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EFFECT OF LEAF LITTERS OF SELECTED NITROGEN FIXING ALBIZIA TREES ON THE GROWTH AND YIELD OF GINGER (*Zingiber officinale Roscoe*)

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ABSTRACT

There is paucity of quantified information on the plant based organic manuring of Zingiber officinale. In this light, a Completely Randomized Design with five replications was laid out to assess the effect of leaf litters of selected nitrogen fixing albizia trees (Albizia zygia, Albizia coriaria, Albizia ferruginea, Albizia lebbeck and Albizia saman) and control on the growth and yield of Zingiber officinale on the field of Federal College of Forestry Mechanization, Afaka, Kaduna State, Nigeria. The experiment consists of 6 treatments replicated five times. A propagule represented a replicate. The total number of thirty propagules of approximately equal weight (20 g) was involved in the experiment. The same quantity of leaf litters (100 g) was placed at 5 cm depth and 5 cm radius from planted propagule in the heap of about 3 kg of soil. Water (500 mL) was applied per heap before and after planting the propagule. Zingiber officinale growth parameters evaluated include height, girth, number of leaves, leaf area, leaf area index, total fresh and dry weight. Data collected was subjected to one way Analysis of Variance (ANOVA) and significant means were separated using Fischer's Least Significant Difference (LSD). Leaf litters of nitrogen fixing albizia trees significantly (P<0.05) influenced growth and yield of Z. officinale. The significant height (37.34 cm)., widest girth (2.68 cm), significant leaf area index (3.28)., significant total fresh weight (72.95 g) and total dry weight (3.86 g) were recorded from seedlings of propagules planted in leaf litters of A. saman between 4-12weeks after planting (WAP) respectively. Significant fresh weight (69.75 g) and dry weight (3.60 g) were recorded for the roots (yield) of seedlings from propagules planted in the soil incorporated with leaf litters of A. saman. The use of leaf litters of A. saman on the soil enhanced the growth and yield of Z. officinale.

Key words: Nitrogen fixing trees, Leaf litters, Manure, Amendment, Growth, Propagules

INTRODUCTION

Ginger, *Zingiber officinale* belongs to the family Zingiberaceae and it is an important commercial crop grown for its aromatic rhizomes which are consumed as a spice (Jakes, 2007) in medicine, and as a special vegetable in daily diets worldwide (Agbede, 2013) and as a delicacy (Egbuchua and Enujeke 2013). Asumugha *et al*. (2006) and Jakes (2007) reported that it is also used largely as recipes such as ginger bread, cookies, crackers, cakes, ginger-ale and ginger beer. Research has shown increase in ginger production in Nigeria in the past years. Nigeria's ginger production in 2006 which was put at 134, 000 metric tonnes increased to 140,000 metric tonnes in 2008 (FAO, 2009) which is 4.3% increase.

Okafor (2012) reported that out of this production, an average of 10 % is locally consumed as fresh ginger, while 90 % is dried and 20 percent of the dried ginger is consumed locally for various uses while the remaining is exported. *Zingiber officinale* has been used for thousands of years for the treatment of numerous ailments, such as colds, nausea, arthritis, migraines, and hypertension (Bode and Dong, 2011). The medicinal, chemical, and pharmacological properties of *Z. officinale* have been extensively reviewed (Ernst and Pittler, 2000; Afzal *et al.*, 2001; Boone and Shields, 2005; Borrelli *et al.*, 2005; Chrubasik and Pittler, 2005; Chrubasik *et al.*, 2005; Grzanna *et al.*, 2005; Thompson and Potter, 2006; Eliopoulos, 2007;

Shukla and Singh, 2007; White, 2007; Ali *et al.*, 2008; Nicoll and Henein, 2009).

The major production problems responsible for *Z. officinale* low yield are continues decline in soil fertility and lack of soil management requirement for its cultivation (Agbede, 2013). Sarvade *et al.* (2014) reported that the loss of soil productivity and shortfall of food and cash crops are the immediate impact of land degradation. Like any other plant, *Z. officinale* requires the right kind of nutrients to sustain its growth and maximum yield (Egbuchua and Enujeke, 2013). Adekola and Usman (2009) also mentioned that the insufficiency, bulkiness, offensive odour and disease outbreak have limited the use of animal manure as fertilizer. Excessive input of chemical fertilizer contaminates the environment (Olowe and Akintunde, 2012). The scarcity and expensiveness of chemical reduces its adoption by poor farmer. Adekola and Usman (2009) stated that these challenges have resulted in a general negative nutrient balance in most fields. To overcome these challenges, agro-forestry is a viable option (Adelani *et al.*, 2014).

Biomass transfer is an agro-forestry practice. Adelani *et al.* (2020 a) stated that biomass transfer is an agro-forestry practices that involve the cut and carry of litters of agro-forestry tree species from mother trees to place of restoring soil fertility. Schroth and Sinclair (2003) reported that biomass transfer systems represent an intermediate situation in which the nutrients in the biomass are removed from one site and added to another site within the same landscape for soil fertility restoration. Lehmann *et al.* (2002) and Bhardwaj *et al.* (2005) documented that leaf litter inputs from agro-forestry trees could provide sufficient nutrients and organic matter to sustain crop growth. In spite of the enormous potentials of agro-forestry, there is dearth of quantified information on organic manuring of *Z. officinale* with leaf litter of nitrogen fixing trees in the Northern Guinea Savannah ecological zones of Nigeria. Therefore, this experiment on effect of leaf litters of selected nitrogen fixing albizia trees on *Z. officinale* was conducted.

MATERIALS AND METHODS

Experimental site

The research was conducted on the field of Federal College of Forestry Mechanization, Afaka, Kaduna. The college is located in the Northern Guinea Savannah ecological zones of Nigeria. The college lies within latitudes 10 °35 ′ and 10 ° 34 ′ and longitudes 7 ° 21 ′ and 7 ° 20 ′ (Adelani, 2015). The vegetation is open woodland with tall broad trees, usually with small boles and broad leaves (Otegbeye *et al.*, 2001).

Sample Collection and Preparation

The rhizomes of ginger were sourced from farmers in Kagarko Local Government Area, Kaduna State. The propagules were washed and air dried for 30 minutes. The propagules were cut into equal sizes, labelled and weighed (20g). The biomass transfer method which involves the collection of wet leaves of nitrogen fixing trees from their locations was used. The nitrogen fixing trees were not in the same site but the same environment. The samples of the different leaves of nitrogen fixing albizia trees were air dried and pulverised. The samples of each leaves were weighed (100 g). The heap of about 3 kg each was made on the field.

Chemical Analysis of Leaf litters of Selected Nitrogen Fixing Albizia Trees and Soil of the Site

Each sample of pulverized leaves of nitrogen fixing albizia trees (*Albizia zygia*, *Albizia coriaria*, *Albizia ferruginea*, *Albizia lebbeck* and *Albizia saman*) after air dried was analyzed chemically for nitrogen, phosphorus and potassium (NPK) content at the Federal University of Agriculture Abeokuta, Ogun State, Nigeria laboratory. The samples of the soil of the experimental site were taken from three different portion of site, air dried and pooled together for analysis. Determination of total nitrogen was done by Macro Kjeldahi method. Available phosphorus (P) was extracted by Bray-1 method and determined colourimetrically. Extracts from the digestion of the leaves of the agro-forestry tree species and soil sample were used to determine potassium by flame photometry.

Experimental Design

A Completely Randomized Design (CRD) with five replications was laid out to assess the effect of leaf litters of selected nitrogen fixing albizia trees (*Albizia zygia*, *Albizia coriaria*, *Albizia ferruginea*, *Albizia lebbeck*, *Albizia saman*) and a control on the growth and yield of *Zingiber officinale*. The experiment consists of 6 treatments replicated five times. A propagule represented a replicate. The total number of thirty (30) propagules of approximately equal weight (20 g) was involved in the experiment. The sample of the propagule was weighed on the Mettler Top loading weighing balance. A modification of fertilizer banding placement in one side method by Bakhtiari *et al.* (2014) was adopted; the same quantity of leaf litters of nitrogen fixing trees was placed at 5 cm depth and 5 cm radius from planted propagule in the heap of about 3 kg of soil with espacement of 30 cm within and between the heaps. To prevent easily washing away of the nutrient before seedling growth well to access it, fertilizer banding placement in one side method was used. The heap without the leaves of nitrogen fixing albizia trees represented the control. Water (500 mL) was applied per heap before and after planting the propagule to wet the heap to field capacity. Seedling assessment was carried out after four weeks of planting.

Growth parameters were monitored every two weeks for 12 weeks. Growth parameters assessed include: Seedling height using meter rule; girth using venier caliper; number of leaves were counted manually and leaf area was obtained by linear measurement of leaf length and leaf width as described by Clifton-Brown and Lewandowski (2000).

$$LA = 0.74 \times L \times W \quad \text{............ [1]}$$

Where: LA = leaf Area

LxW = Product of linear dimension of the length and width at the broadest part of the leaf.

$$LAI = \frac{LA}{LDA} \quad \text{............ [2]}$$

Where: LAI = leaf Area Index
LDA= land Area

The fresh and dry weight were determined by the use of Mettler Top Loading Weighing Balance, but dry weight was taken after oven dried the seedlings at 70 ^{o}C for 72 hours (Umar and Gwaram, 2006).

Data Analysis

The data on the effect of leaf litters of selected nitrogen fixing albizia trees on the growth and yield of ginger was subjected to one way Analysis of Variance (ANOVA) using SAS (2003). Comparison of significant means was accomplished using Fishers Least Significant Difference (LSD) at 5 % level of significance.

RESULTS

Effect of Leaf litters of Selected Nitrogen Fixing Albizia Trees on the Height of *Z. officinale*

Tallest plant (37.34 cm) was recorded from *Z. officinale* planted in the soil incorporated with *A. saman.*, while the least height (5 cm) was recorded from *Z. officinale* planted in the soil without amendment of leaf litters of nitrogen fixing albizia trees (control). A significant height of 37.34 cm was recorded from seedlings planted in soil influenced with *A. saman* at 12 weeks after planting (WAP) (Table 1).

Table 1: Effect of leaf litters of selected nitrogen fixing albizia trees on the height (cm) of *Z. officinale*

NFAT	Weeks After Planting				
	4	**6**	**8**	**10**	**12**
A.saman	19.26^{b}	20.24^{b}	21.72^{b}	21.72^{b}	37.34^{a}
A.coriaria	5.90^{b}	6.26^{b}	12.98^{ab}	13.84^{ab}	17.14^{a}
A.zygia	13.88^{b}	18.04^{ab}	18.56^{ab}	19.52^{ab}	20.10^{a}
A.lebbeck	12.30^{c}	13.00^{c}	21.22^{b}	24.16^{ab}	29.70^{a}
A.ferruginea	12.30^{c}	14.18^{bc}	19.96^{b}	25.06^{ab}	30.10^{a}
Control	5.00^{a}	5.30^{a}	8.84^{a}	9.28^{a}	9.62^{a}
SE ±	1.13	1.82	1.88	2.09	4.80

**Means on the same rows with the same alphabet are not significantly different at (P<0.05)*

Key: NFAT-Nitrogen fixing albizia trees

Effect of Leaf litters of Selected Nitrogen Fixing Albizia Trees on the Girth of *Z. officinale*

Widest girth of 2.68 cm was recorded from *Z. officinale* planted in the soil amended with *A. saman.* The least value of 0.38 cm was recorded from *Z. officinale* planted in the soil without amendment of leaf litters of nitrogen fixing albizia trees (control). A significant girth of 2.68 cm was recorded from seedlings of propagules planted in the soil influenced with *A. saman* at 12 WAP (Table 2).

Table 2: Effect of leaf litters of selected nitrogen fixing albizia trees on the girth (cm) of *Z. officinale*

NFAT	Weeks After Planting				
	4	6	8	10	12
A.saman	1.96^{a}	2.02^{a}	2.12^{a}	2.26^{a}	2.68^{a}
A.coriaria	0.68^{a}	0.90^{a}	1.42^{a}	1.44^{a}	1.54^{a}
A.zygia	1.20^{b}	1.38^{ab}	2.16^{ab}	2.48^{ab}	2.56^{a}
A.lebbeck	1.38^{a}	1.58^{a}	1.76^{a}	1.86^{a}	2.54^{a}
A.ferruginea	1.42^{a}	1.44^{a}	1.52^{a}	1.68^{a}	2.02^{a}
Control	0.38^{a}	0.40^{a}	0.56^{a}	1.26^{a}	1.44^{a}
SE ±	0.71	0.55	0.48	0.48	0.46

Key: **Means on the same rows with the same alphabet are not significantly different at (P<0.05);* NFAT-Nitrogen fixing Albizia trees

Effect of Leaf litters of Selected Nitrogen Fixing Albizia Trees on the Number of Leaves of *Z. officinale*

Highest number of leaves (12.6) recorded from *Z. officinale* planted in the soil incorporated with *A. lebbeck* was significantly different from others. The least value of 1.6 was recorded for number of leaves of *Z. officinale* planted in the soil amended with *A. coriaria* at 4WAP (Table 3).

Effect of Leaf litters of Selected Nitrogen Fixing Albizia Trees on the Leaf area of *Z. officinale*

Widest leaf area (17.22 cm^2) was recorded for *Z. officinale* planted in the soil enhanced with leaf litters of *A. saman*, while the narrowest leaf area (1.51 cm^2) was recorded from seedlings of propagules planted in the soil influenced with *A.coriaria*. A significant leaf area of 17.22 cm^2 was recorded from *Z. officinale* planted in the soil enhanced with *A. saman* (Table 4).

Effect of Leaf litters of Selected Nitrogen Fixing Albizia Trees on the Fresh and Dry Weight of *Z. officinale*

Significant fresh weight (69.75 g) and dry weight (3.60 g) were recorded for the roots of seedlings from propagules planted in the soil incorporated with leaf litters of *A. saman* respectively. Lowest values of 0.15 g (fresh leaf) and 0.04 g (dry shoot) were recorded from seedlings of propagules planted in the soil without the addition of leaf litters of nitrogen fixing trees (control) respectively (Table 5).

Table 3: Effect of leaf litters of selected nitrogen fixing Albizia trees on the number of leaves of *Z. officinale*

NFAT	Week After Planting				
	4	6	8	10	12
A. saman	4.80^{b}	4.80^{b}	7.80^{ab}	10.00^{a}	11.40^{a}
A. coriaria	1.60^{b}	1.80^{b}	4.40^{ab}	6.60^{ab}	7.80^{a}
A. zygia	4.00^{a}	4.20^{a}	5.60^{a}	7.00^{a}	8.80^{a}
A. lebbeck	2.80^{b}	3.00^{b}	6.80^{b}	10.40^{ab}	12.60^{a}
A. ferruginea	4.20^{b}	4.60^{b}	7.00^{ab}	9.00^{ab}	10.60^{a}
Control	1.80^{a}	1.80^{a}	3.80^{a}	4.80^{a}	5.00^{a}
SE ±	1.34	1.38	2.08	2.76	2.87

Key: **Means on the same rows with the same alphabet are not significantly different at (P<0.05);* NFAT- Nitrogen fixing Albizia trees

Table 4: Effect of leaf litters of selected nitrogen fixing albizia trees on the leaf area (cm^2) of *Z. officinale*

NFAT	Weeks After Planting				
	4	6	8	10	12
A. saman	11.40^{a}	11.50^{a}	12.30^{a}	15.00^{a}	17.22^{a}
A. coriaria	1.51^{b}	4.70^{b}	5.58^{ab}	8.00^{ab}	14.62^{a}
A. zygia	8.92^{a}	9.62^{a}	11.06^{a}	14.22^{a}	14.22^{a}
A. lebbeck	6.90^{a}	6.90^{a}	10.78^{a}	11.30^{a}	12.82^{a}
A. ferruginea	9.70^{a}	9.74^{a}	11.84^{a}	11.96^{a}	13.98^{a}
Control	2.00^{a}	2.00^{a}	5.78^{a}	5.86^{a}	6.38^{a}
SE ±	3.98	4.74	3.64	3.42	4.29

Key: **Means on the same rows with the same alphabet are not significantly different at (P<0.05);* NFAT-Nitrogen fixing Albizia trees

Table 5: Effect of leaf litters of selected nitrogen fixing albizia trees on the fresh and dry weight (g) of *Z. officinale*

NFAT	FW(g)			TFW(g)	DW(g)			TDW(g)
	L	S	R		L	S	R	
A.saman	1.15^{c}	2.60^{b}	69.75^{a}	72.95^{a}	0.16^{b}	0.10^{c}	3.60^{a}	3.86^{a}
A.coriaria	1.00^{b}	1.45^{b}	41.40^{a}	43.85^{b}	0.21^{b}	0.12^{c}	1.79^{a}	2.11^{b}
A. zygia	1.05^{b}	1.15^{b}	37.20^{a}	39.40^{c}	0.18^{b}	0.10^{c}	1.54^{a}	1.82^{c}
A.lebbeck	0.20^{b}	0.25^{b}	12.20^{a}	12.65^{e}	0.04^{c}	0.44^{b}	0.51^{a}	0.59^{d}
A.ferruginea	0.40^{b}	0.90^{b}	31.10^{a}	32.40^{d}	0.10^{b}	0.08^{b}	1.67^{a}	1.82^{c}
Control	0.15^{b}	0.45^{b}	3.45^{a}	4.05^{f}	0.06^{b}	0.04^{b}	0.16^{a}	0.26^{d}
SE ±	0.9	0.20	0.40	0.30	0.04	0.05	0.40	0.25

**Means on the same rows with the same alphabet are not significantly different at (P<0.05) for fresh and dry weight*
**Means on the same columns with the same alphabet are not significantly different at (P<0.05) for TFW and TDW*
FW- Fresh weight, L-Leaf, S-Shoot, R-Root, TFW-Total fresh weight, DW-Dry weight, TDW-Total dry weight

Percentage Nutrient Composition of Leaf litters of Selected Nitrogen Fixing Albizia Trees

Highest percentage composition values of 9.37% (nitrogen) and 61.10% (potassium) were recorded for leaf litters of *A. saman* respectively. Highest value of 257% (phosphorus) was recorded for *A. lebbeck.* The least values of 6.66% (nitrogen), 151.91% (phosphorus) and 47.98% (potassium) were recorded for *A. coriaria*, *A. zygia and A. ferruginea* respectively.

Table 6: Percentage nutrient composition of leaf litters of selected nitrogen fixing albizia trees and experimental site soil

NFAT	N %	P %	K %
A. saman	9.37	160.39	61.10
A. coriaria	6.66	219.15	51.09
A. zygia	7.25	151.91	49.64
A. lebbeck	6.91	257.00	52.87
A. ferruginea	8.32	240.34	47.98
Site soil	0.04	0.70	0.15

Key: N=Nitrogen, P=Phosphorus, K=Potassium

DISCUSSION

Highest growth parameters were recorded from seedlings planted in the soil enhanced with *A. saman.* It could be deduced that growth recorded from seedlings planted in soil influenced with *A. saman* was as a result of its ability to release nutrient into the soil, which enriched the soil for *Z. officinale* roots to absorb for growth and yield better than other species investigated. This result is in consonance with reports that the leaf litters of superior tree species influence nutrient release into soil **(**Manlay *et al.,* 2000, Diedhiou *et al.,* 2009) as well as enhancing growth and yield better than others investigated species (Sarkar *et al.*, 2010). A significant girth recorded from seedlings of propagules planted in the soil influenced with *A. saman* is in consonance with the report of Adelani *et al*. (2020a) who recorded widest girth for *C. albidum* seedlings planted in the soil amended with leaf litters of *Acacia leucophloea* at 8 weeks after transplanting.

The excellent number of leaves recorded from *Z. officinale* planted in the soil enhanced with *A. lebbeck* was attributed to its richness in nutrients. Similar observation has been made by Jeptoo *et al.* (2013) who reported that more leaf numbers recorded from carrot as a result of rich tithonia manure application could be ascribed to enhanced levels of major nutrients (NPK) in tithonia manure as revealed by improved nutrient levels in the soil at the end of each growing season. The widest leaf area recorded from *Z. officinale* planted in the soil influenced with leaf litters of *A. saman* trees could be adduced to its ability to release nutrient for growth of leaf area. This is consonance with the report of Adelani *et al.* (2020b) who stated that a significant leaf area recorded for *Citrus tangelo* seedlings planted in the soil influenced with *Jacaranda mimosifolia* is an indication that *Jacaranda mimosifolia* gave the seedlings appropriate nitrogen to enhance the growth parameters.

Significant fresh weight and dry weight recorded for the roots of seedlings from propagules planted in the soil incorporated with leaf litters of *A. saman* respectively. Similar observation has been made by Adelani *et al.* (2020a) who recorded significant fresh weight and dry weight for *C. albidum* seedlings planted in the soil influenced with leaf litters of *Acacia senegal*.

Significant growth parameters recorded from seedlings of propagules planted in soil amended with *A. saman* leaf litters could be traced to its ability to release nitrogen content better than other investigated species. This result is in consonance with the reports of Gaisie *et al.* (2016) who stated that nitrogen released from *Albizia lebbeck* was significantly greater than that of *Senna siamea.* This is consistent with the report of Iloyanomon and Ogunlade (2011) who stated that highest nitrogen content of 107.3 kg/ha was recorded from leaf litters of kola under plantation A. Mahmood *et al.* (2009) stated among the considered species, *Eucalyptus camaldulensis* leaf litter was found to be the best in terms of nitrogen release to the soil. The leaf litters of nitrogen fixing albizia trees are sources of nitrogen which influences *Z. officinale*. Nitrogen is part of various enzymatic proteins that catalyses and regulates plant-growth process (Sinfield *et al.*, 2010). It is a component of chlorophyll (Anderson, 2015). Nitrogen has been called the growth element because it is a vital part of protoplasm. Protoplasm is the seat of cell division (Abod and Siddiqui, 2002).

Highest growth parameters recorded from seedlings planted in the soil enhanced with *A. saman* could also be traced to its ability to supply sufficient potassium to the soil for plant absorption for growth and yield. This result is in the same trend with report of Sarkar *et al.* (2010) who stated that the highest exchangeable K (0.44 cmol kg-1) was obtained from soil treated with teak leaf litter followed by the exchangeable K 0.41 (acacia), 0.43 (eucalyptus), 0.36 (sal), 0.21(chemical fertilizer) and 0.19 cmol kg-1(control) obtained respectively when red amaranth was planted in these leaf litters. Mahmood *et al.* (2009) reported that among the considered species, leaf litters of *Swietenia macrophylla* was found to be the best in terms of potassium return to the soil.

The leaf litters of nitrogen fixing trees are sources of potassium which enhances the growth of *Z. officinale*. Potassium is an essential element that function in activation of enzymes (Mengel and Kirkby, 2001); stomatal movement, the translocation of photosynthates and the synthesis of cellulose, a building block of every plant cell wall (Anghinoni and Bissani, 2004; Havlin *et al.*, 2005; Sardans and Penuelas, 2005; Marschner, 2012; Wang *et al.*, 2013); transplant of sugars from leaves to fruits, and production and accumulation of oils (Romheld and Kirkby, 2010); energy transfer, phloem transport, cation-anion balance and stress resistance (Marschner 2012).

CONCLUSION

In this study, effect of leaf litters of selected nitrogen fixing albizia trees on the growth and yield of *Z. officinale* revealed that planting of *Z. officinale* in the soil influenced with *A. saman* enhanced its growth and yield well compared to other species investigated. Nitrogen-fixing albizia trees, owing to their rich in nitrogen, phosphorus and potassium content as obtained in this study could be used as potential plants in the recovery of degraded land, increase food security, environmental security as well as to increase biodiversity conservation in the tropics.

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