islamabad, (33° 42' N, 73º 10' E) Pakistan, under rainfed conditions during the winter season 2023-24.

Physiochemical traits of experimental site

Soil samples were randomly collected before sowing from depths of 0 to 15 cm and 15 to 30 cm with the help of augur, mixed samples of different depths distinctly, made composite, and treated to record physiochemical characteristics (ICARDA, 2013) (Table 1).

Weather elements

Weather data were collected and summarized (Table 2).

Treatments

The experiment was comprised of two variables a) different crop stages in the main plot (tillering, booting, and heading) and b) foliar application of urea in subplots (control, 2%, 4%, 6%, 8%, and 10%).

Experimental design

In this study randomized complete block design with a split-plot arrangement along with three replications was followed.

Imposition of treatments:

Different percentage of urea foliar spray was applied at the initiation of the respective growth stage of wheat. All other crop management practices were kept uniform for all the treatments.

Statistical analysis:

Statistical analysis of recorded data was done by the Fisher Analysis of Variances Technique and treatments' means were compared by using Tukeys' HSD test at 5% probability level (Steel *et al.*, 1997).

Agronomic practices

Sowing was done through hand drill with a recommended seed rate of 100 kg ha^{-1} by maintaining R × R distance of 22.5 cm. Phosphorus and Nitrogen at the rate of 60 kg ha^{-1} and 75 kg ha^{-1}, respectively were applied as band placement in soil at sowing, while 75 kg nitrogen per hectare was applied with first irrigation. Irrigation was applied at critical growth stages of wheat. The net plot size was 3.0 m × 0.90 m and it comprised four rows of wheat.

Observations recorded

Data regarding yield components viz. plant height, number of the productive tiller (m^{-2}), spike length, spikelet per spike, number of grains spike^{-1}, 1000 grain weight, grain yield, biological yield, and harvest index were noted. After harvesting at maturity, the grain yield data were recorded and grain samples were dried at 70ºC till constant weight in an oven and ground in a Wiley micro mill. For nitrogen estimation, the dried ground material (0.5 g) was digested in sulphuric acid using a digestion mixture, distilled, and titrated against 0.1N H_2SO_4 (Jackson, 1973). Nitrogen uptake by grain was calculated by multiplying grain yield with nitrogen concentration (%) in grain. Protein (%) was also calculated after the calculation of nitrogen in grains.

Results

Yield components and grain yield

Urea foliar spray either from tillering, booting, or heading significantly increased grain yield and components. However, the heading stage of wheat depicted more increase in yield and yield components than the tillering and booting stage of wheat. Grains per spike, productive tillers, 1000-grain weight, and grain yield were significantly affected by wheat growth stages and levels of urea foliar spray. Maximum values of all these parameters were observed with 4% urea foliar spray which was closely followed by 6% urea foliar spray. Among the growth stages of wheat maximum number of grains per spike (47.33), more number of productive tillers (4.79), maximum 1000-grain weight (49.33 g), and grain yield (6.98 t ha^{-1}) were recorded at the heading stage of wheat, and minimum at tillering stage. The interaction of urea foliar spray and wheat growth stages was non-significant for these parameters. Significantly more grains per spike, productive tillers, 1000-grain weight, and grain yield were observed under the heading and booting wheat stages as compared to the tillering wheat stage. Whereas, the heading stage of wheat showed the maximum values of these traits. The number of grains per spike, productive tillers, 1000-grain weight, and grain yield were enhanced with increasing concentration of urea foliar application. However, a statistically similar number of grains per spike, productive tillers, 1000-grain weight, and grain yield with 4 and 6% urea foliar application. Whereas, a comparatively lesser and statistically similar number of grains per spike, productive tillers, 1000-grain weight, and grain yield were observed for control (Figure 2).

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Table. 1: Chemical analysis of soil before sowing of crop

Characteristics	Unit	Value	
Depth of sample	Cm	0-15	15-30
Texture	-	Loam	
pH	-	8.00	8.00
Sand	%	33.78	33.78
Silt	%	34.12	34.12
Clay	%	32.23	32.23
EC	dSm^{-1}	1.05	0.96
Organic matter	%	0.35	0.77
Nitrogen (N)	%	0.058	0.053
Phosphorus (P)	ppm	3.2	2.9
Potassium (K)	ppm	180	180

Table 2: Weather conditions during crop growing period

Weather elements	November	December	January	February	March	April	May
Average temperature (°C)	17.39	13.23	10.23	12.23	16.98	20.97	28.21
Relative humidity (%)	69	64	72	67	68	66	50
Rainfall (mm)	85.44	00.00	52.16	33.59	121.40	43.60	8.72
Pan evaporation (mm)	50.46	36.58	30.76	57.31	85.22	113.55	254.30
Wind speed (km h^{-1})	6.71	4.97	5.96	22.58	37.27	42.20	53.51

Figure: 1. Effect of urea foliar spray in minimisation of yellowing of wheat lower leaves

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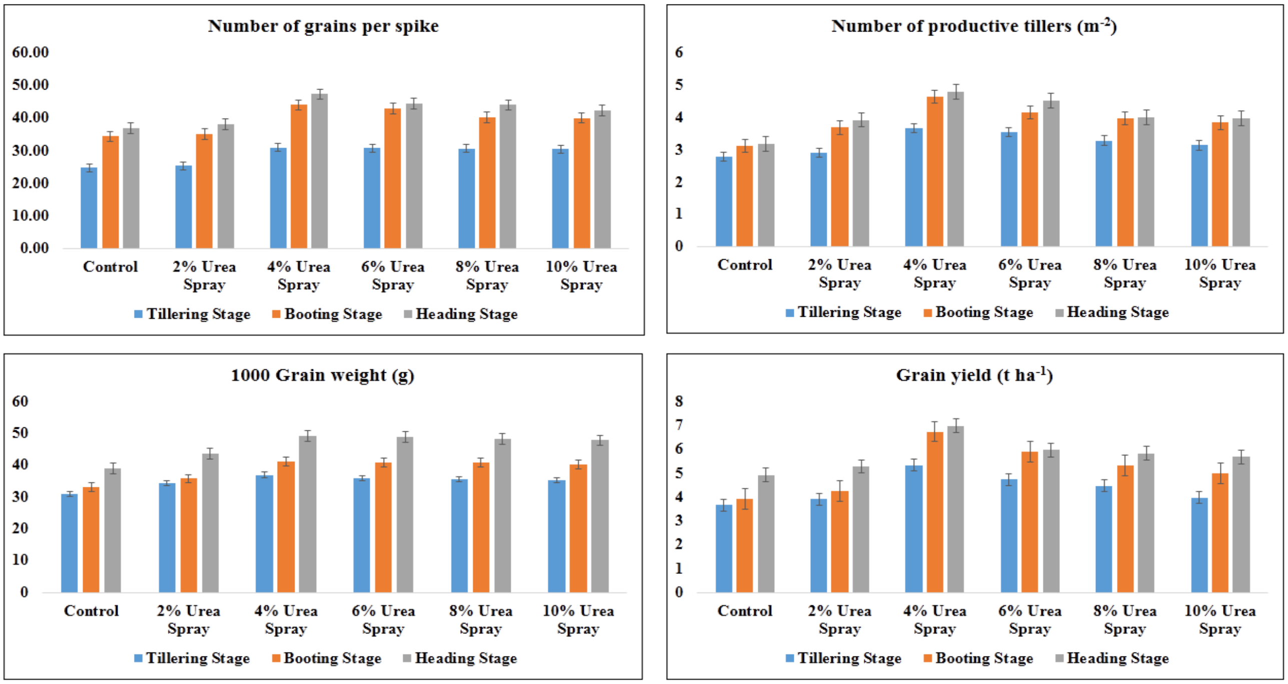

Figure: 2. Effect of urea foliar spray on yield components and grain yield of wheat at different growth stages

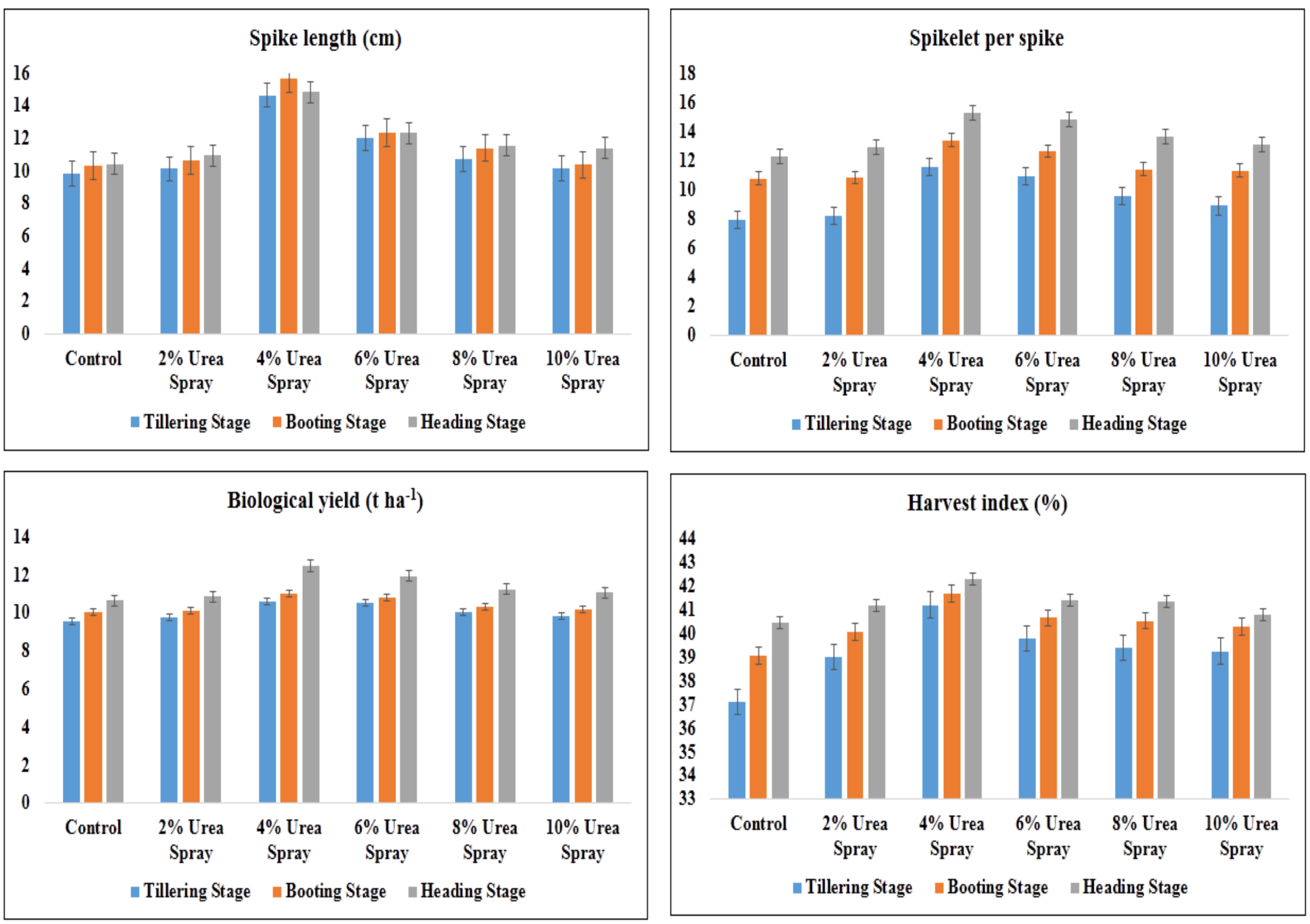

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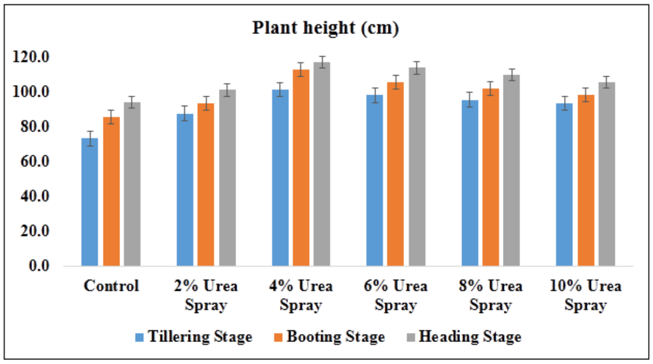
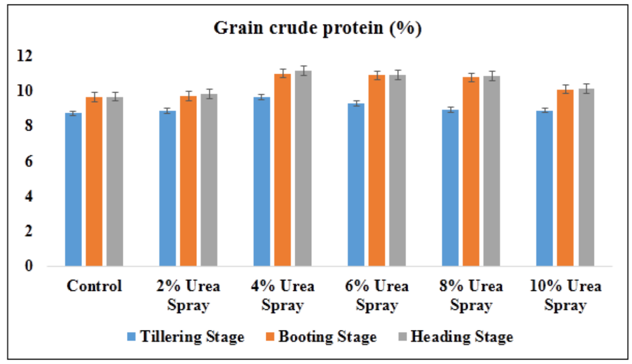
Figure 3. Effect of urea foliar spray on spike growth and biomass accumulation traits of wheat at different growth stages





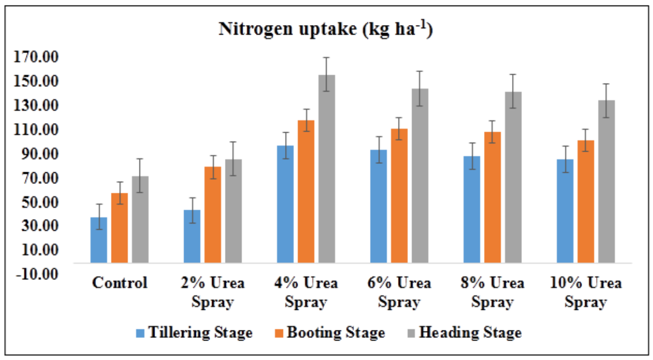


Figure: 4. Effect of urea foliar spray on plant height and quality parameters of wheat at different growth stages

Growth of spike

Heading and booting growth stages of wheat significantly increased spike length and spikelets per spike compared to the tillering stage of wheat. Foliar application of urea significantly enhanced spike length and spikelets per spike compared to control/water spray. Moreover, quite similar trends were observed with different urea concentrations in all main plots that resulted in non-significant 'wheat growth stages × urea foliar spray' regarding growth of spike. Significantly more and statistically similar spike length was measured under heading and booting wheat stages compared to the tillering wheat stage. While a significantly higher number of spikelets per spike were obtained under the heading wheat stage compared to booting and tillering wheat growth stages. Different concentrations of exogenous urea varied significantly for spike growth. Relatively more spike length and spikelets per spike were recorded with 4 and 6% exogenous urea compared to control/water spray (Figure 3).

Biomass accumulation

Two different wheat stages (booting and heading) significantly increased the biological yield, harvest index, and plant height compared to (tillering) wheat stage. More increase in these traits was observed in the heading stage compared to the booting and tillering stages. Yet, exogenously applied urea of different concentrations depicted significant improvements in biomass accumulation attributes compared to control/water spray under different growth stages. Similar trends of urea-modulated improvements under all main plots were observed which resulted in non-significant interaction. More increase in plant height, biological yield, and harvest index was observed in plots where crops remained under longer duration in the heading stage. While crops in other stages of growth gained lower values for these parameters. Biomass accumulation attributes were improved significantly under exogenous urea application. Statistically similar and relatively more biological yield, harvest index, and plant height were recorded with 2, 4, and 6% foliar urea compared to other concentrations (Figure 3).

Quality attributes

The growth stages of wheat caused a notable increase in nitrogen contents and grain crude protein contents in heading, booting, and tillering respectively. Furthermore, statistically similar and comparatively more nitrogen contents and grain crude protein contents were quantified with 4 and 6% of foliar urea compared to other concentrations of urea. Conversely, control/water spray and 2% exogenous urea exhibited comparatively lesser nitrogen contents and grain crude protein contents (Figures 3 & 4).

Discussion

Fertilizers are an essential component of better crop production technology (Abbasi *et al*., 2010). The right amount of fertilizer application is regarded as critical to bumper crop yield. Foliar fertilization can supplement and ensure the availability of nutrients to crops, resulting in increased yields (Arif *et al*., 2006). Our findings are comparable to those of Alston (1979), who found that foliar nitrogen administration in the form of urea improved wheat vegetative development. Similarly, foliar spraying of various nutrients, either alone or in combination, resulted in a considerable increase in plant height in wheat crops (Arif *et al*., 2006). Increase in plant height following nitrogen foliar spray (Veesar *et al*., 2017). Foliar urea administration significantly enhanced plant height, spike length, number of grains spike^{-1}, 1000 grain weight, grain yield, and crop nitrogen uptake when applied during tillering, stem elongation, and booting (Saeed *et al*., 2012). Favorable response when foliar nitrogen concentration was administered at various growth stages of wheat. Foliar spray of urea during the tillering stage had a good effect on spike length (Saeed *et al*., 2012). Gooding and Devies (1992) demonstrated improved wheat crop performance with a foliar nitrogen spray. Significant increase in the number of spikelets per spike of wheat when urea was administered as a foliar spray (Seth and Mosluh, 1981). Nitrogen promotes cell division and growth. This nitrogen function may be the cause of enhanced grain spike^{-1}, since Barbottin *et al*. (2005) found that it also played a role in grain formation. The current study's findings are congruent with those published by Yaseen *et al*. (2010), who found that using urea and micronutrients as a foliar spray significantly boosted 1000-grain weight. Improved crop responses with N spray as a foliar spray (Rahman *et al*., 2014). Foliar spray of urea and micronutrients boosted wheat grain yield by 24-38% over the control (Yaseen *et al*., 2010). These findings are also consistent with Chaudry *et al*. (2007), who found that combining B spray with a basal dose of NPK considerably boosted wheat yield. Foliar spray can balance and ensure the availability of nutrients for greater yields (Arif *et al*., 2006). These findings are consistent with those of Wagan *et al*. (2017), who found that foliar application of urea led in a significant increase in wheat yield. Nitrogen has a considerable effect on the wheat harvest index (Khan *et al*., 2005). Foliar application of nitrogen in the form of urea increased assimilate deposition and improved protein quality (Tea *et al*., 2007). Foliar application of urea is an effective nitrogen fertilization strategy. Foliar spraying of urea greatly enhanced wheat N absorption. Foliar urea fertilization during crop growth can help boost plant mineral status and vigor (Khan *et al*., 2009). According to the findings, combining urea as a foliar spray with various micronutrients appears to improve the concentration and uptake of these elements in grains; this effect could be attributed to the acceleration of micronutrient uptake in the presence of nitrogen as a urea foliar spray source. Nitrogen uptake increased, as expected, with increasing foliar urea application, regardless of soil type. Foliar spraying of urea greatly enhanced wheat N absorption (Khan *et al*., 2009). A foliar spray of 4% urea solution was discovered to be the most effective dose for N uptake by wheat. The latter suggested that urea be employed as a foliar N source to increase growth, yield, N content, and uptake. Nitrogen is a plant-mobile element and nitrogen in the form of urea application is only possible with the presence of water and no rainfall for a longer time causing yellowing of lower leaves in wheat in rainfed areas. Urea foliar application of different concentrations is also the solution to overcome the yellowing of leaves in wheat under the application of nitrogen in rainfed areas.

Conclusion

The results indicate that in case of a shortage of urea at the time of sowing and no rainfall in rainfed areas which caused yellowing of lower leaves in wheat can be minimized by foliar application of 4 and 6% urea solution at tillering, booting, and heading stages. Foliar applied urea @ 4% at the heading stage performed better and enhanced wheat productivity as compared to other treatments.

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Declaration

Ethics Approval and Consent to Participate

Not applicable.

Consent for Publication

The study was approved by authors.

Funding Statement

Not applicable

Conflict of Interest

There is no conflict of interest among the authors regarding this case study.

Authors Contribution

All authors contributed equally.

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