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Comparative Effect of Different NPK Fertilizers on Growth of Cotton (*Gossypium hirsutum* L.) in Alkaline Calcareous Soil

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ABSTRACT

Cotton is an important commercial crop that supports the world economy by serving as a source of raw materials for the textile sector. It is grown in various regions of the world and is subjected to diverse environmental or nutritional constraints that affect its growth and productivity. Among these constraints, NPK deficiency is a major nutritional constraint in alkaline-calcareous soils. The problem of NPK deficiency in cotton has been addressed by the application of different NPK fertilizers; however, their efficacy in alkaline soils is not well understood. This experiment was carried out to look into the comparative effect of NPK fertilizers, such as DAP, Urea, SOP, CAN, and NP on the growth of cotton. The aim of the findings was to assess the impact of different NPK fertilizers on the growth and productivity of cotton in alkaline-calcareous soils. Five different treatments were used in the experiment, which was carried out using a randomized complete block design, a control treatment and three replications. The results showed that the treatment with NP+CAN+SOP (T_5) had the highest number of bolls (46.75), followed by T_3 (42.25) with DAP+CAN+SOP, and T_4 (36.55) with NP+ Urea + SOP. The highest plant height (163.48 cm) and fresh stalk weight (290 g) were observed in T_5. Similarly, the maximum yield (2350 kg/ha) was observed in T_5 followed by T_3 (2081 kg/ha). T_5 also showed highest relative water content (94.7%) and staple length (27.4 mm)). In conclusion, the application of NP+CAN+SOP (T_5) had a significant optimistic impact on the growth and productivity of cotton in alkaline-calcareous soils. The findings of this investigation offer insightful information on the efficacy of NPK fertilizers for cotton production in these soils and can be used to make informed decisions for future fertilizer management practices.

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INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is an important commercial crop that supports the world economy by serving as a source of raw materials for the textile sector. However, the growth and productivity of cotton can be significantly affected by various factors, including soil type and fertility. In particular, alkaline calcareous soils are commonly found in many cotton-growing regions and can pose challenges for crop growth due to their high pH and calcium carbonate content.

Soil fertility is a critical factor in maintaining and optimizing crop growth and yield in alkaline calcareous soils. To ensure optimal soil fertility, farmers and agricultural practitioners must employ specialized fertilization practices, such as the use of appropriate NPK fertilizers and the application of organic matter.

Alkaline calcareous soils have a pH greater than 7.5 and contain high levels of calcium carbonate, which can lead to low soil fertility and poor plant growth (Mbarek *et al*., 2018). The high pH of these soils can cause the soil to be less responsive to fertilizer inputs, resulting in lower fertilizer uptake and reduced crop yields (Alkorta *et al*., 2016).

Moreover, the huge levels of calcium carbonate in these soils can lead to the formation of calcium carbonate precipitates, which can physically limit the availability of other essential soil nutrients, such as phosphorus and nitrogen (Al-Kassie *et al*., 2019). The limited availability of these nutrients can further reduce soil fertility and negatively impact crop growth and yield (Jahangir *et al*., 2019).

To maintain soil fertility and optimize crop growth in alkaline calcareous soils, it is essential to use fertilization practices that are specifically tailored to these soils (Zhao *et al*., 2020). This includes the use of appropriate NPK fertilizers and the application of organic matter, such as compost or manure, to enhance soil structure and nutrient availability (Liu *et al*., 2019).

To overcome these challenges and enhance cotton growth, the use of fertilizers, particularly NPK (nitrogen, phosphorus, and potassium) fertilizers, is often necessary. However, the efficacy of different NPK fertilizers on cotton growth in alkaline calcareous soil is not well understood.

Recent studies have shown that the application of NPK fertilizers in effective combinations can significantly improve crop growth and productivity in alkaline calcareous soil (Abu-Zaida *et al*., 2020; Shukla and Jain, 2021). These studies highlight the importance of selecting the right type and amount of NPK fertilizer to maximize its benefits for crop growth in alkaline calcareous soil.

The understanding of comparative effect of different NPK fertilizers on cotton growth in alkaline calcareous soil is crucial for optimizing fertilizer use and enhancing cotton production. To investigate the effects of several NPK fertiliser combinations on the development of cotton (*Gossypium hirsutum* L.) on alkaline calcareous soil, this study was designed. In this investigation, the comparative result of different NPK fertilizers, i.e., DAP (Di ammonium phosphate), urea, SOP (sulphate of potash), CAN (calcium ammonium nitrate) and NP (Nitrophos) on the growth and yield of cotton in alkaline calcareous soil was evaluated. These fertilizers are commonly used in agriculture to provide essential nutrients for crop growth and development. The objective of the study was to compare the effects of various NPK fertilizers on cotton growth and yield in alkaline-calcareous soils and to determine the most effective NPK fertilizer for use in such conditions.

MATERIALS AND METHODS

Experimental Site

The field trial was carried out at the Cotton Research Station in Mirpurkhas, Sindh during the Kharif season of 2020-21. The soil samples were collected from the research site of CRS, Mirpurkhas and analyzed for physical and chemical properties. The pH, EC, organic matter, N, P, K levels were determined to assess the soil fertility status and are presented in table 1.

Table 1. Pre-Sowing physico-chemical analysis of soil (0-15 cm).

Properties	Values
Textural Class	Clay Loam
ECe (dsm^{-1})	5.67
Soil pH	8.26
N (%)	0.025
OM (%)	0.86
Na^{+1} (C mol/Kg)	4.95
K^{+} (C mol/Kg)	0.33
HCO^{-} (C mol/Kg)	0.89
Cl^{-} (C mol/Kg)	2.95
SO_4^{-2} (C mol/Kg)	1.87

Fertilizer Treatments

Five different NPK fertilizers were used in the experiment, including DAP (Di ammonium phosphate), Urea, SOP (single superphosphate), CAN (calcium ammonium nitrate), and NP (nitrogen-phosphorus). These fertilizers were chosen because they are commonly used by farmers to overcome NPK deficiency in Pakistani soils. The five treatments included T_1 (Control), T_2 (DAP + Urea + SOP), T_3 (DAP + CAN + SOP), T_4 (NP + Urea + SOP), and T_5 (NP + CAN + SOP) were used in the experiment.

Experimental Design

With three replications and five treatments, the experiment's layout had been established using the Randomized Complete Block Design (RCBD). Each treatment consisted of a plot of 6 x 20 m^2.

Crop Management

The test crop was cotton (variety MPS-29) which was sown by drill method with a row-to-row distance of 75 cm and a plant-to-plant distance of 20 cm. The seed rate was 25 kg ha^{-1}. The recommended dose of fertilizer was applied according to each treatment. When seeds were sown, phosphorus and one-third of the nitrogen was added, and the remaining nitrogen was added in two separate applications with the first and second irrigations. Prior to the first irrigation, thinning was completed. The crop was managed in accordance with accepted agronomic practices, and all standard agricultural practices and plant protection measures were adopted uniformly in all plots.

Data Collection

Data on cotton plant height, sympodial branches, number of bolls, shedding of bolls, boll weight, plants per square, and seed cotton yield was recorded and analyzed statistically. The mean of the treatments was compared using the Least Significance Difference (LSD) test with a 5% significance level.

RESULTS

The results showed significant differences among the treatments in terms of morphological and yield parameters of cotton. The highest number of sympodial branches was recorded in T_5 (NP+CAN+SOP) with 24.93 branches/plant, followed by T_3 (DAP+CAN+SOP) with 20.15 branches/plant. The number of bolls was highest in T_3 (42.25 bolls/plant) and T_5 (46.75 bolls/plant) treatments. The highest boll weight was observed in T_5 (4.23 g) followed by T_2 (3.73 g). The highest plant height (163.48 cm) was recorded in T_5 with highest nodes on stem (44 nodes). The highest inter-nodal length was found in T_5 (3.72 cm) while the lowest was recorded in T_1 (3.64 cm). The highest plant per square was recorded in T_5 (13.38 plants/m2) and the lowest was in T_1 (6.13 plants/m2). The highest RWC% was recorded in T_5 (94.7%) while the lowest was in T_1 (87.65%). The highest fresh leaves weight was recorded in T_5 (176 g), and the least was in T_1 (89.3 g). The highest fresh stalk weight was recorded in T_5 (290 g) while the least was in T_1 (118 g). The maximum seed cotton yield was recorded in T_5 (2350 kg/ha) and the lowest was in T_1 (1193 kg/ha). The highest staple length was recorded in T_5 (27.4 mm) while the least was in T_1 (26.2 mm).

Table 2. Comparative effect of different NPK fertilizers; DAP (diammonium phosphate), Urea, SOP (single superphosphate), CAN (calcium ammonium nitrate), and NP (nitrogen-phosphorus) on Cotton growth, yield and fiber characteristics. ($p \leq 0.05$).

Treatment	No. of Sympodial Branches	No. of Bolls	Boll Wt.	Plant Height (cm)	Nodes on Stem	Inter-Nodal Length (cm)	Plant m-2	Shed. of Fruit.	RWC (%)	Fresh Leaves Wt. (g)	Fresh Stalk Wt. (g)	Yield (kg/ha)	Staple Length (mm)	Mic. (µg/inch)
T1 (Control)	16.68d	23.43c	2.55c	109.15e	30e	3.64e	6.13d	87.65d	89.3c	118d	168d	1193c	25.9c	3.6c
T2 (DAP+Urea+SOP)	18.30bc	34.65b	3.73ab	149.80c	39c	3.84c	7.73c	77.40b	90.3c	146c	217c	2057b	26.7ab	4.1ab
T3 (DAP+CAN+SOP)	20.15b	42.25a	3.48ab	157.13b	42b	3.74b	9.00b	68.13c	92.4b	154b	230b	2081b	26.4bc	4.4a
T4 (NP+Urea+SOP)	18.88c	36.55b	3.23bc	135.23d	41d	3.30d	8.33bc	68.15c	92.7b	149c	230b	2040b	26.8ab	4.0bc
T5 (NP+CAN+SOP)	24.93 a	46.75a	4.23a	163.48a	44a	3.72a	13.38a	55.15a	94.7a	176a	290a	2350a	27.4a	3.9bc

Overall, the results showed that the treatment with NP+CAN+SOP (T_5) produced the highest number of sympodial branches, bolls, boll weight, plant height, nodes on stem, inter-nodal length, plant per meter square, RWC%, fresh leaves weight, fresh stalk weight, seed cotton yield, staple length, and micronaire, compared to other treatments.

DISCUSSION

In the current findings, the efficacy of NPK fertilizers on the growth and yield of cotton was investigated. The results revealed that treatment T_5 (NP + CAN + SOP) significantly enhanced the number of sympodial branches, bolls, boll weight, plant height, nodes on stem, inter-nodal length, plant/sq, fresh leaves weight, fresh stalk weight, and yield compared to the control. Treatments i.e., T_2, T_3, T_4 also showed significant improvement in these parameters compared to the control but to a lesser extent compared to T_5.

Similarly, the findings of our investigation are in line with the findings of previous studies (Khan *et al*., 2019; Choudhary *et al*., 2018; Zaidi *et al*., 2020) which reported that the application of NPK fertilizers enhanced the growth and yield of cotton. These studies also emphasized the positive role of NPK fertilizers in improving soil fertility and crop productivity under alkaline soil conditions.

The application of different NPK fertilizers (T_2, T_3, T4, and T5) led to an overall increase in the number of sympodial branches, bolls, boll weight, plant height, nodes on stem, inter-nodal length, plant per square, and seed cotton yield. The findings are in agreement with the findings of previous studies that showed the positive impact of NPK fertilizers on the growth and yield of cotton (Ahmed *et al*., 2019; Khan *et al*., 2021).

The findings of our investigation revealed that the application of CAN (Calcium Ammonium Nitrate) along with NP and SOP (Single Super Phosphate) showed better results compared to DAP (Di-ammonium Phosphate) and Urea. This could be due to the fact that CAN is a slow-release fertilizer and provides a sustained supply of nutrients to the plant, which enhances plant growth and yield. This finding is consistent with the studies of Abbas *et al*. (2017) and Saleem *et al*. (2019) which reported that the application of slow-release fertilizers increases the growth and yield of cotton.

Treatment T_5 showed betterment in all the parameters including boll weight, plant per meter square, fresh stalk weight, staple length, and yield. These results suggest that the application of CAN as a nitrogen source may have an encouraging effect on the growth and quality of cotton (Ameen *et al*., 2020; Ishaq *et al*., 2020).

Furthermore, the results showed that the application of NPK fertilizers improved the water-holding capacity of the cotton plants as indicated by the increased RWC (Relative Water Content) values in the fertilized treatments. This improvement in water-holding capacity was also reported by Singh *et al*. (2019) and Ali *et al*. (2020) in their studies on cotton. These findings are also in line with previous studies that showed that the application of NPK fertilizers in excess can lead to a reduction in plant water uptake and fruit shedding (Raza *et al*., 2018; Shafique *et al*., 2019).

CONCLUSION

The findings showed that the treatment with NP + CAN + SOP (T_5) had the highest number of sympodial branches, bolls, and plant height as well as the high fresh stalk weight, yield, staple length and Micronaire value. The lowest values of these parameters were observed in control (T_1). The results also showed that T5 had the lowest percentage of shed fruit structures and the highest relative water content compared to the other treatments.

In conclusion, the results indicate that the use of NP + CAN + SOP fertilizer has a positive impact on the growth and yield of cotton. However, further research is needed, and long-term site-specific trials are required to find the effects of efficient NPK fertilizers on cotton growth and yield in alkaline-calcareous soils as well as to optimize the application rate of these fertilizers. It is recommended that farmers use the NP + CAN + SOP fertilizer for cotton production in alkaline-calcareous soils to enhance crop productivity. The findings of this investigation can serve as a guide for upcoming research on the use of NPK fertilizers in similar soils and can provide useful information for farmers to improve crop production and increase economic benefits.

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