Impact of Rock Phosphate Levels, Placement Methods, And Cowpea Varieties on Growth Parameters in Sokoto

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Abstract
Cowpea (Vigna unguiculata) is an essential legume crop widely cultivated in arid and semi-arid regions due to its adaptability to low soil fertility. However, phosphorus deficiency remains a major constraint to its optimal growth. This study investigates the impact of rock phosphate (RP) application levels, placement methods, and cowpea variety selection on growth parameters in Sokoto during the 2024 cropping season. A randomized complete block design (RCBD) was used with two cowpea varieties (Sampea-7 and Baadare), three RP levels (25, 50, and 75 kg ha^{-1}), and three placement methods (plough-sole, broadcast, and side-band). Results showed that increasing RP levels improved canopy height, leaf number, and canopy spread, with 75 kg RP ha^{-1} yielding the highest vegetative growth. The plough-sole placement method enhanced nutrient uptake, resulting in superior growth parameters compared to broadcast and side-band methods. Additionally, Baadare exhibited better canopy height, while Sampea-7 displayed wider canopy spread and earlier maturity. These findings highlight the importance of optimizing phosphorus application strategies to improve cowpea productivity in phosphorus-deficient soils.

Keywords*: Cowpea, rock phosphate, sustainable agriculture, phosphorus application, nutrient management.*

INTRODUCTION

Cowpea (*Vigna unguiculata*) is an essential crop in Nigeria, particularly in arid and semi-arid regions such as Sokoto, where it plays a crucial role in food security and income generation for smallholder farmers. The crop is well-adapted to harsh environmental conditions and poor soil fertility, making it a valuable component of sustainable agricultural systems. In addition to providing high-quality protein and essential nutrients, cowpea contributes to soil fertility through biological nitrogen fixation, enhancing soil health and reducing reliance on synthetic fertilizers (Singh et al., 2017).

Despite its adaptability, cowpea growth is often limited by soil nutrient deficiencies, particularly phosphorus (P) deficiency, which affects critical growth parameters such as canopy development, leaf production, and root expansion. Phosphorus plays a fundamental role in plant metabolism, energy transfer, and cellular development, influencing overall vegetative growth and physiological functions (Bationo et al., 2018). In phosphorus-deficient soils, cowpea exhibits stunted growth, reduced leaf expansion, and delayed flowering, ultimately leading to poor vegetative performance and lower biomass accumulation.

To enhance cowpea growth, researchers and agricultural practitioners have explored the use of rock phosphate, a natural and cost-effective phosphorus source, as an alternative to synthetic fertilizers. Rock phosphate gradually releases phosphorus into the soil, making it a sustainable option for improving nutrient availability and uptake in phosphorus-depleted soils (Chien et al., 2011). The effectiveness of rock phosphate application is influenced by factors such as application rate and placement method. Studies have shown that strategic placement methods, such as the plough-sole technique, enhance phosphorus incorporation into the root zone, thereby improving nutrient uptake and plant growth (Freiling et al., 2022).

This study investigates the impact of different rock phosphate levels and placement methods on cowpea growth parameters in Sokoto. By examining key vegetative traits such as canopy height, leaf number, canopy spread, and days to flowering and maturity, the research aims to provide insights into optimizing phosphorus application strategies to enhance cowpea growth and productivity in phosphorus-deficient regions.

MATERIALS AND METHODS

Experimental Site

The experiment was conducted at the dry land farm of Usmanu Danfodiyo University, Sokoto, during the 2024 cropping season. Soil samples were analyzed for physico-chemical properties, revealing a predominantly sandy soil with low organic carbon, total nitrogen, available phosphorus, and potassium content (Rao *et al.*, 1983).

The rainfall data for Sokoto State collected from the Sokoto Metrological Agency in July, August, and September 2024 reveals significant variations in precipitation levels. July recorded a total rainfall of 446.0 mm, with a daily average of 13.9 mm and a maximum daily rainfall of 223.0 mm, indicating moderate rainfall 1096.6 mm, a daily average of 34.3 mm, and an extreme maximum daily rainfall of 548.3 mm, highlighting its status as the peak month for precipitation. In September, rainfall decreased to a total of 744.8 mm, with a daily average of 23.3 mm and a maximum daily rainfall of 372.4 mm, marking a transition toward the end of the rainy season. The relative humidity is typically low throughout the year, ranging from 20–35% in January to 60–80% in August, however the temperature fluctuates throughout the year.

Treatments and Experimental Design

The study employed a randomized complete block design (RCBD) with three replications. Treatments comprised two cowpea varieties (Sampea-7 and Baadare), three rock phosphate levels (25, 50, and 75 kg ha^{-1}), and three placement methods (plough-sole, broadcast, and side-band), totaling 18 treatment combinations.

Each plot measured 4 m × 4.5 m, with an intra-row spacing of 40 cm and inter-row spacing of 75 cm. Seeds were planted manually. Rock phosphate was applied at sowing based on the assigned placement method. Urea (10 kg N ha^{-1}) was applied at land preparation (Chien & Menon, 1995).

Field Layout and Cultural Practices

Each plot measured 4 m x 4.5 m, with six rows of cowpea stands. Seeds were sown at an intra-row spacing of 40 cm and inter-row spacing of 75 cm. Fertilizer application included 10 kg N ha^{-1} from urea during land preparation and rock phosphate applied at sowing using the specified placement methods (Chien & Menon, 1995).

Table 1 shows that rock phosphate application significantly enhances cowpea growth parameters. Canopy height and leaf number increased with higher phosphorus levels, peaking at 53.44 cm and 51.01 leaves, respectively, at 75 kg RP ha^{-1}, indicating improved vegetative growth and photosynthesis. The widest canopy spread (61.90 cm) was observed at 25 kg RP ha^{-1}, suggesting an optimal phosphorus range for lateral expansion. Phosphorus also accelerated flowering and maturity, with the earliest flowering at 75 kg RP ha^{-1} (47.00 days).

Placement methods also influenced growth, with the plough-sole method yielding the highest canopy height (52.72 cm), leaf number (51.70), and canopy spread (62.51 cm), demonstrating its effectiveness in nutrient uptake. Broadcast and side-band methods recorded lower values, with side-band placement showing the least canopy height (45.64 cm) and spread (58.14 cm).

Results and Discussion

Table 1: Growth Parameters as Influenced by Rock Phosphate Level, Placement Method, and Variety in 2024 Cropping Season

Treatment	Canopy Height (cm) ± SE	Leaf Number ± SE	Canopy Spread (cm) ± SE	Days to 50% Flowering ± SE	Days to 50% Maturity ± SE
0 (control)	35.70 ± 0.89	40.00 ± 1.50	51.50 ± 1.77	50.67 ± 0.90	91.00 ± 0.95
25 kg RP ha^{-1}	46.01 ± 0.90	49.06 ± 1.50	61.90 ± 1.77	47.89 ± 0.90	87.44 ± 0.95
50 kg RP ha^{-1}	47.62 ± 0.90	47.00 ± 1.50	58.11 ± 1.77	47.61 ± 0.90	88.39 ± 0.95
75 kg RP ha^{-1}	53.44 ± 0.90	51.01 ± 1.50	60.17 ± 1.77	47.00 ± 0.90	88.17 ± 0.95
Placement Methods					
Plough-sole	52.72 ± 0.90	51.70 ± 1.50	62.51 ± 1.77	46.39 ± 0.90	87.89 ± 0.95
Broadcast	48.71 ± 0.90	47.92 ± 1.50	59.52 ± 1.77	47.89 ± 0.90	88.67 ± 0.95
Side-band	45.64 ± 0.90	47.44 ± 1.50	58.14 ± 1.77	48.22 ± 0.90	87.44 ± 0.95
Variety					
Baadare (Local)	52.75 ± 0.73	48.36 ± 1.22	58.62 ± 1.45	47.19 ± 0.73	90.82 ± 0.77
Sampea-7 (Improved)	45.30 ± 0.73	49.69 ± 1.22	61.50 ± 1.45	47.82 ± 0.73	85.19 ± 0.77

The effects of different rock phosphate levels, placement methods, and cowpea varieties on key growth parameters. Results indicate that increasing rock phosphate application enhances *canopy height, leaf number, and canopy spread, with the highest values recorded at 75 kg RP ha^{-1}.*

Varietal differences were evident, with Baadare showing superior canopy height (52.75 cm), while Sampea-7 had a slightly higher leaf number (49.69) and the widest canopy spread (61.50 cm). Sampea-7 also matured earlier (85.19 days) compared to Baadare (90.82 days), making it more suitable for short-duration cropping cycles.

The study's results demonstrate that rock phosphate (RP) application significantly impacts cowpea growth parameters. Increasing phosphorus levels generally enhanced vegetative growth, with the highest canopy height (53.44 cm) and leaf number (51.01) observed at 75 kg RP ha^{-1}. This aligns with existing literature highlighting phosphorus's vital role in plant metabolism, energy transfer, and overall vegetative vigor (Marschner, 2012; Bationo et al., 2018). Phosphorus is essential for photosynthesis, root development, and cell division, all of which contribute to robust plant growth and higher biomass accumulation. Furthermore, phosphorus deficiency has been linked to stunted growth and delayed development in legumes, emphasizing the necessity of adequate phosphorus application (Taiz et al., 2015).

Interestingly, canopy spread was widest at 25 kg RP ha^{-1} (61.90 cm), followed by 75 kg RP ha^{-1} (60.17 cm), suggesting a potentially optimal range for phosphorus influencing lateral expansion. This finding may indicate that excessive phosphorus levels beyond a certain threshold could limit lateral growth by prioritizing vertical expansion. The acceleration of flowering at higher phosphorus levels, with the earliest flowering at 75 kg RP ha^{-1} (47.00 days), further supports phosphorus's crucial role in reproductive development. Phosphorus plays a key role in enzyme activation and hormonal regulation, which in turn promotes early flowering and seed formation (Taiz et al., 2015).

The placement method also played a crucial role, with the plough-sole method consistently resulting in the highest canopy height (52.72 cm), leaf number (51.70), and canopy spread (62.51 cm). This finding supports the notion that deeper placement enhances nutrient availability to the roots, improving uptake efficiency (Freiling et al., 2022). Phosphorus is relatively immobile in soil, and deep placement ensures that it remains accessible to growing roots, maximizing nutrient absorption and utilization efficiency. In contrast, broadcast and side-band methods yielded lower values, consistent with studies showing reduced phosphorus availability with surface applications due to fixation and leaching losses (Holford, 1997).

Varietal differences were evident, with the local variety (Baadare) exhibiting superior canopy height (52.75 cm), indicating its potential adaptation to local conditions, while the improved variety (Sampea-7) showed a slightly higher leaf number (49.69) and wider canopy spread (61.50 cm), suggesting a potentially better vegetative expansion potential. The ability of Sampea-7 to produce more leaves and spread laterally may contribute to higher photosynthetic efficiency and increased biomass production. Additionally, Sampea-7 matured earlier (85.19 days) than Baadare (90.82 days), potentially offering advantages for short-duration cropping systems (Ehlers & Hall, 1997). Early-maturing varieties are particularly advantageous in regions with unpredictable rainfall patterns, as they can complete their life cycle before moisture becomes limiting.

The importance of rock phosphate application extends beyond cowpea, as it can also enhance the growth and productivity of other legume crops, such as soybeans, which contribute significantly to human and animal nutrition (Masuda and Goldsmith, 2009). Phosphorus deficiency in legumes has been shown to impair nitrogen fixation, reducing overall crop productivity. Therefore, ensuring adequate phosphorus availability through rock phosphate application is crucial for optimizing legume production systems. Moreover, proper rock phosphate application reduces dependency on synthetic fertilizers, promotes sustainable soil fertility management, and improves long-term agricultural productivity (Zapata and Roy, 2004). These findings emphasize the necessity of adopting efficient phosphorus application strategies to enhance cowpea and other legume production in phosphorus-deficient regions.

Conclusion

This study demonstrated that rock phosphate application, placement method, and varietal selection significantly influenced cowpea growth parameters in Sokoto. Increasing RP levels up to 75 kg ha^{-1} generally improved canopy height and leaf number, while the plough-sole placement method consistently outperformed broadcast and side-band applications in enhancing canopy height, leaf number, and canopy spread. The local variety, Baadare, showed superior canopy height, suggesting its adaptation to local conditions, whereas Sampea-7 exhibited a wider canopy spread and earlier maturity. Optimizing RP application through appropriate levels and the plough-sole method can effectively address phosphorus deficiency, improve cowpea growth, and potentially enhance yields in the region. Further research should focus on refining RP application rates and exploring the long-term effects of these practices on soil fertility and cowpea productivity.

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