DISCOVERY

Response of wheat to different application doses of Diammonium Phosphate

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ABSTRACT

This study aimed to investigate the impact of various dosages of diammonium phosphate (DAP) on the growth and production of wheat crops. The experiment was conducted using a randomized complete block design with three replications at MNS University of Agriculture, Multan. Four treatments were applied, including a control group (T1) and three different dosages of DAP (T2: 50 kg/acre, T3: 35 kg/acre and T4: 20 kg/acre). Various growth parameters, including plant population, plant height, number of tillers, number of grains per spike, 1000 grain weight, yield per kanal and estimated yield per acre, were measured and analyzed. The results showed that the application of DAP had significant effects on the measured parameters. Treatment T2, with the recommended dosage of 50 kg/acre of DAP, exhibited the highest plant population, tallest plants, highest number of tillers, highest number of grains per spike, heaviest 1000 grain weight and the highest yield per kanal and estimated yield per acre. Conversely, the control group (T1) had the lowest values for all parameters. These findings suggest that the application of DAP, particularly at the recommended dosage of 50 kg/acre, positively influenced the growth and production of wheat crops. Farmers and agricultural practitioners can utilize this information to optimize fertilizer application strategies for improved wheat cultivation. Further studies can explore additional factors and optimize dosages to maximize crop productivity while considering environmental sustainability.

Keywords: diammonium phosphate; environment; sustainability

1. INTRODUCTION

Over the past five decades, there has been a consistent rise in the demand for wheat worldwide. In 2019, global grain production reached 770 million tons, more than double the quantity produced in 1969, which was 300 million tons (FAOSTAT, 2022). 12% of the world's population still experiences extreme food insecurity despite this increase and experts anticipate that by 2050, the global food demand will increase by 35% to 56% (Dijk et al., 2021). Since more than two-thirds of the world's wheat crop is utilized for food, wheat is essential for guaranteeing nutrition security, especially since it provides a cost-effective staple food for around 35% of the world's population. Whole grain wheat, in particular, provides essential dietary components and serves as a valuable source of energy, with protein being one of its key nutritional components (Grote et al., 2021; Wieser et al., 2020).

Whole grains were officially defined by the American Association of Cereal Chemists (AACC) International in 1999 and subsequently adopted by the US Food and Drug Administration, (2006). According to this definition, whole grains consist of the intact, ground, cracked or flaked fruit of the grain, maintaining the same relative proportions of its principal components—the starchy endosperm, germ and bran (FDA, 2006). Improving wheat crops involves enhancing the protein quality, enriching them with essential amino acids and trace elements and increasing resistance to unfavorable environmental conditions.

Researchers have recently utilized different methods to analyze storage proteins, starch, lipids and DNA in species of the Triticum genus. These methods have been found to be highly valuable. The composition and proportions of gluten fractions in wheat play a significant role in determining the rheological properties of dough and consequently, the wheat quality. Therefore, when classifying wheat into specific groups based on quality, gluten is quantitatively and qualitatively assessed. Additionally, the activity of amylolytic enzymes in wheat grains can also affect the characteristics of dough and determine the grain's suitability for specific purposes. Applying nitrogen (N) fertilizer to crops can improve their performance.

However, it is important to be cautious with excessive use, as it can harm the environment. Nitrogen fertilizers are responsible for the majority (63%) of global fertilizer consumption, with over half of them being used in Asia, according to the FAO, (2010). Specifically, when growing wheat an average of 98 kg of nitrogen fertilizer is used per hectare as reported (West et al., 2014). Sadly, around 60% of the nitrogen fertilizer applied in agricultural fields does not actually reach the plant roots. This can happen due to factors like evaporation, leaching or remaining in the soil after harvesting, as highlighted by Azad et al., (2020) and West et al., (2014).

Phosphorus (P) plays a vital role in the growth and productivity of plants, ranking second only to nitrogen in terms of importance. However, when it comes to the actual uptake by plants, only a small fraction, approximately 25%, of the applied phosphorus is absorbed. The reason behind this lies in the strong attachment of phosphorus to soil particles and divalent cations, resulting in the formation of insoluble P-complexes. As a result, the majority of phosphorus stays in the soil, building up a significant reservoir of inorganic phosphorus. Improving the availability of phosphorus in soil is extremely important in a way that is environmentally sustainable (Ghosh et al., 2023; Rashid & Salim, 2022).

Phosphorus can be found in both organic and inorganic forms within the soil. One method of enhancing phosphorus availability to crops involves a process known as hysteresis, which helps to release adsorbed phosphorus. Researchers have discovered that increasing the silicate content and reducing the pH of alkaline soil can effectively enhance phosphorus availability in agricultural soils (Alam et al., 2022; Ghosh et al., 2023).

2. METHODOLOGY

The main objective of this research, conducted at MNS University of Agriculture, Multan (MNS-UAM) C Block, aimed to investigate the impact of different dosages of diammonium phosphate on the growth and yield of wheat crops. The experiment followed a randomized complete block design (RCBD) with three replications. In November 2022, the crop, specifically the Fakhar Bakhar variety of wheat, was sown using the drill technique at a seed rate of 50 kg per acre. Four treatments were used, including a control group (T1) and three different recommended dosages of diammonium phosphate (T2: 50 kg/acre, T3: 35 kg/acre and T4: 20 kg/acre).

Each treatment covered an area of 1 kanal and the experiment was replicated three times, resulting in a total of twelve experimental plots. Throughout the cultivation phase, a total of six irrigations were applied, with the first irrigation, known as rouni, performed before planting. At particular times during the crop's development, five more irrigations were carried out. 23 days after sowing, the second irrigation was applied and 43 days later, at the tillering stage, the third irrigation was applied. The fifth irrigation was applied during the booting stage, 70 days after sowing and the fourth irrigation was applied 95 days after sowing.

The sixth and final irrigation was carried out 125 days after sowing, at the milking stage of grain growth. The parameters that were studied during manual harvesting included plant population (m^2), plant height (cm), number of tillers (m^2), number of grains per spike, weight (g) of 1,000 grains and grain yield (kg/acre). For each experimental plot, these variables were meticulously documented. Version 8.1 of the statistical programme as well as Excel was used to analyze the data that had been gathered.

A detailed statistical analysis that included calculating means, standard deviations and other pertinent statistical measures for each therapy was carried out. In order to visualize the information and reach relevant conclusions, graphical representations like charts and graphs were also created. Overall, this technique used a well-designed experimental setting, precise data collecting and rigorous statistical analysis utilizing the proper software tools to examine the impact of diammonium phosphate on wheat harvests.

Doses of diammonium

The diammonium phosphate was administered in two stages: Half of the doses were applied during sowing, while the remaining doses were applied during the first irrigation after sowing.

Table 1 Diammonium phosphate treatments

Treatments	Applied Doses kg/kanal
T1	Control
T2	7
T3	5
T4	3

3. RESULTS AND DISSCUSIONS

Plant Population (m^2)

The plant population varies depending on the various diammonium phosphate treatments. The average plant density in the control group (T1) was 132.67 plants per square meter (m^2). The largest plant population was seen in Treatment T2, which applied the prescribed 50 kg/acre of DAP and used 162.33 plants/m^2. Plant populations in treatments T3 and T4, which received 35 kg/acre and 20 kg/acre of DAP, respectively, were 159.33 plants/m^2 and 155.67 plants/m^2, respectively. Khan et al., (2010) and Maqbool et al., (2012) have reported that different sources of phosphorus have a notable impact on both plant height and plant population.

Plant Height (cm)

The different treatments of diammonium phosphate showed an impact on the plant's height. The average plant height in the control group (T1) was 77.667 cm. The tallest plants, with an average height of 92.333 cm, were produced by treatment T2, with the prescribed administration of 50 kg/acre of DAP. The average plant heights for treatments T3 and T4, which received 35 kg/acre and 20 kg/acre of DAP, respectively, were 87.333 cm and 85.333 cm. These findings are in line with a previous study that found that the application of elemental Phosphorus or sulphur plus phosphorus sources boosted plant height and kernel weight per cob of maize (Khan et al., 2005).

Number of Tillers (m^2)

For each treatment of diammonium phosphate, a different number of tillers per square meter (m^2) were used. There were on average 236.33 tillers/m^2 in the control group (T1). The most tillers were seen in Treatment T2, which had an application of 50 kg/acre of DAP as advised. The average numbers of tillers for treatments T3 and T4, which received 35 kg/acre and 20 kg/acre of DAP, respectively, were 277.67/m^2 and 269.33/m^2, respectively. Wheat's development and yield characteristics, including the number of tillers and grain weight, can be improved by giving it a consistent supply of phosphorus (P) during the growth period. Using polymer-coated DAP, which has the benefit of releasing phosphorus over a longer period of time than uncoated DAP, is one efficient way to deliver phosphorus. These results were seen in research by Yaseen et al., (2014) and Yaseen et al., (2017).

Number of Grain per Spike

The various treatments of diammonium phosphate showed an impact on the quantity of grains per spike. There were, on average, 37.333 grains per spike in the control group (T1). The treatment T2 produced the maximum number of grains per spike, with an average of 44.667 grains, by applying the required amount of DAP (50 kg/acre). The average number of grains per spike for treatments T3 and T4, which received 35 kg/acre and 20 kg/acre of DAP, respectively, was 41.431 and 39.333. Mutar and Musleh, (2020) investigated how DAP fertilizer affected soft wheat cultivar yield and cultivar-specific traits. Their findings support our observation that DAP increases the number of grains per spike.

1000 Grain Weight (g)

For each diammonium phosphate treatment, the weight of 1000 grains was different. The typical weight of 1000 grains was 36.323g in the control group (T1). Treatment T2 had the greatest average weight of 45.137g and was advised to apply 50 kg/acre of DAP. Treatments T3 and T4 had average weights of 43.117g and 40.111g, respectively and received 35 kg/acre and 20 kg/acre of DAP, respectively. Diammonium phosphate (DAP) has been shown to enhance the growth of plants and improve their yield characteristics, such as increasing the weight of grains (Noor et al., 2017; Mutar and Musleh, 2020).

Yield (kg/kanal)

The various treatments of diammonium phosphate had an impact on the yield per kanal (a measure of land area). The average yield in the T1 control group was 436.2 kg/kanal. The treatment T2 produced the highest average yield, 532.6 kg/kanal, with the recommended application of 50 kg/acre of DAP. Average yields were 479.7 kg/kanal and 466.0 kg/kanal for treatments T3 and T4, which received 35 kg/acre and 20 kg/acre of DAP, respectively.

According to a study conducted by Noor et al., (2017), they discovered that using polymer coated DAP (diammonium phosphate) as a fertilizer can significantly enhance the growth, yield and phosphorus utilization efficiency of wheat crops compared to regular commercial DAP. The use of polymer-coated fertilizer enhanced several yield elements, including the weight of a thousand grains, the quantity of grains per spike and the number of viable tillers, in addition to increasing grain production overall. This combined advantage shows how well polymer coated DAP works to increase wheat crop production.

Estimated Yield (kg/acre)

Based on the various treatments of diammonium phosphate, the expected yield per acre was calculated. Yield showed in the control group (T1) was 1745.7 kg per acre. The maximum expected to yield was found in Treatment T2, with a recommended application of 2130.7 kg/acre of DAP. There were estimated yields of 1917.7 kg/acre and 1864.0 kg/acre for treatments T3 and T4, which received 35 kg/acre and 20 kg/acre of DAP, respectively. To enhance the growth and productivity of wheat, it has been observed that providing a consistent amount of phosphorus (P) throughout its growth stage can be beneficial.

One effective method of supplying phosphorus is by utilizing polymer-coated DAP instead of uncoated DAP. The advantage of using polymer-coated DAP is that it gradually releases phosphorus over an extended period of time. The research conducted by Yaseen et al., (2014) and Yaseen et al., (2017) demonstrated these positive outcomes in terms of wheat's development, such as increased tiller count and grain weight.

Table 2 Comparison of treatment effects: Assessing the impact of DAP on plant growth and Yield

Treatment	Plant Population (m^2)	Plant Height (cm)	No. of Tillers (m^2)	No. of grain per spike	1000 Grain weight (g)	Yield kg/kanals	Estimated Yield kg/acre
T1 (Control)	132.67^{c}	77.667^{c}	236.33^{d}	37.333^{bc}	36.323^{c}	436.2^{c}	1745.7^{c}
T2 Recommended DAP 50kg/acre	162.33^{a}	92.333^{a}	285.33^{a}	44.667^{a}	45.137^{a}	532.6^{a}	2130.7^{a}
T3 Recommended DAP 35kg/acre	159.33^{ab}	87.333^{ab}	277.67^{b}	41.431^{ab}	43.117^{ab}	479.7^{b}	1917.7^{b}
T4 Recommended DAP 20kg/acre	155.67^{b}	85.333^{b}	269.33^{c}	39.333^{b}	40.111^{b}	466.0^{bc}	1864.0^{bc}

Note: The values in the table are arranged in columns for easier readability. The labels "a", "b", "c" and "d" are used to indicate significant differences between treatments.

4. CONCLUSION

Overall, according to the findings, the treatment with the recommended application rate of 50 kg/acre of DAP (Treatment T2) produced the largest plant population, tallest plants, number of tillers, number of grains per spike, highest 1000 grain weight and maximum yield per kanals and acre. While to a smaller extent than the control group (T1), treatments T3 and T4, which received lower doses of DAP (35 kg/acre and 20 kg/acre, respectively) and also shown benefits. These results indicate that DAP fertilizer treatment can have a favourable effect on plant population, height, tillering, grain production and yield in terms of weight and size. To optimize the DAP dose and determine if employing DAP fertilizer in wheat production is cost-effective, more study and investigation are advised.

Informed consent

Not applicable.

Ethical approval

The ethical guidelines for plants & plant materials are followed in the study for sample collection & identification.

Conflicts of interests

The authors declare that there are no conflicts of interests.

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Data and materials availability
All data associated with this study are present in the paper.

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