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Research Article

Efficacy of *Jatropha curcas* and *Azadirachta indica* Seed Cake on the Germination and Growth of Corn (*Zea mays* L.) Seedlings

[1]Mary Garba, [1]Thliza Ijai Ayuba, [2]Ahmed Ibrahim and [3]Mary Asugu Mbahi

[1]Department of Biological Science, Federal University Gashua, Gashua, Yobe, Nigeria
[2]Department of Science Education, Federal University Kashere, Kashere, Gombe, Nigeria
[3]Department of Biological Sciences, Federal University Kashere, Kashere, Gombe, Nigeria

Abstract

Background and Objective: *Jatropha curcas* and *Azadirachta indica* (Neem) are known for their potential as organic fertilizers due to their nutrient-rich seed cake. The study examines the efficacy of *Jatropha curcas* and *Azadirachta indica* seedcake on the germination and growth of corn *Zea mays* L. seedlings. The study aims to provide sustainable alternatives to chemical fertilizers, enhancing agricultural productivity and soil health. **Materials and Methods:** The study was carried out in the Department of Biological Science in the Botanical Garden at Federal University Gashua, Nigeria. The experiment adopted a randomized block design. The physicochemical parameters of the garden soil and seed cake of both *Jatropha curcas* and *Azadirachta indica* were analyzed for nutrient content (NPK) before planting and after planting using standard methods. **Results:** The pH of the soil analyzed before planting was 7.03, after harvest at week 5, Neem+soil had the highest of 5.90, while the control soil had the lowest 5.20. The organic carbon before planting was 0.44, after harvest NPK+soil and Neem+soil recorded the highest and lowest organic carbon, respectively. The organic matter of the soil before planting was 0.68, *Jatropha*+soil and Neem+soil had the highest and lowest contain of 6.65 and 3.72. The soil's total nitrogen, phosphorous and potassium before planting were 305.43, 19.36 and 363.97, respectively. The *Jatropha*+soil growth medium recorded the highest germination rate of 91.66% while the NPK+soil had the lowest of 33.33%. The growth rate was significantly different at $p<0.05$ within the weeks, the highest growth rate of maize seedlings was observed at week 5. **Conclusion:** *Jatropha* and Neem seed cakes effectively support the growth and development of *Zea mays* L. throughout all stages of the growth process.

Key words: *Jatropha curcas*, *Azadirachta indica*, maize, growth rate, organic substances

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Corresponding Author: Ahmed Ibrahim, Department of Science Education, Federal University Kashere, Kashere, Gombe, Nigeria

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Maize is scientifically known as *Zea mays* L. an important cereal crop that originated from Mexico, became a popular crop in Central and South America and occupies a prominent position in global agriculture after wheat and rice[1]. The most widely grown crop worldwide is maize, which is grown in temperate, tropical and subtropical climates. It was introduced to Africa in the 1500s and quickly rose to prominence as a staple food crop. Africa produces 6.5% of the world's total grain production, with Nigeria producing nearly 8 mL tonnes annually of the 785 mL tonnes produced worldwide[2,3]. Globally, 67% of maize is used for livestock feed, 25% for human consumption and the rest for industrial purposes[4]. Physiologically, maize is a C4 plant that has higher grain yield and wider adaptation over a wide range of environmental conditions. Maize contains essential microelements like copper, manganese and magnesium. It is also rich in vitamins, antioxidants such as carotene and xanthophyll and unsaturated fatty acids like linoleic and oleic acids. These components are crucial for a balanced diet and play a significant role in disease prevention[5]. Germination is the most crucial and delicate stage in the life cycle of plant growth and development which is significantly affected by environmental factors such as temperature, water, humidity, soil aeration, soil salinity, soil pH, soil texture, soil biota, seed quality, physiological and biochemical process of the seeds[6].

Germination, the initial stage in a plant's life cycle, involves the emergence and establishment of seedlings, which is crucial for plant survival and growth. Key indicators of this process are shoot and root length, as roots directly interact with the soil to absorb water and essential nutrients, which are then transported to the shoot to support metabolic processes[7]. The growth medium significantly influences seed germination, growth and development[8]. An optimal growth medium, rich in nutrients and water, supports plant growth by facilitating oxygen passage to the roots, enabling gaseous exchange between the roots and the surrounding atmosphere[9].

Globally, there is demand for productive and sustainable crop production that will provide a holistic soil management strategy that will sustain soil biodiversity, establish a healthy environment for agricultural activities and thus maintain a balanced nutrient essential for plant growth and development. The use of a synthetic substance such as herbicides, insecticides and fertilizers coupled with the indiscriminate cutting of trees and bush burning resulting in deforestation have exposed agricultural soil to numerous challenges such as poor soil nutrients, runoff, erosion, mass movement of fine soil particles, loss soil biotas thereby affecting soil water retention capacity, soil aeration, soil texture and microbial activities which have a direct consequence on the productivity and human survival[10].

Jatropha curcas L. is a tropical species of flowering plant in the spurge family Euphorbiaceae[10]. *Jatropha curcas* has attracted significant interest globally, including from both oil and non-oil-producing nations. African countries, such as Mali and Tanzania, have been extracting *Jatropha curcas* oil for several years[11]. Several studies have reported on the production of organic fertilizer from the seed residues, *Jatropha curcas* seed cake contains 58% of crude protein by weight and the percentages of nitrogen (N), phosphorous (P) and potassium (K) range from 3.2-4.5%, 1.4-2.1% and 1.2-1.7%, respectively[10].

Azadirachta indica is a member of the Meliaceae family that originates from the Indian subcontinent and is now valued worldwide as an important source of phytochemicals for human health and pest control[12]. The main Neem product is the oil extracted from the seeds[12]. Neem leaves can be utilized to create vermicompost, which serves both as a fertilizer and a pesticide[13,14]. The phytochemicals, such as limonoids, in Neem exhibit dual-purpose potential as a bio-fertilizer when incorporated into the soil, enhancing soil fertility and protecting plant roots from nematodes and whiteflies in tomato cultivation[15]. Neem leaf manure is becoming increasingly popular due to its eco-friendly nature and its ability to boost soil nitrogen and phosphorus levels[16].

Organic substances are vital for soil nutrients, being both eco-friendly and cost-effective. When applied to farmland, they decompose through humification and mineralization, which helps prevent runoff, erosion and the displacement of fine soil particles. This process also enhances soil water retention, air pore space and overall productivity[17]. Additionally, organic substances improve soil structure, water holding capacity, infiltration, biodiversity and nutrient availability[18]. A major challenge of agriculture is to increase food production to meet the needs of the growing world population without damaging the environment[15]. Farming systems based on cereals, when lacking adequate nutrient inputs, have caused widespread declines in soil fertility and consistently poor crop yields[19]. Continuous crop production without sufficient fertilizer nutrients can lead to rapid depletion of soil nutrients like nitrogen (N), phosphorus (P) and potassium (K), resulting in reduced crop growth and yields[20]. A decline in soil fertility significantly reduces crop productivity, leading to food insecurity. Other consequences include reduced fodder for cattle, less fuel wood for cooking and fewer crop residues and cattle manure for nutrient recycling. These effects often result in increased runoff and erosion due to diminished plant cover protecting thesoil[21].

Additionally, soil fertility depletion decreases biodiversity both above and below ground and leads to the encroachment of forests and woodlands as more agricultural land is needed[22]. Limited use of fertilizers in cropping systems is becoming rampant such that crop productivity is low[23]. Where fertilizers are obtained in the midst of the difficulties and even applied, most nutrients are lost through leaching and poor nutrient uptake by crops resulting in low yields. The study investigated the efficacy of *Jatropha curcas* and *Azadirachta indica* seed cake on the germination and growth of corn (*Zea mays* L.) seedlings.

MATERIALS AND METHODS

Study area: The study was conducted at the Department of Biological Sciences in the Botanical Garden at Federal University Gashua, Nigeria, from December, 2023 to May, 2024. The study area is situated on Latitude 5°20" N and 5°30" N, Longitude. 7°27" E. The hottest months are March, and April, with temperature ranging from 38-40°C. The rainy season is from June, to September, temperature fall between 23-28°C with annual rainfall of 500-1000 mm. The town lies close to the Hadejia-Nguru Wetlands, an important ecological point. The major occupation of the people is farming and rearing of animals.

Experimental design: For each Block, 5 polythene bags were used. Block A (untreated garden soil) contains garden soil, Block B (garden soil+*Jatropha curcas* seed cake) contains a proportion of a 3:1 mixture, Block C (garden soil+*Azadirachta indica* seed cake) contains a proportion of 3:1 and Block D (garden soil+NPK fertilizer) contains a proportion of 3:1. The experiment adopted randomized block design. The physicochemical parameters of the garden soil and seed cake of both *Jatropha curcas* and *Azadirachta indica* were subjected to nutrient (NPK) analysis before planting and after harvest of the cultivated crop.

Collection of soil sample: A soil auger was used to randomly collect soil samples in the Botanical Garden at a 0-30 cm depth. The soil samples were thoroughly mixed as bulked, air dried, crushed with mortar and pestle and sieved using a 2 mm mesh sieve for physicochemical analyses as described by Lu *et al.*[24].

Determination of soil physicochemical parameters

Determination of organic carbon and organic matter: The organic carbon will be measured using Walkley Black rapid dichromate oxidation, where 10 mL 1N potassium dichromate ($K_2Cr_2O_2$) and 20 mL concentrate H_2SO_4 were added to 5 g soil. After 30 min, 200 mL of distilled water was added along with 10 mL of 85% phosphoric acid and 1mL DPA indicator and titrated against 2/N ferrous ammonium sulphate $(NH_4)_2Fe(SO_4)_2$-$6H_2O$. The value obtained was multiplied by the factor 1.724 to obtain organic matter content as described by Hossain *et al.*[25].

Determination of soil grain size: The soil grain size was determined using the sieve grain size analysis method as described by Hossain *et al.*[25].

Determination of soil and seed cake pH: The pH of the samples will be measured using HANNA (HI 98129, HANNA) multi-parameter instrument[26].

Determination of soil and seed cake nitrogen: The nitrogen concentration was measured using the micro-Kjeldahl method as described by Yadav *et al.*[26].

Determination of soil and seed cake phosphate: The concentration of phosphate was determined by a digital spectrophotometer (SP-UVG752 manufactured by Systronic in Thiruvananthapuram, India) potash by a flame photometer (Mediflam manufactured by Drawell Scientific Company in Dubai, United Arab Emirate) and available nitrogen by micro-Kjeldahl method as described by APHA[27].

Determination of soil potassium: The concentration of potassium in the sample was determined using 1 normal ammonium acetate at pH 7, with the reading obtained using an Absorption Spectrometer (SP-VG722 manufactured by Scitek Global Inc, Houston, United States) as described by Yadav *et al.*[26].

Determination of germination and growth parameters

Planting of maize seed: The 2 seeds per polythene were planted across the 3 treatments at different concentrations of 2, 4, 6, 8 and 10 g mixed with the garden soil. The percentage of germination was calculated using the formula described by Mathowa *et al.*[8].

$$\text{Germination (\%)} = \frac{\text{Number of seed germinated}}{\text{Total number of seed sowed}} \times 100$$

Plant height: The 10 maize plants from the central rows per treatment were randomly selected tagged and measured from the soil level to the topmost visible node at 2 weeks' intervals. The arithmetic mean was computed for the determination of growth rate as described by Zuazo and Pleguezuelo[21].

Number of plant leaves and width: The number of leaves per plant was counted while the width was measured using a meter ruler as described by Zuazo and Pleguezuelo[21].

Statistical analysis: The germination rate of each treatment will be subjected to descriptive statistics in percentage rate in tabular form while the shoot length, shoot width, leaf length and leaf width of each treatment will be subjected to ANOVA, where significant differences occur, the mean will be separated using LSD at $p<0.05$.

RESULTS

Physicochemical parameters of growth media: The result in Table 1 shows the physicochemical parameters of growth media. The pH of the soil analyzed before planting was 7.03, after harvest at week 5, Neem+soil had the highest of 5.90 while the control soil had the lowest 5.20. The organic carbon before planting was 0.44, after harvest at week 5, NPK+soil and Neem+soil recorded the highest and lowest organic carbon, respectively. The organic material of the soil before planting was 0.68, *Jatropha*+soil and Neem+soil had the highest and lowest contain of 6.65 and 3.72. The soil's total nitrogen, phosphorous and potassium before planting were 305.43, 19.36 and 363.97, respectively. The NPK+soil had the highest concentration of total nitrogen and the control soil recorded the highest concentration of phosphorous and potassium after harvest of maize seedlings at week 5. The texture of the soil or growth media is loamy sand.

Germination rate of maize: The result in Table 2 shows the germination rate of maize (Appendix I). The *Jatropha*+soil growth medium recorded the highest percentage of 91.66% while the NPK+soil had the lowest percentage of 33.33% but was unable to survive.

Maize seedlings growth on different mediums for 5 weeks: Table 3 shows maize seedlings growth on different mediums for 5 weeks. The result is significantly different at $p<0.05$ within the weeks. The highest growth rate of maize seedlings was observed at week 5 with the lowest growth rate at week 1 across all the growth media.

***Zea mays* L. growth parameters on different media:** Table 4 means *Zea mays* L. growth parameters on different media for 5 weeks. The *Zea mays* L. grow on Neem+soil had the highest plant height, leaf length, number of leaves and mean of 32.00 cm at week 5 while at week 1, *Zea mays* L. cultivated on NPK+soil had the lowest plant height, leaf length, number of leaf and leaf width of 02.49 cm, 2.00 cm, 01.04 and 0.06.

Table 1: Physicochemical parameters of growth media

							Soil particle size (%)			
Media	pH	OC	OM	TN	P	K	Clay	Silt	Sand	Soil texture
*Soil	7.03	0.44	0.68	305.43	19.36	363.97	4.50	18.375	77.125	Loamy sand
Neem+soil	5.90	2.16	3.72	0.47	53.77	0.32	4.00	20.00	76.00	Loamy sand
Jatropha+soil	5.55	3.20	6.65	0.69	52.31	0.46	4.00	19.50	76.50	Loamy sand
NPK+soil	5.30	3.86	5.54	0.84	52.66	0.44	4.50	18.50	77.00	Loamy sand
Soil (control)	5.20	3.31	5.70	0.71	56.77	0.60	5.50	15.50	79.00	Loamy sand

*Soil analyzed before planting, OC: Organic carbon, OM: Organic material, TN: Total nitrogen, P: Phosphorous and K: Potassium

Table 2: Germination rate of maize on different media

Treatment	Total seed planted	Total seed germinated	Seed germinated (%)
Neem+soil	12	10	83.33
Jatropha+soil	12	11	91.66
NPK+soil	12	04	33.33
Soil (control)	12	11	91.66

Table 3: Mean of maize seedlings growth on different medium for 5 weeks

Weeks	Neem+soil	*Jatropha*+soil	NPK+soil	Soil (control)
1	4.38^{e}	5.13^{e}	2.49^{e}	1.75^{c}
2	6.88^{d}	9.50^{d}	3.50^{d}	2.50^{c}
3	11.88^{c}	11.50^{c}	4.50^{c}	2.50^{c}
4	15.00^{b}	15.63^{b}	5.75^{b}	3.58^{b}
5	21.88^{a}	22.63^{a}	7.50^{a}	6.25^{a}
SE±	0.29	0.34	0.28	0.30

Means along the column with the same superscript alphabet are not significantly different at $p<0.05$

Table 4: Mean of *Zea mays* L. growth parameters on different media

		Growth parameter			
Week	Treatment	Plant height (cm)	Leaf length (cm)	Number of leaf	Leaf width (cm)
1	*Jatropha*+soil	06.00[a]	08.00[a]	02.94[c]	02.00[b]
	Control	05.50[b]	04.50[b]	03.00[b]	02.00[b]
	NPK+soil	02.49[c]	02.00[c]	01.04[d]	02.06[c]
	Neem+soil	06.00[a]	08.00[a]	04.00[a]	03.00[a]
2	*Jatropha*+soil	10.00[a]	14.00[a]	04.00[c]	03.00[b]
	Control	07.50[b]	13.00[b]	04.50[b]	03.00[b]
	NPK+soil	03.50[c]	02.05[d]	00.00[c]	00.00[c]
	Neem+soil	10.00[a]	11.00[c]	05.50[a]	04.00[a]
3	*Jatropha*+soil	15.00[b]	17.00[a]	06.00[a]	03.00[b]
	Control	15.00[b]	13.50[c]	06.00[a]	03.00[b]
	NPK+soil	04.50[c]	03.00[d]	00.00[bc]	00.00[c]
	Neem+soil	17.50[a]	15.50[b]	06.00[a]	04.00[a]
4	*Jatropha*+soil	20.00[b]	20.00[b]	8.00[a]	04.33[b]
	Control	17.50[c]	17.50[c]	07.50[b]	04.00[c]
	NPK+soil	05.75[d]	04.00[d]	00.00[c]	00.00[d]
	Neem+soil	22.50[a]	25.00[a]	07.50[b]	06.00[a]
5	*Jatropha*+soil	28.00[b]	30.00[b]	10.00[a]	08.00[b]
	Control	27.50[c]	28.50[c]	10.00[a]	08.00[b]
	NPK+soil	07.50[d]	05.03[d]	02.00[b]	00.00[c]
	Neem+soil	32.00[a]	32.00[a]	10.00[a]	09.00[a]

Means along the column with the same superscript alphabet are not significantly different at $p<0.05$

DISCUSSION

The pH across all the growth media before planting and after harvesting is within the range that will not inhibit germination or subject the plants under stress even though it was moderately acidic after harvesting across all the soil media containing Neem, *Jatropha*, NPK fertilizer and the control. This finding agreed with the result of Ekanem and Akpheokhai[16] who reported the pH value of the medium to be acidic. Both organic carbon and organic matter of the soil before planting were low and both organic carbon and organic matter across all the growth media after harvest. This implies that the deposition of organic materials has increased the content of organic carbon and organic matter thereby increasing the fertility of the soil to support the growth and development of *Zea mays* L. The result contradicted the findings of Ekanem and Akpheokhai[16] who reported a varied concentration of organic matter in the soil growth media used for the cultivation of *Telfairia occidentalis.* There is a high concentration of nitrogen, phosphorus and potassium in the soil growth medium, the concentration of nitrogen and potassium reduces significantly with a significant increase in the concentration of phosphorus. Significant reduction in the nitrogen and potassium implies that the *Zea mays* L. grown on the media utilized the nitrogen and potassium, the increase in the concentration of Phosphorous indicates that the organic materials of Neem, *Jatropha* and Phosphorous content of the fertilizer NPK attributed to the increased with less demand for Phosphorous by the *Zea mays* L. grown on the media. This Phosphorous by the *Zea mays* L. grown on the media. This finding was not in agreement with the result reported by Xu *et al.*[1]. The difference could be attributed to varied quantities of both organic and inorganic fertilizer applications. The texture of all the growth media used for the cultivation of *Zea mays* L. seedlings is sandy-loam in nature. This finding was in collaboration with the results of Mbewe *et al.*[28].

The germination rate of the *Zea mays* L. varied among the different growth media (treatment), soil sample treated with *Jatropha* and the control had the highest germination rate while soil treated with inorganic fertilizer (NPK) recorded the lowest germination. A similar observation was made by Ayuba *et al.*[5] who reported the lowest percentage of 26.67% of *Zea mays* L. planted on medium containing NPK fertilizer. The low germination rate on the growth medium with NPK fertilizer could attest to the fact that NPK fertilizer inhibits germination due to its acidic nature. The acidic nature of the growth medium treated with NPK fertilizer can degrade the reserve food affecting the germination potential energy thereby inhibiting germination capacity[7].

Growth parameters of *Zea mays* L. seedlings across the different growth media indicate significant wide-ranging plant height, leaf length, number of leaves and leaf width at week 5 across all the growth media (treatment), including the soil used as a control in an order of *Jatropha*+soil>Neem+soil>NPK+soil>soil (control). This finding contradicted the results reported by Iwuagwu *et al.*[29] who observed a high growth rateand number of leaves on *Zea mays* L. grown on a growth medium treated with NPK fertilizer. Differences in findings could be attributed to the variation in the treatment coupled with cultivars used. This implies that the use of *Jatropha* could provide a suitable source of soil nutrients that is less expensive and promote the maintenance of healthy soil that is friendly to man's environment and soil biota.

CONCLUSION

Jatropha and Neem seed cake are found to support the growth and development of *Zea mays* L. at all levels of the growth process however, the soil organic carbon, organic matter and Phosphorous increase after harvest while nitrogen and potassium decrease. The use of both *Jatropha*, Neem and NPK fertilizer tends to change the soil pH thereby harming stored food and soil aeration which results in poor seed germination. The NPK fertilizer affects seed germination hence, it should be applied after germination. There is a need to examine the nitrogen, Phosphorous and potassium content of both *Jatropha* and Neem seed cake. Agencies and ministries responsible for agricultural activities should promote the use of *Jatropha* and Neem seed cake as a source of soil nutrients for the cultivation of *Zea mays* L.

SIGNIFICANCE STATEMENT

This study aims to evaluate the efficacy of *Jatropha curcas* and *Azadirachta indica* (Neem) seed cakes on the germination and growth of corn (*Zea mays* L.) seedlings. By comparing the effects of these organic amendments, the research aims to determine their potential as sustainable alternatives to chemical fertilizers in enhancing corn seedling development and overall agricultural productivity. The findings could contribute to eco-friendly farming practices and provide a holistic soil management strategy to sustain soil biodiversity.

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