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# Prospecting for the allelopathic effect of *Tithonia diversifolia* on the growth of some cucurbits – *Citrullus lanatus*, C*itrullus colocynthis* and C*ucumis sativus*

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## Abstract

This study was conducted to ascertain the allelopathic relationship between Tithonia diversifolia and some cucurbits *C. sativus, C. colocynthis* and *C. lanatus*. Seeds of the cucurbits were treated every 24 hours with 10ml of different concentrations (0% [control], 25%, 50% and 100%) prepared from 2.5g/ml stock solution of aqueous extracts of *T. diversifolia*. Two experiments (the Petri and micro plot experiments) were conducted concurrently and were both laid out in a completely randomized design with four replicates in the Green house of Centre for Ecological Studies, University of Port Harcout. Data were taken on Radicle length, Plumule length, Number of leaves (NOL), Plant Height (PH), Fresh weight and Dry weight for five weeks after plating / sowing for the test cucurbits. Results showed that, compared to the control, there were no significant ($p \leq 0.05$) difference in all the parameters investigated for the three cucurbits studied after treatment with different concentrations of T. diversifolia. Results from the analysis shows that for laboratory (Petri dish) experiment, *T. diversifolia* inhibited the plumule of C. calocynthis in 25% concentration at 5 days after plating; the radicle and plumule of C. lanatus in 50 and 100% concentrations at 5 and 7 days after plating (WAP). *T. diversifolia* showed no effect on the radicle and plumule length of *C. sativus*. For Green house (potted) experiment, it stimulated the growth of *C. sativus* and *C. calocynthis* in 50% at 5WAP and stimulated the growth of C. lanatus in 25% at 5WAP. Conclusively, there are possibiliites that T. diversifolia possess allelopathic effect on the growth and development of some cucubits.

**Keywords:** Allelopathy; Cucurbit; *Cucumis sativus; Citrullus colocynthis; Citrullus lanatus;* Petri dish*;* Micro Plots*;* Green house

## 1 Introduction

Cucurbitaceae is a plant family, also known as gourd family, which includes crops like cucumbers, squashes, luffas and melons. Cucurbits form an important and a big group of vegetables crops cultivated extensively in the subtropical and tropics countries. The family reportedly consists of about 118 genera and 825 species (Roopashree *et al*., 2008). Plants of this family have many medicinal and nutritional benefits (Gill and Bali, 2011).

Cucumber (*Cucumis sativus)* fruit is one of the widely cultivated monoecious annual crops in the gourd family of Cucurbitaceae, which also includes important crops such as melon, water melon and squash (Vivek *et al*., 2017). Reports have it that the plant has been cultivated by man for well over 3,000 (three thousand years) (Adetula and Denton, 2003; Okonmah, 2011). Cucumber, has been severally implicated for its use as medicinal remedies to certain ailments such as bacterial and fungal infections. Reports have it that *Cucumis sativus* possess poor activity against *Pseudomonas aeruginosa* (Khan *et al*., 2013). Mallik and Akhter (2012) has also reported on the antifungal potentials of the ethanol extract of *Cucumis sativus* assessed against six fungal species. *C. sativus* is used for jaundice, bleeding disorders and

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anuria; while its seeds are highly nourishing (Gogte, 2000. This is backed up by the works of Agatemor *et al.*. (2018) who established the proximate properties of *C. sativus* as having most of the important phyto-constituents that are necessary for general good human health.

*Citrullus colocynthis* (Bitter apple, Bitter cucumber or Nigerian Egusi) is also one of the widely consumed cucurbits in West Africa. The fruit is intense and globular with a smooth surface. It is hard and has a skin around it and contains 200–300 seeds/gourd. Seeds are small (6mm in length), ovoid, compressed, smooth and brownish when ripe. It is reported that seeds constitute about 75% of the weight of fruit of *Citrullus colocynthis* (Hussain *et al*., 2014). Recent reviews by Prashant *et al*. (2017) and Al-Snafi (2016) have revealed *C. colocynthis* as being a highly medicinal plant, and described it as having antioxidant activity (Kumar *et al*., 2008), antihyperlipidemic effect (Zamani *et al*., 2007), antimicrobial effect (Gurudeeban *et al*., 2010), and antifungal activity (Eidi *et al*., 2015).

Watermelon (*Citrullus lanatus*) a fruit crop, is herbaceous creeping plant that belongs to the family *Cucurbitaceae*. It can be grown along the coastal areas of Ghana, the forest zone and especially along river beds in the Northern Savannah areas (Ministry of Food and Agriculture, 2011).

Medicinal plants are good source of antioxidants, vitamin and mineral. They can be used to develop different type of food products like cookies to increase their nutritional values, which are helpful in fulfiling nutritional requirement and combat various degenerative disease (Gupta *et al*., 2018). The ethnomedicinal utility of *C. lanatus* was also confirmed by Omigie and Agoreyo (2014) who also implicated the plant as having antidiabetic properties. Agricultural malpractices (such as intercropping and the use of certain allelopathic plants as biofertilizers) of most farmers may lead to reduced yield and economic losses. It is no more news that some plants have chemical influence (positive or negative) on the growth of other plants growing around them (Jabran, 2017), a concept called Allelopathy. Several reports (Uzoma *et al*., 2018, 2019; Ochekwu *et al*., 2019, 2020) have implicated a plethora of plants as having allelopathic potencies. One of such plants that have been severally reported as a notorious allelopathic plant is *Tithonia diversifolia* (Aladejimokun *et al*., 2014; Oyeniyi *et al*., 2016; Oyerinde *et al*., 2009; Musyimi *et al*., 2012). Despite having certain economic benefits as a pesticide and medicinal plant, *T. diversifolia* has been reported as being an aggressively invasive weed that restructures the floral distribution of whatever ecosystem it invades (Oludare and Muoghalu, 2014). A review by Kato-Noguchi (2020) has argued that the aggressive invasiveness of *T. diversifolia* is to be attributed to its allelopathic potential. Kato-Noguchi (2020) explained that, following its 30 years' notoriety as an allelopathic plant, it is possible that some phytotoxic substances in *T. diversifolia* may be released into the soil through the decomposition of the plant residues and the exudation from living tissues of *T. diversifolia*, including its root exudates, which act as allelopathic substances. Those allelopathic substances can inhibit the germination and growth of neighbouring plants, enhance the competitive ability of the plants and make them invasive. Other publications have also reported *T. diversifolia* as exhibiting targeted allelopathy, as most of its allelopathic influence is on economically important food crops like maize (*Zea mays*), cowpea (*Vigna unguiculata*) and Spider plant (*Cleome gynandra*) (Aladejimokun *et al*., 2014; Oyeniyi *et al*., 2016; Oyerinde *et al*., 2009; Musyimi *et al*., 2012); and thus, it can only be left to the imagination what could likely be the outcome of *T. diversifolia* invading a farm in which our subject cucurbits are planted. Jama *et al*. (2000) revealed that some farmers grow *T. diversifolia* in their farms, as the flowers serve as attractants to insect pollinators, the whole plant serves as compost manure for the growth of vegetables, while the extract exhibits pesticidal effects against termites. This, in addition to the fact that the allelopathic effect of *T. diversifolia* could either be stimulatory or inhibitory (Oyerinde *et al*., 2009), led to the aim of this study which is to establish the allelopathic relationship existing between *T. diversifolia* and some select economically viable cucurbits (*C. sativus*, *C. lanatus* and *C. colocynthis*) in the West African sub-region.

## 2 Material and methods

### 2.1 Experimental site

The potted experiment was conducted at the Centre for Ecological Studies in the Department of Plant Science and Biotechnology, University of Port Harcourt, Rivers state, Nigeria. It is on geographical coordinates: latitude 4°52' N and 4°55' N Longitudes 6°54' E and 6°56' E in Obio/Akpor Local Government Area (LGA) Rivers State. It is situated in the Niger Delta wetland of Southern Nigeria. The climatic weather condition of the area is characterized by tropical monsoon climate with mean annual temperature of 25°C to 28°C and annual rainfall of over 3000mm. The relative humidity is very high with an annual mean of 85% while the soil is usually sandy or sandy loam underlain by a layer of impervious pan.

### 2.2 Sand sterilization and determination of pH

Sand obtained from river bank (4.885°N, 7.174°E) was sterilized by soaking in boiled water (100°C) for 15 minutes, and then allowed to cool. This was done to remove inherent seed bank and plant pathogens. The pH level was determined using a pH meter (Suptra Scientific, Canada), and was augmented up to pH of 7.0±0.3 by adding drops of 1M NaOH.

### 2.3 Duration of the experiment

The germination experiment comprised of 48 petri dishes (16 petri dishes for each plant, and each containing 10 seeds of *C. sativus*, *C. colocynthis* and *C. lanatus*). The laboratory experiments were carried out four different times for all three test seeds. Each laboratory experiment lasted for 4 weeks. The plant pot experiment comprised of 48 pots (16 pots for each plant, and each containing 2 seeds of *C. sativus*, *C. colocynthis* and *C. lanatus*). The pot experiments were carried out once (four treatments and four replicates) for all three test seeds. The pot experiment lasted for 5 weeks.

### 2.4 Source of plant materials

The seeds of the test crops were obtained from an open market in Port Harcourt, Rivers State and identified by the departmental herbarium. The leaves of *Tithonia diversifolia* were collected within the UniPark Campus, University of Port- Harcourt, and Rivers State Nigeria.

### 2.5 Viability test on seeds

Germination viability test was conducted to ascertain the viability of the seeds. Ten seeds from the test seeds (*C. sativus*, *C. colocynthis* and *C. lanatus*) were placed in Petri dishes lined with Whatmann No. 1 filter paper and appropriately moistened with 10 ml of distilled water (every 3 days) for 7 days. A 90-100% viability was observed for the respective seeds.

### 2.6 Preparation of stock solution

The leaves of *Tithonia diversifolia* were harvested, rinsed, air-dried for 30 minutes and then finely pulverized with an electric blender. 2.5kg of the pulverized plant sample was macerated in 10 liters of distilled water, with intermittent agitation, for 96 hours (four days) following the method of Uzoma *et al*. (2018). The setup was filtered using Whatmann No. 21 filter paper to give a stock solution of 2.5g/ml. The extract obtained under this process was used as the 100% (2.5g/ml) concentration of the leaves aqueous extract of *T. diversifolia*. Further dilution with distilled water was used to obtain subsequent concentrations (25% and 50%) and distilled water (0%) served as the control. The extract was refrigerated to prevent the degradation of its components.

### 2.7 Experimental design

The experimental design used in this work is Complete Randomized Design (CRD) with four replicates.

### 2.8 Establishment of allelopathic relationship

#### *2.8.1 Germination experiment (Petri dish)*

Four (4) sterilized Petri dishes, lined with Whatmann No. 1 filter paper and seeded with 10 seeds per dish of each plant (*C. sativus*, *C. colocynthis* and *C. lanatus*), were treated with different concentrations of the stock solution of the T. diversifolia leaves aqueous extract as follows: 0% (which served as the control), 25%, 50%, 75% and 100% respectively. The seeds of each plant were wetted with 10ml of the respective concentration while the control (0%) was wetted with 10ml of distilled water. The radicle and plumule length were measured on the 7th days for the three test plants. The experiment was repeated four times.

#### *2.8.2 Greenhouse (potted) experiment*

Plastic pots were filled with 400 g of sterilized river bed sand. 16 plates were used for each crop and 5 seeds were planted and labeled according to their concentrations. Plantlets were each treated with different concentrations of *T. diversifolia* extract as follows; 0 (which served as control), 25, 50 and 100%. The experiment was laid out in a completely randomized design (CRD) with four replicates. The plants were moistened daily with 10ml of water throughout the 5-week duration of the experiment. Measurement on Number of leaves (NOL), Plant Height (PH) in (cm) were taken from two weeks after planting to 5 weeks after planting. At termination (after the fifth week), treated and untreated plants were uprooted, rinsed with tap water to remove adhering soil, and excess water removed with paper towel, and the fresh weight was taken. Subsequently, plants were labelled and oven dried at 45°C, after which the dry weight was taken.

*2.8.3 Parameters studied*

Number of leaves (NOL), Plant Height (PH), Radicle length, Plumule length, Fresh weight and Dry weight.

*2.8.4 Determination of root length*

The radicle length was determined (on the 7th day after seeding) by measuring the length of the radicles of each seed in a Petri dish using a metric rule, and the radicle length was taken as the average of the mean radicle lengths of the germinated seeds in the dish.

*2.8.5 Determination of plumule length*

The plumule length was determined (on the 7th day after seeding) by measuring the length of the plumules of each seed in a Peti dish using a metric rule, and the plumule length was taken as the average of the mean plumule lengths of the germinated seeds in the dish.

*2.8.6 Measuring the Plant Height*

The plant height was measured using a ruler by measuring from the base of the plant to the topmost leaf. The plant height was taken as the average of the plant height of all the plants in the for that particular treatment.

*2.8.7 Measuring the Number of Leaves*

The number of leaves was obtained by visual counting of the leaves. The number of leaves was taken as the average of the number of leaves of all the plants in the pot for that particular treatment.

*2.8.8 Measuring the Fresh Weight*

The plants were weighed using a weighing balance. The average weights of the plants in a pot for that particular treatment were taken as the fresh wet weight.

*2.8.9 Measuring the Dry Weight*

The plants were oven-dried at 80°C for 72 hours. The individual dry weights of the plants were obtained using an electronic weighing balance; and the average of all the plants in a pot was taken as the dry weight.

*2.8.10 Data analysis*

Data were analyzed with Analysis of Variance (ANOVA) using statistical analyses system package 9.1 (2002). Means were separated using Least Significant Difference (LSD) at 5% level of probability.

## 3 Results

After the prospecting of *T. diversifolia* for potential allelopathic effect on the cucurbits *C. sativus*, *C. colocynthis* and *C. lanatus*, it was found that the increasing application of the aqueous extract of *T. diversifolia* yielded no significant effect on the cucurbits. The only difference came with some parameters studied for *C. sativus*, but those differences were not significant at (P≤ 0.05), and could not result to a trend. Attached herewith are the tabulated outcome of the study.

**Table 1a** Results for the treatment of *C. sativus* radicle length with aqueous extracts of *T. diversifolia*

| Parameter | Treatment | Weeks after planting (wap) | | | | |
|---|---|---|---|---|---|---|
| | | 1 WAP | 2 WAP | 3WAP | 4 WAP | 5 WAP |
| Radicle length | 0 | 8.95±1.56[a] | | | | |
| | 25 | 9.70±0.46[a] | | | | |
| | 50 | 9.15±0.46[a] | | | | |
| | 100 | 5.45±0.67[b] | | | | |
| | LSD | 1.54 | | | | |

**Table 1b** Results for the treatment of *C. sativus* plumule lenght with aqueous extracts of *T. diversifolia*

| Parameter | Treatment | Weeks after planting (wap) | | | | |
|---|---|---|---|---|---|---|
| | | 1 WAP | 2 WAP | 3WAP | 4 WAP | 5 WAP |
| Plumule length | 0 | 4.07±0.56[a] | | | | |
| | 25 | 5.12±0.55[a] | | | | |
| | 50 | 5.25±0.46[a] | | | | |
| | 100 | 3.57±0.32[b] | | | | |
| | LSD | 0.75 | | | | |

**Table 1c** Results for the treatment of *C. sativus* plant height (cm) with aqueous extracts of *T. diversifolia*

| Parameter | Treatment | Weeks after planting (wap) | | | | |
|---|---|---|---|---|---|---|
| | | 1 WAP | 2 WAP | 3WAP | 4 WAP | 5 WAP |
| Plant height | 0 | | 0.62±1.25[b] | 0.7±1.4[b] | 0.9±1.8[b] | 1.07±2.15[b] |
| | 25 | | 4.52±0.83[a] | 5.07±0.76[a] | 5.82±0.82[a] | 6.37±0.65[a] |
| | 50 | | 5.15±0.78[a] | 6.02±0.92[a] | 6.62±0.75[a] | 7.35±1.04[a] |
| | 100 | | 4.4±1.33[a] | 5.4±0.58[a] | 6.7±1.96[a] | 6.90±2.40[a] |
| | LSD | | 1.66 | 1.48 | 2.22 | 4.08 |

**Table 1d** Results for the treatment of number of leaves of *C. sativus* with aqueous extracts of *T. diversifolia*

| Parameter | Treatment | Weeks after planting (wap) | | | | |
|---|---|---|---|---|---|---|
| | | 1 WAP | 2 WAP | 3WAP | 4 WAP | 5 WAP |
| Number of leaves | 0 | | 0.75±1.5[b] | 1.2±2.5[b] | 1.3±3[b] | 3.25±3.77[b] |
| | 25 | | 3.25±0.5[a] | 5.52±0.5[a] | 6.0±1.41[a] | 7.25±2.5[ab] |
| | 50 | | 4.0±0[a] | 6.0±0.81[a] | 6.5±2.38[a] | 8.25±2.62[a] |
| | 100 | | 3.25±0.5[a] | 5.0±1.15[a] | 5.0±1.41[a] | 6.0±0.81[ab] |
| | LSD | | 1.27 | 2.24 | 3.32 | 4.08 |

**Table 1e** Results for the treatment of fresh weight (g) of *C. sativus* with aqueous extracts of *T. diversifolia*

| Parameter | Treatment | Weeks after planting (wap) | | | | |
|---|---|---|---|---|---|---|
| | | 1 WAP | 2 WAP | 3WAP | 4 WAP | 5 WAP |
| Fresh weight | 0 | | | | | 0.77±1.55[a] |
| | 25 | | | | | 2.27±0.56[a] |
| | 50 | | | | | 3.22±2.03[a] |
| | 75 | | | | | 5.02±2.07[a] |
| | LSD | | | | | 2.09 |

**Table 1f** Results for the treatment of dry weight (g) of *C. sativus* with aqueous extracts of *T. diversifolia*

| Parameter | Treatment | Weeks after planting (wap) | | | | |
|---|---|---|---|---|---|---|
| | | 1 WAP | 2 WAP | 3WAP | 4 WAP | 5 WAP |
| Dry weight | 0 | | | | | 0.57±1.15[a] |
| | 25 | | | | | 0.8±0.27[a] |
| | 50 | | | | | 1.7±1.60[a] |
| | 100 | | | | | 1.95±1.85[a] |
| | LSD | | | | | 2.23 |

Treatments (0%, 25% and 50% ) were significantly (P≤ 0.05) highly that treament 100% aqeous solution on the radicle and plumule lenghts (Tables 1a and 1b). Plant height had the control treatment to be significantly (P≤ 0.05) lower than other treatments from 2WAP through 5WAP (Table 1c). The same trend was observed for number of leaves where treatment 50% aqeous solution of *T. diversifolia* was significantly (P≤ 0.05) higher than other treatments; treatments 50% and 100% had no significant (P≤ 0.05) difference between them but is significantly higher than the control treatment (Table 1d). Fresh and dry weights had no significant (P≤ 0.05) differences among all the treatments (Tables 1e and 1f).

**Table 2a** Results for the treatment of *C. colocynthis* radicle length with aqueous extracts of *T. diversifolia*

| Parameter | Treatment | Weeks after planting (wap) | | | | |
|---|---|---|---|---|---|---|
| | | 1 WAP | 2 WAP | 3WAP | 4 WAP | 5 WAP |
| Radicle length | 0 | 4.42±4.45[a] | | | | |
| | 25 | 3.95±3.60[a] | | | | |
| | 50 | 3.22±3.75[a] | | | | |
| | 100 | 3.3±2.47[a] | | | | |
| | LSD | 5.61 | | | | |

**Table 2b** Results for the treatment of *C. colocynthis* plumule lenght with aqueous extracts of *T. diversifolia*

| Parameter | Treatment | Weeks after planting (wap) | | | | |
|---|---|---|---|---|---|---|
| | | 1 WAP | 2 WAP | 3WAP | 4 WAP | 5 WAP |
| Plumule length | 0 | 1.0±1.35[a] | | | | |
| | 25 | 1.15±1.26[a] | | | | |
| | 50 | 1.22±1.48[a] | | | | |
| | 100 | 1.45±1.51[a] | | | | |
| | LSD | 2.17 | | | | |

**Table 2c** Results for the treatment of *C. colocynthis* plant height (cm) with aqueous extracts of *T. diversifolia*

| Parameter | Treatment | Weeks after planting (wap) | | | | |
|---|---|---|---|---|---|---|
| | | 1 WAP | 2 WAP | 3WAP | 4 WAP | 5 WAP |
| Plant height | 0 | | 1.67±1.13[a] | 2.6±1.92[a] | 3.27±2.35[a] | 3.57±2.50[a] |
| | 25 | | 2.8±2.11[a] | 3.72±2.55[a] | 4.47±3.06[a] | 5.0±3.35[a] |
| | 50 | | 3.95±0.59[a] | 4.5±0.63[a] | 5.37±0.87[a] | 6.1±1.01[a] |
| | 100 | | 2.67±1.93[a] | 3.2±2.26[a] | 3.62±2.45[a] | 4.6±3.10[a] |
| | LSD | | 2.41 | 3.05 | 3.59 | 4.09 |

**Table 2d** Results for the treatment of number of leaves of *C. colocynthis* with aqueous extracts of *T. diversifolia*

| Parameter | Treatment | Weeks after planting (wap) | | | | |
|---|---|---|---|---|---|---|
| | | 1 WAP | 2 WAP | 3WAP | 4 WAP | 5 WAP |
| Number of leaves | 0 | | 2.0±1.41[a] | 3.5±2.38[a] | 3.25±2.36[a] | 5.57±4.27[a] |
| | 25 | | 2.0±1.41[a] | 3.5±2.51[a] | 4.25±1.41[a] | 6.25±4.92[a] |
| | 50 | | 2.25±1.50[a] | 4.0±0.81[a] | 5.25±3.30[a] | 7.0±3.55[a] |
| | 100 | | 2.5±1.73[a] | 4.0±2.70[a] | 4.75±3.20[a] | 7.75±5.31[a] |
| | LSD | | 2.34 | 3.44 | 4.00 | 7.03 |

**Table 2e** Results for the treatment of fresh weight (g) of *C. colocynthis* with aqueous extracts of *T. diversifolia*

| Parameter | Treatment | Weeks after planting (wap) | | | | |
|---|---|---|---|---|---|---|
| | | 1 WAP | 2 WAP | 3WAP | 4 WAP | 5 WAP |
| Fresh weight | 0 | | | | | 0.93±0.65[a] |
| | 25 | | | | | 1.87±1.56[a] |
| | 50 | | | | | 2.10±0.94[a] |
| | 75 | | | | | 3.5±2.67[a] |
| | LSD | | | | | 2.72 |

**Table 2f** Results for the treatment of dry weight (g) of *C. colocynthis* with aqueous extracts of *T. diversifolia*

| Parameter | Treatment | Weeks after planting (wap) | | | | |
|---|---|---|---|---|---|---|
| | | 1 WAP | 2 WAP | 3WAP | 4 WAP | 5 WAP |
| Dry weight | 0 | | | | | 0.62±0.58[a] |
| | 25 | | | | | 1.35±1.16[a] |
| | 50 | | | | | 1.22±1.13[a] |
| | 100 | | | | | 2.37±2.33[a] |
| | LSD | | | | | 2.23 |

This explains that for all parameters (radicle length, plumule length, plant height, number of leaves, fresh and dry weight) studied for *C. colocynthis*, none was significantly (P≤ 0.05) affected by the increasing application of the aqueous extracts of *T. diversifolia* (Tables 2a - 2f).

**Table 3a** Results for the treatment of *C. lanatus* radicle length with aqueous extracts of *T. diversifolia*

| Parameter | Treatment | Weeks after planting (wap) | | | | |
|---|---|---|---|---|---|---|
| | | 1 WAP | 2 WAP | 3WAP | 4 WAP | 5 WAP |
| Radicle length | 0 | 2.25±3.30[a] | | | | |
| | 25 | 2.37±2.75[a] | | | | |
| | 50 | 0±0[a] | | | | |
| | 100 | 0±0[a] | | | | |
| | LSD | 3.31 | | | | |

**Table 3b** Results for the treatment of *C. lanatus* plumule lenght with aqueous extracts of *T. diversifolia*

| Parameter | Treatment | Weeks after planting (wap) | | | | |
|---|---|---|---|---|---|---|
| | | 1 WAP | 2 WAP | 3WAP | 4 WAP | 5 WAP |
| Plumule length | 0 | 1.22±2.31[s] | | | | |
| | 25 | 3.75±4.34[s] | | | | |
| | 50 | 0±0[s] | | | | |
| | 100 | 0.25±0.5[s] | | | | |
| | LSD | 3.81 | | | | |

**Table 3c** Results for the treatment of *C. lanatus* plant height (cm) with aqueous extracts of *T. diversifolia*

| Parameter | Treatment | Weeks after planting (wap) | | | | |
|---|---|---|---|---|---|---|
| | | 1 WAP | 2 WAP | 3WAP | 4 WAP | 5 WAP |
| Plant height | 0 | | 3.42±0.29[a] | 5.12±1.08[a] | 5.35±1.08[a] | 5.77±0.82[a] |
| | 25 | | 3.8±2.66[a] | 4.42±2.96[a] | 5.3±3.57[a] | 7.5±0.76[a] |
| | 50 | | 3.1±2.27[a] | 5.8±0.57[a] | 6.97±0.42[a] | 7.45±0.73[a] |
| | 100 | | 2.5±2.33[a] | 5.35±1.08[a] | 5.57±1.08[a] | 7.42±1.33[a] |
| | LSD | | 3.25 | 2.61 | 3.01 | 1.45 |

This explains that for all parameters (radicle length, plumule length, plant height, number of leaves, fresh and dry weight) studied for *C. lanatus*, none was significantly (P≤ 0.05) affected by the increasing application of the aqueous extracts of *T. diversifolia* (Tables 3a - 3f).

**Table 3d** Results for the treatment of number of leaves of *C. lanatus* with aqueous extracts of *T. diversifolia*

| Parameter | Treatment | Weeks after planting (wap) | | | | |
|---|---|---|---|---|---|---|
| | | 1 WAP | 2 WAP | 3WAP | 4 WAP | 5 WAP |
| Number of leaves | 0 | | 2.0±0[a] | 3.25±0.5[a] | 4.25±0.5[a] | 5.0±0.82[a] |
| | 25 | | 1.5±1.0[a] | 2.7±2.06[a] | 3.25±2.87[a] | 4.5±1.73[a] |
| | 50 | | 1.5±1.50[a] | 3.25±0.5[a] | 4.5±0.57[a] | 5.25±0.95[a] |
| | 100 | | 1.75±1.73[a] | 3.2±0.5[a] | 3.0±0.81[a] | 4.0±1.41[a] |
| | LSD | | 1.45 | 1.72 | 2.37 | 1.97 |

**Table 3e** Results for the treatment of fresh weight (g) of *C. lanatus* with aqueous extracts of *T. diversifolia*

| Parameter | Treatment | Weeks after planting (wap) | | | | |
|---|---|---|---|---|---|---|
| | | 1 WAP | 2 WAP | 3WAP | 4 WAP | 5 WAP |
| Fresh weight | 0 | | | | | 1.37±0.41[a] |
| | 25 | | | | | 1.22±0.08[a] |
| | 50 | | | | | 1.45±0.57[a] |
| | 75 | | | | | 0.32±2.67[a] |
| | LSD | | | | | 0.61 |

**Table 3f** Results for the treatment of dry weight (g) of *C. lanatus* with aqueous extracts of *T. diversifolia*

| Parameter | Treatment | Weeks after planting (wap) | | | | |
|---|---|---|---|---|---|---|
| | | 1 WAP | 2 WAP | 3WAP | 4 WAP | 5 WAP |
| Dry weight | 0 | | | | | 0.42±0.23[a] |
| | 25 | | | | | 0.72±0.60[a] |
| | 50 | | | | | 0.62±0.44[a] |
| | 100 | | | | | 0.62±0.30[a] |
| | LSD | | | | | 0.64 |

## 4 Discussion

For all parameters (Radicle length, Plumule length, Plant Height, Number of leaves, Fresh weight, Dry weight) investigated in all the three plants, aqueous extracts of *T. diversifolia* failed to significantly establish any form of allelopathy, be it stimulatory or inhibitory. Despite the slight undulations in the values obtained for all parameters for the three plant samples investigated, especially observations at the plumule length, plant height and number of leaves for *C. sativus*, this failed to hold statistical implication as further increase in the treatment did not result to a significant increase in the value of the parameters in subject. This finding is leading to the conclusion that, for all three cucurbits investigated (*C. sativa*, *C. colocynthis* and *C. lanatus*), the aqueous extract of *T. diversifolia* does not have any alllelopathic effect. This inference can be further extrapolated to the Cucurbitaceae family, and thus be rephrased to imply that aqueous extracts of *T. diversifolia* do not have allelopathic effect on the Cucurbits. This is out of line with the findings of Oyeniyi *et al*. (2016) who established that both aqueous and methanolic extracts of *T. diversifolia* reduced the growth parameters of *Vigna unguiculata*. Contrary to the findings of this study and that of Oyeniyi *et al*. (2016), Aladejimokun *et al*. (2014) maintained that extracts of *T. diversifolia* stimulated the growth of *Vigna unguiculata* and *Zea mays*. Despite

the dispositions of Oyeniyi *et al*. (2016) and Aladejimokun *et al*. (2014), Olabode *et al*. (2010) have suggested, in what looks like a corroboration to the finding of this work, that aqueous extracts of *T. diversifolia* do not show any significant difference in the germination of *Zea mays* and *Glycine max*. Owing to the myriad of literature reporting *T. diversifolia* as a notoriously allelopathic plant, one could infer the possibility of *T. diversifolia* being selectively allelopathic. This inference is supported by Oyerinde *et al*. (2009) and Musyimi *et al*. (2012) who stated that aqueous fresh shoot extracts of *T. diversifolia* have both stimulatory and inhibitory effects on plants. A similar case of selective allelopathy has been reported by Ochekwu *et al*. (2020) who established that *Juglans nigra* exhibited a form of "bilateral influence on plants, even at the family level". This statement was made when they observed that *Juglans nigra* inhibited the height and number of leaves of *Triticum aestivum*, while increasing the height and number of leaves of *Oryza sativa*, despite both plants being members of the same Poaceae family. To validate this, they explained that the "bilateral influence" served as a pointer to certain biochemical differences between the two plants, despite their phylogenetic similarity. Also in the same line of thought, Oyerinde *et al*. (2009) reported a case of what looked like selective allelopathy and what Ochekwu *et al*. (2020) called "bilateral influence", when he revealed that the application of the shoot aqueous extract of *T. diversifolia* was observed to significantly enhance the morphological parameters (fresh weight, dry weight and leaf area) of *Zea mays*, while it inhibited the chlorophylls content A and B. He reiterated that the "fresh shoot aqueous extract of *T. diversifolia* could have differing effects (inhibitory and stimulatory) on seedling growth of this test crop, depending on plant's growth stage". *T. diversifolia* exhibits both bilateral influence and selective allelopathy. Bilateral influence being that it can inhibit or stimulate different parameters in the same plant, such that some parameters are stimulated while other are inhibited; while selective allelopathy explains that the plant or its extracts can have either inhibitory, stimulatory or neutral effect on different plants, such that some plants (and their parameters) can be stimulated while other plants (and their parameters) are inhibited. This is also suspected by Oyerinde *et al*. (2009) who wrote that "the allelopathic function of *T. diversifolia* is not only species-selective, but also has selectivity on the developmental stages of the test plant". Therefore, as an inference to this study, it is noteworthy to conclude that *T. diversifolia* is allelopathic, but not to cucurbits tested for in this study.

## 5 Conclusion

From the outcome of this study, and not to undermine the plethora of reports that have implicated *T. diversifolia* as an allelopathic plant, it can be categorically inferred that *T. diversifolia* is not allelopathic to Cucurbits. This goes to show that the plant itself is selectively allelopathic, hence having stimulatory, inhibitory or neutral (indifferent) effect, depending on the species. The cucurbits *Cucumis sativus*, *Citrullus colocynthis* and *Citrullus lanatus* are economically viable plants that are widely consumed in Western Africa as snacks, salads or soups. But, certain agricultural malpractices of farmers have led to the intercropping of these important plants with other less important plants. One of such plants used as either an intercrop, pesticide (insect repellent) or compost manure is the severally reported plant *diversifolia*, which has been documented since three decades ago as a notorious allelopathic plant. Following the result of this study, and also owing to its widespread utility as a pesticide and compost manure, it is safe to suggest that *T. diversifolia* can be safely used as such (pesticide and compost manure/mulch or intercrop) in the cultivation of Cucurbits.

## Compliance with ethical standards

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No conflict of interest exists amongst the Authors.

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