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Growth and Yield Response of Maize (*Zea mays* L.) to Slow-Release Organo-Mineral Fertilizer Formulations in the Sudan Savannah of Nigeria

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Abstract

A field experiment was conducted during the 2026 dry season at the Dryland Teaching and Research Farm of Usmanu Danfodiyo University, Sokoto, to evaluate the response of maize (*Zea mays* L.) variety Oba Super 11 to slow-release organo-mineral fertilizer (SROMF) formulations under the Sudan Savannah agro-ecological zone of Nigeria. The study was laid out in a Randomized Complete Block Design (RCBD) with five fertilizer treatments: (i) mineral fertilizer (NPK 20:10:10), (ii) NPK SROM fertilizer (20:10:10), (iii) NPK SROM fertilizer (15:10:10), (iv) NPK SROM fertilizer (12:6:6), and (v) a control (no fertilizer), replicated three times. Data were collected on growth and yield parameters. Results showed that fertilizer treatments significantly ($p \leq 0.05$) influenced all growth and yield parameters measured. At 9 weeks after sowing (WAS), the tallest plants (181.5 cm) were recorded under NPK organo-mineral fertilizer (12:6:6), while the shorter plants (83.1 cm) were recorded in the control plot. Grain yield was highest in NPK SROM fertilizer (20:10:10), producing 6.6 t ha^{-1}, followed by the mineral fertilizer treatment (5.5 t ha^{-1}), while the control had the lowest yield (1.1 t ha^{-1}). Similarly, the highest dry matter yield (6.6 t ha^{-1}) was obtained from the NPK SROM fertilizer (20:10:10) treatment. The study concludes that slow-release organo-mineral fertilizers significantly enhanced efficient nutrient utilization and in turn improved growth and yield performance of maize under Sudan Savannah conditions, with the NPK SROM fertilizer (20:10:10) formulation showing superior grain yield performance and is therefore recommended as a sustainable nutrient management strategy for improving maize productivity while potentially reducing nutrient losses under different soil textural classes.

Keywords: Maize, Oba Super 11, Organo-Mineral Fertilizer, Slow-Release Fertilizer, Sudan Savannah, Nigeria.

Introduction

Slow-release organo-mineral fertilizers play a significant role in sustainable soil fertility management by integrating the advantages of nutrients from organic and mineral sources into a single formulation (Adediran *et al*., 2003). The organic component improves soil physical properties such as aggregation, porosity, and water-holding capacity, while also stimulating microbial activity and nutrient cycling (Singh *et al*., 2024). The mineral fraction provides readily available essential nutrients required for immediate plant uptake (Sahu *et al*., 2017). This combined action enhances nutrient synchrony with crop demand, reduces nutrient losses through leaching and volatilization, and improves overall nutrient use efficiency in crop production systems (Singh *et al*., 2025). Studies have shown that organo-mineral fertilizers can significantly improve soil fertility status and crop performance compared to sole application of inorganic fertilizers, particularly in nutrient-depleted tropical soils (Adediran *et al.,* 2003; Anetor & Omueti, 2014; Singh *et al*., 2024).

In addition to improving agronomic performance, slow-release organo-mineral fertilizers contribute to environmental protection by minimizing nutrient runoff and reducing groundwater contamination associated with excessive use of conventional mineral fertilizers (Bationo *et al*., 2018). Their slow-release nature ensures a more gradual and sustained nutrient supply throughout the crop growth period, which is particularly beneficial for high-demand cereal crops such as maize (Haider *et al.,* 2023). This approach supports sustainable intensification by increasing productivity while maintaining soil health and reducing ecological risks. In sub-Saharan Africa, research has demonstrated that integrated nutrient management practices involving organo-mineral fertilizers can significantly enhance maize yield and improve fertilizer efficiency under rainfed conditions (Bationo *et al*., 2018). Conventional mineral fertilizers such as NPK 20:10:10 are commonly used to improve crop productivity. However, their efficiency is often limited due to nutrient losses through leaching, volatilization, runoff, and fixation in the soil (Bakar *et al*., 2025). These losses not only reduce fertilizer use efficiency but also increase production costs and contribute to environmental problems. The current high cost of inorganic fertilizers occasioned by the Russia-Ukraine war globally and the high cost of organic fertilizers due to high cost of animal feeds in addition to cattle rustling in most states of northern Nigeria calls for judicious use of fertilizers in crop production. The production of slow – release organo-mineral compound fertilizers could minimize production cost and lead to increase profit by smallholder farmers. This will lead to improved livelihood of the farming communities as well as a reduction in greenhouse gas

emission resulting from continuous fertilizer application to meet crop requirements.

Slow release fertilizers (SRFs) are products that are able to supply plants with nutrients for a period of several weeks that offers numerous advantages such as: nutrient availability, reduced fertilizer applications and risk of nutrient runoff and leaching (Alumtari, 2023). Global fertilizer industry has been working to develop new fertilizers called controlled-release fertilizers (CRFs) and slow-release fertilizers (SRFs) (Lawrencia *et al*., 2021). These fertilizers have become more and more popular in recent years (Seddighi *et al*., 2024). However, these fertilizers are currently not available in many developing countries in Sub-Saharan Africa especially in Nigeria. A number of materials are used to improve the nutrient release capacity of both organic and inorganic fertilizer leading to controlled release or slow release nature of these fertilizers.

For example, neem tree (*Azadirachta indica)*, which grows in many parts of Nigeria, is used as nitrification inhibitor, insect repellent, antimicrobial potential and also used for the production of neem coated urea (NCU) (Wylie and Merrell, 2022). A lac coated urea (LCU) was developed by the Indian Lac Research Institute, Ranchi. Singh *et al.* (1999) showed improved yields of LCU over urea in rice-wheat cropping systems. The use limestone and high activity clays (HAC) in granulating organo-mineral compound fertilizers could offer great potential in improving soils with sandy textures. Sharif *et al.* (2022) reported remarkable improvement in the CEC of the soils amended with high activity clays in irrigated rice production. In response to these challenges, three slow-release organo-mineral fertilizers were formulated as a sustainable alternative to conventional fertilizers and were evaluated on an improved maize hybrid (Oba Super 11). These fertilizers combined organic materials with inorganic nutrient sources, enabling a gradual release of nutrients that better matches crop demand throughout the growth cycle.

Maize (*Zea mays* L.) is one of the most important cereal crops in the world, serving as a staple food, livestock feed, and raw material for several agro-industries (Kumar and Bhatt, 2012). In sub-Saharan Africa, maize plays a central role in food security and rural livelihoods due to its wide adaptability, high yield potential, and multiple uses (Wang and Zhang, 2024). In Nigeria, maize is cultivated across different agro-ecological zones, with the Sudan Savannah zone contributing significantly to national production. Despite its importance, maize productivity in the Sudan Savannah agro-ecological zone of Nigeria remains below its genetic potential due to declining soil fertility, poor nutrient management practices, and inefficient fertilizer use (Jandong, 2023).

To address yield limitations, improved maize varieties such as Oba Super 11 have been developed and widely adopted by farmers in Nigeria. Oba Super 11 is a high-yielding hybrid maize variety known for its early maturity, good grain quality, and adaptability to diverse environmental conditions. However, despite its genetic potential, the productivity of Oba Super 11 is still constrained by suboptimal soil fertility and inefficient fertilizer utilization, particularly in the Sudan Savannah zone (Adnan *et al*., 2022; Aboderin *et al*., 2024).

In view of the above, this study was therefore conducted to evaluate the nutrients management as well as it`s utilization efficiency by the tested maize variety under the formulated slow release organo-mineral fertilizers as compared to the conventional mineral fertilizer in the study area. Generating such information is essential for developing sustainable fertilizer recommendations that can enhance maize productivity while minimizing environmental degradation.

MATERIALS AND METHODS

Study Area

The experiment was conducted during 2026 dry season at the Dryland Teaching and Research Farm, Faculty of Agriculture, Usmanu Danfodiyo University, Sokoto, located at Latitude: 13° 56'N, Longitude: 5° 15'E and an altitude of 350m above sea level. Sokoto State falls within the Sudan Savannah agro-ecological zone characterized by semi-arid climate conditions involving alternative wet and dry season (Alhassan *et al*., 2024). The area received an annual rainfall commencing between mid-May to early June reaching its peak at August, with the hottest months as March and April while coolest months are from November to January which is characterized by harmattan wind. The relative humidity of 40.7%, average annual temperature of 28.3 °C and average annual rainfall of about 629 mm (NiMet, 2024).

Treatments and Experimental Design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with five fertilizer treatments replicated three times. Treatments included: Mineral Fertilizer (NPK 20:10:10) Slow-release organo-mineral fertilizers formulated at (20:10:10), (15:10:10) and (12:6:6) and control (no fertilizer). The Fertilizers were applied at the recommended rate (NPK 120:60:60kg NPK/ha^{-1}) for Maize in Sudan Savanna agroecological zones of Nigeria. The experimental area consisted of three (3) blocks, with each block containing 15 plots measuring 3m × 2m (6m²). Blocks were separated 1m apart and 0.5m between the plots.

Fertilizer Formulations

The formulation integrates both organic and inorganic sources to achieve a staggered nutrient release profile as follows:

Poultry droppings and Neem seed provided organic-bound nitrogen and micronutrients, which mineralize gradually over time. Similarly, the neem contribute substances that lowers the rate of nitrification. Urea and DAP offer readily available N and P for immediate crop uptake, while SRP ensures a sustained phosphorus supply due to its lower solubility. MOP delivers soluble potassium for quality and stress tolerance.

Limestone buffers soil acidity, optimizing nutrient availability. The inclusion of High Activity Clay (HAC) is critical for its high cation exchange capacity adsorbs soluble nutrients (especially NH_4^+ and K^+), reducing leaching losses and releasing them slowly in synchronization with plant demand.

The materials were grounded, homogeneously blended and into pellets.

Growth and Yield Parameters

Plant height

Plant height was taken with a meter rule (from the base to the tip of plant) at 3, 6 and 9 weeks after sowing (WAS) from the five tagged plants within the net plot. Average height was then computed and recorded as the plant height of the particular treatment plot.

Number of leaves per plant

The number of leaves per plant was counted at 3, 6 and 9weeks after sowing from the five tagged plants within the net plot. Average number counted was recorded as the number of leaves per plant.

Cob length (cm)

After harvest, cobs harvested from each tagged plants were measured with the meter rule and average cob length from each plot was recorded.

Grain Yield

This was obtained after harvesting. The grains obtained from each net plot were weighed and the grain yield was calculated using the formula reported by Soro *et al.,* (2015).

$$\text{Grain yield (t/ha)} = \frac{Grain\ weight\ (t)}{Harvested\ area(ha)}$$

Data Analysis

Data collected for growth and yield characteristics were subjected to analysis of variance (ANOVA) procedure for RCBD using Genstat 17th edition and means separation was done using Least Significant Difference (LSD) at 5% level of significance.

RESULTS AND DISCUSSION

The result of the initial soil characterization is presented in Table 1. The result revealed that the soil of the area is sandy loam and neutral in pH. Organic carbon was medium while total nitrogen and available phosphorus were low. All the exchangeable bases considered (Ca^{2+}, Mg^{2+}, Na^{2+} and K^{+}) were moderate while the calcium cation capacity (CEC) was low Esu (1991).

The low nutrients levels obtained could be attributed to continuous cultivation, farmers' dependence on mineral fertilizer with unguided application schedule. Loks *et al*. (2014), stated that the Northern Nigeria Savanna soils, as it`s the characteristic of soils of the tropics, are poor because they are highly weathered and leached over prolong period of time, with little or no fertilizer and/ or farm yard manure use. Osundare (2008) reported that one of the major constraints to crop production in the tropics is the inherent low fertility status of most of the soils, characterized by low activity clays, low levels of organic matter, nitrogen, phosphorus,

potassium and exchangeable bases. Hence, the need for sustainable soil fertility approach that will revive the productive capacity of the soil in the study area.

Table 1. Initial Soil Characterization

Parameter	Value
pH	6.70
EC dS/m	0.04
Organic carbon g/kg	7.06
N g/kg	0.49
P mg/kg	0.33
Ca cmol/kg	1.16
Mg cmol/kg	0.66
Na cmol/kg	2.01
K cmol/kg	1.82
CEC cmol/kg	6.89
Sand %	70.65
Silt %	14.46
Clay %	14.89
Textural class	Sandy loam

Effect of Slow-Release Organo-Mineral Fertilizer on Plant Height

Fertilizer application significantly influenced maize plant height at all growth stages (Table 2). At 9 WAS, the tallest plants were observed in NPK SROM fertilizer (12:6:6) treatment (181.5 cm), followed by mineral fertilizer (177.0 cm), while the control recorded the lowest value (83.1 cm). The superior performance of fertilized treatments may be attributed to improved nutrient availability, particularly nitrogen, which enhances vegetative growth and cell division (Leghari *et al*., 2016). The gradual nutrient release from organo-mineral fertilizers likely sustained plant growth over time, which was consistent with findings that integrated nutrient sources improve maize growth performance in nutrient-depleted soils (Adams *et al.,* 2016).

Table 2. Mean Plant height of Maize as Affected by Fertilizer Treatments at 3, 6 and 9 weeks after sowing

Treatment	3 WAS (cm)	6 WAS (cm)	9 WAS (cm)
NPK Mineral Fertilizer 20:10:10	95.0ab	139.5a	177.0ab
NPK SROM Fertilizer 20:10:10	98.0ab	120.9a	159.4bc
NPK SROM Fertilizer 15:10:10	92.6ab	128.8a	148.3c
NPK SROM Fertilizer 12:6:6	102.0a	142.0a	181.5a
Control	82.8b	78.7b	83.1d

Means followed by same letters across column are not statistically significant at (p>0.05). SROM = Slow-release organo mineral

Effect of Slow-Release Organo-Mineral Fertilizer on Number of Leaves

The number of leaves of maize (*Zea mays* L.) as influenced by fertilizer treatments at 3, 6, and 9 weeks after sowing (WAS) was shown in Table 3. Results showed that fertilizer application significantly influenced leaf production at all growth stages compared with the control treatment.

At **3 WAS**, leaf number ranged from 4.0 in the control to 7.0 in the NPK SROM fertilizer (20:10:10) treatment. Fertilized plots generally produced more leaves than the control, indicating that nutrient availability at early growth stages enhances vegetative development. Nitrogen, in particular, plays a key role in promoting leaf initiation and expansion in maize by stimulating cell division and chlorophyll synthesis (Sun *et al*., 2025).

At **6 WAS**, all fertilized treatments performed statistically similarly, producing between 12.0 and 13.0 leaves, while the control recorded significantly lower values (6.7 leaves). This suggests that nutrient supply from both mineral and organo-mineral fertilizers supported sustained vegetative growth during the active growth phase. The similarity among fertilized treatments at this stage may indicate that nutrient demand was adequately met across treatments, reducing observable differences.

At **9 WAS**, significant differences became more pronounced. The highest number of leaves was recorded in the NPK SROM fertilizer (20:10:10) treatment (20.0 leaves), followed by NPK SROM fertilizer (15:10:10) (18.3 leaves), mineral fertilizer (18.0 leaves), and NPK SROM fertilizer (12:6:6) (18.0 leaves), while the control produced the lowest value (12.0 leaves). The superior performance of the NPK SROM fertilizer (20:10:10) treatment suggests improved nutrient synchronization and sustained release, which supported continuous leaf formation during later growth stages.

The higher leaf production observed under slow-release organo-mineral treatments may be attributed to improved nutrient use efficiency and better soil nutrient retention associated with the organic component (Asbai *et al*., 2025). Organic matter enhances microbial activity and nutrient cycling, while the mineral fraction provides readily available nutrients for plant uptake (Nair *et al*., 2022). These findings are consistent with earlier reports that integrated nutrient sources improve vegetative growth and leaf development in maize under tropical conditions (Anetor and Omueti, 2014). Overall, the results indicate that slow-release organo-mineral fertilizers, particularly the NPK SROM fertilizer (20:10:10) formulation, enhance leaf production in maize variety Oba Super 11, which is essential for increasing photosynthetic capacity and ultimately improving yield potential.

Table 3. Mean Maize Number of leaves as Affected by Fertilizer Treatments at 3, 6 and 9 weeks after sowing (WAS).

Treatment	3 WAS (cm)	6 WAS (cm)	9 WAS (cm)
NPK Mineral Fertilizer 20:10:10	6.0ab	12.5a	18.0ab
NPK SROM Fertilizer 20:10:10	7.0ab	13.0a	20.0a
NPK SROM Fertilizer 15:10:10	6.6ab	12.8a	18.3ab
NPK SROM Fertilizer 12:6:6	6.0a	12.0a	18.0b

Control	4.0b	6.7b	12.0c

Means followed by same letters across column are not statistically significant at (p>0.05). SROM = Slow-release organo mineral

Effect of Slow-Release Organo-Mineral Fertilizer on Matured Dry Cob Weight

The effect of fertilizer treatments on mature dry cob weight of maize (*Zea mays* L.) variety Oba Super 11 is presented in Table 4. Results showed that fertilizer application significantly ($p \leq 0.05$) influenced cob weight compared with the control treatment. NPK SROM fertilizer (20:10:10) produced the heaviest cob weight (240 g), followed by mineral NPK fertilizer (210 g). The lowest cob weight was recorded in the control treatment (106 g), indicating a strong response of maize to external nutrient application. The significant superiority of fertilized plots over the control confirms that adequate nutrient supply is essential for proper cob development and grain filling in maize under Sudan Savannah conditions.

The higher cob weight observed in the NPK SROM fertilizer (20:10:10) treatment may be attributed to improved nutrient availability throughout the reproductive stage due to the slow-release nature of the fertilizer. This ensures a continuous supply of essential nutrients such as nitrogen, phosphorus, and potassium during grain filling stage, which directly influences cob development, kernel size, and overall yield formation (Subedi and Ma, 2009).

The mineral NPK fertilizer (20:10:10) also performed well (210 g), but its lower cob weight compared to the NPK SROM fertilizer (20:10:10) treatment suggests that conventional fertilizers may have limited nutrient retention capacity due to losses through leaching and volatilization (Ashitha and Rakhimol, 2021). In contrast, slow-release organo-mineral fertilizers improve nutrient use efficiency by combining organic matter with mineral nutrients, thereby enhancing soil nutrient retention and gradual nutrient release. The reduced cob weight observed in the lower-grade NPK SROM fertilizer formulations (15:10:10 and 12:6:6) may be due to lower nutrient concentration, particularly nitrogen and potassium, which are critical for grain filling and cob development (Subedi and Ma, 2009). Nitrogen plays a key role in photosynthetic activity and assimilate production, while potassium enhances carbohydrate translocation to developing grains (Guo *et al*., 2019). The control treatment recorded the lowest performance (106 g), reflecting the inherently low fertility status of soils in the Sudan Savannah agro-ecological zone. Similar findings have been reported in previous studies where maize yield components significantly declined under unfertilized conditions due to nutrient limitation (Vanlauwe *et al.,* 2014; Bationo *et al.,* 2018).

Overall, the results demonstrate that slow-release organo-mineral fertilizer, particularly the NPK SROM fertilizer (20:10:10) formulation, enhances cob development and final yield components of maize by improving nutrient availability and synchronizing nutrient release with crop demand due to Better nutrient retention, slow nutrient release and improved grain filling.

Table 4. Mean Dry Cob Weight of Maize as Affected by Fertilizer Treatments

Treatment	Mature Dry Cob Weight (g)
NPK Mineral Fertilizer 20:10:10	210b
NPK SROM Fertilizer 20:10:10	240a
NPK SROM Fertilizer 15:10:10	193bc
NPK SROM Fertilizer 12:6:6	178c
Control	106d

Means followed by same letters across column are not statistically significant at (p>0.05). SROM = Slow-release organo mineral

Effect of Slow-Release Organo-Mineral Fertilizer on Cob Length of Maize

The effect of fertilizer treatments on cob length of maize (*Zea mays* L.) variety Oba Super 11 is presented in Table 5. Results showed that fertilizer application significantly ($p \leq 0.05$) influenced cob length compared with the control treatment. The longest cob length (23 cm) was recorded in the NPK SROM fertilizer (20:10:10) treatment, followed by the mineral NPK fertilizer (20 cm). The shortest cob length was obtained in the control treatment (9 cm), indicating a strong positive response of maize cob development to fertilizer application under the Sudan Savannah agro-ecological conditions.

The superior performance of the NPK SROM fertilizer (20:10:10) treatment may be attributed to improved nutrient availability and sustained nutrient release throughout the reproductive phase of maize growth. Adequate nitrogen enhances vegetative growth and photosynthetic capacity, while phosphorus supports energy transfer and reproductive development, and potassium plays a key role in assimilate translocation to developing cobs (Guo *et al*., 2019). The combination of these nutrients in a slow-release organo-mineral form ensures a continuous supply during the critical stages of cob initiation and elongation. The mineral NPK fertilizer (20:10:10) also produced relatively high cob length (20 cm), but its lower performance compared to the organo-mineral formulation suggests possible nutrient losses through leaching and reduced nutrient synchrony with crop demand. This agrees with findings that conventional fertilizers often supply nutrients rapidly but inefficiently, especially under sandy soils and high rainfall variability typical of the Sudan Savannah zone. The lower cob length observed in the NPK SROM fertilizer (15:10:10) and (12:6:6) treatments may be due to reduced nutrient concentration, particularly nitrogen, which is essential for cell division and cob elongation. Insufficient nitrogen supply during reproductive growth stages can limit cob development and reduce final yield potential (Subedi and Ma, 2009).

The control treatment recorded the poorest cob length (9 cm), reflecting the inherently low fertility status of the soil and the inability of maize to express its genetic yield potential without external nutrient input. Similar trends have been reported in previous studies where maize yield components such as cob length were significantly improved with integrated nutrient management strategies (Vanlauwe *et al.,* 2014; Bationo *et al.,* 2018).

Overall, the results demonstrate that slow-release organo-mineral fertilizer, particularly the NPK SROM fertilizer (20:10:10) formulation, enhances cob development in maize by

improving nutrient availability, increasing nutrient use efficiency, and ensuring synchronized nutrient release during the reproductive stage.

Table 5. Mean Cob Length of Maize as Affected by Fertilizer Treatments

Treatment	Cob Length (cm)
NPK Mineral Fertilizer 20:10:10	20b
NPK SROM Fertilizer 20:10:10	23a
NPK SROM Fertilizer 15:10:10	15bc
NPK SROM Fertilizer 12:6:6	12c
Control	9d

Means followed by same letters across column are not statistically significant at (p>0.05).
SROM = Slow-release organo mineral

Effect of Slow-Release Organo-Mineral Fertilizer on Maize Grain Yield

Grain yield was significantly affected by fertilizer treatments. The highest grain yield (6.6 t ha^{-1}) was obtained from NPK SROM fertilizer (20:10:10) treatment, which outperformed mineral NPK fertilizer (5.5 t ha^{-1}) and all other treatments (Table 6). The improved yield from organo-mineral fertilizer may be due to enhanced nutrient synchrony between release and crop uptake, reducing nutrient losses and improving kernel formation. Similar findings have been reported where integrated organic-mineral nutrient sources significantly improved maize yield in sub-Saharan Africa (Vanlauwe *et al*., 2004; Chojnacka, 2025).

Table 6. Mean Grain Yield of Maize as Affected by Fertilizer Treatments

Treatment	Grain Yield (tha^{-1})
NPK Mineral Fertilizer 20:10:10	5.5b
NPK SROM Fertilizer 20:10:10	6.6a
NPK SROM Fertilizer 15:10:10	4.7bc
NPK SROM Fertilizer 12:6:6	4.4c
Control	1.1d

Means followed by same letters across column are not statistically significant at (p>0.05).
SROM = Slow-release organo mineral

Effect of Slow-Release Organo-Mineral Fertilizer on Maize Dry Matter Yield

The results presented in Table 7 showed that fertilizer application significantly influenced the dry matter yield of maize. Among the treatments evaluated, NPK SROM fertilizer (20:10:10) produced the highest dry matter yield of 6.6 t ha^{-1}, which was significantly higher ($P < 0.05$) than the yields obtained from the other fertilizer treatments and the control. This superior performance may be attributed to the balanced nutrient composition and slow-release characteristics of the fertilizer, which likely ensured a sustained supply of essential nutrients throughout the growth period. Adequate and continuous nutrient availability promotes

vigorous vegetative growth, enhanced photosynthetic activity, and greater biomass accumulation in maize plants (Fageria *et al*., 2011).

The conventional NPK mineral fertilizer (20:10:10) recorded a dry matter yield of 5.6 t ha^{-1}, which was statistically higher compared to NPK SROM fertilizer (15:10:10) with a yield of 5.1 t ha^{-1} but significantly lower than NPK SROM fertilizer (20:10:10). This finding suggests that while mineral fertilizers provide readily available nutrients that support crop growth, the slow-release formulation may improve nutrient use efficiency by reducing nutrient losses through leaching, volatilization, and fixation, thereby enhancing dry matter production (Trenkel, 2010). The improved nutrient synchronization between crop demand and nutrient release from slow-release fertilizers has been reported to increase nutrient uptake and biomass accumulation in cereal crops (Shaviv, 2005).

The NPK SROM fertilizer (12:6:6) produced a dry matter yield of 4.1 t ha^{-1}, which was significantly lower than the yields obtained from the higher nutrient formulations. This result indicates that nutrient concentration plays a critical role in determining maize growth and biomass production. Nitrogen, phosphorus, and potassium are essential macronutrients required for cell division, root development, chlorophyll synthesis, and energy transfer processes in plants. Reduced nutrient availability can therefore limit plant growth and dry matter accumulation (Marschner, 2012).

The control treatment, which received no fertilizer application, recorded the lowest dry matter yield of 1.2 t ha^{-1}. The markedly poor performance of the control highlights the importance of external nutrient inputs in maintaining soil fertility and supporting maize productivity. In many tropical soils, nutrient depletion resulting from continuous cultivation and inadequate nutrient replenishment often constrains crop growth and biomass production (Sanchez, 2019). The substantial increase in dry matter yield observed in fertilized plots compared with the control demonstrates the positive response of maize to nutrient supplementation and confirms the critical role of balanced fertilization in achieving optimum crop performance.

Overall, the results indicate that NPK SROM fertilizer (20:10:10) was the most effective treatment for enhancing maize dry matter yield. The findings suggest that slow-release organo-mineral fertilizer formulations with adequate nutrient concentrations can improve nutrient use efficiency and biomass production, making them a promising alternative to conventional mineral fertilizers for sustainable maize production.

Table 7. Mean Dry matter Yield of Maize as Affected by Fertilizer Treatments

Treatment	Dry matter yield (tha^{-1})
NPK Mineral Fertilizer 20:10:10	5.6b
NPK SROM Fertilizer 20:10:10	6.6a
NPK SROM Fertilizer 15:10:10	5.1bc
NPK SROM Fertilizer 12:6:6	4.1c
Control	1.2d

Means followed by same letters across column are not statistically significant at (p>0.05).
SROM = Slow-release organo mineral

CONCLUSION

The study revealed that slow-release organo-mineral fertilizers significantly improve maize growth and yield under Sudan Savannah conditions. The NPK SROM fertilizer (20:10:10) treatment performed best in terms of grain and dry matter yield, indicating its potential as a superior fertilizer option compared to conventional mineral NPK fertilizer and the other tested organo-mineral fertilizer formulations. NPK SROM (20:10:10) fertilizer treatment is therefore recommended for maize production in the Sudan Savannah zone. Farmers should adopt slow-release organo-mineral fertilizers to improve yield and reduce fertilizer losses. Further research should assess long-term soil fertility impacts and economic viability of organo-mineral fertilizers.

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