Biochemistry & Molecular Biology Letters
ISSN: 2454-9304

Research & Reviews in Biosciences

Research | Vol 12 Iss 3

Effect of Recycled Plant Residues Used as Bio-Fertilizers on Early Growth of Maize in North-Western Nigeria

Sanda A and Anka SA*

Department of Biological Sciences, Usmanu Danfodiyo University, Sokoto, Nigeria

***Corresponding author:** Anka SA, Department of Biological Sciences, Usmanu Danfodiyo University, Sokoto, Nigeria, Tel: 8061273474; E-mail: sulealiyu_anka@yahoo.com

Received: August 21, 2017; **Accepted:** October 29, 2017; **Published:** November 02, 2017

Abstract

This research was conducted at the botanical garden of the Usman Danfodiyo University Sokoto Nigeria, using digested plant materials of *Oryza sativa, Commelina diffusa, Sorghum vulgare, Vigna unguiculata, Pennisetum typohides* and *Pistia stratiotes* to test the effect of biofertilizer on early growth of maize. The undigested plant materials of the same sources were used as control for comparison. 3 kg of sand was mixed with 500 g of each of the plant materials (digested and undigested) to serve as sowing medium. The same contents were put in labeled plastic containers for growing maize. The potting mixtures were watered thoroughly before sowing. Data were collected on weekly intervals for 42 days and subjected to simple descriptive statistics to compare the mean values of maize growth parameters. These include stem height, number of leaves, stem girth and root length. The results indicated highest stem height of 80.3 cm in sowing medium containing digested sorghum against 65.5 cm stem height recorded with the control at 6 WAP. The same treatment had the highest number of 7 leaves per plant at 6 WAP as against 6 leaves in the control. Stem girth ranges from 1 cm in rice treated medium at 1 WAP to 9.7 cm in sorghum treated medium at 6 WAP over and above 0.5 cm to 8.9 cm in the control treatments at 6 WAP. The highest root length of 19.8 cm was obtained in sorghum treated medium against 15.5 cm root length in the control at 6 WAP. Sorghum treated medium yielded the best results in terms of stem height, number of leaves, stem girth size and root length and is therefore recommended for use as bio-fertilizer in maize production.

Keywords: Bio-fertilizer; Fermentation; Slurry; Early growth; Methanogenesis; Recycled plant residues; Maize production; Northern Nigeria

Citation: Sanda A, Anka SA. Molecular Genetic Effect of Recycled Plant Residues Used as Bio-Fertilizers on Early Growth of Maize in North-Western Nigeria. Res Rev Biosci. 2017;12(3):131

Introduction

Agriculture had been the mainstay of Nigerian's economy prior to the oil boom providing about 70% of the employment opportunities and about 60% export commodities [1]. Greater percentage of the country's people have been characterized as poor-resourced, operating at subsistence level, living in the rural areas without basic necessities of life, such as portable drinking water, good roads, education, electricity and modem farming equipment. Food production has fallen drastically short of meeting the local demand thereby resulting in increased food import bill for the country [2]. It is therefore pertinent for food production sufficiency and security in this nation particularly in the northern parts with relatively low rainfall in many parts to devote for food production. Maize is one of the staple crops with the potential for solving the problems of hunger and starvation in sub-Saharan countries [3]. Pointed out that maize is the highest yielding farm crop with multiples uses for food and industrial purposes. It ranks first after rice in the global production of cereal crops [4]. Global maize utilization in 1996 total 579 million tones with 387 million tones used as animal feed. The development of early and extra early maturing varieties has enabled maize production to expand into the Sudan Savanna Zone. The single major problem of producing this important staple crop in the north-western Nigeria is the inherent nutrient-poor soils of the area and the fertilizer is increasingly becoming very expensive and unavailable to the reach of the peasant farmers [5].

The low performance of maize can be attributed to among other things, the bulk of the country's farming (over 90%) being dependent on subsistence agriculture with rudimentary farming system, low capitalization and low yield per hectare (Olayemi, I994). Price fluctuation, diseases and pests, poor storage facilities were the other identified problems of low maize production in Nigeria [6]. Alternative arrangements that address the problems of low productivity of staple crops like maize must be put in place to ensure sustainable and improved production of these crops. A veritable way of addressing this problem is the incorporation of crop residues (e.g. leaves and all other degradable parts of the plants) into farming system. Important and readily available materials that could be used include by-products of methanogenesis called slurry obtained from these digested plant residues. The application of these residues as bio-fertilizer agents that are recycled back to arable land ensures that crop receive the majority of the essential nutrients required for growth [7]. The current research focuses on the effect of digested and undigested plant materials on the early growth of maize crop.

Materials and Methods

The study area

The study was carried out at the botanical garden, Usmanu Danfodiyo University Sokoto, on latitudes 11° 30 to 14° 00'N, longitudes 4° 00 to 6° 40'E and altitude 351.0 m above sea level, in the Sudan savanna ecological zone of Nigeria [8]. Sokoto ranks second in livestock production in Nigeria with over eight (8) million animals and 2.8 million people as projected in 1997 Census [9]. The vegetation of the area is characterized by scattered trees and shrubs with more or less dense continuous grass cover. The climate of the area is of two seasons namely, rainy and dry seasons. The rainy season starts from May-October with 500 mm-750 mm of rainfall [10]. The dry season starts from October and ends in May with strong wind storms and severe dryness. Temperature is averagely about 32°C during the wet period and 44°C in the dry periods. Humidity is recorded to be constantly below 40% during the dry periods but can rise up to 70% during the wet periods. Soil types vary but are mostly sandy and low in organic matter due to scanty vegetation but susceptible to wind and water erosion [11].

Digestion of the plant materials

The process of methanogenesis adopted from [12] was employed in the production bio-fertilizer from the plant test products. Six sets of materials necessary for the process were assembled: Micro digester, retort stand, water bath, rubber tube and measuring cylinder. One set each for the rice husk (*Oryza sativa*), *Vigna unguiculata, Pistia stratiotes, Commelina difussa, Pennesitum typophoides and Sorghum vulgare*. For each of the six plant residues, 100 g was obtained and mixed with 100 ml of water, to form slurry that was put inside a micro digester. The digester was shaken occasionally to prevent scum from building up and inhibiting the process of gas formation and was connected to a measuring cylinder *via* a rubber tube. The cylinder was filled up and inverted with nearly a quarter of it submerged in water inside a water bath. Fermentation took place and gas evolved from the digester down to the measuring cylinder through the rubber tube causing the same quantity of water to be displaced. The process of methanogenesis terminated at 21 days after which the by-products of these plants were obtained as sludge (bio-fertilizer).

Field experiment

Effects by-products of the test plants after fermentation were examined as follows:

500 g of each plant residue was obtained and mixed with 3 kg of pure sand. 12 empty plastic containers were used as growing media and the prepared potting mixtures were later transferred to the growing media and labeled according to the type of plant residue. Below each of the 12 containers was a small container to receive water dripping from the larger containers above, which were collected and ploughed back to the larger containers to prevent loss of nutrients over time. Data were collected on maize stem height, number of leaves, girth of the stem and root length on weekly basis for a period of six weeks. Watering of the maize plant was done in the morning at an average daily interval of 24 h. Average values of the maize growth parameters were determined for both media treated with the digested and undigested test plant residues.

Results and Discussion

The results indicated variation in stem height, number of leaves, stem girth and root length within and across the digested and undigested plant materials used. The digested slurry compared favorably higher than the undigested materials in virtually all the growth parameters (TABLES 1 to 4). The highest maize stem height of 29.8 cm was obtained in the growing medium treated with digested *Sorghum vulgare* and the lowest stem height of 17.3 cm came from medium with undigested rice husk (TABLE 1).

The highest number of leaves per maize plant was obtained in the growth media treated with digested rice and sorghum with 5 leaves each at 6 WAP and the least was 4 leaves, which came from the remaining treatments (TABLE 2). Highest maize stem girth of 5.5 cm was obtained from digested sorghum treated medium, while the least, which is 1.6 cm came from undigested rice treated medium (TABLE 3). Similar trend was observed in root length, with the highest value of 19. 8 cm obtained from the digested sorghum and the lowest value of 13.5 cm from the undigested rice (TABLE 4).

TABLE 1. **Average stem height of maize (cm) at 6 WAP.**

S/No.	Plant material	Digested	Undigested
1.	*Oryza sativa*	23.3	17.3
2.	*Vigna unguiculata*	24	20.3
3.	*Pista stratiotes*	22.2	-
4.	*Commelina diffusa*	26.8	21.4
5.	*Pennisetum typhoides*	29.7	24.2
6.	*Sorghum vulgare*	29.8	24.5

TABLE 2. **Average number of leaves per maize plant at 6 WAP.**

S/No.	Plant material	Digested	Undigested
1.	*Oryza sativa*	5	4
2.	*Vigna unguiculata*	4	4
3.	*Pista stratiotes*	4	-
4.	*Commelina diffusa*	4	4
5.	*Pennisetum typhoides*	4	4
6.	*Sorghum vulgare*	5	4

TABLE 3. **Average girth size of maize stem (cm) at 6 WAP.**

S/No	Plant material	Digested	Undigested
1.	*Oryza sativa*	2.2	1.6
2.	*Vigna unguiculata*	2.4	2
3.	*Pista stratiotes*	2.6	-
4.	*Commelina diffusa*	3.4	2.8
5.	*Pennisetum typhoides*	4.2	3.2
6.	*Sorghum vulgare*	5.5	4.4

TABLE 4. **Average root length of maize (cm) after harvest 6 WAP.**

S/No.	Plant materials	Digested	Undigested
1.	*Oryza sativa*	15.8	13.5
2.	*Vigna unguiculata*	15.2	13.7
3.	*Pistia stratiotes*	15.0	-
4.	*Commelina diffusa*	15.2	13.5

5.	*Pennisetum typhoides*	18.5	15.0
6.	*Sorghum vulgare*	19.8	15.5

The general trend of the data indicated that better maize performance in terms of stem height, girth and root length resulted from the digested slurry and this is attributable to the fast decomposition of the slurry in the media. In addition, the results show strong relationship between stem height and root length, that is, the longer the maize root the higher the maize stem. However, growth medium treated with undigested *Pistia striotes* indicated zero germination of maize, which may be due to some possible inhibitory secretions from the plant residue in question. In related studies, [13] reported that fertilization of soil with biogas slurry generated from cattle dung improved the yield of wheat over the non-modified controls. [14], further revealed that, biogas residue provides effective nitrogen source to farm crops, increase yields of alfalfa, safflower, vegetables etc. and improve soil texture through enrichment with heavy degradable compounds.

Conclusion

Digested sorghum slurry was found to be more effective than the other test materials in promoting early growth of maize. This is evident in the highest values of stem height, stem girth, root length and number of leaves obtained in growth medium treated with the digested material. Utilization of these recyclable products as bio-fertilizer would reduce the requirements for the production of inorganic fertilizers, greenhouse gas emissions to the atmosphere, enhance efficient waste utilization and increase global economic benefits.

Recommendations

For consolidating the gains of this work the following recommendation are made:

- Further investigation should focus on determining the factor (s) responsible for the non-germination of maize treated with undigested residue of *Pistia stratiotes*.
- Farmers should be encouraged to identify with research centers in their home countries to enable easy access to bio-fertilizer products at little or no cost.
- Special training and contact programs can be initiated to train local farmers on the utilization of local products from plants to increase soil fertility for affordable and sustainable crop production.

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