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Research Article

Allelopathic Effect of *Pentaclethra macrophylla* Benth. Leaf Extracts on Germination and Seedling Growth of Maize and Okra

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Abstract

Background and Objective: *Pentaclethra macrophylla* Benth. is an indigenous leguminous tree of southern Nigeria's agroecosystems, whose seeds are used as spices; however, its allelopathy potential is not understood. Therefore, this study was aimed at investigating *P. macrophylla* allelopathic effects on germination and seedling growth of maize and okra. **Materials and Methods:** Allelopathic effects of Aqueous Leaf Extracts (ALE) of *P. macrophylla* at 0 (control), 10, 20, 40 and 80% concentrations on maize (n = 200) and okra (n = 200) seed germination and seedling growth were assessed in laboratory and screen house nursery. Total germination (%) for both crops was determined at one Week After Sowing (WAS); while Number of Leaves (NL), Plant Height(PH) (cm), Root Length (RL) (cm) and Dry Weight (DW) (g) were evaluated at 8 WAS. Experimental design used in the study was completely randomized design. Data were analyzed using descriptive statistics and ANOVA at $\alpha_{0.05}$. **Results:** Above 90.0% germination was recorded for maize in all the ALE concentrations, while for okra ALE-10 gave significantly highest germination (90.0±8.7%) and ALE-80 gave least (42.5±26.3%). Maize and okra seedlings given ALE-40 had highest NL, PH and DW;* while ALE-0 (control) had least values in PH and DW, respectively. Control had highest RL in both crops. The ALE-10 gave least RL in maize and ALE-20 gave least RL in okra. **Conclusion:** *Pentaclethra macrophylla* aqueous leaf extract at 10% enhanced germination, while 40% concentration encouraged dry matter accumulation and height in maize and okra seedlings.

Key words: Agroecosystem, allelopathy, germination, indigenous leguminous tree, *Pentaclethra macrophylla*, 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

Effects of leachates from plants, plant extracts and decomposing plant residues have been the focus of several investigators concerned with the role of allelopathy in agronomy and forestry. Allelopathy is a kind of interference mechanism, in which live or dead plant materials release biochemical substances (called allelochemicals), which inhibit or stimulate the associated recipient plant growth, development, reproduction and germination[1,2]. The allelopathic tendency in plants can affect many aspects of plant ecology, including species abundance, growth and plant succession, the structure of plant communities, dominance, diversity and plant productivity; allelopathy may also play an eminent role in the intra specific and inter specific competition and may determine type of interspecific association among plant community[3].

Inhibitory role of allelochemicals is well explored and previously was the only known dimension of allelopathy. This role has been directly and indirectly used for weed management. A lot of research work has been done to explore the inhibitory potential of different allelopathic arable crops and trees for weed management [4-7]. It is a pragmatic substitute to synthetic herbicides as allelochemicals do not have residual or toxic effects[8]. This inhibitory feature is attributed to the blockage or cessation of important physiological and metabolic processes of affected plant. On the other hand, allelochemicals promote growth and impart resistance against several abiotic stresses[9] at low concentrations. However, relatively few studies have been carried out to investigate the growth promotion by the allelochemicals. Allelopathic water extracts application at lower concentrations stimulates germination and growth of different arable crops[10,11]. Important secondary metabolites identified as allelochemicals are phenolics, alkaloids, flavonoids, terpenoids, momilactone, hydroxamic acids, brassinosteroids, jasmonates, salicylates, glucosinolates, carbohydrates and amino acids[12,13]. Actions of these compounds are concentration dependent, as these inhibit the plant growth at high concentrations and promote growth at low concentrations[14,15]. These allelochemicals may thus be used as natural pesticides at high concentration or possibly as growth stimulator at low concentration.

Pentaclethra macrophylla Benth. (African oil bean) is an indigenous tree of sub-Saharan Africa distribution belonging to the family Fabaceae (leguminosae) and sub-family mimosoideae[16,17]. African oil bean tree root nodulation potentials and ability to fix soil nitrogen has been reported by Sprent[18] and Diabate *et al.*[19]. The tree has been used as source of mulch materials, nurse and shade trees in traditional home garden farming system in southeast Nigeria agroecosystem where it grows alongside arable crops; however, its allelopathic effect on crops, such as maize and okra, is not understood. Previous studies had focused on the species' food values[20-23] and information about *P. macrophylla* allelopathy property is limited. Besides, maize (*Zea mays*) and okra (*Abelmoschus esculentus*) are among the major vegetable and staple crops of Nigeria cultivated by most farmers in southern part of the country. Therefore, the objective of this study was to investigate *P. macrophylla* allelopathic effects on maize and okra in south eastern Nigeria.

MATERIALS AND METHODS

Location of study: Nursery experiments were carried out at the Teaching and Research Farm of the Federal College of Agriculture (FCA), Ishiagu, Ebonyi state, Nigeria. Ishiagu lies within the southeast derived Savanna ecological zone of the country. It is located along latitude 05° 52'N, longitude 07° 35'E and altitude 57 m above sea level. The mean annual rainfall and mean monthly temperature reach up to 1944.9 mm and 31.7°C, respectively. Rainfall distribution is bimodal with peaks in the months of July and September or October. The dry season spans November to March or April with characteristic cold dry dust laden interval known as harmattan, during the months of December through to February.

Source of African oil bean planting materials: Seeds of Oba Super-4 maize variety and NHAe47-4 okra variety used in the study were obtained from the National Cereal Research Institute (NCRI) sub-station, Amakama, Umuahia Abia state and National Horticultural Research Institute (NIHORT), Mbato sub-station, Okigwe, Imo state, Nigeria, respectively.

Experiment 1: This experiment was conducted to determine potential allelopathic effect of *P. macrophylla* aqueous leaf extracts on germination performance of maize and okra seeds. The treatments for study comprised of five different concentrations of the aqueous leaf extract (80, 40, 20 and 10% w/v) including water as control (0%). The experiment was laid out in Completely Randomized Design (CRD) with four replicates. Experimental layout for this study comprised of 20 Petri dishes (for each crop) lined with moistened Whatman No. 1 filter papers and 10 seeds of the crop placed in each Petri dish. Five mileletter of each treatment concentration was applied to its respective replicates in the Petri dishes daily using hypodermic syringe, while the control received only water accordingly. Germination of test crop seeds in the Petri dishes were observed on daily basis for 7 days at laboratory room temperature of 27°C. The protrusion of radicle and plumule were taken as evidence of complete germination[24]. Parameters observed for assessment of treatment effect were: daily germination count for 7 days, day to first germination, day to 50% germination, total germination percentage at 7 days after sowing (7 DAS i.e., one week), seedling sprout length (i.e., sum of plumule and radicle lengths [cm]) and seedling dry weight, i.e., biomass (g) at 7 DAS.

Experiment 2: Experiment 2 was performed to determine possible allelopathic effect of *P. macrophylla* aqueous leaf extracts on early growth of maize and okra young plants according to Fatunbi *et al.*[25] and Owoseni and Awodoyin[26]. Garden topsoil was collected from Teaching and Research Farm of FCA, Ishiagu, Nigeria, and filled into each plastic nursery pots (15 cm by 30 cm dimension) with 12 kg of the soil. This experiment followed similar pattern as in experiment 1 with 5 treatments (namely 80, 40, 20, 10 and 0% concentrations of the aqueous leaf extracts) and four replicates which were laid out in Completely Randomized Design (CRD). Five seeds of maize and okra were sown separately per pot and supplied with 200 mL of water daily for two weeks before thinning the emerged seedlings to two stands per pot. Thereafter, 200 mL of each treatment concentration of the aqueous leaf extract solutions were administered to the seedlings from two Week After Sowing (2 WAS) up to 8 WAS, during which the effect of the treatment applied were observed.

Parameters monitored included: Plant height (cm), stem diameter (mm) and number of leaves at 4, 6 and 8 weeks after treatment application (WAS); root length (cm) and seedling dry weight (g) at 8 WAS.

Preparation of leaf extracts aqueous solution: The aqueous leaf extracts were prepared by following the Daniya *et al.*[27] procedure with modifications as in Ngonadi[28]. In the present experiment, matured leaves of *P. macrophylla* were harvested from Tree Crop mixed plantation at FCA Ishiagu, Nigeria, shade dried and ground to powdery form. The ground dried plant materials were then weighted into 100, 200, 400 and 800 g and soaked separately in 1000 mL of distilled water in beakers to have 10, 20, 40 and 80% (w/v) concentrations, respectively. The contents in beakers were thereafter; covered with aluminum foils and kept at room temperature for 24 h. The various concentrations were obtained by filtering the soaked dried leaf materials through muslin cloth and Whatman No. 1 filter paper separately. The extract solutions were stored in refrigerator at 15°C. The same procedure was followed to routinely prepare each fresh stock solution as the need arose.

Table 1: Effect of *Pentaclethra macrophylla* aqueous leaf extracts on day to 50% germination and total germination (%) of maize and okra seeds at 7 DAS

	Maize seed		Okra seed	
Extract concentrations	D50%G	TG%	D50%G	TG%
0% (control)	3.00±0.00	97.50±5.00	2.75±0.50	77.50±9.57
10%	3.00±0.00	100.00±0.00	3.00±0.50	90.00±8.66
20%	3.00±0.00	97.50±5.00	2.75±0.50	72.50±16.39
40%	3.25±0.50	97.50±5.00	4.50±1.73	55.00±30.82
80%	3.50±0.58	100.00±0.00	4.30±2.06	42.50±26.30
$LSD_{(0.05)}$	ns	ns	0.73	1.08
CV (%)	11.63	3.72	27.38	3.26

Values are Mean±SD (n = 40), D50%G: Day to 50 % germination, TG%: Total germination % at 7 days after sowing (DAS), ns: Non significant

Table 2: Effect of *P. macrophylla* aqueous leaf extracts application on maize and okra seedling sprout length† (cm) and seedling dry weight (g) at 7 days after sowing (7 DAS)

	Maize seedling		Okra seedling	
Extract concentrations	Seedling sprout length (cm)	Seedling dry weight (g)	Seedling sprout length (cm)	Seedling dry weight (g)
0% (control)	12.54±4.78	3.23±0.13	5.56±2.86	0.53±0.04
10%	10.43±3.62	3.18±0.05	2.55±0.90	0.45±0.15
20%	8.34±4.44	3.06±0.05	0.30±0.47	0.35±0.09
40%	5.52±2.54	3.10±0.14	0.23±0.41	0.43±0.13
80%	2.59±0.77	2.98±0.22	0.10±0.28	0.43±0.08
$LSD_{(0.05)}$	3.00	ns	0.79	ns
CV (%)	5.33	4.81	12.79	28.18

†Seedling sprout length: Plumule length+radicle length. Values are Mean±SD (n = 40), ns: Non significant

Data analysis: Data collected from the field and nursery experiments were analyzed using two-way Analysis of Variance (ANOVA), while mean separation was carried out using Fisher's Least Significant Difference (LSD) at 5% probability level. Descriptive statistics was also used where appropriate.

RESULTS

Experiment 1

Day to 50 % germination and total germination: It took longer time for germination in maize to attain 50% when seeds received higher concentrations (40 and 80%) of the aqueous leaf extracts. The control treatment (0% concentration) had the earliest day to 50% germination in maize (3.0 DAS), just like seeds treated with 10 and 20% concentrations of the aqueous leaf extract (Table 1). However, the various treatments effects were not significantly different from the control ($p<0.05$) among maize seeds. Okra seeds had prolonged days to 50% germination (from 2.75-4.50 DAS) with increasing concentrations of the aqueous leaf extracts which were also significantly different ($p<0.05$) from the control mean day to 50% germination. Higher concentrations of the leaf extract application delayed germination in okra seeds than lower concentrations in days to 50% germination (Table 1). Maize seeds that received both 0% (control) and various extract concentrations scored above 95% total germination at 7 DAS and none of the treatment effects were markedly different from the other. On the other hand, leaf extract application at 10% concentration, on okra seeds mostly enhanced total germination (90%) better than control treatment and higher concentrations (Table 1).

Seedling Sprout Length (SSL): From Table 2, it is obvious that the leaf extract application impacted negatively on maize SSL, which dropped from 12.54-2.59 cm in inverse manner to concentrations (0-80%). The treatment effects of higher concentrations (40 and 80%) were significantly lower than the control ($p<0.05$).

Similarly, the leaf extract application had adverse effect on okra SSL, as the length decreased steadily from 5.56 cm for 0% (control) to 0.10 cm for 80% concentration which were also significantly different from the control ($p<0.05$) (Table 2).

Seedling dry weight: Response of maize and okra seedlings dry weight to application of varying concentrations of *P. macrophylla* aqueous leaf extracts were not significant as shown in Table 2. However, maize seedlings dropped marginally in dry weight (from 3.23-2.98 g) as the leaf extract concentrations increased from 0-80%. Similar trend was also shown by okra seedlings which barely decreased from 0.53-0.43 g dry weight.

Table 3: Effect of *P. macrophylla* aqueous leaf extracts application on maize (*Zea mays*) and okra (*Abelmoschus esculentus*) seedlings number of leaves at 4, 6 and 8 weeks after sowing (WAS)

	Maize seedling no. of leaves			Okra seedling no. of leaves		
Extract conc. (%)	4 WAS	6 WAS	8 WAS	4 WAS	6 WAS	8 WAS
0% (control)	6.0±0.71	6.5±0.53	8.0±1.12	4.8±1.90	4.3±1.79	4.9±1.79
10%	6.6±0.70	6.0±3.54	7.0±4.15	4.9±1.27	4.5±1.66	4.8±1.30
20%	6.5±1.12	8.3±1.09	8.8±3.80	4.4±1.56	4.8±2.38	5.3±2.45
40%	6.6±0.69	8.4±0.70	9.5±1.07	5.3±0.97	5.4±0.99	5.5±1.12
80%	7.1±0.60	7.8±0.97	9.6±1.50	4.9±0.78	5.5±0.71	5.6±0.68
$LSD_{(0.05)}$	ns	ns	ns	ns	ns	ns
CV (%)	8.98	22.19	23.64	15.10	18.92	15.46

Values are Mean±SD (n = 8), ns: Non-significant

Table 4: Effect of *P. macrophylla* aqueous leaf extracts solution on maize (*Zea mays*) and okra (*Abelmoschus esculentus*) seedlings stem diameter at 4, 6 and 8 weeks after sowing (WAS)

	Maize stem diameter (mm)			Okra stem diameter (mm)		
Extract conc. (%)	4 WAS	6 WAS	8 WAS	4 WAS	6 WAS	8 WAS
0% (control)	4.6±1.37	6.7±1.43	5.2±1.52	4.8±2.81	8.8±7.08	7.3±3.22
10%	6.3±1.70	7.5±4.65	1.5±1.44	5.8±2.02	5.9±2.92	8.6±3.58
20%	6.5±1.06	9.1±1.75	2.1±2.22	5.5±2.40	6.3±4.26	8.9±5.66
40%	6.3±0.89	9.9±1.35	3.8±2.07	6.2±2.00	7.1±2.38	7.6±2.41
80%	6.7±1.08	8.8±1.84	5.3±1.98	7.3±2.85	7.0±3.29	6.9±2.05
$LSD_{(0.05)}$	ns	1.834	2.151	ns	ns	ns
CV (%)	21.74	21.08	16.90	47.12	34.13	30.64

Values are Mean±SD (n = 8), ns: Non-significant

Experiment 2

Seedling number of leaves at 4, 6 and 8 week after sowing (WAS): The seedling number of leaves used to assess the two test crops responses did not show significant difference among the treatments at 4, 6 and 8 week after sowing and administering the leaf extract solutions (Table 3). Both maize and okra seedlings mean number of leaves increased with increasing concentrations (10-80%) of the leaf extract solutions at 8 WAS and regular applications on the crops. For maize seedlings, mean number of leaves increased steadily from 8.0±1.12 to 9.6±1.50 with increase in leaf extract concentrations at 8 WAS. While okra seedlings had mean number of leaves increased from 4.9±1.79 for control treatment (0%) to 5.6±0.68 for 80% concentration of the *P. macrophylla* aqueous leaf extract at 8 WAS.

Seedling stem diameter at 4, 6 and 8 week after sowing (WAS): Results from Table 4 indicated that maize seedlings stem diameters responded directly to increased concentrations of the leaf extract solution applications across the 8 WAS. At 4 WAS, there was no statistical difference among treatment means of the various levels of leaf extract solutions given to maize seedlings, although the direct response (from 4.6-6.7 mm) to increased concentrations (0-80%) was evidence. However, at 6 WAS, overall the maize seedlings growth were significantly improved by increased concentrations of the leaf extracts application ($p<0.05$) as compare to control.

On the other hand, application of the various concentration of the leaf extract solutions did not show remarkable effect on okra seedlings stem diameter across 8 WAS (Table 4). The okra seedlings mean stem diameter at 4 WAS increased from 4.8-7.3 mm as leaf extract concentrations increased from 0-80%. It was observed no that statistically significant ($p<0.05$) relationship between the applied leaf extract concentrations and okra seedling stem diameter growth responses at 6 and 8 WAS.

Seedling plant height at 4, 6 and 8 week after sowing (WAS): Generally, both test crops seedling plant height indicated clear direct relationship to increased concentration of the *P. macrophylla* leaf extracts application (Table 5). At 4, 6 and 8 WAS, maize seedlings consistently grew taller with increase in concentrations of the leaf extract treatments (0-40%). Higher concentration of 80% caused drop in maize seedlings height. Okra seedlings followed similar growth pattern in response to the leaf extract application, including the observed decrease in seedling height with 80% concentration application (Table 5).

Seedling root length and dry matter production at 8 WAS: Root length showed inverse relationship to increased. concentrations of the *P. macrophylla* leaf extracts application

Table 5: Effect of *P. macrophylla* aqueous leaf extracts on maize (*Zea mays*) and okra (*Abelmoschus esculentus*) seedlings plant height at 4, 6 and 8 weeks after sowing (WAS)

	Maize seedling plant height (cm)			Okra seedling plant height (cm)		
Extract conc. (%)	4 WAS	6 WAS	8 WAS	4 WAS	6 WAS	8 WAS
0% (control)	23.0±3.40	43.8±6.96	68.9±20.04	11.7±7.88	28.1±11.5	34.1±14.56
10%	26.3±2.03	37.9±22.8	74.8±45.53	19.8±3.44	38.6±13.16	41.5±14.43
20%	25.5±3.09	51.3±7.56	86.0±48.15	18.7±8.42	42.5±22.16	46.5±26.28
40%	28.3±2.22	54.1±5.28	94.9±18.21	23.5±2.83	46.8±5.12	52.3±10.86
80%	25.8±2.69	44.6±5.91	75.4±21.59	15.8±3.13	35.4±8.89	41.5±8.79
$LSD_{(0.05)}$	ns	ns	ns	4.54	ns	ns
CV (%)	10.14	22.76	35.19	23.09	38.55	31.27

Values are Mean±SD (n = 8), ns : non significant

Table 6: Effect of *P. macrophylla* aqueous leaf extracts application on maize (*Zea mays*) and okra (*Abelmoschus esculentus*) root length (cm) and seedling dry matter production (g) at 8 weeks after sowing (SAW)

	Seedling root length (cm)		Seedling dry weight (g)	
Extract conc. (%)	Maize	Okra	Maize	Okra
0% (control)	23.5±10.63	17.1±12.03	6.3±2.46	1.2±0.46
10%	17.7±11.24	11.4±3.50	10.7±3.51	1.6±1.49
20%	23.1±11.31	8.8±5.50	10.5±3.78	1.8±1.16
40%	21.8±3.49	15.7±5.46	18.6±1.47	2.5±1.81
80%	18.9±5.00	13.6±5.47	8.3±2.62	1.4±0,96
$LSD_{(0.05)}$	ns	4.87	ns	ns
CV (%)	30.42	35.51	37.50	8.11

Values are Mean±SD (n = 8), ns: Non-significant on both test crops seedling as compare to control (Table 6) Maize and okra seedlings administered with the control treatment (i.e., water only) had most extended mean root length (23.5 and17.1 cm, respectively) at 8 WAS; while the least root length (17.7 and 8.8 cm, respectively) was recorded in the maize seedlings given 10% of the leaf extract and okra seedlings treated with 20% leaf extract.

Seedling dry matter production in maize and okra showed direct response to increased leaf extract concentrations application (Table 6). All the treated seedling of both crops had higher dry matter production than the untreated seedlings (control) which produced the least dry matter (6.3 ± 2.46 and 1.2 ± 0.46 g, respectively). In addition, maize and okra seedlings that received 40% leaf extract concentration yielded the highest dry matter (18.6 ± 1.47 and 2.5 ± 1.81 g, respectively) among the treatments at 8 WAS.

DISCUSSION

In this study it was observed that seeds of maize administered with both control and various other concentrations of the leaf extract solution exceeded 90% total germination at 7 day after sowing (DAS), although day to 50% germination was slightly delayed in higher concentrations of 40 and 80% of the leaf extract, but this was not significantly different from the control (0%). However, 80% concentration of the leaf extracts had pronounced inhibitory effect on maize seedlings plant height. This finding corroborated with the previous reports by Farooq *et al.*[9] and Anwar *et al.*[10] on probable stimulatory tendency of some allelochemical substances at low concentrations which is supposed to be beneficial to the interacting crop's growth. Okra seeds and seedlings on the other hand, obviously showed reduced germination in response to the leaf extract treatments. The NHAe47-4 okra variety seeds experienced significant delay in day to 50% germination as well as significant drop in total germination as the concentrations increased from control 0-80%. Similar inhibitory effect of *P. macrophylla* leaf extract aqueous solution was recorded on okra seedling plant height which showed inverse response to increasing extract concentrations application as compare to control. The control (0%) treatment recorded longest mean seedling plant height and highest dry matter production at 7 DAS. Nonetheless, dry matter of both crops seedlings at 7 DAS indicated non-significant effect of the aqueous leaf extract application; thus showing that some attributes of the crops could withstand inhibitory impact of the allelochemical that may be present in the tree leaf extract solution. This finding could only suggested probable presence of inhibitory biochemical substance in *P. macrophylla* leaf extract leachate[11], even though some crops like maize may be able to tolerate its apparent inhibitory effect without remarkable decline in its germination and seedling growth performance, while other crops may not. However, it should be noted that the observed allelopathic effects (whether inhibitory or stimulatory) depend on leaf extract concentrations as lower concentrations of 10 and 20% did not show pronounced negative responses on the growth parameters assessed unlike higher concentration of 40 and 80%. The results corroborated the reports of earlier investigators Einhellig[14] and Narwal[15] on concentration dependence of allelochemicals. Admittedly, leaf extract solutions of some leguminous trees (including *Albizia lebbeck*, *Acacia auriculiformis*, *A. leucophloea* and *A. mearnsii* among others) in the Mimosoideae sub-family have been reported to possess allelochemicals that exert inhibitory effects on germination and seedling early growth of some annual crops[25,29,30], but this phenomenon may not be generalized after all considering the selective effect of *P. macrophylla* leaf extract solution.

Noticeable trend in the seedling growth parameters in both maize and okra points to the fact that despite the non-significant effect of the leaf extract application, generally, the higher concentrations of the aqueous extracts promoted seedling growth and were as good as the control (0%) if not better in all the parameters assessed except root length. Present finding in this study supported the previous reports[15] and proved that the aqueous leaf extract of *P. macrophylla* even at high concentrations may be rather beneficial than inhibitory to the test crops growth exposed to its treatment once the crop seedlings have established. This is also in agreement with the nitrogen-fixing capacity of *P. macrophylla*[18,19] which the local farmers in southeast Nigeria exploit through seasonal leaf pruning of on-farm stands of species as well as the naturally shed leaves to enrich their farm/garden soils and manage their agroecosystems[23]. Therefore, by inference of the combined laboratory and nursery investigations of probable allelopathy property of *P. macrophylla* leaf extract solutions, concrete and inhibitory allelopathic impact could not be established, instead the extracts upon increased concentrations were found to enhance to remarkable extent the tested maize and okra are most growth parameters.

CONCLUSION AND RECOMMENDATION

From the present study, there was little evidence to attest to potential adverse allelopathic effect of *P. macrophylla* leaf extract solutions on germination and seedling growth of maize and okra. Conclusively, *Pentaclethra macrophylla* aqueous leaf extract at 10% enhanced total germination, while 40% concentration encouraged dry matter accumulation and height in maize and okra seedlings. However, further investigations are recommended to assay and identify particular allelochemical(s) present in the species leaves and the concentrations in order to explore the allelopathy potentials of this tree in agroecosystems.

SIGNIFICANCE STATEMENT

This study discovered the allelopathy property of *Pentaclethra macrophylla* that can be beneficial for growers of maize and okra in southern Nigeria, agroecosystems as well as advocates of agroforestry farming system. This study will help the researchers to uncover the critical areas of the allelochemical contents of the species that many researchers were not able to explore. Thus a new theory on how these allelochemicals concentrations affect yields of the given arable crops may be arrived at.

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