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Allelopathic Potentials of *Cyperus esculentus* (L.) on the Germination of *Zea mays (* l.)

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ABSTRACT

Cyperus esculentus is a prevalent weed in various agricultural systems, particularly in tropical and subtropical regions. It exhibits allelopathic properties by releasing biochemical that can inhibit the germination and growth of neighboring plants. This study investigate the allelopathic potentials of *Cyperus esculentus* on the germination of *Zea mays*. Complete Randomize Design (RCBD) with 5 replications was adopted for the experimental design .The poly bag experiment was carried out using sterilize and unsterilized soil by planting the seed of *Zea mays* together with *Cyperus esculentus* and the control were the maize seed planted alone. Germination counts (%) of seeds, plant height, leave length and number of leaves were arranged for statistical analyses using ANOVA with the randomized complete block design (RCBD) in 5 replications. The test plant that grew together with Zea mays in the poly bag experiment significantly ($P<0.05$) reduces the germination of the maize seeds in varying degrees. The significant difference was more pronounced in the sterilized soil. This indicates the allelopathic tendency of *Cyperus esculentus* on *Zea mays*.

Keywords:

INTRODUCTION

Cyperus esculentus is a plant species in the sedge family (Cyperaceae). It is commonly called tiger nut or earth almond.it belongs to the genus *Cyperus*. It propagates entirely with underground tubers in the soil (Micheal, S. Defelice 2002). *Cyperus esculentus* are monocot flowering plant with reduced, mostly wind pollinated (anemophious) flowers. Cyperus spp a native to Africa and parts of Europe and Asia. It is widely consumed in Nigeria, where it is known as "aya" and used to prepare beverages like kunu aya .it is cultivated for its edible tubers. Its tubers are rich in starch, fat, sugar, protein and dietary fiber. The tuberous rhizomes of *Cyperus esculentus* have been used as food by hunter-gatherers and agricultural societies for millennia. There are a variety of active components in Cyperus, such as volatile oil, organic acids, alkaloids, phenols, terpenoids, anthraquinone, steroids, etc., which have antibacterial, antioxidant and antitumor activities. It was reported that the consumption of Cyperus could help prevent heart disease and thrombosis, improve blood circulation and lower the risk of colon cancer [Chukwuma, E.R.; Obioma, N.; Cristopher, O.I.2010).The tiger nut is a good source of edible oils that contain a lot of monounsaturated fatty acids. The nutritional value of tiger nut oil is similar to olive oil. (Gao et.al 2021)

Cyperus esculentus grows spontaneously as a weed plant in several regions of the world. A weed is a plant growing where it is not needed and it competes with desirable cultivated crop. Weeds compete with crops for sunlight, space, moisture and essential nutrients, they inhibit or stimulate the crop growth by releasing substances (allelochemicals) into the growing environment. (Alam and Azmi, 1991). Inhibitory

or stimulatory effect of weeds on growth of some crops depends upon the concentration of allelochemicals, which inhibit the growth of some crops at a certain concentration, and may stimulate the growth of same of different crops at lower concentrations. (Narwal, 2006) Weed outbreaks are relatively constant, occurring in the same fields year after year due to latent dormancy in the seed and the overtime gathering of weed seed banks in the soil (Gianessi and Sankula, 2003). *Cyperus esculentus* is a prevalent weed in various agricultural systems, particularly in tropical and subtropical regions. Beyond its competitive growth habits, *Cyperus esculentus* exhibits allelopathic properties releasing biochemical that can inhibit the germination and growth of neighboring plants.

The term allelopathy originates from the Greek word; allelon; each other and pathos meaning suffering and was coined by plant physiology, Hans Molisch, University of Vienna, Austria. 'Pathos" also means 'feeling' or sensitive and could therefore be used to describe both positive (sympathetic) and negative (pathetic) interactions (Guo et al.,2010). Many ecologist however favor definitions including only negative effects in allelopathy. (Lambers et al.,1998)

Allelopathy refers to a biological situation in which chemicals (allelochemicals) are released by some plants into the environment, this influence the survival, growth or reproduction of other plants in such environment. These chemicals can be released through roots, leaves, seeds and decomposing plant material. Allelopathy pertain to the chemical inhibition of one plant species by another through the release of bioactive compounds into the environment (Taylor and Francis 2015).It is reported that Cyperus spp has a strong allelopathic effect (inhibition) on many crops [Papadi, A.; Oluwale, B.; Ismail, K.2013)

Research question: Does *Cyperus esculentus* inhibit or reduce the germination and growth of *Zea mays*?

Research Hypothesis

H_0: Null hypothesis : **(**There is no significant difference in the germination and growth performance of mixed crop of *Zea mays* and *Cyperus esculentus* and the *Zea mays* grown alone).

H_A: Alternate Hypothesis: (There is significant difference in the germination and growth performance of mixed crop of maize and *Cyperus esculentus* and *Zea mays* grown alone).

MATERIALS AND METHOD

Cyperus esculentus tuber and *Zea mays* seed were obtained from 'Hausa Quarters' along Sakpoba road, Benin City with Latitude6.32893◦N and Longitude 5.62803◦E. The tubers were carefully selected for healthy looking ones.

Viability test using floatation techniques

The healthy carefully selected seeds of *Cyperus esculentus* and *Zea mays* were soaked in a beaker containing deionized water for 1-2 minutes. The seeds which floated were discarded and the seed that settled at the bottom of the beaker were selected as viable.

Soil Preparation

Sterilized and non-sterilized soil was used for this study. Loamy soil were obtained from a fallow land behind Botany department, University of Benin. Using a top loading field balance, 5kg soil sample was weighed into 15 labelled experimental pots perforated underneath

Experimental design

The experimental design used for this study is completely randomized design, this is done to apply equal treatment to all the plants and to reduce error. The experiment was performed on the field.

Field experiment

The field work was done using the sterilized and the non-sterilized soil. The setup for the field work was done in five (5) replicates with three treatments. These treatments include the following

Treatment 1: *Cyperus esculentus* (Tiger nut)

Treatment 2: *Zea Mays* (Maize)

Treatment 3: *Cyperus esculentus* and *Zea mays*

The seeds of plants were sown in 5 replicates into experimental pots following the treatment plan designed above. The seeds were sown in both the sterilized and non-sterilized soil sample with 15 experimental pots used for sterilized soil and 15 pots used for unsterilized soil.

Field Data Collection

The germination and growth parameters that were analyzed served as the response variables, these include the following

i. Germination: This is done every day until the 15th day after planting.
ii. Plant height: This is done every two weeks by using a measuring tape and a ruler
iii. Number of leaves; this is done every two weeks by counting the numbers of leaves on each plant.
iv. Leaf Length: This is done every two weeks using a measuring tape and a ruler

Determination of pH

The pH of the soil samples were determined every two weeks and the reading were obtained with the aid of an Hanna microprocessor pH multimeter which was earlier standardized with buffer 4.0, 7.0,and 9.0.Twenty grams of the fresh soil sample was weighed into a 100ml glass beaker. Twenty (20) milliliters of sterile distilled water was added and the suspension was stirred continuously for 30 minutes. The mixture was allowed to stand for 30 minute undisturbed .The pH meter was dipped into the solution and steady readings noted.

RESULTS

Percentage germination for the field experiment in unsterilized soil

Table 1 presents the percentage germination of maize seed sown along with *Cyprus esculentus* in unsterilized soil. The result of the field experiment in unsterilized soil shows that there is no significant difference in the percentage of the maize seed planted along side with *Cyperus esculentus* and the ones that grow alone ($p>0.05$). The highest percentage germination for *Zea mays* grown alone was 42% while that of the maize that was grown alongside with *Cyperus esculentus* was 38%.

Table 1: Percentage germination of maize seed sown along with *Cyperus esculentus* in unsterilized soil

Treatment	Combination in Experimental Plot	Day 3	Day 6	Day 9	Day 12	Day 14
Cyperus only	Alone	-	30.00±14.14	88.00±16.43	96.00±8.49	96.00±8.49
Maize Alone	Alone	00.00± 0.00	33.33± 25.17	38.00± 29.50	42.00± 31.14	42.00± 31.14
Cyperus + Maize	Cyperus	00.00± 0.00	00.00± 0.00	22.50±19.57	34.00± 8.94	38.00± 10.95
	Maize	00.00± 0.00	20.00± 8.37	32.00± 13.4	38.00± 13.4	42.00± 8.37

*The values represent that of the first plant in the combination (mean ± SD)

Percentage germination of the field experiment in sterilized soil

Table 2 presents germination of maize seed sown along with Cyperus esculentus in sterilized soil. The result of the percentage germination for the sterilized soil shows that there was a significant difference ($p<0.05$) in the percentage germination of the seed of maize grown alone and the seeds grown alone side with the Cyperus. The highest percentage germination for the seed of maize that grew alone was 44% while that of the maize that grow along side with Cyperus seed was 22%.

Table 2: Percentage germination of maize seed sown along with *Cyperus esculentus* in sterilized soil

Treatment	Combination in Experimental Plot	Day 3	Day 6	Day 9	Day 12	Day 14
Cyperus only	Alone	00.00 ± 0.00^{a}	00.00 ± 00.0^{a}	40.00 ± 29.4^{a}	42.50 ± 32.0^{d}	36.00 ± 16.00^{a}
Maize Alone	Alone	00.00 ± 0.00^{d}	35.00 ± 7.07^{d}	37.50 ± 29.86^{d}	44.00 ± 23.02^{ac}	44.00±
Cyperus + Maize	Maiz	16.67 ± 11.55^{e}	20.00 ± 0.00^{2}	25.00 ± 12.90^{e}	22.00 ± 13.04^{b}	22.00 ± 13.04^{e}
	Cyperus	00.00 ± 0.00^{abf}	20.00 ± 0.00^{bc}	27.50 ± 15.00^{ab}	30.00 ± 14.14^{e}	32.00 ± 14.83^{g}

*The values above with similar alphabet superscript on the same column do not differ significantly ($p<0.05$)
Figure: mean + SD

Measurement of Growth Parameters for the Field Experiment in Sterilized Soil

Table 3 presents height of plants grown in sterilized soil. The result of the growth parameters for the field experiment in the sterilized soil shows that there were significant difference in the height of plant, length of leaves and numbers of leaves for the seed of maize grown alone and the seeds of maize grown together with Cyperus seed. The significant difference was at $p<0.05$.The highest height of maize grown alone was 67.14cm while that of the maize grown together with Cyperus was 49.52%.

Table 3: Height of plant grown in sterilized soil

Treatment/weeks	Combinations in Experimental Plot	Week2	Week4	Week6	Week8
CYPERUS ONLY	ALONE	16.44 ± 76^{a}	32.84 ± 5.45^{c}	37.08 ± 7.47^{e}	39.44 ± 6.69^{c}
CYPERUS+MAIZE	CYPERUS	22.75 ± 6.67^{fg}	32.00 ± 7.81^{f}	32.72 ± 12.93^{g}	40.56 ± 13.10
	MAIZE	19.56 ± 8.15^{d}	29.46 ± 5.77^{d}	38.80 ± 7.27^{b}	49.52 ± 8.13^{e}
MAIZE ONLY	ALONE	19.24 ± 3.99^{e}	37.42 ± 6.04^{e}	60.28 ± 17.37^{a}	67.14 ± 8.13^{d}

*The values above with similar alphabet superscript on the same column do not differ significantly ($p<0.05$)
Figure: mean ± SD;

Table 4 presents length of leaves of plants grown in sterilized soil In the length of the leave, the highest length of *Zea mays* that was grown alone was 45.12cm while the maize that grew together with *Cyperus* spp was 35.08cm. There was a significant difference in the length of leaves grown alone compare to the one grown alongside with *Cyperus* spp at $P<0.05$.

Table 4: Length of leave of plant grown in sterilized soil.

Treatment/weeks	Combinations in Experimental Plot	Week2	Week4	Week6	Week8
CYPERUS ONLY	ALONE	14.46 ± 4.75^{a}	25.94 ± 4.75^{b}	30.80 ± 7.44^{d}	34.04 ± 5.64^{a}
CYPERUS+MAIZE	CYPERUS	19.88 ± 5.93^{f}	25.58 ± 6.17^{g}	31.76 ± 11.28^{f}	32.32 ± 10.92^{f}
	MAIZE	16.20 ± 6.80^{C}	22.58 ± 4.12^{C}	29.42 ± 6.18^{ab}	35.08 ± 6.12^{e}
MAIZE ONLY	ALONE	15.06 ± 4.03^{d}	28.90 ± 4.17^{e}	42.06 ± 6.23^{c}	45.12 ± 6.49^{d}

*The values above with similar alphabet superscript on the same column do not differ significantly ($p<0.05$)
Figure: mean + SD;

Table 5 presents number of leaves per plant grown in sterilized soil. The number of leaves produced in the sterilized soil differ significantly in the various treatment in this research work at $p<0.05$. The highest number of leaves produce in *Zea mays* plant that grew alone was 7.80cm while the one that grew alongside with Cyperus plant has 6.80cm.

Table 5: Number of leaves per plant grown in sterilized soil

Treatment/weeks	Combinations in Experimental Plot	Week2	Week4	Week6	Week8
CYPERUS ONLY	ALONE	5.40 ± 0.89^{a}	6.20 ± 0.45^{a}	7.20 ± 1.09^{a}	7.80 ± 0.45^{a}
CYPERUS+MAIZE	CYPERUS	5.25 ± 0.50^{d}	7.00 ± 1.41^{e}	7.60 ± 1.34^{c}	7.70 ± 0.55^{d}
	MAIZE	4.00 ± 0.00^{e}	5.20 ± 0.45^{d}	6.60 ± 0.55^{d}	6.80 ± 0.84^{e}
MAIZE ONLY	ALONE	4.40 ± 0.55^{f}	5.60 ± 0.55^{f}	7.00 ± 0.71^{e}	8.60 ± 0.89^{f}

*The values above with similar alphabet superscript on the same column do not differ significantly ($p<0.05$)
Figure;mean± SD;

Measurement of growth parameters for field experiment in unsterilized soil

Table 6 presents height of plants grown in unsterilized soil**.** The measurement of the growth parameters for field experiment in unsterilized soil shows that there is a significant difference in the height of *Zea mays* plant grown alone and the ones grown alongside with Cyperus spp. The significant difference differ at $P<0.05$.The highest height of maize grown alone was 68.38cm while the height of maize grown with Cyperus spp was 47.04cm.

Table 6: Height of plants grown in unsterilized soil

Treatment/weeks	Combinations in Experimental Plot	Week2	Week4	Week6	Week8
CYPERUS ONLY	ALONE	10.52 ± 2.79^{a}	19.6 ± 2.33^{a}	43	$.34\pm1.43^{b}$
CYPERUS+MAIZE	CYPERUS	10.66 ± 2.13^{e}	16.62 ± 7.72^{d}	40.12 ± 8.10^{e}	44.36 ± 6.98^{e}
	MAIZE	9.80 ± 0.97^{f}	19.54 ± 2.76^{e}	39.54 ± 7.59^{f}	47.04 ± 10.03^{f}
MAIZE ONLY	ALONE	15.24 ± 1.31^{g}	22.08 ± 5.25^{f}	55.80 ± 8.42^{fg}	68.38 ± 9.45^{g}

*The values above with similar alphabet superscript on the same column do not differ significantly ($p<0.05$)
Figure: mean +SD;

Table 7 presents length of leaves of plants grown in unsterilized soil. The length of leaves produced from the *Zea mays* that grew alone and the maize plant that grew together with Cyperus spp differ significantly at $P<0.05$. At week eight (8) the length of leave produced for the maize that grew alone was 43.76cm while the once that grew together with *Cyperus* spp was 34.14cm. The same trend occurred in all other weeks of the experiment.

Table 7: Length of leaves of plants grown in unsterilized soil

Treatment/weeks	Combinations in Experimental Plot	Week2	Week4	Week6	Week8
CYPERUS ONLY	ALONE	8.46 ± 1.72^{a}	16.24 ± 1.98^{b}	38.44 ± 2.89^{c}	38.86 ± 6.57^{d}
CYPERUS+MAIZE	CYPERUS	8.56 ± 1.81^{e}	13.84 ± 6.55^{e}	32.16 ± 0.89^{e}	37.98 ± 7.41^{f}
	MAIZE	7.76 ± 0.89^{f}	15.52 ± 2.53^{ab}	28.97 ± 5.7^{f}	34.14 ± 8.33^{e}
MAIZE ONLY	ALONE	12.36 ± 0.89^{g}	16.88 ± 4.52^{e}	40.14 ± 5.41^{g}	43.76 ± 5.13^{g}

*The values above with similar alphabet superscript on the same column do not differ significantly ($p<0.05$)
Figure;mean+_SD;

Table 8 presents number of leaves per plant grown in unsterilized soil. The number of leaves produced in the maize plant and the one produced in the maize plant that grew together with Cyperus spp showed a significant difference at $P<0.05$. The mean number of leaves produced at week e for the maize that grew alone was 6.60 while the maize that grew alongside with Cyprus spp show a leave mean number of 5.80.

Table: 8 Number of leaves per plant grown in unsterilized soil

Treatment/weeks	Combinations in Experimental Plot	Week2	Week4	Week6	Week8
CYPERUS ONLY	ALONE	4.00 ± 0.00^{b}	5.80 ± 0.45^{a}	7.40 ± 0.50^{e}	7.60 ± 0.55^{bs}
CYPERUS+MAIZE	CYPERUS	3.80 ± 0.80^{f}	5.60 ± 0.55^{ce}	6.00 ± 0.00^{bc}	6.40 ± 0.89^{ac}
	MAIZE	4.00 ± 0.00^{d}	6.00 ± 0.00^{ab}	6.00 ± 0.00^{b}	7.20 ± 1.30^{a}
MAIZE ONLY	ALONE	3.80 ± 0.45^{a}	6.40 ± 0.55^{abd}	6.60 ± 0.89^{c}	-6.60 ± 1.14^{c}

*The values above with similar alphabet superscript on the same column do not differ significantly ($p<0.05$)
Figure;mean+_SD;

Physicochemical parameters of the unsterilized soil

Table 9 presents physicochemical parameters of the soil used for the research. The result of the physicochemical parameter of the soil indicate that the pH of the soil was slightly basic with the value of 7.34.The electrical conductivity of the soil was very high with the value of 774.50.The nitrogen content was low with the value of 0.06% and the carbon content is o.54%.The carbon to nitrogen ration is low which indicate that the soil is very fertile and good for agricultural purpose .The soil used for the experiment contained magnesium, sodium, potassium, calcium .The result indicates that there are no trace of heavy metals in the soil used for the experiment and there is no trace of any soil polluted material that can affect the growth parameters of the plant used for the experiment.

Table 9: Physicochemical parameters of the soil

Parameter	Values
Ph	7.34
Electrical conductivity	774.50
Phosphorus (mg/Kg)	7.79
Carbon (%)	0.54
Nitrogen (%)	0.06
Magnesium (meq/100g)	1.12
Potassium (meq/100g)	0.07
Sodium (meq/100g)	0.11
Cation Exchange Capacity (meq/100g)	9.70
Clay (%)	4.70
Silt (%)	2.70
Sand (%)	92.60

Soil pH of the sterilized and unsterilized soil

Table 10 shows the pH values of the sterilized and unsterilized soil every two weeks after the 6th week of planting. The pH table for sterilized and unsterilized soil shows an increase in the pH value from week 2 to week 14. The value ranged from 7 to 7.6 for the soil that was used in planting only *Zea mays* and only *Cyperus* spp but the pH value decreases as the *Cyperus* was planted together with maize. The trend was very clear in the unsterilized soil.

Table 10: Showing the pH values of the sterilized and unsterilized soil every two weeks after the 6th week of planting

Weeks	Cyperus seed		Maize seed		Cyperus+Maize seed	
	Sterilized	Unsterilized	**Sterilized**	Unsterilized	**Sterilized**	Unsterilized
6 weeks	7.3	**7.6**	7.2	**7.5**	7.2	7.7
8 weeks	7.2	7.3	7.4	7.9	7.3	7.7
10 weeks	7.2	7.6	7.5	7.8	7.4	7.6
12 weeks	7.4	7.4	7.9	7.5	7.7	7.7
14 weeks	7.3	7.5	7.3	7.6	7.2	7.6

DISCUSSION

The allelopathic effect of *Cyperus esculentus* was seen on *Zea mays* at the field experiment. In the percentage germination of sterilized soil, the effect of the allelopathy was seen clearly resulting in the significant difference in the percentage germination of maize that grew alongside with Cyperus compared with the seeds that grew alone at $P<0.05$.The effect was also seen in the growth parameters studies such as the plant height, leave number and leave length. The trend was the same for unsterilized soil. Seeds are mostly sensitive to allelochemicals. There was a significant difference in the allelopathy effect of *Cyperus esculentus* on *Zea mays* in this experiment.

Although there was no significant difference in the percentage germination for the plant in unsterilized soil. This may be because of the activities of the microorganism and environmental factors that may help degrading the phytochemicals that were released by *Cyperus esculentus.* The allelopathic effect was demonstrated clearly when the sterilized soil was used because the activity of microorganism was no longer active thereby bringing up a significant difference in the percentage germination. The negative effect of *Cyperus esculentus* on maize was similar to that obtained by Ali (2005).The great suppression in the growth parameters of *Zea mays* was is attributed to the presence of phenolic acid.

As mentioned in the introduction, the main principal in the phenomenon of allelopathy is the fact that plants produce thousands of chemicals which may alter the growth and physiological functions of other species. This report is in conformity with the findings of Chikoye,D.,Ekeleme F.,& Akobundu, I.O.(2000) on maize plant.

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