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Effect of Different Urea Doses on the Performance of Wheat Under the Agro-Climatic Conditions of Mansehra, Khyber Pakhtunkhwa, Pakistan

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ABSTRACT

The research conducted aimed to evaluate the impact of varying urea doses on the performance of wheat (Triticum aestivum), with a focus on growth, yield, and nitrogen use efficiency. Urea, a common nitrogen fertilizer, is crucial in enhancing crop productivity. The experiment was conducted in 2022-2023 at the Agriculture Research Station Baffa Mansehra in Khyber Pakhtunkhwa, Pakistan. The research material consisted of a Wheat variety. The Seeds were sown in RCBD design on 15th October 2022 at an Agriculture Research Station Baffa Mansehra. The experiment used a randomized complete block design with three replications. In the agro-climatic conditions of Mansehra, comprehensive data were gathered on various morphological and yield-related attributes. These included morphological parameters such as days to heading, leaf area index (cm), days to maturity, number of tillers/ plant-1, plant height (cm), spike length (cm), spikelet /spike, thousand-grain weight (g), grain yield kg/ha-1, and biological yield kg/ha-1. The study concludes that from experiments that wheat on different urea applications gives significant results from germination to till harvesting under the agro-climatic condition of Mansehra. It means that the wheat on different Urea applications shows improvement in Plant height, Spike length, Spikelet /spike, 1000-grain weight, grain yield and biological yield. Based on these results, it is recommended to apply urea at optimal rates to enhance wheat growth and yield, with the most effective rate being 65 grams per 6 m².

INTRODUCTION

Wheat (Triticum aestivum L.), the world's most significant crop, is classified as a monocot in the Poaceae family. Wheat is a cereal plant belonging to the Triticum genus. This grain is known as the 'King of Cereals' due to its vast cultivation, high yield, and critical role in the world food trade. Most current wheat varieties are derived from three principal species in the genus Triticum: the hexaploid Triticum aestivum (42 (n=21) chromosomes), the tetraploid Triticum durum (28 (n=14), and the diploid Triticum monococcum (14 (n=7) chromosomes, according to (Kumar et

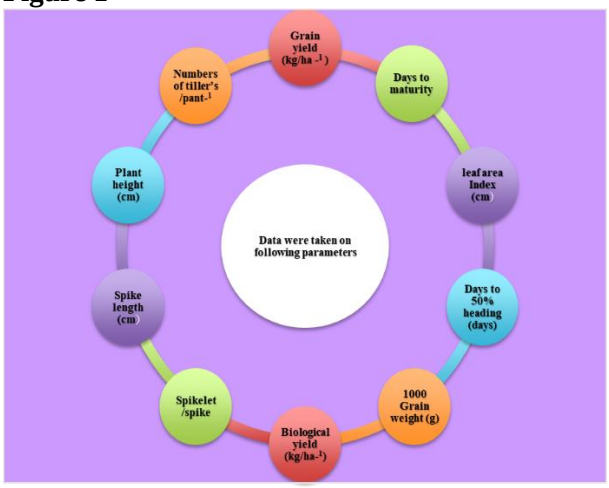
al.2019). Wheat (Triticum aestivum L.) is grown in many nations to provide the population's nutritional requirements. Likewise, it is a significant cereal crop. It is an important source of food in Pakistan. According to the (FAO 2021), wheat demand is estimated to be approximately 840 million tons in 2050, compared to current production of 750 million tons. In Pakistan, wheat is one of the main basic foods. Pakistan cultivates wheat on 9.042 million hectares of land, producing 23.86 million tons of wheat annually at an average yield of approximately 2639 kg ha^{-1} (Anonymous *et al.*, 2010). Pakistan has a higher potential output, but its average wheat grain yield is still far lower than that of the majority of other nations, including China, India, the United States, Russia, and France. Several factors contribute to Pakistan's low wheat yield, including low-quality seed, salinity, waterlogging, improper fertilizer use, scarce irrigation water, high input costs, low farmer education, inadequate farming of wheat varieties under regionally distinct agro-climatic conditions, and insufficient use of organic and micronutrient fertilizers (Ummer et al. 2024). To convene the demand for dietary grains for the increasing population, declining yield and quality are the greatest challenges. According to (Ullah et al., 2024) research findings, fertilizers are responsible for increased crop output since they play a vital role in plant development. Overall, Pakistani soils are poor in nitrogen and must be supplemented with inorganic fertilizers to increase yield. However, the present efficient usage of nutrients, particularly nitrogen fertilizers, is quite low. Although nutrient uptake through the soil cannot be replaced, foliar application of nutrients has been proven to be the most rapid indication of overcoming nutrient deficits throughout the critical periods of crop blooming and grain filling (Kolota and Osinska, 2001). Foliar treatment is only intended to accelerate crop growth and development during critical stages to maximize output. According to (Bagchi et al.,2020), foliar fertilizer spray is a practical means of ensuring rapid nutrient availability during the crucial stages of blooming and grain filling. This study aims to evaluate the impact of varying urea fertilizer doses on the growth, yield, and nitrogen use efficiency of wheat (Triticum aestivum) under the specific agro-climatic conditions of Mansehra. the study aims to identify the optimal urea application rate that maximizes wheat productivity while ensuring efficient nitrogen utilization in the region's unique environmental conditions.

MATERIALS AND METHODS

The current study was conducted in 2022-2023 at the Agriculture Research Station Baffa, Mansehra in Khyber Pakhtunkhwa, Pakistan. Mansehra district is placed on the eastern side of Khyber Pakhtunkhwa, 244 miles from Peshawar and 170.5 kilometers from Islamabad. The district's coordinates on a world map are latitude (34.35 degrees), or 35° 20' 23" north of the Equator, and longitude (73.3 degrees), or 73 12' 0" east of the Prime Meridian. Mansehra has a mild and moderate climate. Mansehra has considerable rainfall, even in the driest month. The average annual rainfall is 1444 millimeters. Three replications of a Randomized Complete Block Design (RCBD) were used in the experiment. Every replication had twenty plots, with four rows of each plot that were 5m long and spaced 30 cm apart. The plot dimensions were 2.28 m^2. The field was properly prepped, following traditional practices. The research material consisted of a Wheat Variety Production at different urea applications. Seeds were sown in the field on 15th October 2022 at the Agriculture Research Station Baffa Mansehra. Fertilizer doses were split, with 65 grams of urea applied at planting time. To manage narrow and wide-leaf weeds, wheat crops were treated with the appropriate post-emergence herbicide. Harvesting occurs at physiological maturity when the spike's colors become green to yellow. The data were collected by randomly picking three plants from each plot and then averages were taken. The data were statistically analyzed using Microsoft Excel and Statistic 8.1 software according to the model for the randomized complete block. Means of different traits were separated at a probability level of 5%

using the least significant difference (LSD) test (Steel and Torrie, 1980).

Figure 1



RESULTS AND DISCUSSIONS

Fertilization with roots and leaves had a significant favorable effect on yield in both wheat verities. Foliar urea spraying at various growth stages has a considerable influence on crop yields. Combinations of foliar sprays at various crop stages resulted in better yields than normal soil treatments. Both wheat cultivars responded differently to urea foliar spray depending on the development stage combination. Tillering is a key stage in wheat growth where maxima yield advantages from foliar urea sprays may be reached, since any shift beyond this stage has been shown to reduce grain yields. The findings show that foliar spraying, as a complement to soil fertilization, is an excellent approach for promoting crop health and vitality through quick phloem absorption and increased transport of nitrogen received from leaves to various plant organs. Cells (Arif et al., 2006).

Days to Heading (Days)

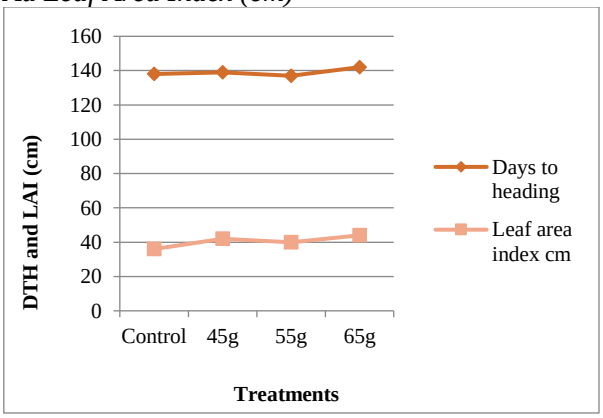
Heading is an important phonological feature that predicts a variety's behavior in a specific region (Arain et al., 2017). According to the findings, plant height showed significant variations in wheat. The mean results in (Figure 1) indicated that wheat at 65g urea application resulted in the highest days to heading (142.00). The minimum days to heading in wheat was found in the control group (138.00). days to heading owing to their genetic composition and indicating spring-like activities. (Bhatarai et al., 2017) and (Bayisa et al., 2019) reported similar disparities in days to 50% heading. In late January, temperatures rise over 25ºC, accelerating the transition of spring wheat from node elongation to booting and heading.

Leaf Area Index (cm)

The main source of plant nutrition is their leaves. leaf area index measurement is a key selection factor in wheat breeding programs. According to (Makino et al., 2022), the flag leaf is the most important source of photosynthetic products, which changes the grain-filling period and directly affects seed size. According to the findings, leaf area index showed significant variations in wheat. The mean results in (Figure 1) indicated that wheat at 65g urea application resulted in the maximum leaf area index (44.00). The minimum leaf area index in wheat were found in the control group (36.00). The leaf area index is extensively used to understand the physiological processes that occur in forest and crop canopies, as well as to anticipate their development and production (Feng et al. 2019).

Figure 2

Effect of different treatments on Days to Heading Ad Leaf Area Index (cm)



The figure (2) shows the effect of various treatments on days to heading and leaf area index, emphasizing the ongoing improvement with higher treatment doses. The control group received no treatment and had the minimum days to heading and the leaf area index, but these parameters steadily increased with each dose of treatment. The 65 (g) treatment gave the best results, which indicates that increasing treatment doses improves days to heading and leaf area index.

Days to Maturity

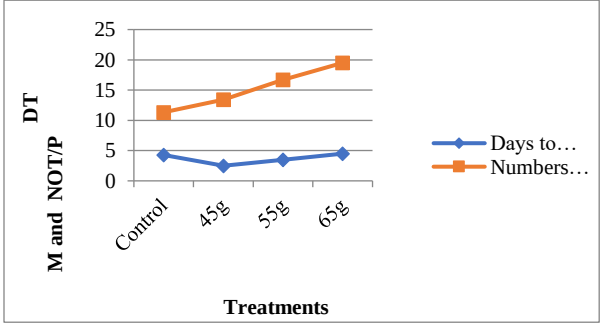
Days to maturity in wheat is an important phonological feature influenced by genetics and environmental conditions. Wheat cultivars treated with appropriate nitrogen levels, including urea foliar treatments, have been demonstrated in studies to have longer vegetative and reproductive phases, resulting in delayed maturity. According to the findings, plant height showed significant variations in wheat. The mean results in (Figure 2) indicated that wheat at 65g urea application resulted in the maximum days to maturity (147.00). The minimum days to maturity in wheat was found in the control group (139.00). According to (Bhattarai et al.,2017) and (Baissa et al., 2019), increased nitrogen consumption can delay ripening, boosting grain filling and yield potential. This emphasizes the need of regulating fertilization strategies to time ripening with optimum weather conditions.

Number of Tillers / Plant^{-1}

The production of viable tillers is a crucial factor in determining wheat output; the more fertile tillers there are, the higher the grain yield. According to the findings, number of tillers/ plant-^{1}showed significant variations in wheat. The mean results in (Figure 2) indicated that wheat at 65g urea application resulted in the maximum number of tillers/ plant-1(19.50). The minimum number of tillers/ plant-^{1}in wheat were found in the control group (11.33). According to (Arif et al.,2006) proved that fertilization of wheat crops at varying concentrations by foliar feeding greatly increases the number of tillers per plant-^{1} at various phases of plant growth. Similar to (Defan et al.,1999), the amounts of nitrogen urea considerably raise the number of tiler's plant^{-1}.

Figure 3

Effect of different treatments on Days to Maturity and Number of tillers/ plant^{-1}



The figure (3) shows the effect of various treatments on days to maturity and, number of tillers/ plant-^{1}emphasizing the ongoing improvement with higher treatment doses. The control group received no treatment and had the minimum days to days to maturity and number of tillers/ plant^{-1}, but this parameter steadily increased with each dose of treatment. The 65 (g) treatment gave the best results, which indicates that increasing treatment doses improves days to maturity and number of tillers/ plant^{-1}.

Plant Height (cm)

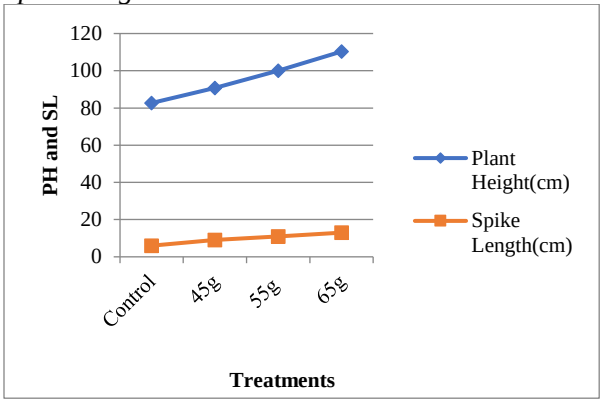
According to the findings, plant height showed significant variations in wheat. The mean results in (Figure 3) indicated that wheat at 65g urea application resulted in the highest plant height (104.67 cm). The minimum plant height in wheat was found in the control group (82.67 cm). The variation in plant height may be due to urea foliar spraying during tillering, which is necessary for cell wall expansion (Umar et al., 2019). Our findings are similar to those of (Wagan et al.,2017), who observed an increase in plant height after foliar spraying with 5% urea during the tillering stage. It is also true that, depending on varietal traits, soil fertility, and climatic conditions, rising plant height is a significant source of lodging in wheat crops. According to (Yousaf et al.,2008), the appropriate range for wheat plant height is commonly regarded to be 60-120 cm.

Spike Length (cm)

Analysis of Variance for Spike Length revealed significantly substantial differences among the Wheat in various treatments (Figure 3). The range of the spike length was 6 to 13 cm. The comparison of all treatments in mean spike length has a critical value of 1.2896. The treatment with 65g of urea resulted in a maximum spike length of 13 cm, highlighting the effectiveness of this dose in enhancing wheat spike length under the studied agro-climatic conditions. Conversely, the control group, which received no urea, had the shortest spike length at 6 cm, and the control group demonstrated the baseline growth, highlighting the effects of limited nitrogen availability. These findings are comparable with those of (Parvez et al., 2009), who discovered that 4% foliar-sprayed urea generated spikes of 11.2 cm in length.

Figure 4

Effect of different treatments on Plant Height and Spike Length.



The figure (4) shows the effect of various treatments on plant height and spike length. The control group received no treatment and had the lowest plant height and spike length, with these parameters steadily increased with each doses of treatment. The 65 (g) treatment give the best results, this indicates that increasing treatment doses improve plant height and spike length.

Spikelet /Spike

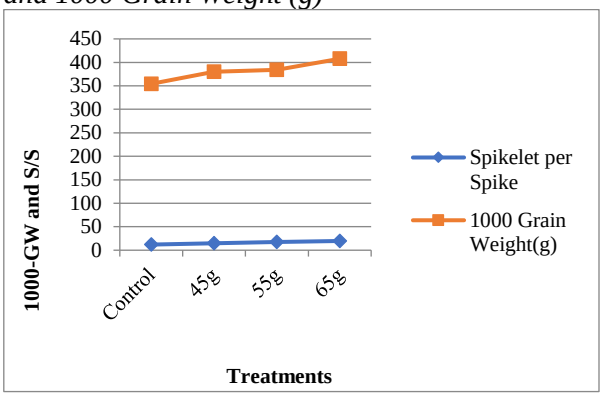
The spikelet per spike data (Figure 4) revealed a highly significant difference between the different urea treatments, indicating that urea application greatly influences spikelet formation in wheat. The 65g urea treatment achieved the highest spikelet count per spike, with an average of 19.667 spikelet's, compared to the control group's 12 spikelet's per spike. The critical value for comparing these treatments was 1.5259, highlighting the substantial effect of urea application on spikelet development. These findings align with previous studies, such as those by (Ahmad et al., 2010), which demonstrated that optimal nitrogen fertilization significantly improves spikelet production in wheat.

1000- Grain Weight (g)

There is a highly significant difference between the treatments according to the data for 1000 grain weight analysis (Figure 4). The average data indicates that the smallest 1000-grain weight was in control (354.33 g), and the greatest 1000-grain weight was in 65g urea application (407.67 g). These findings indicate that 65g of urea is the ideal amount to apply under the agro-climatic conditions of Baffa Mansehra. For comparing these treatments, the significant value is 15.707. According to (Buczek et al. 2017) observed that foliar spraying a wheat variety with 1.5% urea increased a thousand-grain weight to 44.3 g. According to, (Khaled et al., 202) found that foliar-sprayed urea applied to a wheat variety during the tillering stage resulted in 43.25g of seed weight.

Figure 5

Effect of different treatments on Spikelet / Spike and 1000 Grain Weight (g)



The figure (5) shows the effect of various treatments on spikelet/ spike and 1000 grain weight. The bar graph represents spikelets, while the line graph shows grain weight. The control group received no treatment and had the lowest spikelet/ spike and 1000 grain weight, with these parameters steadily increased with each doses of treatment. The 65 (g) treatment give the best results, this indicates that increasing treatment doses improve spikelet/ spike and 1000 grain.

Grain Yields (kg/ha^{-1})

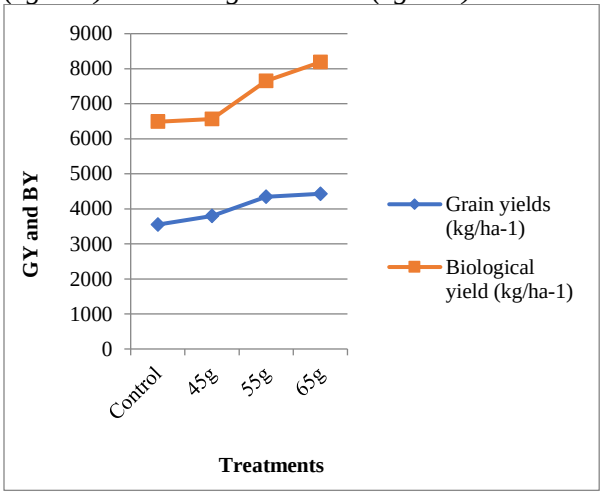
According to (Alam and Jahan, 2013), a cultivar's potential is defined by its genetic makeup in addition to other cultural practices like fertilizer rate and application method. After that, the data was transformed to kg/ha-1. The information in (Figure 5) demonstrated that applying urea topically produced variable degrees of increased yield. The greatest yield, for maximum yield, was recorded at 4,430 kg/ha^{-1}, closely followed by 4,340 kg/ha^{-1}. These results show significant improvements in grain production when compared to lower yields of 3,800 kg/ha^{-1} and 3,550 kg/ha^{-1} in plots with reduced or no urea foliar spray. According to the study, applying nutrients properly during crucial reproductive phases had a major impact on the crop's production performance (Ullah et al., 2024).

Biological Yields (kg/ha^{-1})

All the plants in a particular entry were harvested and then weight to determine biological yield plot$^{-1,}$ and then data was converted into kg/ha^{-1}. The data showed in (Figure 5) significant differences in biological yield among the treatments. The highest biological yield was 8,185.68 kg/ha^{-1}, followed by 7,654.25 kg/ha^{-1}. In contrast, plots with less or no poultry manure yielded lower biological outputs of 6,567.89 kg/ha^{-1} and 6,485.77 kg/ha^{-1}. According to (Fatiam et al., 2024). The effect of foliar urea spray on vegetative development is responsible for the increase in biological yield seen at 5% urea during the tillering stage. This resulted in enhanced tillering and a general rise in biomass production. This suggests that the rise in photosynthetic rate may also have contributed to the increase in biological production (Osman et al., 2013).

Figure 6

Effect of different treatments on Grain Yields (kg/ha^{-1}) and Biological Yields (kg/ha^{-1}).



The figure (6) shows the effect of various treatments on grain yields and biological yields, emphasizing the ongoing improvement with higher treatment doses. The control group received no treatment and had the lowest yield, with yields steadily increasing with each doses of treatment. The 65 g treatment produced the best results, indicating increasing treatment doses improves grain and biological yields. This graph trend demonstrates the positive correlation between treatment doses and crop yield.

CONCLUSIONS

The study concludes that varying urea applications significantly impact wheat growth and yield from germination to harvest in the Mansehra agro-ecological zone. The results indicate that different levels of urea application positively influence key growth parameters, including days to heading, leaf area index (cm), days to maturity, number of tillers/ plant-1plant height, spike length, Spikelet /spike, number of tillers/ plant-^{1}and 1000-grain weight. Among the different treatments, the application of 65g of urea per 2.28 m² consistently yielded the best results, with the highest improvements in days to heading, leaf area index (cm), days to maturity, plant height, spike length, Spikelet /spike, and 1000-grain weight, as well as the highest grain and biological yields. This suggests that urea at this specific rate optimizes the growth conditions and nutrient availability for wheat, leading to superior crop performance. Therefore, based on these findings, it is recommended that wheat growers in the Mansehra region adopt a urea application rate of 65 grams per 2.28 m² to achieve optimal wheat yields and enhance overall crop productivity.

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