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Crop Intensification Assessment On Soil-Health, Nutrient Quality And Profitability Of Irrigated Watermelon In Gashua, Nigeria

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Abstract:
This study evaluated the influence of varying rates of organic inputs, specifically cow dung and poultry droppings (COPODs), alongside different plant spacings and watermelon varieties, on soil quality, fruit nutrient content (NPK), and profitability in Gashua, Nigeria. The factorial design incorporated four COPODs application rates (0, 4t+1t, 8t+2t, 12t+3t), four planting distances (25, 50, 75 and 100 cm), and four watermelon varieties (Sugar baby, Koalack, Royal sweet, and Paradise). Soil samples collected at both the start and end of the experiment helped assess the impacts on soil properties, while a profitability analysis determined the economic viability of each treatment. The results showed that higher COPOD levels led to increased nitrogen, phosphorus, and potassium concentrations in watermelon fruits, with wider spacing promoting more efficient nutrient uptake. Among the varieties, Koalack exhibited superior nutrient absorption at all spacing levels. Furthermore, combining the 8t+2t COPOD rate with a 100 cm spacing provided the highest profit margin. This research highlights the critical role of optimizing organic input levels and plant spacing for sustainable, high-quality watermelon production, particularly in semi-arid climates like Gashua.

Keywords: *Watermelons, COPODs, plant spacing, nutrient content, profitability, Gashua, Nigeria*

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I. Introduction

Watermelon (*Citrullus lanatus* [L.]), valued for its hydrating properties and high-water content, serves as both a staple food and a significant economic asset in Nigeria's northeastern region (Dantata, 2014). The increasing demand for watermelon both locally and internationally has prompted farmers to explore strategies for improving yield and profitability. Crop intensification, which encompasses methods like utilizing high-yield varieties, fertilization, irrigation optimization, and pest management, has emerged as a prominent approach to achieve higher productivity per unit area (Dantata *et al.,* 2016a). However, the long-term implications of these practices on soil health, crop quality, and economic viability warrant close examination. Soil health is central to productive agricultural systems and can directly impact crop growth, resilience, and nutrient composition. Components like soil structure, organic matter, microbial activity, and nutrient availability collectively influence soil fertility (Akinrinade and Obigbesan, 2010). For watermelon, adequate levels of macronutrients-nitrogen (N), phosphorus (P), and potassium (K)-are essential to optimize plant growth, fruit quality, and marketability. Thus, it is essential to understand the effects of intensified crop practices on NPK levels in crops (Yamaguchi, 1983), as they are closely tied to crop yield and economic returns (Dantata, 2013; Dantata, 2017a; Dantata, 2017b). Economic viability is equally important in crop production, particularly when considering investment-intensive practices (Hochmuth *et al.,* 2001). Cost-benefit analyses incorporating input costs (e.g., fertilizers, seeds, labour) against potential revenue can provide insights into the profitability of intensification practices (Gichimu *et al.,* 2008). Sustainable intensification approaches, which combine conventional methods with organic and environmentally friendly practices, can offer a balanced solution that ensures long-term soil health, high-quality produce, and environmental conservation (Dantata and Babatunde, 2013; Dantata *et al.,* 2016b). This study evaluates the effects of crop intensification on soil health, nutrient composition of watermelon fruits, and economic profitability in Gashua, Nigeria. By integrating analyses of soil quality, fruit nutrient composition, and profitability, the study aims to guide farmers toward sustainable practices that enhance both economic viability and environmental stability in semi-arid regions.

II. Materials And Methods

Study Area

This research was conducted at a community based-demonstration farm in Gashua, Yobe State, Nigeria during the 2016/2017 dry season. Gashua is characterized by a semi-arid to Sahelian climate with distinct wet and dry seasons (Kowal and Knabe, 1972). The area is known for its agricultural activities, particularly watermelon cultivation, which is a significant cash crop for local farmers.

Experimental Design

A randomized complete block design (RCBD) with four replications was employed to systematically evaluate the effects of various crop intensification practices on soil vitality, watermelon fruit NPK contents, and economic profitability. The experimental design consists of three main factors; cow-poultry droppings [COPODs] (without COPODs, 4t + 1t COPODs, 8t + 2t COPODs and 12t + 3t COPODs), watermelon varieties (Sugar baby, Koalack, Royal sweet and Paradise) and planting distances (25, 50, 75 and 100 cm). Before planting and after harvest, composite soil samples from the study site were collected for the assessment of soil health. Before planting and after harvest, soil samples of the experimental site were randomly collected at 0 - 30cm depths, using a tubular auger for the assessment of soil health. Composite samples were analyzed for total nitrogen using microkjeidahl method (Bremmer, 1965), available P was determined by Bray 1 method (Bray and Kurtz, 1945). Organic carbon was determined by dichromate wet oxidation method (Wackley and Black, 1965). The exchangeable bases (calcium [Ca], magnesium [Mg], potassium [K], sodium [Na], iron [Fe], cupper [Cu], manganese [Mn], boron [Bo], molybdenum [Mb] and zinc [Zn]) and cation exchange capacity were determined as described by Olsen *et al.* (1954) and read with the atomic absorption spectrophotometer (Head, 1965). Particle size distribution was determined by hydrometer method after dispersion in calgon solution (Day, 1965). The pH was determined in water and calcium chloride using a Cyber scan 20pH meter. The physicochemical properties of the soils are presented in Table 1.

The land was ploughed, harrowed and made to a fine tilt. Sunken beds of 4m x 4m were raised. The plots were spaced 1m x 0.5m between and within replications. Hybrid seeds of the specified watermelon varieties were sown directly into the plots on 10th October, 2016 according to the planting distance- treatments. Four seeds of each watermelon variety were sown and later thinned to one per stand at 3 weeks after sowing (WAS). After harvest, fruit yields were bulked treatment-wise (Dantata *et al.,* 2016a) and from each treatment-bulked, randomly selected fruits were collected for fruit samples of watermelon were analyzed for N,P and K concentrations from Kjeldahl digest using the Micro-Kjeldahl digestion and distillation apparatus and the values read with the atomic absorption spectrophotometer [AAS] (A.O.A.C., 1980; Dantata, 2017a).

Data collected were subjected to analysis of variance [ANOVA] (Steel and Torrie, 1980) using SPSS statistical software packages (SPSS, 1996) to determine the significance of the effects of different treatments on soil health, watermelon nutrient content, and economic profitability. Post-hoc tests as in Duncan's multiple range test [DMRT] was employed to compare treatment means at a significance level of 5% (Duncan, 1955) to identify specific differences between treatment groups and elucidate the effects of various crop intensification practices.

Profitability Analysis

The profitability analysis of the experiment was calculated based on costs and revenuesassociated with various treatments (Scott et al.,1993).

Thekey experimental factors influencing profitability includeCow poultry droppings (COPODs) application rates:

Different levels of organic fertilizer impact both costs and yields.
The cost of applying manure was assessed based on quantity used:
Without COPODs: No cost, Cow manure: ₦150,000 per ton and Poultry droppings: ₦350,000 per ton

Watermelon varieties

Different varieties produced different yields and revenue.

Planting distances

The spacing between plants influences the number of plants per area, directly impacting yield and, therefore, profitability.

Costs of production

The costs of production comprise variable and fixed costs per hectare.

Variable costs
These costs change with specific treatment, variety, and spacing.

Seeds

The cost depends on the number of plants grown. Given varying planting distances, the numberof plants per hectare for each treatment was calculated using the current buying price of ₦9,500 per 500g of hybrid watermelon seeds.

Labour
Labour costs include land preparation, planting, weeding, fertilizing, and harvesting.

Labour was consistent (₦135,000 per hectare for all field operations) across treatments, except for additional labour needed for applying different amounts of COPODs.

Fixed costs
These costs remain constant regardless of treatments.
They include land rent, tools, and irrigation infrastructure, amounting to ₦350,000 per hectare.

Revenues

The revenue from watermelon per hectare is the product of fruit yield (t/ha) at harvest and market selling price (₦/kg). This depends on yield (number of fruits and weight per fruit) and the market price per kilogram. Based on this experiment, key factors influencing average fruit yield (Table 2) are the treatments (varieties, COPODs application rates, and planting distance).
The current market price of watermelon is ₦800 per kilogram.

Profitability calculation
Profitability was calculated based on profit derived from experimental yield as:
Profit (₦)= Revenue (₦) −Variable costs (₦) −Fixed costs (₦).
This equation derived the economic profitability (₦) of the study as shown in Table 7.

III. Results And Discussion

Soil Health

The soil analysis performed before and after the experiment provides insights into the impact of experimental treatments on soil properties. The changes observed in soil texture, chemical composition, and nutrient availability reflect how soil fertility and plant productivity are impacted over time (Dantata *et al.,* 2016a). Findings reavealed that soil texture, determined by the relative proportions of sand, silt, and clay, plays a pivotal role in defining the soil's capacity to retain water, nutrients, and support plant root growth (Brady and Weil, 2008). In this experiment, the soil maintained its clay loam texture both before and after the application of organic amendments. Before the experiment, the particle size distribution was 477.5 g/kg of sand, 215.3 g/kg of silt, and 307.2 g/kg of clay, indicating a balanced clay loam texture, which offers good water retention due to the clay content and adequate drainage due to the sand. After the experiment, the proportions of sand (483.2 g/kg), silt (212.7 g/kg), and clay (304.1 g/kg) remained virtually unchanged. This demonstrates that, in the short term, organic amendments such as cowdung and poultry droppings did not significantly alter the physical structure of the soil. This consistency in soil texture is crucial as clay loam soils are ideal for agriculture due to their ability to retain moisture while allowing for sufficient drainage. In semi-arid regions, these qualities are essential for promoting healthy plant growth and ensuring that water and nutrients remain accessible to crops. The stable texture observed in this experiment suggests that organic amendments can improve soil fertility without degrading its physical properties, which is a positive outcome for promoting sustainable agricultural practices in semi-arid regions (Day, 1965; Dantata, 2017b).

Soil pH is a critical factor affecting nutrient solubility and availability to plants. In the experiment, the soil remained slightly acidic both before and after the application of organic materials. Initially, the soil had a pH of 5.17, which can restrict the availability of key nutrients like phosphorus, calcium, and magnesium, and also hinder microbial activity necessary for nutrient cycling. After the experiment, the soil pH increased slightly to 5.24, indicating a modest buffering effect from the organic amendments. Organic materials, particularly those rich in calcium and magnesium (such as poultry droppings), are known to help neutralize soil acidity over time. The slight increase in pH reflects this buffering effect. However, the soil remained outside the optimal pH range (6.0 - 7.5) for many crops, meaning further interventions, such as liming or additional applications of organic amendments, may be necessary to achieve a more favorable pH for plant growth. This increase, although small, is promising, as it indicates that continued use of organic amendments could gradually improve the soil's pH and enhance nutrient availability, particularly in soils that are naturally acidic (Brady and Weil, 2008; Dantata, 2014; Dantata, 2017b).

Organic carbon is a critical measure of soil health and vitality as it contributes to soil structure, nutrient cycling, and water retention. Organic carbon levels were initially low, at 0.71 g/kg, which is typical of soils in these environments where high temperatures lead to rapid organic matter decomposition. After the experiment, the organic carbon content dropped further to 0.38 g/kg, despite the application of organic amendments. The reduction in organic carbon is concerning, as it indicates that the organic matter added through cowdung and poultry droppings decomposed rapidly, leading to carbon losses. In semi-arid climates, where high temperatures accelerate microbial activity, organic matter is broken down quickly, releasing carbon dioxide through microbial respiration. This rapid decomposition highlights the challenge of maintaining organic carbon levels in such environments. To address this, it may be necessary to incorporate more slow-decomposing organic materials, such as compost or biochar, which can persist in the soil longer and contribute to building organic matter over time. Continued applications of organic amendments, combined with practices like cover cropping and mulching, could help improve soil carbon sequestration and prevent further losses (Brady and Weil, 2008; Dantata, 2014).

Nitrogen (N) is a vital macronutrient for plant growth, influencing vegetative development and crop productivity. However, N levels are often low due to limited organic matter. Initially, the N content in the soil was 0.09 g/kg, which is considered low. After the experiment, N levels decreased further to 0.06 g/kg, despite the application of N-rich organic amendments like poultry droppings. This reduction in N is likely due to N losses through leaching, volatilization, or microbial immobilization. N is highly mobile in the soil, and under the hot and dry conditions of Gashua, N may have been lost before it could be fully utilized by plants. This finding emphasizes the importance of improving N use efficiency in such environments. Strategies such as using slow-release fertilizers, incorporating N-fixing cover crops, or synchronizing organic fertilizer application with the crop's peak N demand can help reduce N losses (Dauda *et al.,* 2008).

Phosphorus (P_2O_5) is essential for root growth, energy transfer, and seed formation. Before the experiment, the available P_2O_5 level was 11.67 mg/kg, which is low and typical of acidic soils where P_2O_5 tends to bind with iron and aluminum, making it unavailable to plants. After the experiment, P_2O_5 levels increased to 13.17 mg/kg, likely due to the application of phosphorus-rich organic amendments, particularly cowdung. The increase in available P_2O_5 suggests that the organic amendments helped improve P_2O_5 availability by releasing organic acids during decomposition, which solubilize phosphorus bound to soil particles. This improvement is particularly significant in acidic soils, where P_2O_5 availability is often limited (Dauda *et al.,* 2008).

Cation exchange capacity (CEC) is a measure of the soil's ability to retain and exchange positively charged ions (cations), which is crucial for maintaining soil fertility. Before the experiment, the soil had a relatively high CEC of 20.14 C mol (+) kg^{-1}, indicating a good capacity to retain nutrients. After the experiment, the CEC dropped to 16.25 C mol (+) kg^{-1}, signaling a reduction in the soil's nutrient-holding capacity (Head, 1965). This decline is concerning as it suggests that nutrients could be lost through leaching, which is a common problem in semi-arid regions with irregular rainfall. The reduction in CEC may be linked to the loss of organic carbon, as organic matter contributes to CEC by providing negatively charged sites that hold onto cations. To improve or maintain CEC, it is essential to continue adding organic matter to the soil. Biochar, a stable form of organic matter, can also be used to enhance CEC and prevent nutrient losses.

Exchangeable bases (calcium [Ca], magnesium [Mg], potassium [K] and sodium [Na]) are vital for plant growth. The experiment revealed a decrease in all these nutrients after the amendments were applied. Ca levels dropped from 3.29 C mol (+) kg^{-1} to 2.58 C mol (+) kg^{-1}, Mg from 0.94 C mol (+) kg^{-1} to 0.68 C mol (+) kg^{-1}, and K from 0.26 C mol (+) kg^{-1} to 0.21 C mol (+) kg^{-1}. Na also decreased but to a lesser extent, from 0.16 C mol (+) kg^{-1} to 0.12 C mol (+) kg^{-1}.

The depletion of these essential nutrients suggests that crops absorbed the nutrients, or they were lost through leaching. To prevent long-term nutrient deficiencies, the continued application of organic amendments may need to be supplemented with other mineral fertilizer sources to replenish these nutrients (Dauda *et al.,* 2008; Dantata, 2013; Dantata *et al.,* 2016a).

Micronutrients (iron [Fe], copper [Cu], manganese [Mn] and zinc [Zn]) are essential for various plant processes. The experiment showed a decrease in all these micronutrients: Fe levels dropped from 7.71 mg/kg to 6.86 mg/kg, Cu from 0.27 mg/kg to 0.19 mg/kg, Mn from 6.33 mg/kg to 4.75 mg/kg, and Zn from 0.73 mg/kg to 0.54 mg/kg. This decline is concerning as micronutrient deficiencies can lead to significant crop yield losses. The loss of organic carbon and the reduction in CEC likely contributed to these decreases. To address these deficiencies, the continued application of organic amendments or the use of micronutrient fertilizers is necessary to restore these levels and support maximum plant growth (Dantata, 2013; Dantata *et al.,* 2016a).

Nutrient Quality of Fruits

Table 3 presents the effects of COPODs, spacing and variety on the nitrogen (N), phosphorus (P), and potassium (K) contents of watermelon fruit. Nitrogen content increases progressively as the rate of COPODs application rises. At 0 t/ha (control), the nitrogen content is 9.829 g/kg, but it reaches 14.342 g/kg with 12CO + 3PODS. Organic matter in poultry droppings is rich in nitrogen and breaks down slowly, releasing nitrogen into the soil over time. The improved availability of nitrogen likely contributes to enhanced nitrogen uptake by the watermelon plants. Phosphorus also shows a marked increase from 122.35 g/kg at 0 t/ha to 179.29 g/kg at 12CO + 3PODS. Phosphorus is crucial for root development, flowering, and fruiting, and poultry droppings tend to improve the bioavailability of phosphorus in the soil by enhancing microbial activity. The organic acids produced during decomposition may solubilize phosphorus, making it more accessible to plants. Potassium content follows a similar trend, increasing from 141.96 g/kg at 0 t/ha to 181.80 g/kg at the highest application rate. Potassium plays a critical role in water regulation, photosynthesis, and overall fruit quality, including sweetness and texture. Higher potassium levels from organic matter improve the water-use efficiency and stress tolerance of the watermelon, resulting in enhanced fruit quality. The positive effect of COPODs on nutrient content emphasizes the importance of organic soil amendments in sustainable agriculture. Organic fertilizers like COPODs not only improve soil structure and nutrient availability but also promote soil microbial health, which supports long-term soil fertility. The results highlight the potential for using organic amendments to increase the nutritional quality of watermelon fruits, making this practice relevant for farmers seeking to improve yields and marketability (Dantata, 2017 a and b).

Wider plant spacing shows an increase in nitrogen content, with the highest nitrogen observed at 100 cm (13.430 g/kg) and the lowest at 25 cm (11.425 g/kg). This can be explained by reduced competition between plants for soil nitrogen. When plants are spaced closer together, they compete more intensely for nutrients, which may limit their ability to take up nitrogen. The phosphorus content also increases with wider spacing. The greater phosphorus availability and uptake at wider spacing (172.22 g/kg at 100 cm) can be attributed to better root development. More space allows watermelon plants to expand their root systems, facilitating improved nutrient absorption, particularly phosphorus, which is relatively immobile in the soil. Potassium levels follow a similar pattern, reaching a maximum at 100 cm spacing. Since potassium is vital for water movement within the plant and helps regulate metabolic processes, wider spacing likely allows for better moisture and nutrient distribution in the soil, which in turn leads to higher potassium content in the fruits. Optimal plant spacing is a crucial aspect of crop management, affecting not only plant growth but also fruit quality and nutrient uptake. Wider spacing allows for improved air circulation, sunlight exposure, and nutrient availability, which positively impacts watermelon growth and fruit composition. However, it must be balanced with land-use efficiency—while wider spacing enhances nutrient content, it reduces the number of plants per unit area, potentially affecting total yield. Farmers must weigh the trade-offs between plant density and fruit quality depending on their production goals (Oyenuga and Fetuga, 1975; Dantata, 2014).

Among the varieties, Koalack has the highest nitrogen content (13.870 g/kg), while Paradise has the lowest (12.198 g/kg). This suggests that Koalack may have a greater genetic ability to absorb nitrogen from the soil or that it has a more efficient nitrogen use mechanism compared to the other varieties. The variability in nitrogen uptake between varieties could be linked to differences in root architecture, nutrient use efficiency, and growth rates. The phosphorus content is significantly higher in Koalack (182.38 g/kg) compared to other varieties, with Paradise recording the lowest value (150.30 g/kg). This could be a reflection of Koalack's superior root system, which is more efficient at exploring the soil and accessing phosphorus. Phosphorus is often a limiting nutrient in many soils, so varieties that can access it more efficiently may exhibit better growth and fruiting. Koalack again shows the highest potassium content (166.16 g/kg), while Paradise has the lowest (152.12 g/kg). Potassium influences fruit firmness, sugar content, and disease resistance, so the higher potassium levels in Koalack might result in better fruit quality overall. The differences in potassium content across varieties may indicate variation in potassium uptake efficiency or demand for potassium during fruit development (Dantata, 2014).

Treatment interaction between COPODs and spacing on the N, P, and K contents of watermelon highlighs the effect of combining varying levels of COPODs and plant spacing on nutrient concentration (Table 4). Without any COPODs (0 t/ha), N content remains low across all plant spacing treatments, ranging from 8.748 g/kg at 25 cm spacing to 10.438 g/kg at 100 cm spacing. This indicates that, in the absence of organic amendments, the availability of N in the soil is limited. Even so, wider spacing (100 cm) allows plants to take up more nitrogen, likely because reduced competition between plants improves root access to nutrients in the soil. As the rate of COPODs application increases, N content improves significantly. At 4CO+1PODS, N content rises to 13.938 g/kg at 100 cm spacing, while it remains at a moderate level (11.807 g/kg) at 25 cm spacing. This increase suggests that the organic material from poultry droppings provides a steady release of N, which becomes more available to the plants over time as the material decomposes.

At the highest COPODs application rate (12CO+3PODS), N content reaches a maximum of 15.247 g/kg at 100 cm spacing. This is the highest N content observed across all treatments, reflecting that both organic matter and wide plant spacing are crucial for optimizing N uptake. The trend is clear, as COPODs application increases and spacing becomes wider, N content consistently improves. This synergy between nutrient availability (from organic matter) and reduced inter-plant competition at wider spacing facilitates better N uptake. Nitrogen is a critical nutrient for plant growth, playing a vital role in photosynthesis, protein synthesis, and overall plant vigour. The results suggest that the addition of COPODs significantly boosts nitrogen availability in the soil, while wider spacing reduces competition, allowing individual plants to absorb more N (Oyenuga and Fetuga, 1975; Dantata, 2014).

In the absence of COPODs (0 t/ha), P content remains low across all spacing treatments, ranging from 115.09 g/kg at 25 cm spacing to 137.85 g/kg at 100 cm spacing. P uptake is relatively poor when no organic material is applied, likely due to the low availability of P in the soil, which is a common limitation in many agricultural systems. Even so, the wider spacing allows for modest improvements in P content, as plants can extend their roots more effectively to access the limited P present in the soil. As the rate of COPODs increases, P content shows a marked improvement. At 4CO+1PODS, phosphorus content rises to 179.21 g/kg at 100 cm spacing, showing a significant increase compared to lower application rates and narrower spacing. This suggests that organic matter enhances P availability by increasing microbial activity in the soil, which helps to solubilize phosphorus and make it more accessible to plant roots (Dantata *et al.,* 2016a and b).

The highest P content (188.12 g/kg) is observed at 12CO+3PODS with 100 cm spacing, reflecting that both high levels of organic matter and wide spacing are critical for maximizing phosphorus uptake. The increase in P with higher COPODs rates is consistent across all spacing treatments, but the most pronounced gains are seen at wider spacing (100 cm). The trend here is similar to N: higher rates of COPODs combined with wider spacing result in significantly improved P content in watermelon fruits. P is essential for energy transfer in plants, playing a key role in root development, flowering, and fruit formation. The results indicate that applying COPODs not only increases the P content in watermelon fruits but also enhances the efficiency of phosphorus uptake when combined with wider spacing. Organic matter improves soil structure and P solubility, while wider spacing allows plants to explore a greater soil volume for nutrient uptake. This further means that optimizing both organic fertilizer application and plant spacing can significantly boost P content in watermelon, leading to better root growth and overall plant health. This can be particularly beneficial in P-deficient soils, where organic amendments can help unlock unavailable P (Oyenuga and Fetuga, 1975; Aguyoh *et al.,* 2010; Dantata, 2014).

K content is lowest without COPODs (0 t/ha), ranging from 134.32 g/kg at 25 cm spacing to 147.17 g/kg at 100 cm spacing. Even at low levels of K availability, wider spacing helps improve K uptake, likely because individual plants face less competition for soil nutrients and water. As COPODs rates increase, K content rises significantly. At 4CO+1PODS, K content reaches153.4 g/kg at 100 cm spacing, showing a notable increase compared to the 25 cm spacing treatment (140.46 g/kg). This suggests that the organic matter enhances K availability by improving soil structure, which facilitates better water retention and nutrient exchange in the root zone. At the highest rate of COPODs application (12CO+3PODS), K content reaches its peak at 185.68 g/kg at 100 cm spacing. This is the highest K content recorded across all treatments, reflecting the combined benefits of high organic matter input and wider plant spacing. Wider spacing ensures that the available K is efficiently absorbed by each plant. Similar to N and P, K content increases progressively with higher COPODs rates and wider spacing, underscoring the importance of both factors in maximizing nutrient uptake. K is a critical nutrient for plant water regulation, enzyme activation, and fruit quality (firmness, sweetness). The results suggest that higher rates of COPODs, combined with wider plant spacing, lead to significant improvements in K content. Organic matter from poultry droppings enhances soil K availability, while wider spacing reduces competition and allows plants to access more K for optimal growth (Oyenuga and Fetuga, 1975; Aguyoh *et al.,* 2010; Dantata, 2013).

Table 5 presents the interaction between COPODs and variety on the N, P, and K contents of irrigated watermelon fruits. Across all varieties, the application of COPODs increases N content significantly. Without COPODs (0 t/ha), N content is highest in the Koalack variety (13.780 g/kg) and lowest in Paradise (8.815 g/kg), suggesting inherent differences in N uptake among varieties even in nutrient-limited conditions. At the lowest COPODs rate (4CO+1PODS), N content improves across all varieties, with Koalack still having the highest N content (13.932 g/kg) and Paradise remaining the lowest (9.550 g/kg). This indicates that while COPODs improve N availability, the variety still plays a crucial role in determining how effectively plants absorb N. As the rate of COPODs increases to 8CO+2PODS and 12CO+3PODS, N content continues to rise across all varieties. At the highest rate (12CO+3PODS), N content reaches a maximum of 15.562 g/kg in Koalack and 11.193 g/kg in Paradise. The results indicate that Koalack responds more positively to higher rates of COPODs, absorbing more N compared to the other varieties. The difference in N uptake between varieties, even at the same COPODs rate, suggests that genetic differences in root structure, nutrient use efficiency, or growth rate may be influencing N uptake. The results confirmed that applying COPODs improves N content in watermelon fruits, but the degree of improvement depends on the variety. Koalack appears to have the highest N uptake potential, making it the most responsive variety to COPODs application. Paradise, on the other hand, shows the least improvement in N content. These differences suggest considerations both for rate of organic fertilizer application and specific cultivable variety to optimize N uptake and fruit quality.

P content follows a similar trend to nitrogen, with Koalack consistently having the highest phosphorus content across all COPODs treatments, while Paradise has the lowest. Without COPODs, P content in Koalack is 157.17 g/kg, compared to only 111.44 g/kg in Paradise, again reflecting the inherent differences in nutrient uptake between varieties. As COPODs rates increase, P content improves significantly across all varieties. At 4CO+1PODS, P content rises to 160.2 g/kg in Koalack and 117.05 g/kg in Paradise. At the highest rate (12CO+3PODS), P content reaches a maximum of 191.86 g/kg in Koalack and 140.50 g/kg in Paradise. This trend shows that while the application of COPODs enhances phosphorus availability, the response is variety-dependent. Koalack shows the greatest improvement in P content, while Paradise consistently lags behind. P is critical for root development, energy transfer, and fruit formation. The results suggest that applying COPODs increases P content in watermelon fruits, but the magnitude of this increase depends on the variety. Koalack again appears to be the most efficient at absorbing P, while Paradise is the least responsive. This means that farmers should carefully select watermelon varieties when applying organic fertilizers to ensure optimal P uptake and improved fruit quality (Oyenuga and Fetuga, 1975; Aguyoh *et al.,* 2010; Dantata *et al.,* 2016a).

K content is highest in Koalack across all COPODs treatments, while Royal sweet and Paradise tend to have lower potassium content. Without COPODs, K content is 174.50 g/kg in Koalack and 136.17 g/kg in Royal sweet. In the absence of organic amendments, Koalack again shows a superior ability to uptake K compared to the other varieties. As COPODs rates increase, K content rises across all varieties. At 4CO+1PODS, K content reaches 178.15 g/kg in Koalack and 137.28 g/kg in Royal sweet, reflecting the beneficial effects of organic matter on K availability. At the highest rate of COPODs (12CO+3PODS), K content peaks at 188.35 g/kg in Koalack, while the lowest K content is observed in Royal sweet (149.18 g/kg) at the same rate. This shows that Koalack not only absorbs more K but also responds more positively to higher rates of COPODs. Paradise, while initially having moderate K levels, shows a more consistent increase in K content as COPODs rates rise, reaching 171.61 g/kg at 12CO+3PODS. This suggests that Paradise, although less efficient in N and P uptake, responds better to K supplementation.

K is important for regulating water movement in plants, enzyme activation, and fruit quality (especially sweetness and firmness). The results indicate that applying COPODs increases K content in watermelon fruits, with Koalack showing the highest K uptake across all COPODs rates. Royal sweet and Sugar baby varieties appear to be less responsive to K supplementation from COPODs.Variety selection is important when aiming to improve K content and fruit quality in watermelons. Koalack appears to be the best choice for maximizing K content and ensuring high-quality fruits. The results demonstrate that the uptake of N, P, and K is significantly influenced by both the application of COPODs and the variety of watermelon being grown. Koalack consistently outperforms the other varieties in terms of nutrient uptake, making it the most responsive to organic fertilization with COPODs. Paradise, on the other hand, shows the lowest nutrient content across all three nutrients, particularly N and P, suggesting that it may require higher fertilizer inputs or specific management practices to improve its nutrient uptake efficiency (Ewulo *et al.,* 2008; Dantata, 2014).

The interaction between COPODs and variety indicates that nutrient management strategies should be tailored to the specific variety being cultivated. For instance, varieties like Koalack may require less intensive fertilization compared to Paradise or Royal sweet, which show lower nutrient uptake efficiency. Farmers growing Paradise or Royal sweet may need to apply higher rates of organic fertilizers or incorporate other soil amendments to improve nutrient availability and uptake.The results underscore the importance of integrating variety selection with organic fertilization strategies. Farmers aiming to improve the nutrient content and quality of watermelon fruits should consider both the rate of organic fertilizer application (COPODs) and the variety being grown. Varieties like Koalack may offer better nutrient use efficiency, resulting in higher yields and better fruit quality, while other varieties may require more intensive management to achieve similar results (Dantata *et al.,* 2016a and b).

Interaction between varieties and planting spacings on the N, P, and K contents in watermelon fruits (Table 6) shows that Koalack gave the highest N content across all spacings, with the highest value of 16.647 g/kg at the widest spacing (100 cm). As the spacing widens, N content in Koalack gradually increases. This suggests that Koalack benefits from more space, likely due to reduced competition for soil nutrients and better root development. Sugar baby has moderate N content, ranging from 11.758 g/kg (25 cm spacing) to 12.898 g/kg (100 cm spacing). Similar to Koalack, N content increases with wider spacing, though the increase is less pronounced. Royal Sweet shows the least variation in N content across spacings, ranging from 11.648 g/kg (25 cm spacing) to 11.737 g/kg (100 cm spacing). The small change in N content suggests that this variety may not be as sensitive to planting density. Paradise has the lowest N content, starting at 10.617 g/kg (25 cm spacing) and increasing to 11.673 g/kg (100 cm spacing). Although N content improves with wider spacing, Paradise consistently lags behind other varieties. The results indicate that spacing plays a significant role in N uptake, with wider spacings generally leading to higher N content. This is particularly true for Koalack, which shows the greatest improvement in N content with wider spacing, suggesting that this variety benefits from reduced plant competition. In contrast, Royal sweet and Paradise show less response to changes in spacing, implying that they may not require as much space for optimal N uptake. Farmers growing Koalack may consider using wider spacing to maximize nitrogen content and improve fruit quality (Ewulo *et al.,* 2008).

Koalack again shows the highest P content, particularly at the widest spacing (100 cm), where P content reaches 256.46 g/kg. This is a dramatic increase compared to the narrower spacings, where P content ranges from 156.46 g/kg (25 cm spacing) to 162.93 g/kg (75 cm spacing). The sharp rise in P content at 100 cm spacing suggests that wider spacing allows Koalack to access more P in the soil. Sugar baby shows moderate P content, with values ranging from 155.75 g/kg (25 cm spacing) to 169.46 g/kg (100 cm spacing). Like Koalack, Sugar baby benefits from wider spacing, though the increase in P content is not as dramatic. Royal sweet shows lower P content overall, with values ranging from 133.96 g/kg (25 cm spacing) to 166.46 g/kg (100 cm spacing). Although P content increases with wider spacing, Royal sweet consistently has lower P content than Koalack and Sugar baby. Paradise has the lowest P content, particularly at the narrowest spacing (25 cm), where P content is only 116.46 g/kg. However, as spacing increases, P content improves, reaching 161.46 g/kg at 100 cm. This suggests that Paradise, while less efficient at absorbing P at narrow spacings, benefits from wider spacing. P content increases with wider spacing, particularly for Koalack, which shows a dramatic improvement at 100 cm spacing. This suggests that wider spacing reduces competition for P, allowing plants to absorb more of this essential nutrient. For Royal sweet and Paradise, P content is lower overall, but these varieties still show improvement with increased spacing. Farmers aiming to optimize P content, particularly when growing Koalack, should consider wider spacing to enhance P availability and uptake (Ewulo *et al.,* 2008).

Koalack exhibits the highest K content across all spacings, with a peak value of 174.97 g/kg at the widest spacing (100 cm). Like N and P, K content in Koalack increases as spacing widens, suggesting that this variety benefits from reduced competition for potassium. Sugar baby shows moderate K content, with values ranging from 161.00 g/kg (25 cm spacing) to 166.72 g/kg (100 cm spacing). The increase in K content with wider spacing is less pronounced compared to Koalack. Royal sweet has relatively low K content, ranging from 136.47 g/kg (25 cm spacing) to 164.81 g/kg (100 cm spacing). While K content improves with wider spacing, Royal sweet lags behind Koalack and Sugar baby in terms of K uptake. Paradise shows the lowest K content, particularly at the narrowest spacing (25 cm), where K content is only 113.97 g/kg. As spacing increases, K content improves, reaching 161.47 g/kg at 100 cm spacing. This indicates that Paradise, while initially poor in K uptake, benefits from wider spacing. K content increases with wider spacing across all varieties, with Koalack showing the most significant improvement. The results suggest that Koalack is the most efficient variety in K uptake, particularly when grown at wider spacings. Sugar baby and Royal sweet show moderate K content, while Paradise has the lowest K uptake but still benefits from wider spacing. Maximize K content in watermelon fruits should consider using wider spacing, especially for varieties like Koalack (Dantata, 2014).

The results show that both variety and spacing significantly influence the nitrogen, phosphorus, and potassium content in watermelon fruits. Koalack consistently has the highest nutrient content across all spacings, particularly at the widest spacing (100 cm), where nutrient content is significantly higher compared to the other varieties. This suggests that Koalack benefits the most from reduced competition for nutrients when given more space to grow. Sugar baby shows moderate nutrient content, while Royal sweet and Paradise tend to have lower nutrient content, especially at narrower spacings. However, all varieties show improvement in nutrient content as spacing increases, indicating that wider spacing generally benefits nutrient uptake. The consistent increase in nutrient content with wider spacing across all varieties suggests that reducing plant density allows for better nutrient absorption by reducing competition for soil nutrients. Koalack, in particular, shows a dramatic improvement in phosphorus and potassium content at the widest spacing, making it the most responsive variety to spacing adjustments. For varieties like Koalack, wider spacing (100 cm) is likely to maximize nitrogen, phosphorus, and potassium content, leading to better fruit quality. For varieties like Royal sweet and Paradise, while nutrient uptake is lower overall, wider spacing still provides some benefits in terms of improved nutrient absorption. For need to adjust spacing based on the specific variety being grown to achieve the best balance between nutrient uptake and land use efficiency (Ewulo *et al.,* 2008; Dantata, 2014).

Profitability

Profitability analysis based on different treatments (Table 7) revealed a positive effect on both yield and profit as the treatment levels increased. At 0 t/ha (Control) treatment, where no compost was applied, yielded 26.65 t/ha, generating a revenue of ₦2,132,000, with total costs amounting to ₦523,000. The profit was ₦1,609,000. This represents the baseline for comparison.

At 4CO+1PODs, yield increased to 31.19 t/ha, with a revenue of ₦2,495,520 and a profit of ₦1,802,520. The application of 4 t/ha of compost resulted in an additional profit of ₦193,520 compared to the control. The compost treatment costs (₦170,000) increased the total costs, but the increase in yield made the treatment profitable. With 8CO+2PODs, the yield further increased to 35.01 t/ha, generating a revenue of ₦2,801,040 and a profit of ₦1,938,040. This level of compost application added more to the treatment cost (₦340,000), but the higher yield compensated for the increased cost, making it the most profitable treatment among the COPODS treatments. At the highest level of compost application (12CO+3PODs), the yield was 36.44 t/ha, producing a revenue of ₦2,914,960 and a profit of ₦1,881,960. Although this treatment resulted in the highest yield, the treatment costs (₦510,000) significantly increased, which led to a slight reduction in profit compared to the 8CO+2PODs treatment. The application of COPODs enhanced the yield and profitability, with the 8CO+2PODs treatment yielding the highest profit (₦1,938,040). These results are consistent with the findings of Sanders *et al.* (1999), who reported that organic fertilizers improve soil fertility, leading to higher yields and profits. However, beyond a certain level (12CO+3PODs), the increase in yield did not significantly offset the additional costs, demonstrating diminishing returns, a phenomenon also discussed by Sandeep and Kumar (2015) in organic farming practices.

Different plant spacings (25, 50, 75, and 100 cm) were tested to assess their impact on yield and profitability. At 25 cm spacing, yield was 28.09 t/ha, revenue ₦2,247,280, and profit ₦1,574,280. This tighter spacing increased plant competition, likely limiting optimal growth. Spacing of 50 cm slightly improved yield to 28.31 t/ha, generating a profit of ₦1,616,960. The treatment cost was lower than the 25 cm spacing, contributing to a marginally better profit. Yield significantly increased to 35.71 t/ha, revenue ₦2,856,800, and profit ₦2,233,800 at 75 cm Spacing. The wider spacing allowed better access to nutrients and sunlight, boosting yield. The widest spacing of 100 cm, yielded 37.19 t/ha, with a profit of ₦2,377,520, the highest profit observed among the spacing treatments. The wider spacing likely reduced competition, enhancing overall plant growth. The profitability results demonstrate that wider spacing (100 cm) resulted in the highest yield and profit, aligning with findings by Dantata (2014), who showed that wider plant spacing reduces competition for resources like water and nutrients, allowing individual plants to reach their full potential. This strategy maximizes yields and profits, making it the most efficient spacing choice for watermelon cultivation in this context (Anon 2008; Dantata, 2014).

Variety Koalack, produced a yield of 32.84 t/ha, revenue of ₦2,627,040, and a profit of ₦2,034,040. This was the most profitable variety. Sugar baby yield was 32.66 t/ha, revenue ₦2,613,040, and profit ₦2,020,040, only slightly lower than Koalack. Royal sweet yield was 32.39 t/ha, revenue ₦2,591,520, and profit ₦1,998,520. The lowest yielding variety at 31.40 t/ha, with a profit of ₦1,919,000 is Paradise. Among these varieties, Koalack had the highest yield and profit, followed closely by Sugar baby and Royal sweet. These results indicate that genetic differences between watermelon varieties influence their productivity, as seen in similar studies by Scott *et al.* (1993), which emphasized that certain varieties have better nutrient-use efficiency and adaptability to local conditions (Scott *et al.,* 1993). Selecting the right variety, such as Koalack (Dantata, 2014), is essential for maximizing profitability (Scott *et al.,* 1993;Taylor *et al.,* 2003).

IV. Conclusion

The study conducted in Gashua emphasizes the importance of continued organic inputs to sustain soil fertility and crop productivity. COPOD applications positively influenced phosphorus availability and slightly buffered soil acidity, but declines in organic carbon, nitrogen, and CEC indicate the need for sustainable soil management practices, such as incorporating biochar or similar materials that decompose more slowly. The combined effects of COPOD levels, plant spacing, and variety selection significantly influenced the nutrient content and profitability of watermelon fruits. The combination of 12t+3t COPOD with 100 cm spacing yielded the highest nutrient content, emphasizing the value of optimizing both organic inputs and plant spacing to achieve sustainable production. The findings support the adoption of organic fertilizers and broader plant spacing to improve watermelon quality, yield, and economic viability.

V. Recommendations

Based on the findings of this study, the following recommendations are proposed for optimizing watermelon production in the study area:

i. Optimize organic fertilizer application:

To improve soil fertility and crop yield sustainably, farmers should adopt moderate levels of organic fertilizer application, specifically the 8t+2t COPODs rate. This level of application provides sufficient nutrients for plant growth without leading to diminishing economic returns, making it a cost-effective choice for enhancing fruit quality yield.

ii. Adopt wider plant spacing:

Wider spacing (100 cm) between plants is recommended to reduce competition for nutrients, light, and water, which supports improved fruit quality and increased nutrient uptake. This spacing maximizes the performance of each plant, making it a suitable approach for semi-arid regions where resources are often limited.

iii. Select high-yield, nutrient-efficient varieties:

Producers are encouraged to cultivate watermelon varieties with proven nutrient efficiency, such as Koalack. This variety consistently demonstrated superior nutrient uptake and yield potential, which translates to higher profitability. Choosing nutrient-efficient varieties can help farmers achieve better economic returns while maintaining soil fertility.

iv. Incorporate long-lasting organic matter:

To counteract the rapid decomposition of organic matter in semi-arid climates, the inclusion of slow-decomposing organic materials, such as biochar, is recommended. These materials can improve soil structure, increase cation exchange capacity (CEC), and help retain essential nutrients in the soil, contributing to long-term soil health.

v. Monitor and adjust nutrient management strategies:

Given the dynamic nature of soil and environmental conditions in semi-arid regions, regular soil testing is recommended to monitor nutrient levels and adjust fertilizer applications accordingly. This practice will allow farmers to tailor their nutrient management to actual soil needs, reducing waste and preventing potential nutrient depletion.

vi. Enhance knowledge of sustainable intensification practices:

Agricultural extension services should focus on educating farmers about the benefits of balanced organic fertilization, proper plant spacing, and variety selection. Training programs can emphasize the economic and environmental benefits of these practices, thereby encouraging broader adoption of sustainable intensification in semi-arid regions.

vii. Explore market opportunities for nutrient-rich produce:

Since watermelons grown under optimized organic and spacing conditions have higher nutrient content, farmers should consider marketing their produce as high-quality or premium-grade. Establishing connections with markets willing to pay higher prices for nutrient-rich watermelons can increase profitability and support the economic resilience of local farmers.

By following these recommendations, watermelon farmers in Gashua and related ecologies can improve productivity, enhance fruit quality yield, and increase profitability, while also promoting sustainable agricultural practices that safeguard soil health for future generations.

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Table 1: Soil analysis of the experimental site before and after experiment in Gashua community based-demonstration farm at 0-30 cm depth during the 2016 dry season

Soil parameters	0-30 cm depth	
	Before experiment	After experiment
Particle size distribution (g kg^{-1})		
Sand	477.5	483.2
Silt	215.3	212.7
Clay	307.2	304.1
Texture	Clay loam	Clay loam
Chemical composition		
Soil pH 1:2 (H_2O)	5.17	5.24
Organic carbon (g kg^{-1})	0.71	0.38
Total nitrogen (g kg^{-1})	0.09	0.06
Available phosphorus (mg kg^{-1})	11.67	13.17
CEC [C mol (+) kg^{-1}]	20.14	16.25
Exchangeable bases [C mol (+) kg^{-1}]		
Ca	3.29	2.58
Mg	0.94	0.68
K	0.26	0.21
Na	0.16	0.12
Fe	7.71	6.86
Cu	0.27	0.19
Mn	6.33	4.75
Bo	0.28	0.19
Mb	0.17	0.13
Zn	0.73	0.54

Table 2: Average fruit yield (t/ha) harvested treatment-wise in Gashua during the 2016/17 dry season

COPODS (t/ha)	Fruit yield (t/ha)	Spacing (cm)	Fruit yield (t/ha)	Variety	Fruit yield (t/ha)
0	26.650	25	28.091	Koalack	32.838
4CO+1PODS	31.194	50	28.312	Sugar baby	32.663
8CO+2PODS	35.013	75	35.706	Royal sweet	32.394
12CO+3PODS	36.437	100	37.194	Paradise	31.400

Table 3: Effect of COPODs, spacing and variety on nitrogen (gkg^{-1}), phosphorus (gkg^{-1}) and potassium(gkg^{-1}) contents of watermelon fruit in Gashua during the 2016/17 dry seasons

Treatments	Nitrogen (gkg^{-1})	Phosphorus (gkg^{-1})	Potassium (gkg^{-1})
COPODS (t/ha)			
0	9.829d	122.35d	141.96d
4CO+1PODS	13.076c	170.19c	149.33c
8CO+2PODS	13.363b	174.47b	163.37b
12CO+3PODS	14.342a	179.29a	181.80a
LS	*	*	*
SE±	0.000	0.000	0.000
Spacing (cm)			
25	11.425d	155.09d	150.42d
50	12.835c	157.52c	159.59c
75	12.920b	161.45b	162.65b
100	13.430a	172.22a	163.79a
LS	*	*	*
SE±	0.000	0.000	0.000
Variety			
Koalack	13.870a	182.38a	166.16a
Sugar baby	12.306b	162.19b	163.08b
Royal sweet	12.236c	151.41c	155.10c
Paradise	12.198d	150.30d	152.12d
LS	*	*	*
SE±	0.000	0.000	0.000
Interactions			
CPDS* Spac	*	*	*
CPDS* Var	*	*	*
Spac* Var	*	*	*
C* Spac* Var	NS	NS	NS

In a column, means followed by same letter are not significantly different at 5% probability level by DMRT LS. Level of significant *Significant NS. Not significant

Table 4: Interaction between COPODs and spacing (cm) on nitrogen(gkg^{-1}), phosphorus(gkg^{-1}) and potassium (gkg^{-1}) contents of watermelon fruit in Gashua during the 2016/17 dry season

Treatments	Nitrogen (gkg^{1}) contents			
	Spacing (cm)			
	25	50	75	100
COPODS (t/ha)				
0	8.748o	10.005n	10.128m	10.438l
4CO+1PODS	11.807k	13.117i	13.312h	13.938e
8CO+2PODS	12.027j	13.477g	13.538f	14.408d
12CO+3PODS	13.117i	14.458c	14.545b	15.247a
SE±	0.000			
Treatments	Phosphorus (gkg^{-1}) contents			
	Spacing (cm)			
	25	50	75	100
COPODS (t/ha)				
0	115.09p	115.74o	120.70n	137.85m
4CO+1PODS	163.95l	166.76k	170.82i	179.21d
8CO+2PODS	168.45j	171.63h	174.07f	183.71b
12CO+3PODS	172.86g	175.93e	180.23c	188.12a
SE±	0.000			
Treatments	Potassium (gkg^{-1}) contents			
	Spacing (cm)			
	25	50	75	100
COPODS (t/ha)				
0	134.32p	141.70n	144.64m	147.17l
4CO+1PODS	140.46o	150.18k	153.28j	153.4i
8CO+2PODS	154.09h	163.45g	166.87f	169.06e
12CO+3PODS	172.82d	183.04c	185.65b	185.68a
SE±	0.000			

In a column, means followed by same letter are not significantly different at 5% probability level by DMRT SE± Standard error of the difference

Table 5: Interaction between COPODs and variety on nitrogen(gkg^{-1}), phosphorus(gkg^{-1}) and potassium(gkg^{-1}) contents of watermelon fruit in Gashua during the 2016/17 dry season

Treatments	Nitrogen (gkg^{1}) contents			
	Variety			
	Koalack	Sugar baby	Royal sweet	Paradise
COPODS (t/ha)				

0	13.780f	12.837j	12.570l	8.815p
4CO+1PODS	13.932e	13.025h	12.623k	9.550o
8CO+2PODS	14.092d	13.115g	12.860i	9.760n
12CO+3PODS	15.562a	14.473b	14.253c	11.193m
SE±	0.000			
Treatments	Phosphorus (gkg^{-1}) contents			
	Variety			
	Koalack	Sugar baby	Royal sweet	Paradise
COPODS (t/ha)				
0	157.17l	160.42j	166.58h	111.44p
4CO+1PODS	160.2k	164.84i	169.15g	117.05o
8CO+2PODS	171.50f	176.24e	180.65d	120.39n
12CO+3PODS	191.86c	196.36b	200.77a	140.50m
SE±	0.000			
Treatments	Potassium (gkg^{-1}) contents			
	Variety			
	Koalack	Sugar baby	Royal sweet	Paradise
COPODS (t/ha)				
0	174.50d	142.13n	136.17p	155.66h
4CO+1PODS	178.15c	145.88l	137.28o	159.09g
8CO+2PODS	186.19b	153.83k	145.19m	167.10f
12CO+3PODS	188.35a	155.48i	149.18j	171.61e
SE±	0.000			

In a column, means followed by same letter are not significantly different at 5% probability level by DMRT
SE± Standard error of the difference

Table 6: Interaction between variety and spacing on nitrogen(gkg^{-1}), phosphorus(gkg^{-1}) and potassium(gkg^{-1}) contents of watermelon fruit in Gashua during the 2016/17 dry season

Treatments	Nitrogen (gkg^{1}) contents			
	Spacing (cm)			
	25	50	75	100
Variety				
Koalack	13.848d	14.308c	15.548b	16.647a
Sugar baby	11.758g	12.668g	12.873f	12.898e
Royal sweet	11.648m	11.685k	11.697j	11.737i
Paradise	10.617p	11.250o	11.588n	11.673l
SE±	0.000			
Treatments	Phosphorus (gkg^{-1}) contents			
	Spacing (cm)			
	25	50	75	100
Variety				
Koalack	156.46j	159.96f	162.93d	256.46a
Sugar baby	155.75l	156.56h	160.36f	169.46b
Royal sweet	133.96m	156.51i	159.46g	166.46c
Paradise	116.46n	156.34k	156.51i	161.46e
SE±	0.000			
Treatments	Potassium (gkg^{-1}) contents			
	Spacing (cm)			
	25	50	75	100
Variety				
Koalack	165.37d	166.47c	166.72b	174.97a
Sugar baby	161.00l	162.43g	164.47f	166.72b
Royal sweet	136.47m	161.57i	161.78h	164.81e
Paradise	113.97n	161.42k	161.47j	161.47j
SE±	0.000			

In a column, means followed by same letter are not significantly different at 5% probability level by DMRT
SE± Standard error of the difference

Table 7: Profitability analysis of watermelon in Gashua during the 2016/17 dry season

Treatments	Profitability analysis							
COPODs (t/ha)	NOS(kg)/ha	SC(₦)	TtC (₦)	LC (₦)	Y(t/ha)	R (₦/ha)	TC (₦)	Profit (₦)
0	2.0	38,000	0	135000	26.650	2,132,000	523000	1,609,000
4CO+1PODS	2.0	38,000	170,000	135000	31.194	2,495,520	693000	1,802,520
8CO+2PODS	2.0	38,000	340,000	135000	35.013	2,801,040	863000	1,938,040
12CO+3PODS	2.0	38,000	510,000	135000	36.437	2,914,960	1,033,000	1,881,960
Spacing (cm)								
25	2.0	38,000	150,000	135000	28.091	2,247,280	673000	1,574,280
50	2.0	38,000	125,000	135000	28.312	2,264,960	648000	1,616,960
75	2.0	38,000	100,000	135000	35.706	2,856,800	623000	2,233,800

100	2.0	38,000	75,000	135000	37.194	2,975,520	598000	2,377,520
Variety								
Koalack	2.0	38,000	70,000	135000	32.838	2,627,040	593000	2,034,040
Sugar baby	2.0	38,000	70,000	135000	32.663	2,613,040	593000	2,020,040
Royal sweet	2.0	38,000	70,000	135000	32.394	2,591,520	593000	1,998,520
Paradise	2.0	38,000	70,000	135000	31.400	2,512,000	593000	1,919,000

NOS. No of Seeds LC. Labour Cost TC. Total Costs SC. Seed Cost Y. Yield (t/ha) TtC. Treatments Cost
R. Revenue

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