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Effect of Phosphate Fertilizer on Growth and Yield of Black Nightshade varieties in Kilifi County, Kenya

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ABSTRACT: Black nightshade is an essential crop that is highly valued along Kenya's Coast. The crop is high in vitamins A, C, and iron. It has a lot of dietary fiber, which helps with digestion and intestinal health. Phosphorus is a necessary nutrient for growth of Black nightshade since it is involved in photosynthesis, energy transfer, and nutrient intake. A lack of phosphorus can result in low-quality food, decreased yield, and stunted development. Recently findings have shown performance of black nightshade to fertilizers application is usually site specific and varies among the various genotypes of solanum, black nightshade leaf yield of 1-3 tons per hectare against potential yield of 30 tons per hectare and that most soils in Kenya are low in phosphorous fertilizer. Our study aimed at investigating the effect of phosphate fertilizer on growth and yield of black nightshade in Kilifi County. The present study was conducted at Msabaha, Kilifi County. For the experiment, a randomized complete block design (RCBD) with three replicates was employed. Five levels of phosphate fertilizer 0, 33, 66, 99, and 132kg/ha were entirely applied to black nightshade. The rate of plant growth was determined through the recording of height, branch count, leaf count, and leaf width especially at an interval of a week's time. The findings indicated that the various fertilizer levels significantly differed in terms of plant height, number of leaves, leaf breadth, and leaf weight at ($P \leq 0.05$). The highest mean leaf weight was observed at 66 kg/ha phosphorus (1.540kg/plot – 6tons/ha), particularly where rainfall is always above 500mm per annum.

KEYWORDS: Phosphate fertilizer, Plant growth, Plant yield, Solanum scabrum, Solanum Villosum.

1. INTRODUCTION

South America provided the majority of Solanum species. The majority of the Solanum species that are indigenous to Africa are found in Europe and Asia. Nigeria and Kenya are primary regions where African nightshade is extensively cultivated (Abukusta-Onyango et al., 2013). Previously the African nightshade species were considered as "meals for the low-class people" among Kenyans, but recently changes have enabled the semi-cultivation of African nightshade (Abukusta-Onyango et al., 2013). S. nigrum plant has medicinal ability for detoxification the human body, clearing heat, treating urethral infections, preventing dysentery, and treating of prostate (Gao et al., 2021).

Black nightshade vegetables, which are primarily grown in little kitchen gardens, significantly contribute to the nutritional requirements of rural residents. The plant is abundant in rare plant nutrients. 80% of the rural population in the world use traditional vegetables as a source of nutrients (World Health Organization, 2013).

Due to prolonged neglect, most of African leafy vegetables like Amaranthus and Solanum varieties grow either as undomesticated, semi-cultivated or small-scale production. Information on production of the vegetables also varies within distinct agricultural ecoregions. The key to production and management information, therefore, is insufficient for enhancing productivity (Kipkosgei et al., 2003).

According to Bernasconi et al. (2011), phosphate (P) is an essential element for nucleic acids and energy transmission. A Phosphate deficit limits the growth of plants, photosynthesis, and root development. Njeru et al. (2016) reported that high dependence on rainfall, low soil health, severe erosion of the land, low quality of seeds and fertilizers are the principal causes of low yields from crops. The absence of fertilizer is one of the issues restricting efforts to enhance production of various African green vegetables, such as Solanum species, according

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to a study of potential yields between western and north-western Kenya (Maundu et al., 1999; Onyango et al., 2000). Ashilenje et al. (2012) recorded solanum scabrum average fresh production of 11 tons per hectare using 48 kg Phosphorous fertilizer per hactare.

Okalebo. (2009) reported that performance of vegetables to fertilizers application is usually site specific and varies among the various genotypes of solanum. Black nightshade is an important leafy vegetable crop in Kenya, particularly in Kilifi County. Because of its resilience to a variety of agro-ecological settings, it is regarded as an important crop for food security and is rich in vitamins, minerals, and antioxidants. However, low soil fertility, particularly phosphate deficiency, frequently limits the productivity of black nightshade in Kilifi County. Omwakwe et al. (2023) reported Phosphorous results from KALRO Msabaha which is a research site within Kilifi County and 1km distance from the experiment site that showed phosphorous levels of 25 mg/kg which is low from the adequate crop production level of 30 - 80 mg/kg. However, there is insufficient information on the right amount of phosphorus to utilize to create the best yields of black nightshade.

The findings of this study will provide important new information into the phosphorus requirements of black nightshade. This knowledge can improve the area's food security and nutrition by generating fertilizer recommendations.

2. MATERIALS AND METHODS

The present study was conducted at Msabaha, Kilifi County. Field trials were carried out in two seasons during both the long and short rains, which range from April to June 2016 and September to October 2016. The experiment used a randomized complete block design (RCBD) with three replicates. Five levels of phosphate fertilizer 0, 33, 66, 99, and 132kg/ha were entirely applied to black nightshade. Plot sizes was 2m by 2m with a spacing of 20cm by 40cm, giving a population of 125,000 plants per hectare. Fields were manually maintained weed-free, whereas the pests were controlled using insecticide and miticide. The rate of plant growth was determined through the recording of height, branch count, leaf count, and leaf width especially at an interval of a week’s time. This was done 3 weeks after the emergence. The height of the plant was measured using a meter rule from the ground to the tip of the youngest leaf. One leaf in each plant at the third node from the ground of the primary stem was marked from which readings of leaf width was taken. Total number of leaves and branches were taken too. Harvesting of leaves only occurred once, 9 weeks after emergence. Fresh leaf harvest was established as average weight in kilograms (kgs) based on the recording of plants per plot. Applied statistical analysis was done through the analysis of variance (ANOVA). Its goal was to ascertain whether different treatments had a significant effect ($P \leq 0.05$) on plant growth rate and leaf yields or not.

3. RESULTS AND DISCUSSION

The study revealed that phosphorus fertilizer application significantly increased the growth and yield parameters of black nightshade.

The findings of this study, demonstrating a significant increase in plant heights (Table 1), leaf number (Figure 1), leaf width (Table 2) and leaf yield (Table 3) with increasing phosphorus (P) fertilizer application, are consistent with previous research. Our results support the observations of Tuwei et al., (2013) who reported similar trends in plant height, leaf number, leaf area, and leaf yield with rising P rates. This positive response to P fertilization can be attributed to its crucial role in various plant growth processes. Phosphorus is a key component of energy transfer molecules (ATP and ADP) and plays a vital role in photosynthesis, nutrient uptake, and cell division. Adequate P availability enhances root development, leading to improved water and nutrient acquisition. It also promotes cell division and expansion, resulting in taller plants with more leaves and potentially higher leaf yield. The findings align with the established understanding of plant nutrition and highlight the importance of optimal P levels for maximizing plant growth and productivity.

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Table 1
ANOVA summary for effect of variety and fertilizer rates on plant height

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Variety	7757.978	1	7757.978	650.282	.000
Fertilizer	929.786	4	232.447	19.484	.000
Variety * Fertilizer	689.700	4	172.425	14.453	.000
Error	596.509	50	11.930		
Total	9973.973	59			

Figure 1
Effect of Phosphorus level and the number of leaves up to four weeks

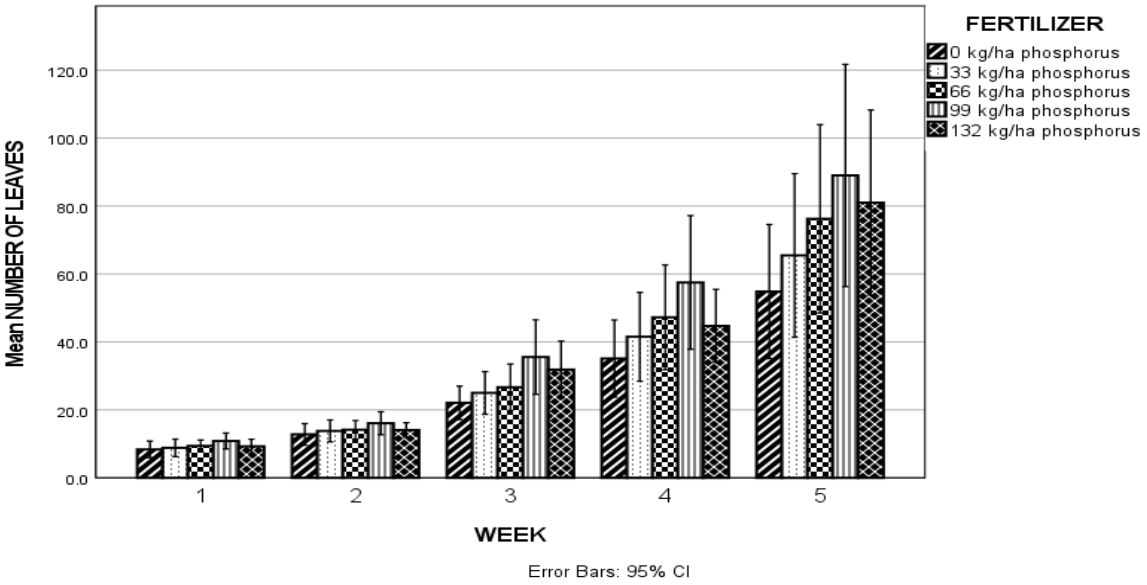

Table 2
ANOVA summary for effect of variety and fertilizer rates on leaf width

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Variety	342.388	1	342.388	377.582	.000
Fertilizer	29.957	4	7.489	8.259	.000
Variety * Fertilizer	13.251	4	3.313	3.653	.011
Error	45.339	50	.907		
Total	430.935	59			

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Figure 3
Effect of Phosphorus level on fresh leaf weight

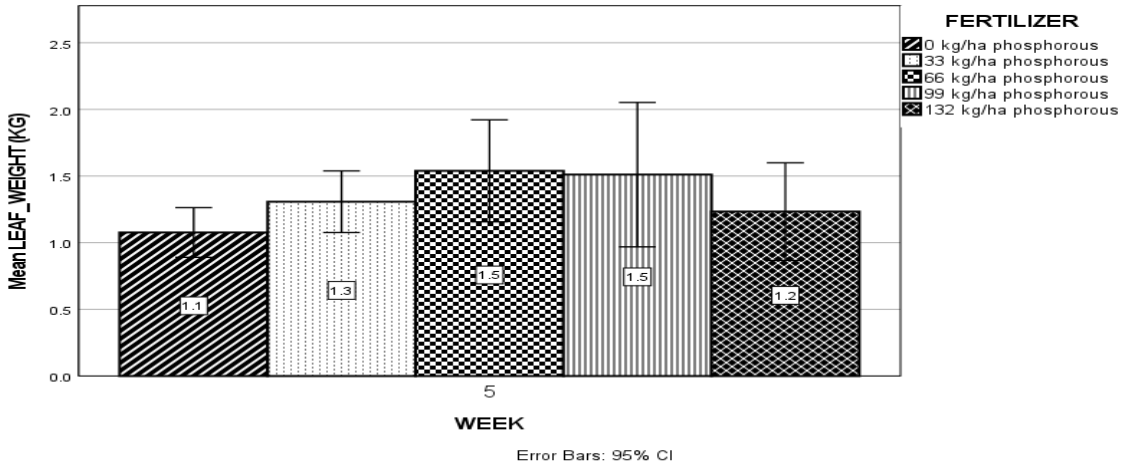

Table 3
Comparison of group means for the effect of fertilizer rates on leaf weight

Fertilizer levels	Mean leaf weight (kg)
0 kg/ha phosphorus	1.077a
132 kg/ha phosphorus	1.233ab
33 kg/ha phosphorus	1.308bc
99 kg/ha phosphorus	1.511cd
66 kg/ha phosphorus	1.540d

The research findings align with previous studies indicating low phosphorus (P) levels in Kilifi County soils. The observed yield increase with increasing phosphorus fertilizer application (Figure 3) suggests that the research site was likely deficient in P. This aligns with the findings of Omwakwe et al. (2023), who reported widespread P deficiencies in Kilifi County. Notably, the P content at KALRO Msabaha, located only 1 km from the research site, was measured at 25 mg/kg, falling below the recommended range of 30-80 mg/kg established by KALRO Msabaha. These findings highlight the prevalence of low P availability in Kilifi County soils and emphasize the potential benefits of phosphorus fertilizer application for improving crop yields in the region.

This study conducted in Kilifi County identified the optimal phosphorous (P) fertilizer level for black nightshade production to be 66kg/ha, resulting in a yield of 6 tha^{-1} (Table 3). These results are consistent with those of Tuwei et al. (2013) in western Kenya, who found that P application increased yield for different kinds of black nightshades (Solanum scabrum, Solanum villosum, and Solanum miniatum). Similar to the present study, their results showed that the highest yields achieved at application rates of 60 kg P/ha. This consistency across geographically distinct locations strengthens the generalizability of the positive P application - yield relationship for black nightshade production. While both studies observed a yield increase with P application, Tuwei et al. (2013) reported a higher yield range (8.671 t/ ha to 13.35 t/ha) compared to our study (6 t/h). Investigating factors contributing to this variation, such as specific black nightshade varieties or soil properties, could be explored in future research.

The results of his study (Figure1) are consistent also with earlier studies by Ogembo (2015) on the positive correlation between phosphate fertilizer application and increased leaf production in black nightshade varieties. Similar to our study, Ogembo's research conducted in Siaya and Kisii counties, Kenya, demonstrated a direct link

between phosphorus levels and leaf number. This consistency strengthens the generalizability of our results and highlights the importance of phosphorus for optimal leaf growth in black nightshade. Further studies could explore the underlying mechanisms behind this observed relationship. Phosphorus plays a crucial role in various plant growth processes, including photosynthesis and energy transfer. Increased availability of phosphorus due to fertilization might enhance leaf cell division and expansion, leading to a greater number of leaves. It is important to acknowledge that optimal phosphorus levels may vary depending on factors like soil composition, specific black nightshade variety, and overall plant health.

The findings of this study have important implications for black nightshade production in Kilifi County. The results demonstrate that phosphorus fertilizer is essential for improving the growth and yield of black nightshade.

4. CONCLUSION

In conclusion, phosphorus fertilizer is a critical input for improving the growth and yield of black nightshade in Kilifi County. The choice of the appropriate phosphorus fertilizer application rate are important factors to consider for optimizing black nightshade production in the region. The findings of this study provide valuable insights for developing sustainable black nightshade production systems that contribute to food security and nutrition in Kilifi County.

Recommendations

Based on the findings of the study, the following recommendations are made:

- The recommended phosphorus fertilizer application rate is 66 kg/ha phosphorus
- Soil testing should be conducted prior to phosphorus fertilizer application to determine the phosphorus status of the soil and adjust the application rate accordingly.
- Split application of phosphorus fertilizer is recommended to improve phosphorus uptake efficiency and minimize environmental impacts.

Recommendations for Future Research

The following topics are some recommended for future research:

- Investigate the effect of different phosphorus fertilizer sources and application methods on the growth and yield of black nightshade.
- Evaluate the impact of phosphorus fertilizer application on the nutritional quality of black nightshade leaves.
- Develop sustainable phosphorus fertilizer management strategies for black nightshade production in Kilifi County, considering economic, environmental, and social factors.
- Study the long-term effects of phosphorus fertilizer application on soil fertility and ecosystem health in Kilifi County.
- Explore the potential of using organic phosphorus sources, such as compost and manure, to improve phosphorus nutrition and soil health in black nightshade production systems.

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