EFFECT OF LEAF LITTERS OF SELECTED NITROGEN-FIXING *ALBIZIA* SPECIES ON THE GROWTH OF AFRICAN STAR APPLE (*Gambeya albida* (G.Don) Aubrév. & Pellegr.) SEEDLINGS

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Abstract
The paucity of quantified information on the growth response of G. albida to plant-based organic manure has limited its propagation. In an attempt to improve the slow growth of G. albida seedlings through an environmentally friendly organic fertilizer, the investigation was conducted to assess the effect of leaf litters of some nitrogen-fixing albizia trees on its growth. The experiment adopted a Completely Randomized Design (CRD) with six treatments replicated five times. The treatments consisted of leaf litters of selected nitrogen-fixing albizia trees (Albizia zygia, Albizia coriaria, Albizia ferruginea, Albizia lebbeck, Albizia saman) and control on the growth of G. albida. A total of thirty seedlings were used in the experiment. A year-old G. albida seedlings were carefully transplanted into polythene pots with and without 200g of leaf litters of nitrogen-fixing albizia trees and subjected to 200ml of water twice daily for six months. Data collected were subjected to one-way Analysis of Variance (ANOVA). The leaf litter of selected nitrogen-fixing albizia trees significantly ($P<0.05$) enhanced the growth of G. albida. A significant height (43.94cm)., girth (1.80cm)., number of leaves (15.00)., leaf area (93.08cm^2)., total fresh weight(18.25g) and total dry weight (7.30g) were recorded from seedlings planted in the soil influenced with leaf litters of A. lebbeck., while least growth parameters were recorded from control. Planting of G. albida in the soil amended with leaf litters of A. lebbeck enhanced its growth.

Keywords: *Leaf litters, Plant-based manure, Nitrogen fixing trees, Slow growth, Indigenous tree species*

Introduction

The increasing demand for forest products has steadily depleted the tropics of their natural forest resources (Abod and Siddiqui, 2002). The genetic erosion of our indigenous tree species is affecting species necessary for survival of present generation as *Gambeya albida*. *Gambeya albida* synonymns *Chrysophyllum albidum* is an indigenous economic tree species **(**Akaneme, 2008; Maurice, 2014; Olayode and Otufale, 2018; The plant list, 2022). *Gambeya albida* is a climax tree species of tropical rainforest that belongs to the family Sapotaceae (Olaoluwa *et al.,* 2012; Wole, 2013) which has up to 800 species and makes up almost half of the order (Ehiagbonare *et al.,* 2008). The World Agroforestry Centre (ICRAF) has identified *G. albida* as one of the top five priority tree species for domestication in the African humid tropics (Tchounjeu *et al.,* 2002). The Yoruba name is "Osan Agbalumo" (Rahaman, 2012) while in Igbo and Hausa languages, it is called "Udara" or "Udala" (Wole, 2013) and Agwaluma or Agwaluba respectively (Adelani *et al.,* 2018).

ICRAF (2007) reported that the popular, edible fleshy and juicy fruits of *G. albida* are a potential source of a soft drink. The different parts of the tree are used in the preparation of medicine for the treatment of fibroids and female sterility (Egunyomi *et al*., 2005). Intake of *G. albida* fruit helps in the prevention of mouth gum disease, treatment of toothache and sore throat as well as helping people to lose weight (Adaobi, 2019). Agustin (2018) stated that the post-birth diagnosis of diabetic disease for pregnant women can be prevented by consuming *G. albida* fruits which contains hypoglycemic that helps to lower blood sugar levels.

Despite the enormous benefits of *G. albida* it has been greatly neglected particularly for its regeneration (Adelani *et al.,* 2014, Adelani *et al.,* 2016, Adelani *et al.,* 2017). Adelani and Muhammed (2017) stated that *G. albida* is a slow-growing tree that needs to be fertilized for fast growth to meet the population demand for its ample benefits. Many studies have highlighted the role of local plants as low-cost fertilizers as an alternative to chemical fertilizers (Palm *et al.,* 2000; Leblanc *et al.,*2006; Kaizzi *et al*., 2007; Abebe *et al.,* 2015).

Chen (2006) stated that commercial N fertilizers are expensive, with only a fraction of this nutrient reaching the plant, which limits efficiency and potentially increases water contamination. Chemical fertilizers contain high nutrients and are readily available to be taken up by plants. However, excess usage of it results in several challenges, such as nutrient loss, surface water and groundwater contamination, soil acidification or basification, reductions in useful microbial communities, and increased sensitivity to harmful insects (Chen, 2006). Chadzon (2003) stated that rapidly-growing tree species, particularly nitrogen-fixing legumes, can increase organic matter in the soil, prevent erosion, and enhance nutrient cycling. Nitrogen fixation is the characteristic of nitrogen fixing trees.

N-fixation also occurs in over 200 non leguminous plants species in 25 genera of 8 families associated with Frankia (Actinomycetes), which are filamentous bacteria (Franche *et al.,* 2009; Russo, 2005). The percentage of N derived from the atmosphere (NDFA) is more than 59% according to a recent analysis of 38 cases using N isotopic analyses (Nygren *et al.,* 2012). Giller (2001) stated that the range of N_2-fixation capacity varies greatly amongst these trees. Many leguminous trees and a few non-leguminous ones have the ability to fix atmospheric nitrogen through symbiosis with bacteria or fungi in root nodules (WAC,

2018). WAC (2018) reported that the fixation of nitrogen has been proven and found to be a significant factor in soil fertility. Nitrogen-fixing tree species have the ability to fix nitrogen to increase soil fertility through the process of nitrogen fixation.
The most popular N_2–fixing trees used in tropical agroforestry systems include the legumes *Acacia spp, Erythrina spp, Gliricidia spp*., *Inga spp* and *Leucaena spp* which form symbiotic associations with a wide variety of N_2-fixing bacterial species (Bala *et al.,* 2003). Sileshi *et al.* (2014) stated that agroforestry practices as alley cropping, improved fallows, cereal-tree legume inter cropping, relay cropping, biomass transfer, fodder banks, multistrata agroforestry, parklands and silvopastoral systems capitalize on biological nitrogen fixation (BNF) from fertilizer trees for the supply of N and organic matter to annual and perennial crops. Among the widely used fertilizer trees are acacia (*Acacia spp*.), albizia (*Albizia spp.),* alder (*Alnus spp*.), calliandra (*Calliandra calothyrsus*), casuarina (*Casuarina equisetifolia*), erythrina (*Erythrina spp*.), faidherbia (*Faidherbia albida*), flemingia (*Flemingia spp.),* gliricidia (*Gliricidia sepium*), inga (*Inga edulis*), leucaena (*Leucaena spp*.), sesbania (*Sesbania* spp.), tagasaste (*Chamaecytisus palmensis*) and tephrosia (*Tephrosia spp*.).
Winrock International (2022) and WAC (2009) also gave comprehensive lists of nitrogen-fixing trees where most of albizias were mentioned. Some albizias are nitrogen-fixers and soil-enhancers. Nygren *et al.* (2012) stated that the potential for N_2-fixing trees to improve soil fertility within perennial-crop agroforestry systems is clear. Nitrogen-fixing trees normally have higher nitrogen concentrations in the biomass than non-fixing species, but this characteristic also varies widely among species (Palm, 1995). Litter improves soil quality by adding the organic matter and nutrients to the soil (Ngoran, *et al.,* 2006; Mahmood and Hoque, 2008; Triadiati *et al.*, 2011). Hossain *et al.* (2011) and Park and Kang-Hyun (2003) reported that relative to other litter types, leaf litter is the main and fastest source of organic matter and nutrients to the soil. Researches have been conducted on the effect of leaf litters of selected nitrogen-fixing acacias (on crops and trees) (Adelani *et al.*, 2020a; Adelani *et al.,* 2021), albizias (on crops) (Adelani *et al.*, 2020b), but remain unexplored for trees as *G.albida*. In this light, an investigation was conducted into the influence of leaf litters of selected nitrogen-fixing albizias on the growth of *Gambeya albida* seedlings with a view to enhancing its growth.

Materials and Method

The research was conducted in the screen house of Federal College of Forestry Mechanization, Afaka, Kaduna State during the wet season of 2018. The College is located in the Northern Guinea Savannah ecological zones of Nigeria. It is situated in Igabi Local Government Area of Kaduna State, Nigeria. It lies between Latitudes 10 º 35' and 10 º 34' and Longitudes 7 º 21' and 7 º 20' (Adelani, 2015). The mean annual rainfall is approximately 1000 mm (Otegbeye *et al.,* 2001). The vegetation is open woodland with tall broad leave trees (Otegbeye *et al.,* 2001).

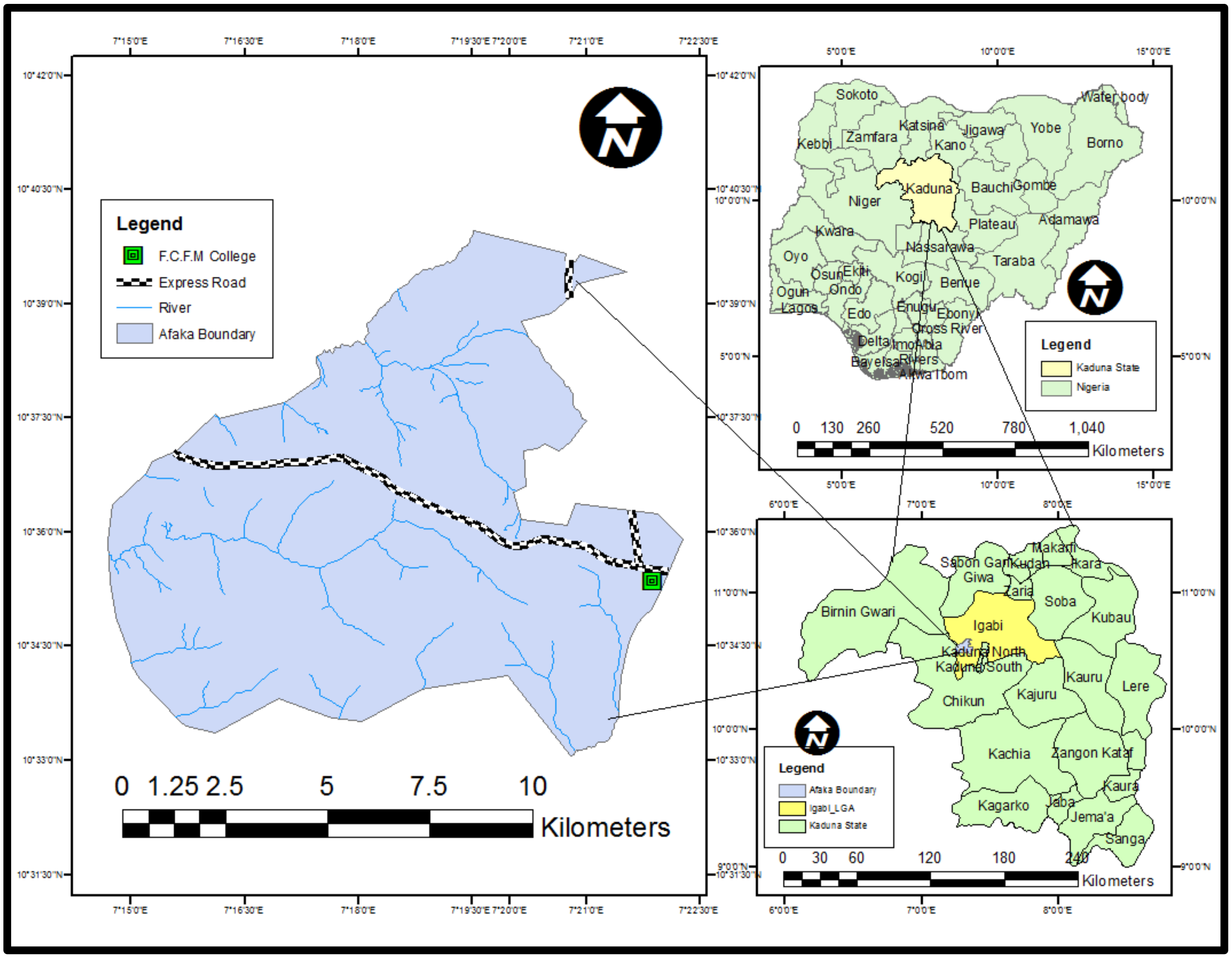

Fig 1: The location of Federal College of Forestry Mechanization, Afaka, Kaduna State, Nigeria
Field survey, 2022.

Experimental Procedure

The fruits were sourced from Osiele village in Odeda Local Government, Ogun State and transported to Kaduna State. The seeds were extracted from fruits and air dried for thirty minutes. Three hundred seeds were extracted from fruits. The viability of the randomly selected seed samples was assessed using the cutting method (Schmidt, 2000). The sowing media (river sand), which was collected from the floor of the College dam was made to pass through a 2mm sieve and then sterilized at 160°C for 24 hours. The polythene pots used were 20x10x10cm^3 in dimension and filled with the sterilized river sand and arranged in the screen house. After a year of germination of seeds, uniform seedlings were available for growth experiment.

The experimental design adopted for investigation of 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 of *G. albida* was a Completely Randomized Design with five replicates. The choice of selected albizias was based on the earlier reports of Adelani *et al.* (2020b) who stated that leaf litters of nitrogen-fixing albizia trees significantly enhanced the growth and yield of *Zingiber officinale* and the same selected albizias was investigated for *Gambeya albida*. A year-old seedlings were carefully transplanted into a potting mixture packed in larger poly pots of 25x20x15cm^3 dimensions. The potting mixture contained samples of sterilized sand thoroughly mixed with each leaf litter of nitrogen-fixing albizia trees at same quantity of 200g.

Each sample of pulverized leaves of nitrogen-fixing trees was analyzed chemically for nitrogen, phosphorus and potassium (NPK). The sand without the addition of leaf litter was analyzed for nutrient content under untreated soil (control). The 200ml of distilled water per seedling was used to water the seedlings twice daily. Growth parameters were monitored every month for 6 months. Growth parameters assessed include; Seedling height (using meter rule); girth (using venier calliper); the number of leaves was 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=0.74xLxW (1)

Where, LA =Leaf area=Product of linear dimension of the length and width at the broadest part of the leaf.

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°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 of *G. albida* seedlings were subjected to one-way analysis of variance (ANOVA) using SAS (2003). Comparison of significant means was accomplished using Fisher's Least Significant Difference (LSD) at a 5% level of significance.

Results

A significant height of 43.94 cm was recorded from seedlings planted in the soil influenced with leaf litter of *A. lebbeck* at 24 weeks after transplanted, WAT. The least value of 17.88 cm was recorded from seedlings planted in the soil without amendment of leaf litters of nitrogen-fixing albizia trees at 4 WAT (Table 1).

Table 1: Effect of leaf litters of selected nitrogen-fixing albizia trees on the height (cm) of *G. albida* seedlings

NFAT			WAT			
	4	8	12	16	20	24
A.lebbeck	19.94^{a}	22.50^{a}	25.68^{a}	28.00^{a}	37.02^{a}	43.94^{a}
A.zygia	18.08^{b}	19.18^{b}	23.40^{b}	24.34^{ab}	28.58^{c}	30.94^{ab}
A.coriaria	18.42^{ab}	22.98^{a}	24.34^{ab}	25.22^{b}	31.60^{b}	34.44^{b}
A.ferruginea	18.52^{ab}	19.44^{b}	19.74^{c}	20.96^{c}	28.02^{cd}	30.24^{c}
A.saman	18.04^{b}	18.70^{b}	19.96^{c}	20.08^{c}	20.78^{d}	21.50^{d}
Control	17.88^{b}	18.86^{b}	20.50^{c}	20.68^{c}	20.99^{d}	21.00^{d}
SE+	0.69	0.63	0.66	0.71	0.70	1.45
p-value	0.01	0.01	0.01	0.01	0.01	0.02

*Means on the same column having different superscripts are significantly different (p<0.05)

Key: NFAT=Nitrogen Fixing Albizia Trees, WAT= Weeks After Transplanting

A significant girth of 1.80cm was recorded from seedlings planted in the soil enhanced with leaf litters of *A. lebbeck* at 24 WAT. The least value of 0.89 cm was recorded from seedlings planted in the soil without the influence of leaf litters of nitrogen-fixing albizia trees (control) at 4WAT (Table 2).

Table 2: Effect of leaflitters of selected nitrogen-fixing albizia trees on the girth (cm) of *G. albida* seedlings

NFAT			WAT			
	4	8	12	16	20	24
A.lebbeck	1.10^{a}	1.12^{a}	1.22^{a}	1.24^{a}	1.56^{b}	1.80^{a}
A.zygia	0.90^{a}	0.92^{a}	0.96^{c}	1.10^{a}	1.68^{ab}	1.79^{ab}
A.coriaria	0.92^{a}	0.98^{a}	1.06^{b}	1.18^{a}	1.30^{c}	1.48^{b}
A.ferruginea	1.06^{a}	1.06^{a}	1.08^{b}	1.08^{a}	1.74^{a}	1.78^{ab}
A.saman	1.00^{a}	1.06^{a}	1.20^{a}	1.36^{a}	1.38^{c}	1.40^{b}
Control	0.89^{a}	0.92^{a}	0.95^{c}	1.00^{a}	1.10^{d}	1.20^{c}
SE+	0.13	0.11	0.04	0.70	0.07	0.05
p-value	0.01	0.01	0.00	0.01	0.00	0.00

*Means on the same column having different superscripts are significantly different (p<0.05)

Key: NFAT=Nitrogen Fixing Albizia Trees, WAT= Weeks After Transplanting

A significant number of leaves of 15.00 was recorded from seedlings improved with leaf litters of *A. lebbeck*., while the least value of 7.50 was recorded from seedlings planted in an unamended soil (control) at 24 and 4 WAT respectively.

Table 3: Effect of leaf litters of selected nitrogen-fixing albizia trees on the number of leaves of *G. albida* seedlings

NFAT			WAT			
	4	8	12	16	20	24
A.lebbeck	8.00^{ab}	8.80^{a}	11.80^{a}	13.00^{a}	13.00^{a}	15.00^{a}
A.zygia	7.60^{b}	8.40^{a}	9.60^{c}	9.89^{c}	12.60^{a}	14.20^{ab}
A.coriaria	8.20^{ab}	8.80^{a}	8.80^{d}	9.40^{c}	10.00^{b}	13.00^{b}
A.ferruginea	7.80^{b}	9.00^{a}	11.00^{b}	11.20^{b}	12.00^{a}	13.40^{ab}
A.saman	8.60^{a}	8.80^{a}	9.60^{c}	9.80^{c}	13.40^{a}	14.80^{a}
Control	7.50^{b}	8.98^{a}	9.30^{d}	9.50^{c}	9.99^{b}	10.50^{c}
SE+	0.31	0.29	0.31	0.33	0.72	0.71
p-value	0.04	0.04	0.04	0.05	0.02	0.02

*Means on the same column having different superscripts are significantly different ($p<0.05$)
Key: NFAT=Nitrogen Fixing Albizia Trees, WAT= Weeks After Transplanting

A significant leaf area of 93.08cm^2 was recorded from seedlings planted in the soil enhanced with leaf litters of *A. lebbeck* at 24 WAT. The least value of 10.09 cm^2 was recorded from seedlings planted in the soil without enhancement of leaf litters of nitrogen-fixing albizia trees (control) at 4 WAT (Table 4).

Table 4: Effect of leaf litters of selected nitrogen-fixing albizia trees on the leaf area (cm^2) of *G. albida* seedlings

NFAT			WAT			
	4	8	12	16	20	24
A.lebbeck	18.75^{a}	27.37^{a}	28.47^{a}	52.99^{a}	64.08^{a}	93.08^{a}
A.zygia	16.84^{a}	21.16^{a}	21.86^{ab}	33.18^{b}	39.79^{c}	83.06^{a}
A.coriaria	19.06^{a}	27.04^{c}	29.63^{a}	40.63^{b}	55.19^{ab}	62.94^{b}
A.ferruginea	17.81^{a}	18.19^{b}	30.25^{a}	43.35^{ab}	44.60^{b}	46.42^{c}
A.saman	15.11^{ab}	20.26^{ab}	21.01^{ab}	36.72^{b}	36.82^{c}	55.91^{bc}
Control	10.09^{b}	15.11^{b}	16.53^{b}	16.80^{c}	19.30^{d}	21.00^{d}
SE+	2.35	3.03	4.11	4.73	5.62	6.54
p-value	0.02	0.03	0.04	0.04	0.04	0.05

*Means on the same column having different superscripts are significantly different ($p<0.05$)
Key: NFAT=Nitrogen Fixing Albizia Trees, WAT= Weeks After Transplanting

A significant total fresh weight (18.25g) and total dry weight (7.30g) were recorded from seedlings planted in the soil influenced by leaf litters of *A.lebbeck*. The least values of 2.79g and 1.25g were recorded for total fresh weight and total dry weight of seedlings planted in the soil without amendment of leaf litters of nitrogen-fixing albizia trees (control).

Table 5: Effect of leaf litters of selected nitrogen-fixing trees on the fresh and dry weight (g) of *G. albida* seedlings

NFAT		FW(g)		TFW(g)		DW(g)		TDW(g)
	L	R	S		L	R	S	
A.lebbeck	10.45^{a}	4.75^{a}	3.05^{a}	18.25^{a}	3.45^{a}	2.05^{a}	1.80^{a}	7.30^{a}
A.zygia	9.75^{ab}	2.65^{b}	3.50^{a}	15.90^{ab}	2.05^{ab}	1.07^{b}	2.00^{a}	5.12^{ab}
A.coriaria	3.40^{b}	1.15^{b}	1.00^{b}	5.55^{b}	1.35^{ab}	0.65^{b}	0.50^{b}	2.50^{b}
A.ferruginea	3.85^{b}	2.25^{b}	1.25^{b}	7.35^{b}	1.30^{ab}	1.03^{b}	0.78^{b}	3.11^{a}
A.saman	1.50^{b}	3.55^{ab}	2.10^{ab}	7.15^{b}	0.52^{b}	1.65^{ab}	1.06^{ab}	3.23^{ab}
Control	1.03^{b}	0.98^{b}	0.78^{b}	2.79^{b}	0.45^{b}	0.41^{b}	0.39^{b}	1.25^{b}
SE+	2.68	0.70	0.66	4.04	1.14	0.36	0.35	1.85
p-value	0.02	0.03	0.03	0.05	0.02	0.03	0.03	0.04

Means on the same column having different superscripts are significantly different ($p< 0.05$)
Key: NFAT=Nitrogen Fixing Albizia Trees, FW= Fresh Weight, TFW-Total Fresh Weight, DW=Dry Weight, TDW=Total Dry Weight, Rs=Rates, L=Leaf, S=Shoot, R=Root

Discussion

The highest growth parameters recorded from seedlings planted in the soil improved with leaf litters of *A. lebbeck* was adduced to its ability to release its rich nutrients. A similar observation has been recorded by Adelani *et al.* (2021) who recorded the highest growth parameters from *Vitellaria paradoxa* seedlings planted in the soil enhanced with *Acacia leucophloea* and linked the performance of *Acacia leucophloea* to the release of its rich nutrient for plant growth.

The excellent growth performance recorded from seedlings planted in the soil enhanced with *A. lebbek* could be traced to the release of its phosphorus content. Adelani *et al.* (2020b) reported the highest phosphorus content for *Albizia lebbeck* used to enhance the growth of *Zingiber officinale.* Phosphorus enhances seedling growth. This aligns with the report of Chotchutima *et al*.(2016) who stated that the maximum rate of P (750 kg/ha) application gave the highest *Leucaena leucocephala* height and stem diameter compared to the other rates during a 2 year study period. The observations revealed that the *Acacia auriculiformis* seedling growth was enhanced significantly with the application of P fertilizer (Uddin *et al.,* 2007).

Conclusion

The use of affordable, accessible and environmentally friendly plant based organic manure to enhance the growth of *G. albida* is important. Investigation conducted into the leaf litters of nitrogen-fixing albizia revealed that planting of *G. albida* in the soil influenced with leaf litters of *A. lebbeck* enhances its growth.

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