Phytotoxic Effects of Aqueous Extracts of *Olax subscorpioidea* Oliv. on Seed Germination and Growth Parameters of Maize (*Zea mays* L.)

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Authors' contributions

This work was carried out in collaboration between both authors. Author OSO designed the study, designed the study, supervised the data collection by author DOA, analysed the data, co-write up the initial manuscript with author DOA. The manuscript was reviewed the author DOA before first submission. Both authors read and approved the final manuscript.

ABSTRACT

Phytotoxicity of wild plants is sometimes utilized in the control of weeds. Their effects on crops are however not extensively documented. Effects of aqueous extracts of *Olax subscorpioidea* Oliv. were thus examined on seeds and seedlings of maize. Two experiments were laid out in complete randomized designs (CRD) and replicated five times. Ten seeds of maize were initially placed in separate petri-dishes and moistened daily with two (2) ml water extracts of different parts of *Olax* sp. while 2 ml of distilled water served as control. Secondly, maize seedlings growing on top soil in experimental pots were treated with 100 ml of extracts at seven days intervals for eight weeks. Data were collected on number of germinated seeds daily, and lengths of five randomly selected plumules and radicles at 7 days after sowing (DAS). Number of leaves, plant height, root dry weight and shoot dry weight of seedling were measured using standard methods. Analysis of variance and Duncan’s Multiple Range Test were conducted to statistically determine significant means at P=0.05. Mean germination of (0.71±0.00) was observed at 2 DAS and 2.81±0.10 at 7 DAS. Leaf extracts significantly reduced germinability, but significantly increase number of leaves, plant height (26±1.28), root dry weight (10.30±3.24) and shoot dry weight (14.99±2.13). The results
showed that *Olax subscorpioidea* has alloallelopathic (phytotoxic) effects on maize seeds, but stimulated growth of maize seedlings. Its use as a bio-herbicide or growth stimulant in should be well-timed.

Keywords: *Olax subscorpioidea*; allelopathy; bio-herbicide; *Zea mays*; phytotoxicity.

1. INTRODUCTION

Allelopathy was first defined by Molisch [1] as any biochemical interaction, whether positive or negative, among plants of all levels of complexity, including microorganisms. It can thus be expanded as an inhibition or stimulation of germination, growth and metabolism of a plant as a result of the release of organic chemicals by another plant [2], meaning that allelopathy has both positive and negative implications for agriculture and natural plant communities. Jabran [3] highlighted the importance of allelopathy in managing weeds and addressing problems of environmental pollution, herbicide resistance evolution in weeds and development of organic agriculture.

It is an example of ammensalism interaction in which one of the relating organisms is losing while the other is unaffected [4,5]. In agricultural practice, allelopathy is exploited for weed control [6]. Association and dissociation pattern between certain plant species are widely known. Such phenomenon may be governed by direct competition for necessary growth factors or through addition of allelopathic chemicals into the soil environment [7,8]. However, it is frequently observed that allelochemicals inhibit the growth of plants or microorganism at certain concentrations. A substance is considered an allelochemical if it is secreted by a plant species and adversely affect germination or growth of another plant species [9]. The phytotoxic activity of allelochemicals in soil can be affected by their soil bioavailability due to their sorption, desorption and degradation processes influenced by soil characteristics [10]. Many plants contain metabolites which have allelopathic effects on other plants like *Sorghum spp*, *Secale cereale*, *Olax subscorpioidea*, and *Leucaena leucocephala*. Allelochemicals that are toxic may inhibit germination, shoot/root growth, nutrient uptake, or may attack some other naturally occurring symbiotic relationship thereby impairing ability to access nutrients for use [11], as has been reported for leachates of some trees [12].

The idea of allelopathy as an ecological phenomenon structuring plant communities is rather recent [13]. Whittaker and Feeny [14] recognized the role of allelochemicals in plant community organization. Through series of field and complimentary laboratory studies, reports have shown that certain plants can influence their neighbouring plants directly by releasing allelochemicals and indirectly by affecting the activity of rhizosphere microbes (Muller [14,15]). Use of allelopathy in agriculture should be based on a proper understanding of behaviour of allelochemicals from different plant sources if the goal of safe sustainable weed management must be achieved. Unwanted autotoxicity outcomes have been recorded in wheat production where wheat straw exerted a toxic effect on following wheat crops, just as there can be alloallelopathy, concurrent and residual allelopathy as exemplified in negative effect of *Lantana camara* on agricultural lands and regeneration of forestry crops [16,17]. *Olax subscorpioidea* has been reported to have significant antimicrobial activity against bacteria and fungi of public health importance because qualitatively, its aqueous extract contains tannins, glycosides and saponins [18], but it has not been screened for allelopathic interaction with germination and subsequent growth of *Zea mays* L. This research was designed to investigate the alloallelopathic effect of *Olax subscorpioidea*, on *Zea mays*, an important cereal crop in the world.

The objective of this study is therefore to determine the phytotoxic effects of aqueous extracts of *Olax subscorpioidea* (plant which is being identified as possible candidate for bio-herbicide) on germination, growth and development of maize crop.

2. MATERIALS AND METHODS

*Olax subscorpioidae* Oliv. Plant (a tree) parts were collected from Oke-Awon village, in Oyo town, Oyo State, Nigeria. The town is located in Guinea savanna agroecological zone of Nigeria [19]. It shares a similar climate with Ogbomoso, also in Oyo State and receives a mean annual rainfall of 1217 mm and mean annual temperature of 26.1°C. The town is Oyo Zone of Agricultural Development Programme (OYSADEP) for the purpose of agricultural extension activities.
Laboratory preparation was conducted at Ecology Research Laboratory of the Department of Crop Protection and Environmental Biology (CPEB), University of Ibadan, (Latitude 7°27.047'; Longitude 3°53.832'; elevation 214 m altitude above sea level), Ibadan, Nigeria. The study was done in 2 trials. The seed germination test was conducted with 10 seeds of maize (ACR91 SUWAN Variety) in three replicates.

2.1 Extracts Preparation

The plant was partitioned into leaf, seed, bark, stem and root. They were further cut into small pieces with a steel knife and air-dried at ambient temperature (28±2°C, RH) for two weeks. The air-dried plant materials were macerated and soaked in distilled water for 72 hours (200 g plant part in 1000 mL of distilled water) to extract water soluble allelochemicals [20,21]. The mixture was sieved and stored at ambient temperature and the extract was applied as indicated in different bioassays as indicated below.

2.2 Allelopathy Bioassay

Seed germination test was conducted with 10 seeds of maize (ACR91 SUWAN Variety) evenly placed on Whatman No.1 filter paper petri dishes (9 cm) in five replicates. The study was done in two trials. The aqueous of the extracts of leaf, bark, fruit, stem and root earlier prepared were added to each set of maize seeds in petri dishes at 2 mL for each treatment using a designated pipette for each treatment. Distilled water was used a control. Germinated seed, defined as the emergence of plumule and radicle were counted from 1 day after the onset of the experiment and continued for seven days after sowing (DAS). At 7 DAS, the length of plumules and radicles were measured (using a metre rule). Five germinating seeds were randomly picked in each petri dish for the measurement.

2.3 Plant Growth Bioassay (Pot Culture)

The plant growth bioassay was conducted using extracts from the plant parts of Olax subscorpioidae at Roof-top garden of the Department of CPEB, University of Ibadan, Nigeria. Plastic pots of top-diameter 26.5 cm and base-diameter of 17.5 cm were filled with 8 kg of soil collected from the Crop Garden of the Department. Each pot was sown with 2 seeds at a depth of 1 cm. The seedlings were thinned to 1 plant per pot 3 weeks after sowing (WAS). Experimental units were and kept in the roof top garden of the Department of CPEB. The experiment followed completely randomized Design with three replications. The extract (100 ml) was added to treated pot while water was used as control once in a week. The pots were watered twice every week. Data on the crop plant height, number of leaves were taken at weekly interval from 3 to 8 WAS.

Growth parameters measured or counted were plant height, number of leaves, and dry weight of plant parts. The plant in each pot was lifted out with the ball of earth and carefully lowered into a bucket of water to loosen the soil so that the roots can be fully recovered. The harvested plants were partitioned into shoots and roots, packaged in separate cardboard envelop, labelled and oven-dried into constant weight at 80°C in a Gallenkamp oven.

2.4 Data Analysis

Analysis of variance was used to analyze the data collected using DSAATAT software (version 1.101). Means that were significant were separated using Duncan’s Multiple Range Test (DMRT) at 5% level of probability. Other descriptive statistics such as standard errors were used to describe the results.

3. RESULTS AND DISCUSSION

3.1 Seed Germination

The percent germinations of maize in all five treatments were retarded compared to control (Table 1). The results showed that germination of maize seeds were inhibited by aqueous extracts from all parts of Olax subscorpioidae. Seeds in Control Petri dishes germinated better than other treatments. Germination at 2 DAS was inhibited by aqueous extracts from all parts of Olax subscorpioidae. In both the control and other treatments in the two trials, steady increases in germination were observed over time. The differences observed between the mean germination percentages of the maize seeds treated with aqueous extracts of Olax subscorpioidae plant parts, though different from the control, were not significantly different from one another (p< 0.05) except leaf extracts that produced highest significant difference from control, and the aqueous extract from the fruit which had the least inhibitory effect on germination. At 7 DAS, the mean germination percentage of Leaf extracts and control were 2.81±0.10 and 3.24±0.00 respectively.
who reported that the study showed a significant difference in results obtained from this statistical analyses (P-value).

The inhibitory response to leaf extracts was summarized as a form of allelopathy by [22] resulting from water soluble metabolites from parts such as leaves, roots, fruits, and seeds in the form of delay or complete inhibition of seed germination. The study was supported by the report of Oyun [23] who reported that aqueous extracts from Gliricidia sepium caused a prolong delay of maize seeds germination, while Aisha et al. [24] and Monica et al. [25] reported similar observation.

### 3.2 Plumule and Radicle Length

The effects of the aqueous extract of the Olax subscorpioidea plant parts on the radicle and plumule lengths of the maize were shown in Tables 2. The results showed that the plant extracts retarded the radicle and plumule lengths of the maize. Maize seeds treated with aqueous extract of bark mostly retarded radicle length (2.01±0.28) while maize seeds treated with aqueous extract of leaf mostly retarded plumule length (1.26±0.18) (Table 2).

Statistical analyses (P< 0.05) revealed that significant difference in results obtained from this study were in agreement with Seerjana et al. [26] who reported that the Parthenium hysterophorus L. leaf aqueous extracts had significant inhibitory effects on seed germination and seedling growth of all test species in cruciferous species. Abu-Romman [27] also reported that phyto-toxins released into the surrounding might inhibit or retard root or radicle and shoot or coleoptile of plants, and which is similar to effects of leachates some trees species [12].

### 3.3 Growth Parameters

Number of leaves, plant height, shoot dry and root dry weight in the control and other treatments were observed to increase steadily with time (Tables 3, 4 and 5). In the control plant, number of leaves, plant height, shoot dry and root dry weight ranged from 7.00 to 21.00 cm, 11.53 g to 3.27 g and other treatment were observed to have values ranging from 7.33-9.67, 22.43 cm-27.67 cm, 10.41 g-14.99 g and 6.39-10.30 g respectively. A gradual increase with in time was observed in No. of leaves throughout the experiment, but there was decrease in rate of growth of plant height after the 7th week in control, stem leaf treatments. Ilori et al. [28] reported a stimulatory effect in Tithonia diversifolia on the germination and growth of Oryza sativa.

### Table 1. Mean Germination percentage of maize seeds treated with different parts of Olax subscorpioidea aqueous extracts at 2, 4 and 7 Days after Sowing (DAS)

| Treatment | Trial 1 | Trial 2 |
|-----------|---------|---------|
| Control   | 1.58±0.25 | 2.06±0.38 |
| Root      | 0.81±0.12 | 1.99±0.34 |
| Stem      | 0.71±0.00 | 2.29±0.46 |
| Leaf      | 0.91±0.14 | 2.66±0.11 |
| Fruit     | 0.99±0.20 | 2.06±0.38 |

### Table 2. Effects of Aqueous extract of different parts of Olax subscorpioidea on Radicle and Plumule length (cm) of maize at 7 Days After Sowing (DAS)

| Treatment | Radicle length | Plumule length |
|-----------|----------------|----------------|
| Control   | 5.89±0.90      | 5.89±0.90      |
| Root      | 2.66±0.80      | 2.29±0.46      |
| Stem      | 2.33±0.43      | 3.19±0.44      |
| Leaf      | 2.42±0.23      | 2.36±0.20      |
| Bark      | 1.69±0.17      | 2.01±0.28      |
| Fruit     | 5.89±0.90      | 2.35±0.61      |

Mean Percentage values with the same letters on the same column are not significantly different using Duncan’s Multiple Range Test (DMRT) at P=0.05; Control=Distilled water only.
Table 3. Effect of aqueous extract of different parts of *Olax subscorpioidea* on number of leaves of maize at different growth periods

| Treatments | 3 WAS | 4 WAS | 5 WAS | 6 WAS | 7 WAS | 8 WAS |
|------------|-------|-------|-------|-------|-------|-------|
| Control    | 4.67a±1.08 | 5.00±1.88 | 5.67a±1.08 | 5.33a±0.41 | 5.33a±0.41 | 7.00±0.71 |
| Root       | 5.00±0.71 | 7.67±0.41 | 7.33a±0.41 | 5.67±0.41 | 5.00±0.00 | 8.00±0.71 |
| Stem       | 4.67a±1.48 | 7.33±1.48 | 7.33a±0.41 | 5.67±0.41 | 5.33a±0.82 | 7.67±1.78 |
| Leaf       | 6.33a±0.82 | 7.33±1.08 | 7.33a±0.41 | 6.33±0.41 | 6.00±0.00 | 7.33±0.82 |
| Bark       | 5.67±1.08 | 8.33±0.41 | 7.33a±0.41 | 6.00±0.71 | 5.33a±0.41 | 9.67±1.08 |
| Fruit      | 5.67a±0.82 | 8.00±0.00 | 7.67±0.41 | 5.33a±0.41 | 5.66±0.41 | 8.67±0.41 |

Mean values with the same letters on the same column are not significantly different using Duncan’s Multiple Range Test (DMRT) at P=0.05; (WAS=Weeks After Sowing) Control=Distilled water only

Table 4. Effect of aqueous extract of different parts of *Olax subscorpioidea* on Plant Height (cm) of maize at different growth stages

| Treatments | 3 WAS | 4 WAS | 5 WAS | 6 WAS | 7 WAS | 8 WAS |
|------------|-------|-------|-------|-------|-------|-------|
| Control    | 5.50±1.07 | 13.50±1.14 | 17.90±0.81 | 19.00±1.42 | 22.77±0.88 | 21.00±0.94 |
| Root       | 8.33±2.91 | 13.63±3.60 | 18.93±3.14 | 21.63±3.94 | 23.37±3.08 | 23.83±3.91 |
| Stem       | 8.13±1.38 | 11.60±4.55 | 15.67±4.38 | 18.33±3.57 | 23.60±1.09 | 22.43±6.12 |
| Leaf       | 9.03±1.62 | 16.10±1.46 | 20.13±0.82 | 21.67±1.78 | 24.27±1.01 | 22.67±2.66 |
| Bark       | 7.20±1.04 | 14.43±2.11 | 18.80±0.93 | 21.33±0.54 | 24.97±1.84 | 26.00±1.28 |
| Fruit      | 6.83±1.38 | 11.97±1.25 | 19.80±2.41 | 22.33±1.79 | 24.17±1.14 | 27.67±2.17 |

Mean values with the same letters on the same column are not significantly different using Duncan’s Multiple Range Test (DMRT) at P=0.05; (WAS=Weeks After Sowing) Control=Distilled water only

Table 5. Effect of aqueous extract of different parts of *Olax subscorpioidea* on shoot dry weight (g/plant) and root dry weight (g/plant) of maize at 8 weeks after sowing (WAS)

| Treatments | Root dry weight | Shoot dry weight |
|------------|----------------|------------------|
| Control    | 3.27±0.23 | 11.53±0.93 |
| Root       | 8.36±2.32 | 10.41±3.61 |
| Stem       | 9.53±3.05 | 10.49±4.52 |
| Leaf       | 6.80±0.52 | 12.50±1.77 |
| Bark       | 6.39±0.82 | 11.41±0.70 |
| Fruit      | 10.30±3.24 | 14.99±2.13 |

Mean values with the same letters on the same column are not significantly different using Duncan’s Multiple Range Test (DMRT) at P=0.05; (WAS=Weeks After Sowing) Control = Distilled water only

4. CONCLUSION

Aqueous extracts of *Olax subscorpioidea* inhibited seed germination of *Zea mays*. The inhibitory effect was more pronounced with leaf extracts than extracts from other plant parts. Extract from the stem had the least effect on germination. The growths of radicle and plumule of maize were retarded by the plant extracts, with the fruit extract having the least negative effect. However, growths of seedlings of maize from three weeks after sowing were stimulated by extracts from all parts of *Olax subscorpioidea*. The highest stimulatory effect was obtained with aqueous root and stem extracts. On the overall, the root dry weight of maize was significantly increased by all extracts of the plant, while the shoot dry weight was biologically increased but with no significant differences between control and the treatments. This study has shown that the aqueous extracts of *Olax subscorpioidea* inhibits seed germination of *Zea mays* and is phytotoxic to radicle and plumule growth. It has also shown that the aqueous extract of the plant is not phytotoxic, but rather stimulates the growth of seedlings of maize from three weeks after sowing. Therefore, caution should be exercised in its use in maize cropping system either as a green manure, suppressant or a growth stimulant, a form of bio-fertilizer.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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