

Impact of Phosphorus Fertilization on Growth, Yield and Economic Efficiency of Cotton (*Gossypium spp.*) in Northeast Climate of Afghanistan

Abstract

A field experiment was conducted at the agronomic research farm of Kunduz University during cropping season of 2023 to investigate the impact of phosphorus fertilization on the growth, yield and economic efficiency of cotton (*Gossypium spp.*) in Northeast Climate of Afghanistan. The experiment was laid out in Randomized complete block design with three replications. The treatments involved absolute control, application of 30 kg P₂O₅/ha, 60 kg P₂O₅/ha and 90 kg P₂O₅/ha. Results showed 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 B: Cost ratio (6) were in 90 kg p₂o₅/hafollowed by phosphorus application of 60 p₂o₅/ha, 30 p₂o₅/ha and absolute Control treatments respectively. It can be 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 Northeast Climate of Afghanistan through the implementation of optimal phosphorus application rates.

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

Introduction

Cotton (*Gossypium hirsutum* 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). 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 and Seerat *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 and B: Cost-benefit ratio of phosphorus fertilization in cotton production in the northeast climate of Afghanistan. To determine the optimal phosphorus fertilization rate for maximizing cotton yield and economic returns in the specific climatic conditions of northeast of Afghanistan. To provide recommendations for sustainable phosphorus fertilization practices to enhance cotton production and economic efficiency in the northeast climate of Afghanistan.

Materials and Methods

A field trial was conducted at the research agronomy 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 experiment was in randomized complete block design (RCBD) with three replications, The experiment consist of 4 treatments, viz. Absolute control, 30 kg $p_{2}O_{5}$ /ha, 60 kg $p_{2}O_{5}$ /ha and 90 kg $p_{2}O_{5}$ /ha. Cotton variety (K-01) was obtained from Kunduz Spinzar Owned Corporation, the net plot size was 3×5 (15 m²), row spacing and plant to plant were 75 cm and 25 respectively, the field was ploughed twice with tractor-drawn disc plough. Harrowing was done with rotivator to achieve desired tilth. Seeds were drilled at the depth of 4 cm. Uniform agronomic 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 Data recorded on different parameters was subjected to ANOVA and the significance of differences in treatment means was compared to critical differences at the 5% level of probability.

Results and Discussions

Phosphorus fertilizer was significantly affected (table 1) on plant height, Leave Area Index, Sympodial Branches/plant and Bolls/plant, the highest plant height (98.44 cm), Leave Area Index (2.78), Sympodial Branches/plant (12.88) and Bolls/plant (27.66) were in treatment 90 $p_{2}O_{5}$ /ha followed by treatment 60 $p_{2}O_{5}$ /ha and the minimum growth parameters were in absolute 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 (*Nazir et al., 2022* and *Hofs et al., 2006*) 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	83.22c	1.70	46.03	9.77c	17.89c
30 p ₂ O ₅ /ha	86.15 bc	2.15	53.99	10.59c	22.00b
60 p ₂ O ₅ /ha	91.36ab	2.49	57.92	11.81b	21.55bc
90 p ₂ O ₅ /ha	98.44a	2.78	46.07	12.88a	27.66a
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 p₂O₅/ha, followed by phosphorus application of 60 p₂O₅/ha, 30 p₂O₅/ha and absolute Control treatments respectively. Economic analysis revealed on figure (3) phosphorus fertilizer was significantly affected on gross return, net return and B: Cost ratio, the highest gross return (260707 AFN/ha), net return (209867 AFN/ha) and B: Cost ratio (6) were in 90 kg p₂O₅/ha followed by phosphorus application of 60 p₂O₅/ha, 30 p₂O₅/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 B: Cost ratio (7.67) was in 90 kg P₂O₅ kg ha⁻¹ followed by phosphorus application of 60 kg P₂O₅ kg ha⁻¹, 30 kg P₂O₅ 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.

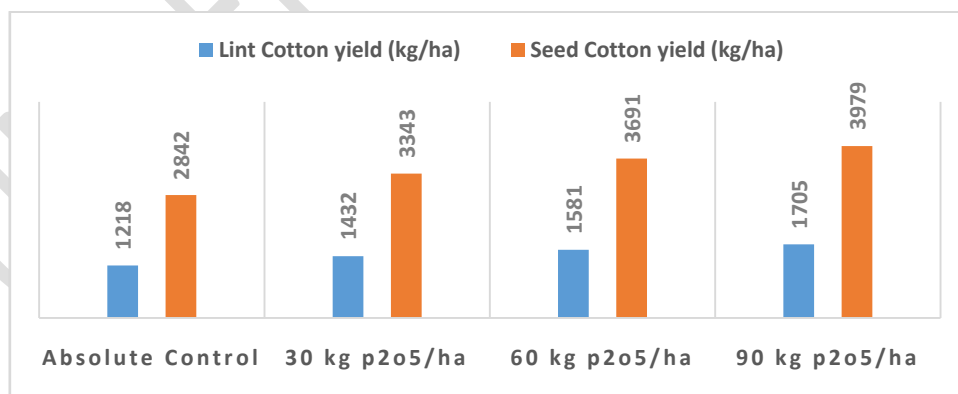


Figure (1): Effect of phosphorus on lint cotton yield (kg/ha) and seed cotton yield (kg/ha)

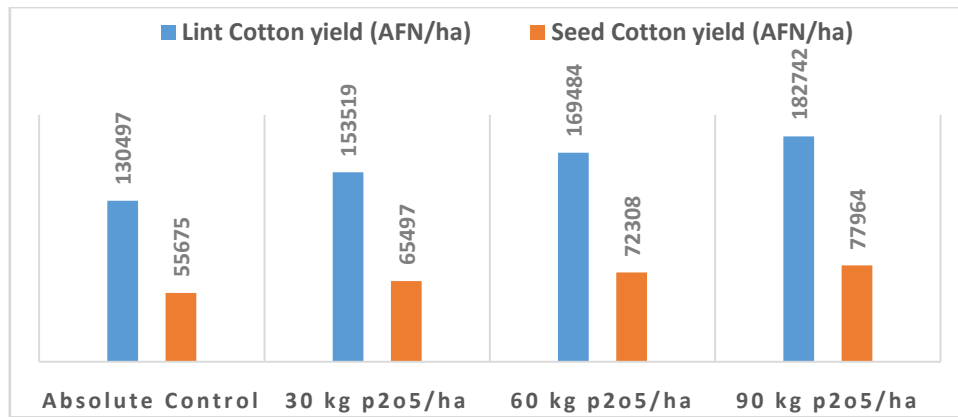


Figure (2): Effect of phosphorus on lint cotton yield (AFN/ha) and seed cotton yield (AFN/ha)

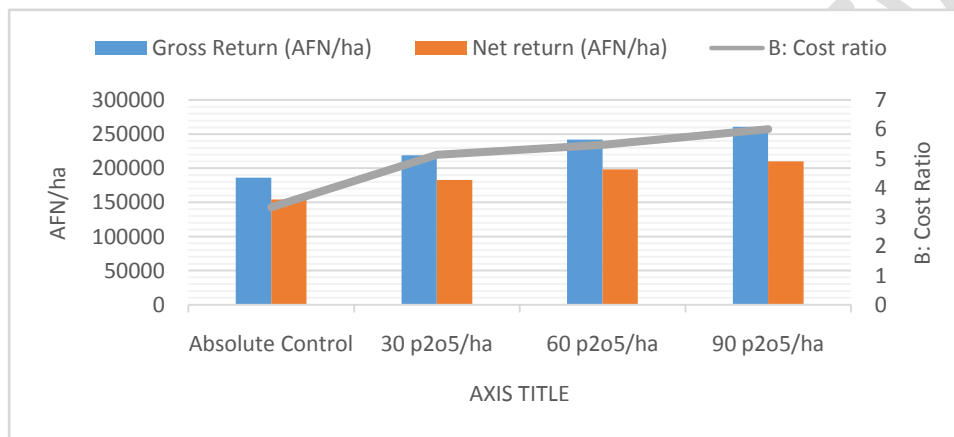


Figure (3): Effect of phosphorus fertilizer on gross return, net return and B: Cost of Ratio

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 P₂O₅/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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