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Research Article
Germination and Seedling Growth Rate of Corn (*Zea mays* L.) on Different Soil Media

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Abstract

Background and Objective: The germination and growth rate of maize is a key factor that regulates cultivated crop productivity. The study examined the germination and seedling growth rate of maize on four different media. **Materials and Methods:** The study was carried out in the Department of Biological Science, at Federal University, Gashua, Nigeria. For each block, 12 polythene bags were used, block A had 2:1:1 mixtures of topsoil, sharp sand and sawdust, subjected to sterilization. Block B had 2:1:1 mixtures of topsoil, sharp sand and cow dung, subjected to sterilization. Block C had 2:1:1 of topsoil, sharp sand and NPK, subjected to sterilization. Block D, contain sow dust which was not subjected to sterilization. The shoot height, shoot width, leaf length and leaf width were measured daily using a ruler for 4 weeks. The biomass was determined using the biomass index. **Results:** Block A had the highest rate of germination at 40%, Block C had the lowest percentage of 26.67% while there was no germination on Block D. There was a significant difference at $p<0.05$ between the treatment among the shoot height, shoot width, leaf length and leaf width at each week. The maize grown on Block B had the highest percentage of 48.6% while the one on Block C had the lowest percentage of the 25.0% of the biomass. **Conclusion:** To avoid poor germination and growth, seeds should be planted in natural soil while fertilizer and manure should be applied at the appropriate time during cultivation.

Key words: Maize, germination, media, organic matter, seedling, growth

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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 (*Zea mays* L.) originated in Mexico and is a popular crop in Central and South America. It was introduced into Africa in the 1500s and becomes the most important staple food crop, Africa generates 6.5% of the world's grain production, while Nigeria producing almost 8 million tonnes per year out of a total global production of 785 million tonnes[1]. Maize is one of the agricultural commodities grown in Nigeria that is both a raw material and a food crop. Maize is a significant crop in the globe and it is frequently utilized for animal feed. Maize ranks third in the world after wheat and rice[2]. Maize contains vitamins, microelements (copper, manganese and magnesium), antioxidant constituents (carotene and xanthophyll) and unsaturated fatty acids (linoleic and oleic), allowing it to be used in the daily diet as well as in the prevention of many diseases[3].

Germination is the first stage of the plant life cycle and one of the most crucial and delicate stages. It is a critical step in seedling development. This stage of development is heavily impacted by environmental factors such as temperature, water, humidity, length of germination, oxygen availability and physiological process. Among the stages of the plant life cycle, seed germination, seedling emergence and establishment are key processes in the survival and growth of plants. The most significant criteria are shoot and root length since roots are in direct touch with the soil and receive water from it, while the shoot supplies it to the rest of the plant Several factors influence seed germination and seedling establishment, including seed quality and environmental parameters[4].

Growth medium has a direct impact on seed germination, growth and development[5,6]. An ideal growth medium with adequate stored nutrient and water, provide support and allow passage of oxygen to the roots thereby allowing gaseous exchange between the roots and the surrounding atmosphere[7].

Soil management in crop production aims to establish a healthy soil environment that can maintain a balanced nutrient status and thus maintain fertility over time. Organic substances are essential components of soil nutrients, environmentally friendly and cost-free. Application of organic materials on farmland undergoes decomposition through humification and mineralization. Decomposed organic components in soil protect soil from runoff, erosion and mass movement of fine soil particles while improving retention of soil water, air pore space and productivity[8]. Organic matter influences the physical, biological, chemical and ecological processes that occur in the soil during crop cultivation, altering the soil structure, texture and chemical composition. They improve soil structure, soil water holding capacity, soil infiltration, soil biodiversity and nutrient availability[9].

However, most of the agricultural soils in Nigeria are poorly fertile due to erosion, flooding, continuous cultivation of land, desertification, climate change, bush burning and over-grazing which expose the soil to harmful environmental factors causing annual yield reductions[10-12].

In Africa more especially in Nigeria, sawdust is widely used and widely available, particularly in forested areas. Sawdust is less expensive than imported growing media and can be used as a growing medium[13]. Physical qualities (biodegradability), low surface specific gravity, high porosity, high water retention, moderate drainage and high bacterial tolerance increased its use as a plant growth medium[14]. Studies conducted on seed germination and growth rate showed seeds planted in river sand had the highest germination of 100% and were significantly different ($p \leq 0.05$) from those sown in other growth media (river sand and river sand combined with sawdust had 96.67% each while topsoil had 80%). The results also indicated that the performance of the seedlings in terms of height, number of leaves, leaf, area and collar diameter planted in the composite mixture of sawdust and river sand was better though not significantly different ($p>0.05$) compared to those in the other growth media except for topsoil medium that had relatively low performance[6,15,16]. This study is geared toward examining the rate of germination and seedling growth of maize on different media to suggest scientific knowledge on the utilization of different growing media in maize production which could curtail poor germination and inversely affect the yield.

MATERIALS AND METHODS

Study area: The research was carried out from February, 2022 to April, 2022 in the Department of Biological Science at the Federal University of Gashua. Gashua is a Yobe State Village located in North-Eastern, Nigeria. Gashua has a surface area of 809.661 km^2, an elevation of 299 m, with a population of 139782[17]. Its coordinates are 12°52'05''N and 11°02'47"E. The average low temperature in December to January, is 10-12°C, while the average maximum temperature in March-May is 34-37°C. The average annual rainfall is 300-500 mm. The rainy season lasts from June through September.

Sample collection: Topsoil measured 10 kg was collected using a hand trowel and was transported to the

laboratory in polythene bags for sterilization. The soil was sterilized using the soil drying/fume extraction oven model ODWF24-SD at a temperature of about 120°C. The cow dung was subjected to dryness under the sun and was broken into pieces using an iron pestle. The sawdust was collected from a carpenter shop and was taken to the botanical garden along the site with the soil topsoil and sharp sand using polythene bags.

Experimental design: For each block, 12 polythene bags were used. Block A (untreated) contain a proportion of 2:1:1 mixture of topsoil, sharp sand and sawdust that was not subjected to sterilization. Block B (treated+manure) contains a proportion of 2:1:1 mixtures of topsoil, sharp sand and cow dung, the soil was subjected to sterilization. Block C (treated+ NPK) contains a proportion of 2:1:1 that were of topsoil, sharp sand and NPK, the soil was subjected to sterilization. Block D (saw dust) contains sawdust, the sawdust was not subjected to sterilization. The experiment adopted random block design (3×4)[18].

Seed planting and maintenance of seedlings: The two viable seeds were planted in each of the polythene bags, placed in an open space at ambient temperature at equal proportions and were watered once. The seedlings were watered once daily after germination and were protected from pests using the net box.

Determination of germination: The germination rate was examined by daily recording the germinated seed number against the range of days it took for germination to occur. The germination rate was expressed in percentage as:

$$\text{Germinatin } (\%) = \frac{n}{N} \times 100$$

Determination of growth: After germination, the first seedling was maintained to determine the growth rate. The shoot height, shoot width, leaf length and leaf width of the plant were measured daily using a ruler in centimeters for a period of 4 weeks.

Determination of biomass: The biomass index of each block of the maize seedling was collected carefully by cutting the polythene bags using a razor blade to remove the soil attached to the root and shoot of the plant. The plant was washed thoroughly using running water from the tap to remove the soil particles. The biomass was determined using a formula:

$$\text{Biomass} = \text{Initial weight-Final weight}$$

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

RESULTS

Result showed the germination rate of the maize: The untreated media had the highest percentage of 40%, the media treated with NPK had the lowest percentage of 26.67% while there was no germination observed when sawdust was used as a growth medium (Table 1). The result in Table 2 showed the average shoot height of maize seedlings planted on different media for the period of 4 weeks. There was a significant difference between the three treatments every week. In week 1, week 2 and week 3, untreated soil media had the highest mean of 183.21, 384.77 and 463.85, respectively while in week 4, the media treated with manure (cow dung) had the highest of 479.10.

Shooting width of the maize seedling planted on different media for the period of 4 weeks: There was a significant difference between the three treatments every week. In week 1, the untreated had the highest mean of 21.20, in week 2 and week 3, treated with manure had the highest of 29.25 and 28.38 while in week 4, the untreated had the highest mean of 18.18 (Table 3).

Table 1: Germination rate of maize planted in different media

Treatment (growth media)	Number of seed planted per pot	Total germinated seed	Seed germinated (%)
Untreated	2	24	40.00
Treated+Manure	2	20	33.33
Treated+NPK	2	16	26.67
Saw dust	2	0	00.00

Leaf length of the maize seedling planted for the period of 4 weeks on different media: There was a significant difference between the three treatments every week. In week 1 and week 2, the media treated with manure had the highest means of 258.48 and 594.45, respectively, in week 3, untreated had the highest of 994.78 and in week 4, the treated had the highest mean of 700.78 (Table 4).

Leaf width of the maize seedling planted for the period of 4 weeks: There was a significant difference between the three treatments every week. In week 1, the media, treated with manure had the highest mean of 46.575 in weeks 2, 3 and 4, untreated had the highest mean of 92.38, 111.80 and 121.40, respectively (Table 5).

Table 2: Average shoot height of maize seedlings planted in different media

Week	Treatment	Number of samples	Mean*
1	Untreated	4	183.21[a]
	Treated manure	4	138.14[b]
	Treated fertilizer	4	138.05[c]
2	Untreated	4	384.77[a]
	Treated manure	4	345.28[c]
	Treated fertilizer	4	265.10[b]
3	Untreated	4	463.85[a]
	Treated manure	4	394.28[b]
	Treated fertilizer	4	322.13[c]
4	Untreated	4	436.93[b]
	Treated manure	4	479.10[a]
	Treated fertilizer	4	336.25[c]

*Letters down the column are significantly different at p<0.05 between the treatments

Table 3: Average shoot width of maize seedlings planted in different media

Week	Treatment	Number of samples	Mean*
1	Untreated	4	21.20[a]
	Treated manure	4	19.38[b]
	Treated fertilizer	4	17.58[c]
2	Untreated	4	25.80[c]
	Treated manure	4	29.25[a]
	Treated fertilizer	4	27.65[b]
3	Untreated	4	28.38[a]
	Treated manure	4	21.83[b]
	Treated fertilizer	4	18.95[c]
4	Untreated	4	18.18[b]
	Treated manure	4	15.28[c]
	Treated fertilizer	4	25.45[a]

*Letters down the column are significantly different at p<0.05 between the treatments

Table 4: Average leaf length of maize seedlings planted in different media

Week	Treatment	Number of samples	Mean*
1	Untreated	4	247.65[b]
	Treated manure	4	258.48[a]
	Treated fertilizer	4	197.50[c]
2	Untreated	4	677.60[a]
	Treated manure	4	594.45[b]
	Treated fertilizer	4	368.30[c]
3	Untreated	4	994.78[a]
	Treated manure	4	652.23[b]
	Treated fertilizer	4	639.15[c]
4	Untreated	4	302.08[c]
	Treated manure	4	310.40[b]
	Treated fertilizer	4	700.78[a]

*Letters down the column are significantly different at p<0.05 between the treatments

Table 5: Average leaf width of maize seedlings planted in different media

Week	Treatment	Number of samples	Mean*
1	Untreated	4	39.38[b]
	Treated manure	4	46.58[a]
	Treated fertilizer	4	37.40[c]
2	Untreated	4	92.38[a]
	Treated manure	4	83.88[b]
	Treated fertilizer	4	61.65[c]
3	Untreated	4	111.80[a]
	Treated manure	4	89.63[b]
	Treated fertilizer	4	80.80[c]
4	Untreated	4	121.40[a]
	Treated manure	4	85.08[c]
	Treated fertilizer	4	100.03[b]

*Letters down the column are significantly different at $p<0.05$ between the treatments

Table 6: Biomass of maize seedlings planted in different media

Treatment	Initial weight (wet)	Final weight (dry)	Biomass (g)	Biomass (%)
Untreated	26.2	7.6	19	26.4
Treated manure	49.9	14.7	35	48.6
Treated fertilizer	22.9	4.8	18	25.0

Biomass of maize seedlings grown for the period of 4 weeks: The media treated with manure had the highest percentage of 48.6% while the one treated with NPK fertilizer had the lowest percentage of 25.0 as shown in Table 6.

DISCUSSION

From the finding, the untreated media had the highest percentage of 40%, the media treated with NPK had the lowest percentage of 26.67% while there was no germination observed when sawdust was used as a growth medium. The highest percentage of germination in the untreated media could be attributed to the fact that the media had good water retention capacity, sufficient nutrients and good aeration coupled with active microbial activities. The lowest percentage of germination observed on media treated with Nitrogen Phosphorus Potassium (NPK) fertilizer could be adduced to the fact that the acidic nature of the media caused by the fertilizer hurts the germination since it can degrade the food reserve which could affect the germination energy and the germination capacity. The absence of germination on sawdust used as growing media could be a result of high-water retention capacity, poor aeration, lack of active microbial activities and insufficient nutrient because the biodegradation of the sawdust requires time before it could provide nutrients that will support seed germination and growth. This finding was not in agreement with the results of a study conducted[19], which reported 70% seed emergence of *Senna fistula* on river sand and 40% on sawdust while a study conducted on *Helianthus annuus* L.[20] reported that, urea had significant maximum germination of 87.5% while manure recorded 85.0%. The difference could be attributed to differences in seed size, seed size, quantity of water applied and hardness of the coat, implying that, seed size coupled with sawdust's moisture content could negatively affect the germination rate. The shoot height of the maize seedlings shows significant variation among the three treatments from the 1st week to the 4th week. The untreated soil media had the highest mean of 183.21, 384.77 and 463.85 cm at week 1 to 3 while at week 4, the media treated with manure had the highest of 479.10 cm. The shoot width of the maize seedling planted on different media for the period of 4 weeks was significantly different. In week 1, the untreated had the highest mean of 21.00, in week 2 and week 3, treated with manure had the highest of 29.25 and 28.38 while in week 4, the untreated had the highest mean of 18.18. The difference in the shoot height and width could be attributed to the difference in nutrient availability and variation in active response to temperature while the media treated with manure, the manure could have degraded which provide a sufficient nutrient supplement to the soil absorbed by the plant. This finding differed from the finding of Mananze *et al.*[21], who reported a maximum shoot height of 2325 mm. This variation could be ascribed to differences in the variety and nature of soil used. The leaf length and width show significant differences. For the leaf length, in week 1 and week 2, the media treated with manure had the highest means of 258.48 and 594.45, respectively, in week 3, untreated had the highest of 994.78 and in week 4, the treated had the highest mean of 700.78. In week 1, the media treated with manure had the highest mean of 46.575 in weeks 2, 3 and 4,

untreated had the highest mean of 92.38, 111.80 and 121.40, respectively for the leaf width. The variation among the treatment could be attributed to differences in physiological processes and cell division coupled with differences in the size of the leaves which has direct correction with the rate of photosynthesis. This result contradicts the findings of researchers[22,23]. The difference could be adduced to variations in agroecological, treatments, varieties and differences in the photosynthetic process due to differences in leaf size and temperature. The media treated with manure had the highest percentage of 48.6% while the one treated with NPK fertilizer had the lowest percentage of 25.0% of the maize seedling biomass. The difference in the biomass could be a result of the difference in the rate of translocation. This finding contradicts the results of Nigussie *et al.*[24], who reported a significantly higher percentage of biomass of 49.7 on chernozem soil and 47.3% on reddish prelude soil. The difference could be adduced differences in variety, cropping system, availability of water and nutrient.

In view of the finding from this study, the application of sawdust and fertilizer could inhibit the germination of seeds. Therefore, sawdust should be applied within an interval of time to permit the sawdust to undergo decompose before planting while fertilizer more especially, the nitrogen base should be applied to the seedling. The timing and quantity of sawdust and nitrogen based fertilizer application should be examined.

CONCLUSION

The use of manure increases the humus content of the topsoil thereby impairing soil aeration which results in poor seed germination. Manure and fertilizer hurt plant growth and development, therefore, seeds should be planted in natural soil while fertilizer and manure should be applied at the appropriate time. Therefore, there is a need for further research on the timing for the application of fertilizer and the use of manure on the soil to achieve a high germination rate and growth.

SIGNIFICANCE STATEMENT

The study observed that the application of sawdust, fertilizer (NPK) and manure during planting could negatively influence the rate of germination of maize. The study discovered that sawdust inhibits seed germination, fertilizer (NPK) and manure were found to reduce the rate of germination while the natural soil was found to encourage seed germination. The fertilizer (NPK) and manure were discovered to promote a high rate of growth and development at the later stage of maize. It further, observed that manure and fertilizer (NPK) enhance high biomass production. Hence, farmers should avoid the application of sawdust, fertilizer (NPK) and manure before planting since they can retain high moisture which could be acidic in nature thereby, inhibiting seed germination and hurting the seedlings.

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