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# Effect of jatropha mulch types and inorganic fertilizers on amaranth (*Amaranthus hybridus) growth* in Akure Southwestern Nigeria

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## Abstract

*Experimental fieldwork was conducted at the CSP Departmental Research Farm at Federal University of Technology Akure. This was to evaluate the effect of Jatropha mulch types and inorganic fertilizers on Amaranthus hybridus growth. The experimental field size was 0.01 hectare (14mx8m). With five treatments and three replications, a Randomized Complete Block Design (RCBD) was used. The plot measured 2mx2m (4m$^2$), with a 1m walkway separating it from the replicates. The treatments and application rate were the control, Jatropha seed cake at 2t ha$^{-1}$, Jatropha ground husk at 2t ha$^{-1}$, NPK 20:10:10 at 200kg ha$^{-1}$, and urea at 100kg ha$^{-1}$. The data obtained on growth parameters were statistically analyzed through Analysis of Variance (ANOVA). The data obtained were subjected to SPSS version 19, and the treatment means were compared using Duncan's Multiple Range Test (DMRT). Results indicated that the incorporation of Jatropha mulches significantly ($p<0.05$) improved the soil organic carbon (SOC), total N, available P, exchangeable bases, and growth parameters of amaranth (Amaranthus hybridus) when compared with control, urea, and NPK treatments; this may be due to the higher nutrient and organic carbon content found in Jatropha cake and husk. This study showed that jatropha mulches improve soil quality for sustainable crop production by removing heavy metal residues left behind by inorganic fertilizers, improving the environment, and elevating living standards through the consumption of healthy vegetables as a good diet.*

**Keywords**: Jatropha cake, Jatropha ground husk, growth parameters, inorganic fertilizers, mulch, crop production.

## Introduction

Fertilizers are vital requirements for optimum crop growth; and they could come in inorganic or organic forms[1]. Since the beginning of the green revolution, inorganic fertilizers have been widely used globally to increase agricultural crop yields[2]. It has been observed over time that continual sole use of inorganic fertilizers often reduces soil fertility in the long run, which eventually culminates in poor crop growth[1]. Also, the persistent application of inorganic fertilizers to boost crop yield has increasingly become a threat to humans, animals, and the environment due to the residues of heavy metals that it leaves behind, some of which can be poisonous. Therefore, there is an urgent need to increase the organic manure ratio for soil fertilization in a bid to boost crop yields[3].

Rapid urbanization in Nigeria has led to a reduction of agricultural lands, resulting also in soil fertility depletion due to persistent cultivation of the same area of land. This has drastically reduced crop yield, forcing most smallholder farmers (a group that constitutes a majority of the farming population in Nigeria) to depend largely on locally sourced organic fertilizers as a result of their inability to afford high-quality inorganic fertilizers[4]. Over the years, farmers have been encouraged to embrace shifting cultivation whenever soil nutrient depletion is noticed. However, the steady reduction in the available agricultural land has limited this option. There is therefore a pressing need to properly manage the land available for agriculture in our locality to maximize profit from farm production. It is agreeable that massive food production is what rural areas are known for and any shortfall in food production will increase the price of food in the larger society.

Jatropha is native to South America (Mexico, Brazil) and Central America with more than 200 species that are widely distributed in the tropics[5]. *Jatropha curcas* is a shrub[6]. Due to its high energy content (18.25MJ kg$^{-1}$), jatropha cake can be utilized in power plants as solid biofuel or manure. Additionally, it can be utilized to create biogas, and the leftover slurry can be used once more as nutrient-rich manure[7]. Jatropha plant requires many nutrients for its growth and a large portion of the nutrients are left in the de-oiled cake. When this jatropha cake is added, it benefits the soil by enhancing its fertility and soil stability which enhances the production system to be environmentally friendly and sustainable. Therefore, the jatropha cake should be applied at a minimum of 1.3t ha$^{-1}$ for maximum effect on crops[7,8]. Since Jatropha appears to have a high nutrient need, it must be used in the replacement of inorganic fertilizers to supply nutrients.

Jatropha wastes as mulch materials are cheap[9,10] and it produces more and better quality crops when used as organic fertilizer[11]. Jatropha seed cake and Jatropha ground husks can simultaneously be used to improve soil fertility[12]. Based on the foregoing, organic farming using Jatropha wastes is the way forward for sustainable and ecological crop intensification as it serves to control soil erosion. Jatropha wastes not only improve the physicochemical properties but will also compensate for nutrient depletion[12].

The high yield potential of amaranths and their rapid growth make them excellent vegetables. As compared to other vegetables, amaranths are *less exposed to the attack of diseases transmitted from the soil,* they are cultivated easily, rotational with any vegetable crop, and they offer a high yield in return and a good nutritional composition by compensating for excessive mineral uptake. Especially organic manure is effective in fertilizing amaranths[13]. Amaranths form a high percentage of leafy vegetable intakes. A growing number of people are becoming aware of the benefits of leafy vegetables for a balanced diet, particularly in areas where animal protein is lacking. In addition to being high in carotene, protein, vitamin C, and minerals, leafy vegetables are also extremely high in calcium[14].

*Amaranthus hybridus* is popularly known as green amaranth, slim amaranth, smooth amaranth, African spinach, bush greens, spinach greens, smooth pigweed, or red amaranth[15]. In order for vegetable amaranth to be grown successfully, it is necessary to have a good understanding of how nitrogen fertilization affects its yield. In essence, Amaranth's production is limited by nitrogen[16]. Since Nigerian soils are low in nitrogen, N fertilizer is often added to this crop, and its significance has increased. While chemical fertilizer can lead to high crop yields, it also pollutes groundwater after crop harvest, which is one of its drawbacks[14].

According to research, organic fertilizers are less likely to leach into groundwater than inorganic fertilizers[17]. As a result, organic fertilizer has proven to boost crop production. This is because it is cheaper and less likely to pollute groundwater. The accurate application of organic fertilizer will increase soil fertility and as well increase the livelihood of farmers through an increase in yield. Like many other crops, amaranthus needs soil with sufficient organic matter content and a high nutrient reserve for optimal yield[18]. Hence, Jatropha wastes as mulches in different formulations tend to be a congruous organic source of the significant amount of nitrogen needed for the growth of Amaranths.

## Materials and Methods

**Experimental Site:** Experimental work was conducted at the CSP Departmental Research Farm at Federal University of Technology Akure. This study area lies between latitude $7^0 18^1$ and longitude $15^0 12^1$ at an altitude of about 374m. It is situated in the rainforest of south-western region of Nigeria. The climate is hot and humid with distinct dry and rainy seasons with an annual rainfall of about 1524 mm, which is bimodally distributed with peaks in June and July. There are around 2000 hours of sunshine on average each year and 81% yearly relative humidity[19]. The average daily temperature is between $27^0$C and $37^0$C[4]. It is estimated that the potential evapotranspiration is 4.87 mm $d^{-1}$ [19] while the wind speed is 1.96km $d^{-1}$ [20]. A medium-grained granite and gneiss soil was found at the experimental site, categorized as Ultisol[21].

**Land Preparation:** Over the years, the experimental site was cropped continuously with maize and okra. Prominent weed species noted were *Cyndrella nodiflora*, *Calopogonium mucunoides, Chromolaena odorata, Euphorbia heterophylla,* and *Panicum maximum.* Blocks and plots were marked out on the experimental site after clearing, ploughing, and harrowing mechanically. The beds were manually prepared with the use of a hoe for growing *Amaranthus hybridus.*

**Experimental Design:** The 0.01ha (14mx8m) experimental field was used for this research work. An experiment with five treatments was conducted in a Randomized Complete Block Design (RCBD) and three replications. Each plot was $4m^2$ (2mx2m), with a 1 m walkway separating it from the replicates. The experiment took place between the 10th of May and the 20th of June, 2021. Treatment levels were the following:
T1 = Control (No NPK + No Urea + No Jatropha seed cake and ground husk).T2 = NPK 20:10:10. T3 = Urea. T4 = Jatropha seed cake. T5 = Jatropha ground husk.

**Planting and Cultural Practices:** *Amaranthus hybridus* seeds were collected from the Seed Centre of the Agricultural Development Project in Akure, Nigeria. They were planted directly on the experimental field. The drilling method of planting was used on the field with a 40cm distance between each plant and 20 cm within plants at a planting depth of 2cm with a total number of fifty (50) amaranth plants per plot. In the experimental plots, weeds weren't allowed to get out of control before being pulled. The first and second weeding was done in the 2nd and 4th weeks after planting.

**Treatment Application:** Jatropha seed cake and Jatropha ground husk at 2t $ha^{-1}$ were applied immediately after planting, NPK at 200kg $ha^{-1}$, and urea at 100kg $ha^{-1}$ were applied two weeks after planting. Jatropha seed cake was obtained from the crushed seed of Jatropha while the Jatropha ground husk was the crushed husk of Jatropha seed.

**Agronomic Data Collection:** Plant height was measured with the use of measuring tape and the number of leaves was determined via counting of the leaves. Leaf area was analyzed with a leaf area meter.

**Data Analysis:** Data on agronomic characteristics were statistically analyzed through ANOVA. Duncan's Multiple

Range Test (DMRT) was used to compare treatment means with SPSS version 19.

## Results and Discussion

**Soil Physico-chemical Properties before the Application of Treatments:** Table-1 shows the soil physical and chemical properties prior to treatment application at the experimental site. The soil included 2.01g $kg^{-1}$ of organic carbon (OC) and 3.47g $kg^{-1}$ of organic matter (OM). The values for N, P, and K were 0.42g $kg^{-1}$, 3.24mg $kg^{-1}$, and 0.65cmol $kg^{-1}$, respectively**.** The other exchangeable bases, such as Ca, Mg, and Na, have centimoles per kilogram of 2.20, 1.25, and 0.15, respectively. The textural triangle demonstrated that the soil's texture was sandy clay loam. This implies that it contains a lot of sand and little organic matter. The soil's pH value was 5.72, which indicates moderate acidity. In comparison to recognized critical levels in a tropical alfisol, the soil fertility was low. According to Akpa et al. [22], the organic matter concentration was below the threshold, which was between 7.2 to 40.9g $kg^{-1}$. According to the critical values of 10–16mg $kg^{-1}$ supplied by Adeoye and Agboola[23], P was insufficient, and N was inadequate in comparison to the critical values of 1.5–2.0g $kg^{-1}$ provided by Sobulo and Osiname[24]. The K component of the soil was high in comparison to the required concentrations of 0.16-0.25 cmol $kg^{-1}$ proposed by Adeoye and Agboola[23]. In comparison to the crucial amounts of 0.2–0.4 cmol kg-1 for Adeoye and Agboola[23] and 2.50cmol kg-1 for Akinrinde and Obigbesan[25], respectively, the magnesium and calcium were sufficient.

Table-2 shows Jatropha seed cake has a comparatively high N content of 4.92% compared to Jatropha ground husk. However, Jatropha ground husk had a K content of 2.42% which was much higher than Jatropha seed cake. P, Ca, and Mg were the other elements that were analyzed. The highest P level was found in NPK 20-10-10 fertilizer, with 9.56% among the treatment. Jatropha seed cake had 2.10% of P and Jatropha ground husk had 1.14% of P which was the lowest P content. Jatropha seed cake also contains the highest Ca and Mg content of 2.70 and 1.90mg/kg while Urea (1.50 and 0.60mg/kg) contains the lowest Mg and Ca. Though, urea contained the most N content of 44.3%. P and K contents were the highest in NPK fertilizer treatment with 9.56% and 9.72% respectively while urea treatment had the lowest P and K contents.

**Table-1:** Physical and chemical characteristics of the experimental site before planting.

| Properties | Values |
|---|---|
| Physical composition (g $kg^{-1}$) | |
| Textural class | Sandy clay loam |
| Clay | 23.50 |
| Silt | 20.20 |
| Sand | 55.10 |
| Chemical Characteristics | |
| Soil pH ($H_2O$) | 5.72 |
| Available P (mg $kg^{-1}$) | 3.24 |
| Total N (g kg-$^{1}$) | 0.42 |
| Organic carbon (g $kg^{-1}$) | 2.01 |
| Organic matter (g $kg^{-1}$) | 3.47 |
| Exchangeable bases (cmol $kg^{-1}$) | |
| K | 0.65 |
| Na | 0.15 |
| Ca | 2.20 |
| Mg | 1.25 |

**Table-2:** Chemical composition of NPK, urea, and jatropha seed cake and ground husk.

| Elements | NPK | Urea | Jatropha Seed Cake | Jatropha Ground Husk |
|---|---|---|---|---|
| N (%) | 18.64 | 44.30 | 4.92 | 2.82 |
| P (%) | 9.56 | 1.12 | 2.10 | 1.14 |
| K (%) | 9.72 | 1.15 | 1.82 | 2.42 |
| Ca (mg/kg) | 1.80 | 1.50 | 2.70 | 2.50 |
| Mg (mg/kg) | 1.20 | 0.60 | 1.90 | 1.70 |

Table-3 shows the effect of different fertilizer sources on the plant height of *Amaranthus hybridus* at a one-week interval over 4 weeks. There was a significant difference ($p < 0.05$) in the plant height of amaranth with urea-produced plants with the tallest height at 3 WAP. Towards 6 weeks after planting, amaranth with Jatropha seed cake and Jatropha ground husk performed relatively well when compared with amaranth with the NPK and urea fertilizer.

Table-4 shows the effects of jatropha seed cake, jatropha ground husk, urea, and NPK fertilizer on the number of leaves from 3 weeks after planting to 6 weeks after planting. There was no significant difference ($p>0.05$) at 3 WAP and 4 WAP. Significantly, jatropha mulch treatments at 2t $ha^{-1}$ had a higher number of leaves when compared with the control. NPK treatment significantly ($p<0.05$) had the highest number of leaves at 6 WAP. Even though jatropha mulch treatments did not have the same number of leaves when compared with NPK treatment, it was deduced that soil analysis after harvesting showed that the soil with the jatropha mulch application had considerably higher nitrogen, phosphorus, and potassium than other treatments. Pandey *et al.*[12] established that marginal soil can be managed with the introduction of *Jatropha curcas*. More so, Ogunwole *et al.*[26] found out that jatropha plantations helped in soil amendments through structural stability with an increase in soil fertility which enables microbial activity around the plant. The soil with the jatropha mulch treatments would be fine for any subsequent cultivation of crops; this is a good side of using organic fertilizer to stabilize and increase soil fertility.

Table-5 shows the effects of jatropha seed cake, jatropha ground husk, NPK, and urea fertilizers on the leaf area at 6 WAP. A comparison of jatropha seed cake, ground husk at 2 t $ha^{-1}$, urea at 100 kg $ha^{-1}$, and NPK at 200 kg $ha^{-1}$ resulted in a significantly greater leaf area. However, NPK at 200kg $ha^{-1}$ manifested the highest leaf area.

Table-6 shows the effects of organic and inorganic fertilizers on physicochemical properties after the amaranth (*Amaranthus hybridus*) harvest. Significant increase concerning soil pH after amaranth harvest was observed in Jatropha mulch treatments in comparison with other treatments. Jatropha mulched plots had higher soil pH levels than control, urea, and NPK treatments. The rise in soil pH might be because of the effect of Jatropha seed cake and Jatropha ground husk. These mulches tend to increase soil exchangeable bases while reducing exchangeable acidity which results in a reduction in soil acidity. This result was also observed by Awopegba et al.[4] when herbaceous and shrub mulches were used to grow maize. The amount of soil organic carbon in mulched plots also increased significantly. Ground husk from Jatropha recorded the greatest rate (2.99 g/kg) compared to all other treatments; which are control, urea, and NPK treatments. The comparison between jatropha wastes and inorganic fertilizers in wet and dry seasons showed that jatropha wastes used as fertilizers increased and favourably impacted soil fertility after crop harvest[27]. The soil organic carbon increased as a result of the addition of Jatropha mulch[28]. This is explained by the presence of more nutrients and organic carbon[4] in the Jatropha treatments. This finding corroborates with the findings of Feller et al.29, which claimed that Jatropha, Prosopis, and Leucaena plantations may improve soil quality, bring about a healthier environment, and enhance people's quality of life.

**Table-3:** Effect of inorganic fertilizers and jatropha mulches on the plant height (cm) of amaranth (*Amaranthus hybridus*).

| Treatments | 3 WAP | 4 WAP | 5 WAP | 6 WAP |
|---|---|---|---|---|
| Control | 7.53ab | 12.34b | 21.57bc | 23.18b |
| NPK 20-10-10 | 9.77ab | 17.63a | 32.66a | 40.24a |
| Urea | 10.19a | 17.06a | 29.43ab | 34.79a |
| Jatropha seed cake | 8.58ab | 14.68b | 23.85b | 28.49ab |
| Jatropha ground husk | 6.8b | 13.72b | 23.69b | 28.53ab |

There is no significant difference ($p > 0.05$) between means followed by the same letters in the same column. WAP: Weeks after planting.

**Table-4:** Effect of inorganic fertilizers and jatropha mulches on the number of leaves of amaranth (*Amaranthus hybridus*).

| Treatments | 3 WAP | 4 WAP | 5 WAP | 6 WAP |
|---|---|---|---|---|
| Control | 7.75a | 10.00a | 12.50c | 14.50c |
| NPK 20-10-10 | 8.25a | 12.00a | 20.00ab | 24.75a |
| Urea | 7.75a | 11.50a | 16.25a | 19.75ab |
| Jatropha seed cake | 6.75a | 10.00a | 14.00b | 17.00b |
| Jatropha ground husk | 7.00a | 10.50a | 14.00b | 16.50b |

There is no significant difference ($p > 0.05$) between means followed by the same letters in the same column.

**Table-5:** Effect of inorganic fertilizers and jatropha mulches on leaf area ($cm^2$) at 6 WAP of amaranth (*Amaranthus hybridus*).

| Treatments | Leaf Area ($cm^2$) |
|---|---|
| Jatropha seed cake | 93.68ab |
| Jatropha ground husk | 93.52ab |
| NPK 20-10-10 | 100.29a |
| Urea | 94.60ab |
| Control | 61.97c |

There is no significant difference ($p > 0.05$) between means followed by the same letters in the same column.

**Table-6:** Physical and chemical properties of the experimental site after harvesting of amaranth.

| Treatments | pH | N (g/kg) | P (mg/kg) | K (cmol/kg) | Mg (cmol/kg) | Ca (cmol/kg) | Na (cmol/kg) | OC (g/kg) |
|---|---|---|---|---|---|---|---|---|
| Control | 5.72b | 0.40d | 3.22ab | 0.53c | 0.60c | 2.10d | 0.15c | 2.10d |
| NPK 20-10-10 | 6.12ab | 0.48c | 3.40b | 0.70b | 0.80b | 3.10a | 0.29ab | 2.52c |
| Urea | 5.74b | 0.56b | 2.12c | 0.66bc | 0.70b | 2.20cd | 0.32a | 2.53c |
| Jatropha seed cake | 6.64a | 0.63a | 3.92a | 0.80ab | 1.30a | 2.50c | 0.10d | 2.99a |
| Jatropha ground husk | 6.62a | 0.62a | 3.90a | 0.84a | 1.30a | 2.70b | 0.10d | 2.72b |

There is no significant difference ($p > 0.05$) between means followed by the same letters in the same column.

## Conclusion

It has been observed over time that continual sole application of inorganic fertilizers often reduces soil fertility in the long run, which eventually culminates in poor crop growth. The persistent application of inorganic fertilizers to boost crop yield has increasingly become a threat to humans, animals, and the environment due to the residues of heavy metals that it leaves behind, some of which can be poisonous. This study showed that the incorporation of Jatropha mulches improved the soil organic carbon, available P, total N, exchangeable bases, and growth parameters of amaranth (*Amaranthus hybridus*). In addition, jatropha mulches improve soil quality for sustainable crop production by removing heavy metal residues left behind by inorganic fertilizers, improving the environment, and elevating living standards through the consumption of healthy vegetables as a good diet.

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