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Allelopathic Effects of Leaf Extracts of *Leucaena leucocephala* (Lam.) de Wit and *Elaeis guineensis* Jacq. on the Germination, Growth and Yield of *Zea mays* L.

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Abstract

This study assessed the allelopathic effects of leaf extracts of Leucaena leucocephala (Lam.) de Wit and Elaeis guineensis Jacq. on the germination, growth and yield of maize. Fresh leaves of Leucaena leucocephala and Elaeis guineensis were air-dried, ground to powder and used to prepare leaf extracts at two concentrations: 3% and 6%. Ten maize seeds were sown in petri-dishes; three petri-dishes representing each treatment, with two replicates per treatment. Number of germinated seeds were recorded daily to determine germination percentage, germination speed, seed vigour index and mean germination time. Three maize seeds were planted in each of 100 polythene pots, twenty pots representing each treatment. The experiment was replicated in another 100 pots with fertilizer application. Plant height, collar diameter, number of leaves and biomass were assessed fortnightly for 12 weeks. Number of days to flowering and number of days to fruiting were also assessed. From the germination experiment, 3% Elaeis and 3% Leucaena had the highest germination percentage (100%), followed by 6% Elaeis (96.7%), while the control had the least (90%). The 3% Leucaena had the highest germination speed (4.81), followed by 3% Elaeis (4.67), while 6% Leucaena had the least (3.99). The 3% Elaeis had the highest seed vigour index (1133.33), followed by 3% Leucaena (1066.67), while 6% Leucaena had the least (780). Control had the longest germination time (2.68 days/seed), followed by 6% Leucaena (2.540 days/seed), while 3% Leucaena had the shortest (2.13 days/seed). There were significant differences in the heights of maize across the treatments. The 6% Elaeis + Urea had the highest height (76.42 cm), while 3% Elaeis had the least (49.58 cm). The 3% Elaeis had the highest collar diameter (8.59 mm), followed by 6% Elaeis (8.44 mm), while control had the least (7.28 mm). The 3% Leucaena had the highest number of leaves (9.00), followed by 3% Elaeis (8.96), while 6% Leucaena had the least (8.12). The 3% Elaeis treatment had the highest biomass (50.41 g), followed by 3% Leucaena (48.94 g), while 6% Leucaena had the least (46.1 g). There were significant differences among the yields of maize across the treatments, with 3% Leucaena + Urea having the highest yield (28.48g), while 3% Elaeis had the least (8.70 g). Lower concentrations of Leucaena leucocephala and Elaeis guineensis had inhibitory allelopathic effects on the growth and yield of maize while higher concentrations had stimulatory effects.

Keywords: Allelopathic effects, Seed vigour, *Leucaena*, *Elaeis* leaf extract.

Introduction

Agroforestry is a land use management system where trees are planted and grown alongside crops and/or animals (Ibrahim *et al.*, 2019). It is a sustainable system that incorporates forestry elements into agriculture in order to maximize benefits. In agroforestry (tree-crop interface), plants exhibit a chemical characteristic known as allelopathy. Allelopathy is the stimulatory and/or inhibitory effects of a plant on the development of neighbouring plants through the release of secondary compounds (Thiebaut *et al*., 2019). Many tree species have been discovered to have inhibitory allelopathic effects on food crops (Ferguson *et al*., 2013; Ishak and Sahid, 2014). Knowledge of the inhibitory and stimulatory allelopathic effects of species will help ascertain their suitability for agroforestry. However, there is little information on the allelopathic effects of *Leucaena leucocephala* and *Elaeis guineensis* (Adesemuyi *et al*., 2022). This study evaluated the allelopathic effects of leaf extracts of *Leucaena leucocephala* and *Elaeis guineensis* on the germination, growth and yield of maize.

Materials and Methods

The experiments were carried out at the Department of Forest Production and Products, Faculty of Renewable Natural Resources, University of Ibadan, Nigeria. The University of Ibadan is located on latitudes 7°26'N - 7°28'N and longitudes 3°52'E - 3°55'E. The wet season occurs from March to October, while dry season occurs from November to February (Oyerinde *et al*., 2013).

Preparation of Extracts

Using the modified method of Catalán *et al*. (2013) fresh leaves of *Leucaena leucocephala* and *Elaeis guineensis* were harvested at the University of Ibadan. These were air-dried and milled to powder using hammer mill machine. The milled leaves were used to prepare crude extracts at two concentrations: 3% and 6%, by soaking 3 g and 6 g of milled samples in 100 ml of distilled water for 24 hours. The solution was filtered to separate leaf particles from the extracts.

Germination Experiment

Using the germination and plant growth experiments proposed by Cipollini and Greenawalt Bohrer (2016): Fifteen petri-dishes were used for the germination experiment; three per treatment. Treatments included: 3% *Leucaena leucocephala*, 6% *Leucaena leucocephala*, 3% *Elaeis guineensis*, 6% *Elaeis guineensis* and 0% (control). Sterile filter paper was placed in each petri-dish and ten maize seeds were sown in them and watered with the extracts, while distilled water was used to water the control. The number of germinated seeds were recorded daily for 5 days.

Plant Growth Experiment

Two hundred 41×34 cm polythene pots were filled with soil and prepared for planting. One hundred pots were used for the extract treatment, while another 100 received fertilizer application. Urea fertilizer was added at two (2) weeks and four (4) weeks in order to supplement the soil nutrients. The pots used for the pure extract treatment did not receive fertilizer application in order to ascertain the primary effects of the treatments. Twenty (20) pots were assigned to each treatment, as follows: 3% *Leucaena leucocephala*, 6% *Leucaena leucocephala*, 3% *Elaeis guineensis*, 6% *Elaeis guineensis* and 0% (control). Three (3) maize seeds were sown in each pot. The seedlings were thinned to one plant per pot after three (3) weeks. The pots were watered with 50 ml of the extracts weekly. Water was also applied to the pots as required (300 ml at seed and emergence level, and 600 ml as the plants grew to maturity).

Data Collection

The number of germinated seeds was used to determine the germination percentage, germination speed and mean germination time. The germination percentage and plumule length were used to calculate the seed vigour index.

$$\text{Germination percentage} = \frac{(\text{Final number of germinated seeds})}{(\text{Total number of seeds})} \times 100$$

Germination speed was calculated using the index provided by Einhellig *et al*., (1982):

$$S = \left(N1 + \frac{N2-N1}{2} + \frac{N3-N2}{3} + \cdots + \frac{Nn-Nn-1}{n}\right) \times 100$$

Where N_1, N_2, N_3, N_n represent the proportion of germinated seeds in days 1, 2, 3…. n after planting. S varies from 0 (if no seeds germinate by the end of the experiment) to 100 (if all seeds germinate on the first day).

Seed Vigour Index (SVI) was calculated using the formula by Gupta (1993) below:

SVI = Germination percentage × plumule length (mm)

Mean germination time was calculated as follows:

$$MGT = \frac{\Sigma\,(fx)}{\Sigma x}$$

Where 'f' is the number of days after seeds were set to germinate and 'x' is the number of newly germinated seeds on each day. Low mean germination time is regarded as an indication of seed vigour (Oyun, 2006). Plant height, collar diameter and number of leaves were assessed fortnightly for twelve weeks. In addition, biomass assessment was carried out fortnightly until the termination of the experiment. The plants were removed from the pots and separated into roots, stem, leaves, flowers and fruits. Each part was weighed to determine the fresh biomass and then oven-dried to determine the dry biomass. After twelve weeks, the fruits of the samples in each treatment were harvested and weighed to determine the yield across treatments.

Data Analysis

The data collected for the germination were subjected to one-way analysis of variance in order to determine the allelopathic effects of the extracts on germination percentage, germination speed, seed vigour index and mean germination time.

Data collected on seedling growth were subjected to one-way repeated measures ANOVA to determine the allelopathic effects of leaf extracts on the plant height, collar diameter and number of leaves, while data collected for plant biomass and yield were subjected to one-way ANOVA. Significant differences among the concentration levels were separated using Duncan Multiple Range Test.

Results

Germination percentage did not significantly differ across treatments. The 3% Elaeis and 3% Leucaena extracts had the highest mean germination percentage (100%), while the control had the least (90%). Similarly, germination speed, seed vigour index and mean germination time were not significantly different. The 3% Leucaena extract had the highest germination speed (4.81), while 6% Leucaena extract had the least (Table 1). The 3% Elaeis extract had the highest seed vigour index (1133.33), while 6% Leucaena extract had the least (780.00). The control had the longest mean germination time (2.68 days per seed), while 3% Leucaena extracts had the shortest (2.13 days per seed). Plant height and yield significantly varied across the treatments. The 6% Elaeis+Urea treatment had the highest plant height (76.42 cm), while 3% Elaeis had the least (49.58 cm) (Table 2). Also, 3% Leucaena+Urea treatment had the highest yield (28.48 g) while 3% Elaeis had the least (8.06 g). Maize seedlings exposed to 3% Elaeis+Urea had the highest collar diameter (8.74 ± 4.06 mm) and number of leaves (10.36 ± 4.48), while those in the 6% Elaeis+Urea treatment had the highest biomass (57.30 ± 29.83 g) (Table 3).

Table 1: Germination parameters of maize seeds treated with *Leucaena leucocephala* and *Elaeis guineensis* extracts

Treatment	Germination %	Germination speed	Seed vigour index	Mean germination time
Control	90.00 ± 10.00	4.03 ± 0.72	943.33 ± 404.52	2.68 ± 0.49
3% Elaeis	100.00 ± 0.00	4.67 ± 0.17	1133.33 ± 305.51	2.20 ± 0.10
6% Elaeis	96.67 ± 5.77	4.25 ± 0.36	900.00 ± 200.00	2.41 ± 0.20
3% Leucaena	100.00 ± 0.00	4.81 ± 0.05	1066.67 ± 230.94	2.13 ± 0.06
6% Leucaena	93.33 ± 5.77	3.99 ± 0.59	780.00 ± 137.48	2.54 ± 0.41

Table 2: Mean height and yield of maize seedlings exposed to varying levels of leaf extracts and fertilizer treatments

Treatment	Height(cm)	Yield (g)
Control	66.18^{ab}	27.44^{ab}
3% Leucaena	53.03^{bc}	9.98^{c}
3% Elaeis	49.58^{c}	8.70^{c}
6% Elaeis	64.00^{abc}	10.60^{c}
6% Leucaena	56.92^{bc}	18.06^{abc}
Control + Urea	56.24^{bc}	14.98^{c}
3% Leucaena + Urea	66.01^{ab}	28.48^{a}
3% Elaeis + Urea	55.21^{bc}	13.14^{c}

Means with same superscript in the same columns were not significantly different at $p<0.05$

Table 3: Growth variables of maize treated with varying levels of leaf extracts and fertilizer treatments (Mean ± Standard deviation)

Treatment	Collar diameter (mm)	Number of leaves	Biomass (g)
3% Leucaena	7.75 ± 4.06	9.00 ± 3.64	48.94 ± 29.82
3% Leucaena + Urea	7.81 ± 4.05	10.00 ± 4.09	53.80 ± 29.85
6% Leucaena	8.12 ± 4.06	8.12 ± 3.32	46.10 ± 29.82
6% Leucaena + Urea	8.24 ± 4.06	9.64 ± 3.83	48.68 ± 29.82
3% Elaeis	8.59 ± 4.06	8.96 ± 3.10	50.41 ± 29.82
3% Elaeis + Urea	8.74 ± 4.06	10.36 ± 4.48	51.00 ± 29.82
6% Elaeis	8.44 ± 4.05	8.40 ± 2.47	48.30 ± 29.86
6% Elaeis + Urea	8.74 ± 4.06	10.16 ± 3.47	57.30 ± 29.83
Control	7.28 ± 4.05	8.80 ± 2.81	46.55 ± 29.84
Control + Urea	7.65 ± 4.05	8.72 ± 3.60	47.74 ± 29.82

Discussion

This study revealed that leaf extracts of *Elaeis guineensis* and *Leucaena leucocephala* stimulated and increased germination and seed vigour of maize at 3% concentration. This aligns with the report of Ishak and Sahid (2014) that *Leucaena leucocephala* inhibited germination of some seeds at higher concentrations, while it stimulated them at lower concentrations. Kalpana and Navin (2015) also found that higher concentrations of *Leucaena leucocephala* leaf leachates had inhibitory effects on seed germination of *Raphanus sativus*, while there was stimulatory effect at lower concentrations. Leachates of different tree species have been identified to have both stimulating and inhibitory effects on germination and growth of maize (Khan *et al.*, 2011). Adesemuyi *et al*. (2022) reported that bio-oils from *Elaeis guineensis* fruit bunches inhibited the germination and growth of tomatoes, okra and amaranthus with increasing concentration. In this study, higher concentrations had inhibitory effects on height development. However, lower concentrations of extracts from both species stimulated the collar diameter, number of leaves and plant biomass.

Leaves of *Leucaena leucocephala* have been found to stimulate shoot growth, collar diameter and root length of *Vigna unguiculata*, *Cicer arietinum*, *Cajanus cajan*, *Albizia procera* (Ahmed *et al*., 2008). Aqueous leaf and seed extracts of *Leucaena leucocephala* were reported as inhibitors of growth of weed species such as *Ageratum conyzoides, Tridax procumbens* and *Emilia sonchifolia* at high concentrations. But on the other hand, stimulated growth when used at low concentrations (Ishak and Sahid, 2014). Sahoo *et al*. (2007) reported the inhibitory effects of aqueous leaf, seed and bark extracts of *Leucaena leucocephala* on the germination, growth and crop yield of *Zea mays* under pot culture conditions.

In this study, maize yield results contradicted the findings of Dargo *et al*. (2012), who found that *Leucaena leucocephala* significantly increased grain yield. It is worthy to note that the yield was relatively low. This could be due to the limited solar radiation received in the screen house. Usually, the photosynthetic rates of maize plants decrease with decreasing solar radiation and results in decreased yield and yield gaps (Yang *et al*., 2021). Nevertheless, in cases where the crops are resistant to allelopathic effects, inhibition can be due to the synergy of a number of factors responsible for germination and growth of plants, such as genetic and environmental factors.

Conclusion

This study assessed the allelopathic effects of leaf extracts of *Leucaena leucocephala* and *Elaeis guineensis* on the germination, growth and yield of maize. Lower concentrations of leaf extracts of *Leucaena leucocephala* and *Elaeis guineensis* had stimulatory effects on the germination of maize, while they had inhibitory effects on growth and yield. However, higher concentrations of the leaf extracts had stimulatory effects on the growth and yield of maize. These findings are essential when considering component interactions at the tree-crop interface in agroforestry.

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