Effect of Phosphorus Fertilization on Growth, Yield and Economic Efficiency of Cotton (*Gossypiumhirustum L.*)underNortheast climate ofAfghanistan

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Abstract

A field experiment was conducted at the agronomic research farm of Kunduz University during cropping season of 2023 to investigate the effect of phosphorus fertilization on the growth, yield and economic efficiency of cotton (GossypiumhirustumL.) underNortheast climate of Afghanistan. The experiment was laid out in Randomized complete block design with three replications. The treatment consists of control without phosphorus fertilizer application, application of 30 kg P_2O_5/ha, 60 kg P_2O_5/ha and 90 kg P_2O_5/ha. Resultshowed that the highest plant height (98.44 cm), Leave area index (2.78), Sympodial Branches/plant (12.88), Bolls/plant (27.66), lint cotton yield (1750 kg/ha), seed cotton yield (3979 kg/ha), lint cotton yield (182742 AFN/ha), seed cotton yield (77964 AFN/ha), gross return (260707 AFN/ha), net return (209867 AFN/ha) and benefit Cost ratio (6) were recorded from 90 kg p_2o_5/hafollowed by application of 60 P_2O_5/ha, 30 P_2O_5/ha and Control treatments respectively. It can be possible to conclude that proper phosphorus fertilization is crucial for optimizing cotton production in this region. The study highlights the potential for improved cotton cultivation practices and increased economic returns for farmers in the Northeastof Afghanistan through the implementation of optimal phosphorus application rates.

Keywords: Cotton, Economic efficiency, Growth, Phosphorus, Yield

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Introduction

Cotton (*Gossypiumhirsutum*L) is major cash crop in both tropical and warm temperate regions of the world including Afghanistan. It is the best for foreign exchange and the most important commercial fiber crop in the world (*Khaleeq et al., 2023d*). Cotton (*Gossypium*spp.) is grown in about 76 countries covering more than 32 million ha, under different environmental conditions worldwide and world cotton commerce is about US$20 billion annually (*Saranga et al., 2001; Khaleeq et al., 2024*). Cotton growth and maturity are altered by cultivars, seasonal management and environmental conditions (*Gwathmey and Craig, 2003, Man et al., 2021*). Phosphorus is an essential plant nutrient required for all physiological processes during plant development, reproduction, and environmental adaptation (*Seleiman et al., 2020*). Phosphorus is an integral component of several important compounds in the plant cells, including the sugar-phosphate intermediates of respiration and photosynthesis, and the phospholipids that make up plant membranes (*Taiz and Zeiger, 2003*). Rate of leaf expansion and photosynthesis per unit leaf area reduced due to phosphorus deficiency (*Sadiq et al., 2023*; *Samim et al., 2023*). Phosphorus is mobile in the plant. Young leaves and developing bolls can be nourished from the Phosphorus which is available in older tissues of the plant. In cotton crop the critical-Phosphorus concentration ranges from 0.20 to 0.31% (*Khaleeq et al.,2023b*). Soil Phosphorus deficiency is one of the most significant abiotic factors limiting crop productivity. Overall, it is reported that 40% of crop production in the world's arable land is limited by Phosphorus availability and sub-optimal levels of Phosphorus can result in 5 to 15% yield losses(*Khaleeq et al., 2023c andSeerat et al., 2023*). The objectives of this study were to assess the impact of different levels of phosphorus fertilization on the growth, yield parameters, economic efficiency in cotton production in the northeast climate of Afghanistan.

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Materials and Methods

A field trial was conducted at the research farm of Kunduz University located in northeast of Afghanistan during cropping season of 2023 to evaluate effect of phosphorus fertilizer on growth and yield of cotton crop,The experimental site was located at 367388884, N latitude and 68.869858 E longitudes with an elevation of 356 meters from the sea level. temperature during the cropping period ranged between 17.50oC to 47.3oC, the humidity 25.52% to 65.25% with 9.5-11.0 hours day length and very little rainfall was recorded, the experiment was in randomized complete block design (RCBD) with three replications, The experiment consist of 4 treatments, viz. Absolute control, 30 kg P_2O_5/ha, 60 kg P_2O_5/haand 90 kg P_2O_5/ha. Cotton variety (K-01) was obtained from Kunduz Spinzar Owned Corporation. The net plot size was 3×5 (15 m^2), row and plant to plant spacing were 75 and 25 cm, respectively. The field was ploughed twice with tractor-drawn disc plough and harrowing was done with rotivator to achieve desired soil. Seeds were drilled at the depth of 4 cm. Uniform allagronomic practices, irrigation, hoeing and weeding were carried out while needed, all phosphorus fertilizer according treatments applied basal at the time of sowing while nitrogen fertilizer applied 100 kg N/ha at sowing time, 30 and 60 days after sowing respectively, The soil of experimental site was sandy loam, free from salinity, low in phosphorus and nitrogen and medium in potassium content. The organic matter content of the soil was low and textural class varying between sandy loams to loamy sand. The soils had lower Cation-exchange capacity due to coarse texture and low in organic carbon content,All Growth parameters were taken by taking the average of five tagged plants, yield attributes and yields were taken from net plot and recorded using standard procedure.The analysis of variance (one–way ANOVAs) was used to determine treatment effects. Standard error of means (SEm±) and least significant difference [LSD (p=0.05)] level of significance worked out for each parameter.

Was 100 kg N/ha given at **:[4WK]Comment** planting and each time 30 and 60 days after planting? It should be written clearly.

Results and Discussions

Phosphorus fertilizer was significantly affected on plant height, Leave Area Index, Sympodial Branches/plant and Bolls/plant (Table 1). The highest plant height (98.44 cm), Leave Area Index (2.78), Sympodial Branches/plant (12.88) and Bolls/plant (27.66) were recorded from application of 90P_2O_5/ha followed by application of60 P_2O_5/ha. The lowest growth parameters were from the Control plot. Our result similar with finding of *Saleem et al., (2010)* and *Khaleeq et al., (2023a)* observed that Phosphorus applications increased plant height, number of Sympodial branches/plant and number of monopodial branches/plant compared to control. (*Copur, 2006*). Number of monopodial branches/plant decreased while number of sympodial branches/plant increased with increasing phosphorus levels. *Khaleeq et al., (2023d)* reported significant differences among the phosphorus levels for the number of bolls per plant while increase in number of bolls per plant with increasing phosphorus levels is also well documented. Boll weight is an important yield determining factor that varies among varieties (*Hofs et al., 2006*and*Nazir et al., 2022)* and with P levels (*Sawan et al., 2008*) reported that positive correlation exists between seed cotton weight per boll and seed cotton yield per plant; the same was confirmed in present studies (*Hemmat et al., 2023, Khaleeq et al., 2023e).*

Table (1): Effect of phosphorus fertilizer on plant height, Leave Area Index, Leaves/plant, Sympodial Branches/plant and Bolls/plant

Treatments	Plant Height (cm)	Leave Area Index	Leaves/plant	Sympodial Branches/ plant	Bolls /plant
Absolute Control	83.22^{c}	1.70^{c}	46.03	9.77^{c}	17.89^{c}
30 P_2O_5/ha	86.15^{bc}	2.15^{bc}	53.99	10.59^{c}	22.00^{b}
60 p_2o_5/ha	91.36^{ab}	2.49^{ab}	57.92	11.81^{b}	21.55^{bc}
90 P_2O_5/ha	98.44^{a}	2.78^{a}	46.07	12.88^{a}	27.66^{a}
SEm±	15.786	0.093	63.914	0.228	4.007
CD (P=0.05)	7.938	0.608	NS	0.955	3.999

Phosphorus fertilizer doses significantly affected on lint cotton yield and seed cotton yield revealed on figure (1, 2), the highest lint cotton yield (1750 kg/ha), seed cotton yield (3979 kg/ha), lint cotton yield (182742 AFN/ha), seed cotton yield (77964 AFN/ha) were in application of 90 kg P_2O_5/ha, followed by phosphorus application of 60 P_2O_5/ha, 30 p_2o_5/ha and absolute Control treatments respectively. Economic analysis revealed on figure (3) phosphorus fertilizer was significantly affected on gross return, net return and benefit Cost ratio, the highest gross return (260707 AFN/ha), net return (209867 AFN/ha) and B: Cost ratio (6) were in 90 kgP_2O_5/ha followed by phosphorus application of 60 P_2O_5/ha, 30 p_2o_5/ha and absolute Control treatments respectively.Our result support the finding of *(Khaleeq et al., 2023d*) who reported the highest Lint Cotton yield (1,627.50 kg/ha), Seed Cotton yield (3,110.38 kg/ha), Lint Cotton Yield (174,370AFN/ha), Seed Cotton yield (142,144 AFN/ha).Our finding similar with *Khaleeq et al., (2023d*) gross return (316,515 AFN/ha), net return (297,790 AFN/ha) and benefit Cost ratio (7.67) was in 90 kg P_2O_5 kg ha^{-1} followed by phosphorus application of 60 kg P_2O_5 kg ha^{-1}, 30 kg P_2O_5 kg ha^{-1} and control respectively. (*Saleem et al., 2010; Farkhari et al 2023*) also reported higher phosphorus dose (90 kg ha^{-1}) was best for achieving more seed cotton yield, lint cotton yield and early maturity than its lower application rates.

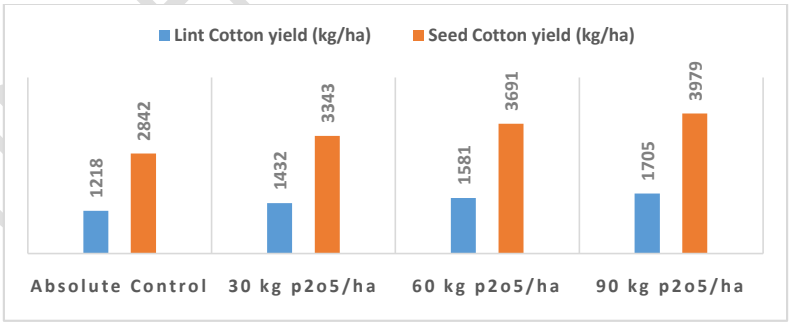

Figure (1): Effect of phosphorus on lint cottonyield (kg/ha) and seed cotton yield (kg/ha)

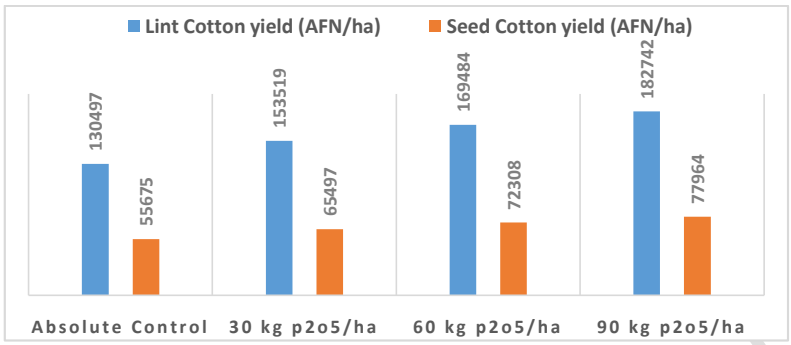

Figure (2): Effect of phosphorus on lint cottonyield (AFN/ha) and seed cotton yieldAFN/ha)

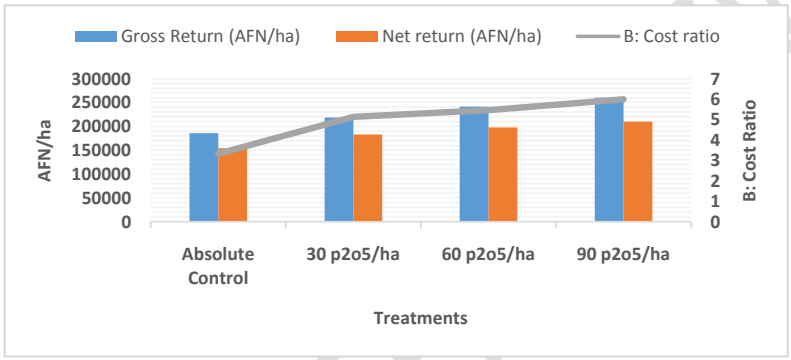

Figure (3): Effect of phosphorus fertilizer on gross return, net return and B: Cost of Ratio

Conclusion

The study demonstrates that phosphorus fertilization has significant impact on the growth, yield and economic efficiency of cotton in the Northeast climate of Afghanistan. The application of 90 kg P_2O_5/ha resulted in the highest level of growth, yield and economic efficiency. This finding suggests that proper phosphorus fertilization is crucial for optimizing cotton production in this region. Further research and practical implementation of this optimal phosphorus application rate could lead to improved cotton cultivation practices and increased economic returns for farmers in the Northeast climate of Afghanistan.

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