Original Research Article

Effect of different levels of Phosphorus on growth and yield of wheat cv. Shatabdi

ABSTRACT

A field experiment was carried out at the farmers field of Gazipur, Bangladesh to evaluate the effect of various level of phosphorous on the growth and yield of wheat (Shatabdi). Four levels of Phosphorous including control *viz*. (i) T0 = 0 kg P ha^{-1} (Control), (ii) T1 = 25 kg P ha^{-1}, (iii) T2 = 50 kg P ha^{-1} and (iv) T3 = 80 kg P ha^{-1}were used as experimental treatments. The experiment was conducted during from December 2021 to March 2022in a randomized complete block design with three replications. Data on different growth and yield parameters like plant height, number of tillers per plant, days to flowering, days to maturity, spike length, grains per spike, grain yield, thousand grain weight, biological yield, and harvest index were collected according to plan. The different level of phosphorous showed significant effect on growth and yield of wheat. TheT2(50 kg P ha^{-1}) treatment gave the tallest plant (85.25 cm), maximum number of tiller plant (8.05), spike length (18.20 cm), grains per spike (42.08), thousand grain weight (36.16), grain yield per plant (37.15 g), straw yield (07.46) and harvest index (50.72%). On the other hand, all the growth, yield and yield attributing characters were found lowest in control treatments.The result of the study indicated that the 50 Kg P/ha would be effective and economic for the cultivation of wheat variety cv Shatabdi.

Keywords:Wheat, Growth, Yield, Phosphorus.

1. INTRODUCTION

The global demand for wheat is expected to reach 950 million tons by 2020, necessitating an annual increase in production of 2.5%. This increase is crucial to ensure global food security, as wheat is the most important crop in this regard, with an annual production of 750 million tons on 220 million hectares [1].

Wheat, a cornerstone of human civilization, emerged as one of the earliest domesticated crops in the Fertile Crescent[2]. Its cultivation revolutionized human society, transitioning nomadic lifestyles to settled agrarian communities. This shift fostered stability, social organization, and the development of complex civilizations. Wheat's global dissemination, facilitated by ancient trade networks, played a pivotal role in shaping diverse cultures and economies[3]. Wheat, originatedin Mesopotamia, was adopted and cultivated in Egypt, Greece, and Rome, significantly influencing the development of Mediterranean civilizations[4]. The Roman Empire, in particular, heavily relied on wheat production to support its expansive population and military endeavours, underscoring the crop's strategic value in ancient times[5].

Wheat, a staple Rabi season crop in Bangladesh, faces a significant supply-demand gap, with domestic consumption outstripping production by approximately fourfold[6]. The growing popularity of wheat-based products can be attributed to its relatively low cultivation costs, affordable market prices, and nutritional value [7]. To mitigate the nation's reliance on imported wheat, it is imperative to augment domestic production. The preeminence of bread wheat in the baking industry is attributed to its distinctive gluten protein structure, which is optimal for leavened bread. The bread's quality is directly influenced by the proportions of gluten, gliadins, and glutenins[8]. Wheat, a staple food, is a nutritional powerhouse. It contains essential nutrients like carbohydrates, proteins, fibres, vitamins (especially B vitamins), and minerals[9]. These components are crucial for maintaining overall health. The Wheat, a globally significant food source, offers a substantial supply of carbohydrates, a primary energy source for the human body. Its versatility allows for processing into various forms, such as flour, semolina, bulgur, and couscous, enabling its incorporation into a wide range of culinary applications[10]. From bread and pasta to pastries and cereals, wheat is a fundamental ingredient in numerous dishes worldwide. Whole wheat products, in particular, are enriched with dietary fiber, promoting digestive health, regulating blood sugar levels, and contributing to a sense of satiety. These benefits are instrumental in weight management and reducing the risk of chronic diseases like diabetes and cardiovascular ailments[11]. Given its high yield potential and adaptability to diverse climates, wheat contributes to food security by providing a reliable source of sustenance for millions of people, especially in regions where other crops may struggle to thrive.

Phosphorus, a vital nutrient for plant growth, is essential for fundamental physiological processes such as photosynthesis, respiration, and energy metabolism[12, 13]. However, its bioavailability is often constrained by soil conditions, with a significant portion of applied phosphorus becoming immobilized through complexation with soil minerals. This limitation underscores the importance of effective phosphorus management strategies to optimize crop yields. Phosphorus is a critical element involved in numerous biological functions, including photosynthesis, respiration, energy metabolism, and cell growth and division[14]. serves as a fundamental structural component of nucleic acids, enzymes, and coenzymes[15]. Moreover, phosphorus is essential for root development and can accelerate crop maturation[16]. Research on phosphorus in wheat focuses on understanding its role in various aspects of plant development, including root growth, photosynthesis, and grain filling. By studying the effects of different phosphorus levels, researchers aim to optimize fertilizer applications for wheat production and improve crop resilience to phosphorus-deficient soils. So, this research was conducted to know the ideal amount of phosphorus for better growth and yield of wheat.

2. Materials and Methods

2.1 Experimental site

The experiment was set up at the farmers field of Gazipur, during the period of 15th November, 2021 to 25th April, 2022. The location of the experimental site was 25^{0}39' N latitude and 88^{0}41' E longitude with an elevation of 37.58 meter above the sea level. The experiment was laid out in a medium high land belonging to the AEZ-1(Old Himalayan Piedmont Plain) area. The soil texture was sandy loam with pH 5.1. The structural class of the soil was fine and the organic matter content was around 1.06%.

2.2 Plant materials

Shatabdi were used as plant material for the present study. Seeds of these varieties were collected from the Bangladesh Wheat and Maize Research Institute, Nashipur, Dinajpur. Four levels of Phosphorous *viz*. (i) T0 = 0 kg P ha^{-1} (Control), (ii) T1 = 25 kg P ha^{-1}, (iii) T2 = 50 kg P ha^{-1} and (iv) T3 = 90 kg P ha^{-1}were used as experimental treatments.

2.3 Experimental layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The size of the individual plot was 3.0 m x 3.0 m and total numbers of plots were 36. There were 36 treatment combinations. Each block was divided into 20-unit plots. Layout of the experiment was done on November 10, 2021 with inter plot spacing of 0.50 m and inter block spacing of 1.0 m.

2.4 Production procedure and data collection

The land of the experimental field was first opened on October 15, 2021with a power tiller. Then it was exposed to the sunshine for 7 days prior to the next ploughing. Thereafter, the land was ploughed and cross-ploughed to obtain good tilth. Deep ploughing was done to produce a good tilth, which was necessary to get better yield of the crop. Laddering was done in order to break the soil clods into small pieces followed by each ploughing. All the weeds and stubbles were removed from the experimental field. The soil was treated with Furadan 5G was used @ 8 kg ha-1 to protect young plants from the attack of mole cricket, ants, and cutworms.All the fertilizers were applied at the rate of BARI recommended dose as 200 kg ha^{-1} Urea, 180 kg ha^{-1} TSP, 50 kg ha^{-1} MOP, 120 kg ha^{-1} Gypsum (BARI, 2010). Fertilizers other than nitrogen were given during final land preparation.Seeds were treated with Vitavex-200 @ 0.25% before sowing to prevent seeds from the attack of soil borne disease.Seeds were sown according to treatment dates continuously in 20 cm apart rows opened by specially made iron hand tine. The seed rate was 120 kg ha^{-1}. After sowing, the seeds were covered with soil and slightly pressed by hands.The intercultural operations like thinning, weeding, irrigation, and pest management were as per need done for ensuring the normal growth of the crop. Data were recorded on plant height (cm), number of tillers per plant, days to flowering, days to maturity, spike length, grains per spike, grain yield, thousand grain weight, biological yield, and harvest index.

2.5 Data Analysis

Analysis of variance was done following two factors Randomized Complete Block Design with the help of computer package STAR (Statistical tool for Agricultural Research). The mean differences among the treatments were adjusted by Duncan's Multiple Range Test (DMRT) at 5% level of significance [17].

3. Result and Discussion

Statistically significant variation was recorded for plant height (30, 60, and 90 DAT) of Shatabdi due to the application of various level of Phosphorus fertilizer (**Table 1**).Results showed that at 30, 60 and 90 DAT, the highest plant height (37.01,65.01 and 85.25 cm respectively) was found in T2 (50 Kg P/ha) treatment which is statistically dissimilar with other treatments while the smallest plant height was observed in T_0treatment (**Table 1**). The 50 kg/ha phosphorus fertilizer dose is optimal for plant height in wheat production because it provides a balanced nutrient availability that supports vigorous growth without causing nutrient imbalances. At control plants likely suffer from phosphorus deficiency, limiting their growth potential. The 25 kg/ha dose may be insufficient to meet the full nutrient needs of the wheat plants, leading to suboptimal growth. Conversely, the 55 kg/ha dosecan lead to excessive phosphorus, potentially causing nutrient antagonism or toxicity, which can inhibit growth and reduce plant height[18]. Statistically significant variation was recorded for number of tiller hill^{-1}(30, 60, and 90 DAT) of Shatabdi due to the application of various level of Phosphorus fertilizer.

Results showed that at 30, 60 and 90 DAT, the highest number of tiller hill^{-1}(6.90, 7.23 and 8.05 respectively) was found in T2 treatment which is statistically dissimilar with other treatments while the smallest plant height was observed in T_0 (control) treatment (**Table 1**). The 50 kg/ha phosphorus fertilizer dose is optimal for the total number of tillers per hill in wheat production because it provides an ideal balance of nutrients, promoting healthy root development and plant growth. At control, phosphorus deficiency limits root expansion and nutrient uptake, resulting in fewer tillers. Conversely, at 80 kg/ha, excessive phosphorus can lead to nutrient imbalances and potential toxicity, hindering plant development. Therefore, 50 kg/ha strikes the right balance, maximizing tiller formation by ensuring adequate but not excessive phosphorus availability[19].The days to flowering of Shatabdivaried significantly as Phosphorus fertiliser levels changed. The control treatmenttaken maximum number of days to flowering (73.02), which is statistically dissimilar to other treatments. The T2 treatment needed the fewest number of days for flowering (67.01), which is statistically equal to T1 (70.51) (**Table 1**). Phosphorus is essential for wheat growth and development, playing a crucial role in various physiological processes. While phosphorus primarily aids in root development and seed formation, it indirectly contributes to flowering by promoting overall plant health and vigor. Adequate phosphorus availability can enhance wheat's ability to uptake nutrients and energy, which can support robust flowering and subsequent grain development. However, the specific impact of phosphorus on flowering may vary depending on various factors such as soil conditions, weather, and management practices[20]. The maximum number of days required for maturity was 103.02 in the control treatment, which differed significantly from the other treatments. The T2 treatment had the minimum number of days for maturity (90.04), which was also statistically significant in comparison to other treatments(**Table 2**).Phosphorus plays a crucial role in wheat development, but its direct impact on the days to maturity is not straightforward. Instead, phosphorus primarily contributes to root development, energy transfer, and overall plant growth[18].The maximum spike length was recorded in T2 (50 Kg P/ha) treatment (18.36 cm) which is statistically dissimilar to other treatments. The shortest spike (18.20 cm) was recorded in control (T0) treatment which is statistically alike to T1 (12.23 cm). The 50 kg/ha phosphorus fertilizer dose is best for spike length in wheat production because it provides an optimal balance of nutrients. Phosphorus is essential for root development and energy transfer within the plant, which promotes healthier and more vigorous growth[20].The maximum number of grains per spike was recorded in T2 treatment (42.08) which is statistically dissimilar to other treatments. The minimum number of grains per spike (21.14) was recorded in control treatment which is statistically alike to T1 treatment. The 50 kg/ha phosphorus fertilizer dose is optimal for grains per spike in wheat production because it provides a balanced nutrient supply that enhances root development and nutrient uptake without causing toxicity or nutrient imbalances. At control, the phosphorus levels are insufficient for optimal plant growth, leading to poor root development and reduced grain formation. The 25 kg/ha dose, while beneficial, might not supply enough phosphorus to meet the higher demands of the wheat plants during critical growth stages. Conversely, the 75 kg/ha dose can lead to excessive phosphorus in the soil, which can interfere with the uptake of other essential nutrients like zinc, potentially reducing grain production. Therefore, the 50 kg/ha dose strikes a balance, ensuring adequate phosphorus availability to maximize grains per spike without negative side effects.The highest 1000 grain weight was recorded in T2 treatment (36.16 g) which is statistically dissimilar to other treatment. The minimum thousand grain weight (25.01 g) was recorded in control treatment which is statistically different to other treatments (**Table 2**).The 50 kg/ha phosphorus fertilizer dose optimizes the 1000 grain weight in wheat production by providing an ideal balance of nutrient availability. At this level, phosphorus enhances root development, energy transfer, and overall plant vigour without causing nutrient imbalances or toxicity. The lower dose (25 kg/ha) may be insufficient to meet the crop's nutrient needs, leading to suboptimal growth and grain development. Conversely, the higher dose (80 kg/ha) could result in nutrient antagonism or environmental stress, which can negatively impact grain weight[19].The maximum grain yield per plant was recorded in T2 treatment (37.15 g) which is statistically similar to T3 treatment. The minimum grain yield per plant (26.04 g) was recorded in control treatment which is statistically alike to T1 treatment (**Table 2**).The 50 kg/ha phosphorus fertilizer dose is optimal for grain yield per plant in wheat production because it strikes a balance between nutrient availability and plant uptake efficiency. At this rate, the phosphorus provided is sufficient to support critical physiological processes, such as energy transfer and root development, without causing nutrient imbalances or toxicity. Lower doses, like 0 and 25 kg/ha, may result in phosphorus deficiency, limiting root growth and grain formation, which are essential for high yields. On the other hand, higher doses, such as 80 kg/ha, can lead to excessive phosphorus in the soil, which can disrupt the absorption of other essential nutrients like zinc and iron, potentially harming plant health and reducing yields. Additionally, excessive phosphorus can lead to environmental issues, such as water pollution from runoff. Therefore, 50 kg/ha provides an optimal balance, maximizing grain yield while minimizing negative side effects [20].The maximum straw yield per plant was recorded in T2 treatment (13.57 g) which is statistically similar to T3 (12.69 g). The lowest straw yield per plant (7.46 g) was recorded in control (0 Kg P/ha) treatment. The null or zero application of Phosphorus fertilizer can result in higher straw yield in wheat production due to soil's existing phosphorus levels being sufficient for initial growth, allowing the plant to focus on biomass rather than seed production. In some soils, excess phosphorus can cause nutrient imbalances, limiting the plant's ability to absorb other essential nutrients. Additionally, phosphorus promotes root development and seed formation, potentially diverting resources away from straw growth. Therefore, in phosphorus-rich soils, applying additional fertilizer may not be necessary and could reduce straw yield[18].Application of different levels of Phosphorus fertilizer on Shatabdi showed significant variation on biological yield per plant (**Table 2**). The maximum biological yield was recorded in T2 (50 Kg P/ha) treatment (50.72) and the minimum biological yield per plant (28.58) was recorded in control treatment which is statistically alike to T1 treatments. The 50 kg/ha Phosphorus fertilizer dose is optimal for biological yield in wheat production as it strikes a balance between nutrient availability and plant uptake efficiency. At this level, plants receive sufficient phosphorus to support essential growth processes such as energy transfer, root development, and flowering, without the negative effects of over-fertilization. Lower doses (0 and 25 kg/ha) likely provide inadequate phosphorus, limiting growth and yield potential. Conversely, higher doses (80 kg/ha) may lead to nutrient imbalances, reduced nutrient use efficiency, or environmental issues such as runoff, thereby not significantly improving yield compared to the 50 kg/ha rate[19].

4. Conclusion

The experiment result showed that phosphorous level significantly impacted the growth and yield of wheat. The optimum doze of phosphorous is essential to get best outcome from yield and economic point of view. We found that the 50 kg/ha phosphorus is best among the studied treatments for successful wheat production.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

The authors certify that this manuscript was composed entirely by human authors without the assistance of generative AI tools like (ChatGPT, COPILOT, etc.) and text-to-image generators.

Table 1: Effect of different level of phosphorus in plant height, number of tillers plant^{-1} and days to flowering in wheat

Treatment	Plant Height at 30 DAS (cm)	Plant Height at 60 DAS (cm)	Plant Height at 90 DAS (cm)	Number of tillers per plant at 30 DAS	Number of tillers per plant at 60 DAS	Number of tillers per plant at 90 DAS	Days to Flowering
(T0) 0 kg ha^{-1}	21.00d	35.21d	60.08d	3.01c	4.10c	4.81d	73.02a
(T1) 25 kg P ha^{-1}	29.05c	44.34c	72.17c	4.00bc	5.02ab	5.02c	70.17bc
(T2) 50 kg P ha^{-1}	37.01a	65.01a	85.25a	6.90a	7.23a	8.05a	67.01c
(T3) 75 kg P ha^{-1}	34.11b	57.13b	80.04b	5.09ab	6.81bc	6.59b	70.51b
CV (%)	1.52	0.99	1.19	8.03	4.00	1.94	0.62
LSD	0.89	1.25	1.58	1.59	2.35	2.03	3.24

Table 2: Effect of different level of phosphorus in spike length, days to maturity, grains spike^{-1}, thousand grain weight, grain yield plant^{-1}, straw yield plant^{-1}, and biological yield in wheat

Treatment	Spike Length (cm)	Days to Maturity	Grains Spike^{-1}	Thousand Grain Weight (g)	Grain Yield Plant^{-1} (g)	Straw Yield Plant^{-1} (g)	Biological Yield
(T0) 0 kg ha^{-1}	7.05c	103.02a	22.03c	25.01c	21.14c	07.46c	28.58d
(T1) 25 kg P ha^{-1}	12.23c	99.02c	33.09c	30.51b	27.07bc	10.66b	37.73c
(T2) 50 kg P ha^{-1}	18.20a	90.04d	42.08a	36.16a	37.15a	13.57a	50.72a
(T3) 75 kg P ha^{-1}	15.00b	96.82b	35.07b	32.00b	32.34ab	12.69ab	45.03b
CV (%)	2.78	0.618	5.24	3.02	4.95	3.06	3.99
LSD	1.75	0.98	1.25	1.57	1.37	1.11	2.54

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