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Allelopathic Effect of Ivory Coast Almond (*Terminalia ivorensis* A. Chev.) Leaf Aqueous Extract on Germination and Early Seedling Growth of Maize (*Zea mays* L.) Cultivars

Lawal, A. S.[1]*, Ogunronbi, O. E.[1], Aliyu, M.[1], Ribado, M. B. [1], Aminu, R. M.[2] and Ojo, O. F.[3]

[1]Department of Biological Sciences, Federal University Gusau, Nigeria
[2]Department of Science Laboratory Technology, Federal Polytechnic Bauchi, Nigeria
[3]International Institute of Tropical Agriculture, Ibadan

Corresponding Author: aminulawalshehu@fugusau.edu.ng

ABSTRACT

Wider distribution of Ivory Coast Almond (*Terminalia ivorensis*) into farmland areas, is getting worrisome in northern part of Nigeria. This study therefore aimed to evaluate the allelopathic effect of *T. ivorensis* aqueous leaf extract on germination percentage and seedling growth of some cultivated maize cultivars (EWH-79, EEWH-123 & TZE-YDT-STR). Petri dish experiment was conducted in the laboratory of Federal University Gusau. Different concentrations of 0% (Distilled water), 5%, 25%, 50% and 100% were prepared from 10g/L crude extract. Germination percentage, length of radicle and plumule were determined. The findings of this study showed Allelopathic interaction of *T. ivorensis* aqueous leaf extract on germination percentage of the three maize cultivars has no significant effect compared with the Control ($P > 0.05$). Inhibitory effect of *T. ivorensis* aqueous leaf extract on plumule length of all the maize cultivars was observed to be significant ($P < 0.05$). EWH-79 and EEWH-123 showed no variation with the control at 5% of the extract concentration. Furthermore, no pronounced allelopathic effect between the aqueous leaf extract and the control in the radicle length of all the maize cultivars. This study delineated allelochemicals of *T. ivorensis* inhibits plumule development of the cultivars which in turn affects the plant physiology. The inhibition in increasing order of EWH-79 > EEWH > TZE-YDT-STR.

Keywords: Maize cultivars, Allelopathic effect, *Terminalia ivorensis*, Aqueous leaf extract, Germination percentage.

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops grown globally, serving as a primary source of food, fodder, and raw material for various industries. It is the third most important cereal in the world after wheat and rice, and is consumed in various forms; fresh, dried or processed (IITA,2020). In Nigeria, maize is a key component of the agricultural system, covering large areas of farmland due to its short growing cycle and economic returns (Smith *et al.,* 2020; Khaeim *et al.,* 2022). Nigeria is the largest maize producer in Africa, with the crop cultivated across almost all agroecological zones, supporting millions of subsistent farmers (Ado *et al.*, 2021). Despite its importance, maize production in Nigeria is often constrained by various environmental factors, including the presence of allelopathic plants like *T. ivorensis*. The potential allelopathic interactions between *T. ivorensis* and maize cultivars require investigation to ensure that maize growth and yields are not adversely affected.

Allelopathy is a natural ecological phenomenon that plays a critical role in plant-plant interactions within ecosystems. It is defined as the biochemical inhibition or stimulation of one plant species by another through the release of certain chemicals, known as allelochemicals. These secondary metabolites, produced by various plant parts such as leaves, roots, stems, or seeds, are released into the environment through volatilization, root exudation, leaching, or decomposition of plant residues (Patel and Sharma, 2016; Wang *et al.,* 2023). The allelochemicals influence the germination, growth, and development of nearby plants, often leading to suppressed growth, reduced nutrient uptake, or disrupted cellular processes (Oladele *et al.,* 2022; Oke *et al.,* 2022). Allelopathy can be either direct, through the transformation of chemicals in the environment, or indirect, by altering soil characteristics (Wang *et al.,* 2018). Allelochemicals or secondary plant metabolites when translocated to the environment, influence the emergence and growth of the seedlings of neighboring weeds (Liu *et al.,* 2016). This process is increasingly recognized for its potential in crop management, particularly for sustainable agricultural practices and weed control strategies.

The study of allelopathy has significant implications in agriculture, as allelochemicals can either inhibit or promote the germination and growth of crops (Lopez *et al.,* 2023; Li *et al.,* 2022). This effect is critical for understanding crop competition, weed suppression, and plant resource utilization. Research has shown that allelochemicals can inhibit seed germination by preventing the hydrolysis of nutrient reserves and obstructing cell division (Johnson *et al.,* 2021). They can also influence the length of plumule and radicle, reducing the overall development of seedlings (Smith *et al.,* 2021). The use of allelopathy in managing weeds and improving crop yields offers an environmentally friendly alternative to chemical herbicides, reducing reliance on synthetic chemicals and promoting ecological balance in agroecosystems (Chen *et al.,* 2022; Zhang *et al.,* 2023).

In Nigeria, *Terminalia ivorensis*, commonly known as Ivory Coast Almond, is getting a wider distribution, especially in the northern regions. This species, belonging to the Combretaceae family, is primarily valued for its timber and is used in reforestation and afforestation programs (Garcia *et al*., 2020). However, recent observations indicate its allelopathic effects on crops, particularly maize, a staple crop in Nigeria, need to be further explored. As the demand for shade trees and other uses of *T. ivorensis* increases, it is important to understand how its biochemical interactions with nearby crops might influence agricultural productivity. This study, therefore, focus on evaluating the allelopathic effect of *T. ivorensis* aqueous leaf extract on the germination and early seedling growth of three maize cultivars: EWH-79, EEWH-123, and TZE-YDT-STR. Understanding these effects provide insight into natural interactions and crop management practices between *T. ivorensis* and maize plants.

MATERIALS AND METHODS

Study Area

The study was conducted in Plant Science & Biotechnology Laboratory of Biological Sciences Department, Federal University Gusau, Zamfara State, Nigeria. Gusau is located at Latitude 12.1628^{0}N, Longitude: 6.6745^{0}E.

Sample Collection

Terminalia ivorensis (Ivory Coast Almond) was collected from the premises of Federal University Gusau, Farmland area, and identified by the departmental herbarium with voucher number FUG/BIO/HEB/2024/127 (see figure 1). It was cleaned with tap water, shade dried and grounded into powder using sterilized pistil and mortar. About 200g each of maize varieties namely, Early Hybrids (EWH-79, EEWH-123) & Early OPV (TZE-YDT-STR) were collected at the Maize Breeding Unit of the International Institute of Tropical Agriculture (IITA) Ibadan.

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Figure 1: *Terminalia ivorensis* leaf

Preparation of Aqueous Leaves Extracts and Germination Bioassay

Ten grams (10g) of the powdered sample was diluted with 1000ml distilled water and kept for 48 hours at room temperature (37ºC) to form the crude extract. The mixture was filtered using Whatman's filter paper and stored in the dark. Different concentrations of 5%, 25%, 50% and 100% while distilled water as a control (0%) were prepared from the stock aqueous extract. Experimental surroundings and petri dishes were sterilized with 70% ethanol and the petri dishes were lined with two layers of Whatman's filter paper for water retention and saturated with 10 ml of each of the aqueous extract concentration. Five seeds of each of maize cultivar were placed in the Petri dishes at different intervals and replicated. Germinated seeds were counted while radicle and plumule lengths were measured using ruler and recorded. Moisture in the Petri dishes was maintained by adding about 1 ml of the existing concentration in each Petri dish to wet the seeds (Johnson *et al.,* 2022).

Data Collection

Germination percentage was calculated as the number of seeds germinated divided by Number of seed tested multiplied by 100 (Guan *et al.,* 2019).

Germination % = (Number of Germinated seed/ Total Number of Seeds) x 100

Statistical analysis

Data collected for germination percentage was analyzed using Analysis of variance (ANOVA) at 95% level of significance ($P<0.05$), while seedling growth parameters (Plumule and Radicle length) were presented in compound bar charts using error bars to determine level of significance at 95% confidence interval in SPSS version 23 statistical tool.

RESULTS

Table 1 showed allelopathic evaluation of *T. ivorensis* aqueous leaf extract on germination percentage of three maize cultivars; The control has 100% germination efficiency across all the maize cultivars, and recorded not less than 80% at all the concentrations level which is a good indicator of very minimal effect (negligible) and statistically showed no significant differences among the means compared with the Control ($P > 0.05$).

Table 1: Allelopathic Evaluation of *T. ivorensis* Aqueous Leaf Extract on Germination Percentage of Three Maize Cultivars.

	Seed Type		
Concentrations	**EWH-79 Mean± SD (%)**	**EEWH-123 Mean ± SD (%)**	**TZE-YDT-STR Mean ± SD (%)**
0%	100 ±. 14.14	100 ± 0.00	100 ± 0.00
5%	100 ± 0.00	100 ± 0.00	80 ± 0.00
25%	90 ± 14.14	100 ± 0.00	100 ± 0.00
50%	90 ± 14.14	100 ± 0.00	100 ± 0.00
100%	100 ± 0.00	90 ± 0.00	90 ± 14.14
P-value	**0. 739**	**0. 486**	**0.486**

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Mean germination percentage has no significant difference at P > 0.05 down the Concentrations. Note: EWH= Early White Hybrid, EEWH= Extra Early White Hybrid, TZE-YDT-STR= Tropical Zea Early Yellow Drought Tolerant Striga Resistant.

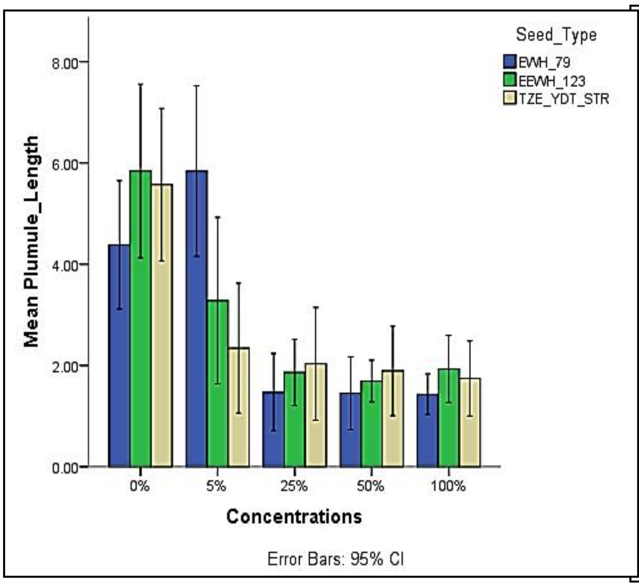

Figure 2: Allelopathic effect of *T. ivorensis* aqueous leaf extract on Plumule Length of the Three Maize Cultivars

Key: A-Early White Hybrid, B-Extra Early White Hybrid, C-Tropical Zea Early Yellow Drought Tolerant Striga Resistant

Figure 2 showed increase in the plumule length of EWH-79, while decrease in the length of the other cultivars' plumule from 5% to 100%. There were significant differences in plumule means of the cultivars at the three later concentrations compared with the control (P< 0.05). EWH-79 and EEWH-123 showed no variation with the control at 5% concentration of the extract (P> 0.05).

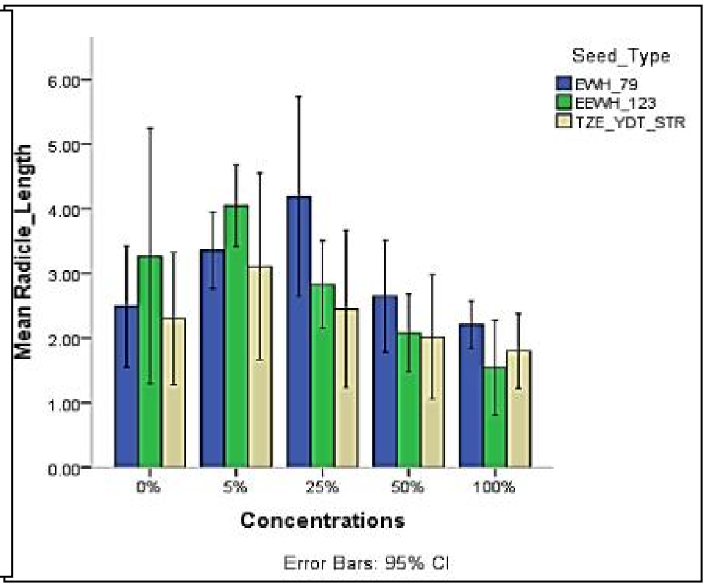

Figure 3: Allelopathic effect of *T. ivorensis* leaf extract on Radicle Length of the three maize cultivars.

Figure 3 showed increase in the mean radicle length of all the cultivars at 5% and 25% apart from EEWH-123 at 25% which decreases to about 2.9 cm. Cultivars radicle length decrease at the 50% and 100% extract except EWH-79 with an increase in length compared with the control at 50% concentration. However, statistically all the cultivars' radicle length has no significant variation across all the treatment compared with the control (P>0.05).

DISCUSSION

T. ivorensis leaf aqueous extract concentrations used in this study does not affect the embryonic development and radicle or plumule protrusion of all the maize cultivars. Probably due to their genetic composition to withstand the biochemical stress during germination. Muntali *et al*. (2012) reported on Baobab seeds that, though the seeds population traits are closely related but their germination percentage are significantly different within and between groups. This finding has gone contrary to most allelopathic research, where allelochemicals inhibits the germination percentage of most seeds. Ayub *et al.* (2013) reported inhibitory activity of legumes leachates on seed germination percentage of maize in both petri dishes and pot experiment. Also, Uka *et al.* (2022) reported inhibitory effects of selected weeds species on germination percentage of maize.

The inhibitory effect of the extract on the plumule length was concentration-dependent; this suggests that the extract exhibits significant allelopathic activity at higher concentration. Plumule length is a sensitive indicator of seedling vigor and early growth potential, and its suppression or reduction implies a negative impact on seedling establishment. Considering all the three maize cultivars have significant decrease in plumule lengths indicating the presence of allelochemicals likely phenolics, flavonoids and other secondary metabolites interfere with and disrupt the seeds' physiological processes of cell elongation and hormonal regulation critical to plumule growth and development. Various phenolic compounds inhibited cell division. It is also possible that cell elongation was affected by extracts of weed residues (Galindo *et al*., 1999). This effect aligns with existing studies, that reported aqueous extracts from allelopathic plants that suppresses shoot elongation and seedling vigor (Ghafar *et al*., 2000; Alemayehu *et al*., 2024). Moreover, Radwan *et al*. (2019) reported presence of bioactive compound extracted from *Calotropis procera* reduced seedling growth of *Triticum aestivium* at higher concentrations of 7% and 10% compared with the control.

Conversely, no effect was observed in the plumule length of EWH-79 and EEWH-123 at 5% concentration delineates cultivar specific tolerance threshold to low concentrations of allelopathic compounds. This tolerance may be due to genetic resilience that helps them to withstand mild biochemical interference without compromising shoot development. Variable genetic composition of the cultivars favored Early White Hybrid (EWH) and EEWH to withstand the allelochemicals in *T. ivoronsis* plant at low concentration. In addition, the findings underscore genotypic differences in maize response to allelopathic stress. TZE-YDT-STR may be more sensitive to the allelochemicals across all concentrations especially in terms of plumule growth. However, these effects may vary depending on the species variety subjected to the allelopathic treatment (Almayehu *et al*., 2024).

In contrast to the plumule suppression, radicle length remained unaffected across all concentrations in all the three maize cultivars but insignificantly increases at lower concentration while decreasing at higher concentration. This suggests that the root system was either more resilient to the allelopathic compounds present in *T. ivorensis,* or that the bioavailability and concentration of inhibitory substances did not reach phytotoxic thresholds for the radicle tissues under the tested condition as the mean trend continue to decrease with concentration. This closely related with the findings of Almayehu *et al*. (2024) reported allelopathic inhibitory effect of *Lantana camara* leaf aqueous extract on root growth of *Capsicum annuum* and *Daucus carota* increases with the concentrations of the extracts and higher concentration had the stronger inhibitory effect whereas the lower concentration showed stimulatory effect in some cases. Allelochemicals can stimulate or inhibit the germination and growth of plants and increase the resistance of crops to biotic and abiotic stresses (Zhang *et al*., 2021).

Despite the fact, only plumule length was significantly inhibited at higher concentrations confirmed the allelopathic effects of *T. ivorensis* on seedling morphology, yet it does not obstruct seeds' germination potential and root elongation.

CONCLUSION

Allelochemicals of *T. ivorensis* have no effect on germination potential of all the maize cultivars in this study. However, Plumule development of all the cultivars were inhibited which in turn affects the seedling growth of the cultivars. In addition, Early White Hybrid -79 (EWH-79) and Extra Early White Hybrid -123 (EEWH-123) has more resistant than Tropical Zea Early Yellow Drought Tolerant Striga Resistant (TZE-YDT-STR). Hence, this study suggests not to sow maize plants of the study where *T. ivorensis* are widely distributed.

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