



Allelopathic Effect of *Bidens pilosa* L. on the Germination of Seeds of selected crops, Ibadan, Nigeria

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ABSTRACT

Bidens pilosa Linn belongs to the family Asteraceae. It is considered a weed in some tropical habitats; however, its allelopathy potential has not been fully established. Therefore, this study aimed at investigating the allelopathic effects of *B. pilosa* on germination of soybean, maize, tomatoes and seedling growth of soybean. Allelopathic effects of *B. pilosa* leachate on soybean, maize, tomatoes germination and soybean seedling growth were assessed in the screen house. Germination percentage (%) for test crops was determined at 10 Days After Sowing (DAS); while Number of Leaves (NL), Plant Height (PH) (cm), Root Length (RL) (cm) and Dry Weight (DW) (g) were evaluated at 9 Weeks After Sowing (WAS). Experimental design used in the study was Completely Randomized Design. Data were analyzed using ANOVA. Means were separated and compared using Least Significant Difference (LSD) at 5% probability. The least germination (27.0 ± 0.3) was recorded for L1-Soybean, while L1-Maize gave the highest germination (60.0 ± 1.0) and L1-Tomatoes gave (37.0 ± 0.3). The L1 soybean seedling had the lowest NL, PH and DW values; while control had highest RL in soybean. *Biden pilosa* inhibited germination in all test crops. The leachate of *Biden pilosa* could be a potential bio-herbicide.

Keywords: Allelopathy, Germination, *Biden pilosa*, Leachate, Soybean, Maize, Tomato

Introduction

The main objective of numerous researchers involved with the function of allelopathy in agriculture and forestry has primarily been on the influence of leachates from plants, plant extracts and plant residue decomposition. Allelopathy is a biological process in which an organism produces and excretes exudates containing one or more

biochemical compounds that influence the growth or failure of other species' germination phylogeny. These biochemical substances can have either a beneficial (positive allelopathy) or a detrimental (negative allelopathy) effect on the target organism and its population (Kohli *et al.* 2008; Scognamiglio *et al.*, 2013)).

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Page | 4334

These positive or negative effects are caused by the release of active bio-molecules commonly referred to as allelochemicals (Soltys *et al.*, 2013). Allelopathic potential in plants may influence many aspects of plant ecology, as well as plant succession, species abundance, vegetation structure, dominance, diversity, growth and plant productivity; allelopathy could also play a major role in intra-specific and inter-specific competition and might even define the quality of inter-specific interaction between other plant communities. Allelopathy is a technique that is natural and environmentally friendly, and has the prospects to be a novel concept to weed management in organic farming. *Biden pilosa* L. var. *radiata* is well-known for being an allelopathic weed (Hsueh *et al.*, 2020). Numerous studies have shown that there are significant suppressive effects on *Bidens pilosa* (Deba *et al.*, 2007; Hsu and Kao, 2009; Zhang *et al.*, 2016). *Bidens pilosa* is an important weed in the tropics, subtropics, and warm temperate zones of the globe. This species has a high reproductive capability and rapid growth rates, which allow it to disperse and repopulate new areas quickly. A single plant can produce up to 6000 seeds per year, and the seeds are easily dispersed by wind and water or attached to animals, birds, or human clothing (Krumsri *et al.*, 2015). A wide range of ecological concerns can be caused by invasive plant species. *Bidens pilosa* produces allelopathic compounds that influence the process of germination, plant growth and plant leaf chlorophyll synthesis (Khanh *et al.*, 2009). The allelopathic effects are also successful in improving its inter-specific competitive and invasive capability.

Phyto-chemicals escape from plants in diverse manners; the mechanisms by which allelochemicals are emitted from plant material may be classified into four main categories: 1) In this manner, dead or living parts of a plant may release the inhibitory contents; 2) volatilization-by which components of terpenes are released from

the leaves of certain plant species; (3) the extraction of allochemicals in this process is released from plant residues; and (4) the exudation in this way of high concentrations of organic compounds released from the roots of both plant and non-plant organisms serves as an inhibitor of the growth of other plants (Scavo *et al.*, 2019). Previous studies such as Xuan and Khanh, (2016) have concentrated on the nutritional profile and health benefits of *Biden pilosa* and there is little knowledge on its property as an allelopathy. The purpose of this research, therefore, was to investigate "allelopathic effects of *B. pilosa* on soybeans, maize and tomatoes in southwestern Nigeria.

Materials and Methods

Location of study

A pot experiments was carried out at the screen house of the Department of Crop Protection and Environmental Biology University of Ibadan, Ibadan (Latitude 7°27.047¹; Longitude 3°53.832¹; elevation 214 m above soil level) South Western Nigeria. Ibadan is in the lowland rainforest savanna transition ecological zone in the Southwestern Nigeria, with a mosaic vegetation of fire tender trees and secondary grassland (Awodoyin *et al.*, 2007).

Source of planting materials

Bidens pilosa seeds were collected from the Ecology sub-unit, Department of Crop Protection and Environmental Biology University of Ibadan, Ibadan. Soybean seeds were collected from the Institute of Agriculture Research and Training, Apata, Ibadan. The variety of *Glycine max* planted was 14481E. Maize seeds (DTMA-STR) were collected from IITA, while NHL158-3 local indeterminate *Solanum lycopersicum* tomatoes seeds were obtained from National Institute for Horticultural Research and Training (NIHORT).

Soil classification

Soil sample for the pot experiment was collected by hand auger to determine physicochemical parameters analysis. The chemical soils analysis was done according to the laboratory standard (IITA, 1982). This was done to determine the cations present in the soil (Table 1).

Table 1: Physico-chemical Properties of Experimental Soil

| Parameters | Values |
|------------------------------------|-------------|
| pH | 6.5 |
| Organic carbon (%) | 2.59 |
| Total Nitrogen (%) | 0.10 |
| Calcium (me/100g) | 8.08 |
| Magnesium (me/100g) | 0.70 |
| Sodium (me/100g) | 0.31 |
| Potassium (me/100g) | 0.09 |
| Phosphorus (ppm) | 33.30 |
| Exchange acidity (me/100g) | 0.04 |
| Cation Exchange Capacity (me/100g) | 9.22 |
| Sand (%) | 76.4 |
| Silt (%) | 20.6 |
| Clay (%) | 3.0 |
| Textural Class | Sandy loamy |

Experiment 1

The two treatments were leachate collected each morning from *B. pilosa* seedling and water as control. Each treatment was replicated three times. Ten seeds each of soybean, maize and tomato were sown in plates filled with 500 g top soil. 200 ml leachate (express water draining out from the bottom of the pots growing with *B. pilosa*) the three pots receiving the treatment and 200 ml water was administered to the control pots. The pots received the treatments daily. Records of germination were taken for each seed type for ten

days after planting (10 DAS) by counting the number of plants that emerged per pot. A plant was taken to have emerged when the cotyledons or the plumule have been raised above the soil surface.

Experiment 2

Seeds of soybean were planted with three replicates and were repeated twice. Three pots were watered with leachate collected from pots that had *B. pilosa* seedlings (L1) and three pots with leachate collected from pots that had no *B. pilosa* seedlings (L0) serving as control. The treatments were replicated three times. The pots were watered daily with L0 and L1 leachate. Growth parameters taken were plant height (cm) and number of leaves per plant at weekly intervals from two to eight after sowing, while root length (cm) and dry weight (g) were measured at 9 WAS.

Results

Physicochemical properties of the soil used for the experiment

The result of the chemical analysis of the experimental soil (Table 1) showed that the soil was slightly acidic (pH 6.5) with low organic matter content (2.59%) and low total nitrogen (0.10%). Using the United State Department of Agriculture (U.S.D.A) textural triangle, the soil was sandy loam.

Effect of *Bidens pilosa* leachate on germination of seeds of soybean, maize and tomato at 1-10 DAS

The observation showed that as the number of days after sowing progressed, the number of germinated seeds increased. Treatments that did not receive leachate (Lo) had the highest percentage of germination at ten days after planting. In the first and second trials respectively, soybean had 63% and 70% germinated seeds, maize had 93% and 97% and tomato had 43% and 37% seeds germination (Table 2). Also, the

differences between treatments were significant in both trials (Table 2).

Effect of *Bidens pilosa* leachate on the plant height of soybean seedlings

There was significance effect of the leachate on the height of maize at 5 and 6 WAS in the first trial (Table 3). In the second trial, there was no significance in the height. The tallest height 16.5 cm for the second trial recorded under the control was superior to the shortest height 11.7 cm recorded under the control.

Effect of *Bidens ss pilosa* leachate on the number of leaves of soybeans seedlings

The effect of the leachate of *B. pilosa* on leaf number of soybean is presented in Table 4. In the first trial, number of leaves in soybean control (L0) was significantly more than the other treatment at 3 and 7 weeks after sowing (Table 4). It was observed that as the days after sowing progressed, the number of leaves increased (Table 4).

Effect of *Bidens pilosa* leachate on the root length of soybean seedlings at 9 WAS

The results obtained showed that the root length of soybean control (L0) was significantly longer than the L1 treatment in both trials (Table 5). This revealed that the leachate of *B. pilosa* on soybean crop significantly reduced the growth length of the root, therefore, as the days after sowing of soybean increased, the root length growth get reduced. The L0 soybeans had roots whose lengths are almost twice that of L1 soybean (Table 5).

Effect of *Bidens pilosa* leachate on the dry weight of shoot and root (g) of soybean seedlings

The shoot dry weights of soybean control (L0) in both trials were significantly greater than the L1 (Table 6). Root dry weight of soybean control (L0) in trial 1 revealed that there was significant difference between soybean control (L0) and the other treatment.

Table 2: Effect of *Bidens pilosa* leachate on germination of seeds of soybean, maize and tomato at 1-10 WAS

| Treatment | Germination of Seeds (%) | |
|----------------|--------------------------|----------|
| | Trial 1 | Trial 2 |
| L0 (Soybean) | 63 ± 0.3 | 70 ± 0.0 |
| L1 (Soybean) | 33 ± 0.7 | 27 ± 0.3 |
| L0 (Maize) | 93 ± 0.3 | 97 ± 1.7 |
| L1 (Maize) | 50 ± 0.6 | 60 ± 1.0 |
| L0 (Tomato) | 80 ± 0.0 | 83 ± 0.3 |
| L1 (Tomato) | 43 ± 0.3 | 37 ± 0.3 |
| LSD (P = 0.05) | 1.1 | 0.8 |
| CV (%) | 10.4 | 9.7 |

L0 – Leachate from pots without *Bidens pilosa* seedlings

L1 - Leachate from pots with *Bidens pilosa* seedlings; Values are Mean ± SE, n = 3

Table 3: Effect of *Bidens pilosa* leachate on the plant height of soybeans at 2, 3, 4, 5, 6, 7, 8 WAS

| Trial 1 | Treatment | 2 WAS | 3 WAS | 4 WAS | 5 WAS | 6 WAS | 7 WAS | 8 WAS |
|---------|--------------|------------|------------|------------|------------|-------------|-------------|-------------|
| | L0 | 15.8 ± 0.4 | 29.1 ± 0.4 | 57.8 ± 2.8 | 79.8 ± 6.0 | 96.8 ± 4.0 | 98.7 ± 4.7 | 105.3 ± 7.8 |
| | L1 | 14.1 ± 1.7 | 21.5 ± 3.2 | 32.2 ± 2.8 | 44.3 ± 2.8 | 55 ± 2.3 | 84.7 ± 3.7 | 81.3 ± 4.4 |
| | LSD (P=0.05) | NS | NS | NS | 18.3 | 12.8 | NS | NS |
| | CV (%) | 20.3 | 17.5 | 14.9 | 13.0 | 7.4 | 8.0 | 11.7 |
| Trial 2 | Treatment | 2 WAS | 3 WAS | 4 WAS | 5 WAS | 6 WAS | 7 WAS | 8 WAS |
| | L0 | 16.5 ± 0.6 | 30.8 ± 0.3 | 58.2 ± 10 | 76.2 ± 4.7 | 102.4 ± 3.1 | 111.9 ± 4.3 | 119 ± 8.9 |
| | L1 | 11.7 ± 0.2 | 20.6 ± 0.9 | 31.8 ± 1.7 | 43.8 ± 3.0 | 56.4 ± 3.0 | 67.5 ± 2.6 | 88.7 ± 4.1 |
| | LSD (P=0.05) | 1.8 | 2.8 | 5.5 | 15.5 | 51.2 | 13.8 | 27.1 |
| | CV (%) | 5.8 | 4.7 | 5.4 | 11.5 | 6.6 | 6.8 | 11.5 |

L0 – Leachate from pots without *Bidens pilosa* seedlings. **L1** - Leachate from pots with *Bidens pilosa* seedlings
Values are Mean ± SE, n = 3

Table 4: Effect of *Bidens pilosa* leachate on the number of leaves of soybean at 2, 3, 4, 5, 6, 7, 8 WAS

| Trial 1 | Treatment | 2 WAP | 3 WAP | 4 WAP | 5 WAP | 6 WAP | 7 WAP | 8 WAP |
|---------|--------------|-----------|------------|------------|----------|------------|------------|------------|
| | L0 | 7 ± 1.7 | 12 ± 0.6 | 17 ± 1.7 | 21 ± 1.0 | 28 ± 1.7 | 39.3 ± 2.3 | 66.7 ± 5.9 |
| | L1 | 6.7 ± 1.8 | 10.7 ± 0.3 | 16.7 ± 0.3 | 19 ± 0.6 | 21 ± 0.6 | 29.7 ± 0.6 | 43.3 ± 6.6 |
| | LSD (P=0.05) | NS | 1.9 | NS | NS | NS | 6.9 | NS |
| | CV (%) | 37.8 | 7.3 | 12.9 | 41.2 | 28.8 | 8.8 | 19.8 |
| Trial 2 | Treatment | 2 WAP | 3 WAP | 4 WAP | 5 WAP | 6 WAP | 7 WAP | 8 WAP |
| | L0 | 8 ± 1.2 | 14.7 ± 0.7 | 17.3 ± 0.7 | 24 ± 2.0 | 32 ± 1.2 | 44 ± 1.2 | 62.7 ± 1.8 |
| | L1 | 6 ± 1.2 | 8 ± 1.2 | 10 ± 1.2 | 16 ± 1.2 | 22.7 ± 1.8 | 31 ± 1.5 | 39 ± 1.5 |
| | LSD (P=0.05) | NS | 3.7 | 3.7 | 6.4 | 5.9 | 9.6 | 6.5 |
| | CV (%) | 28.6 | 14.4 | 12.0 | 14.1 | 9.5 | 6.0 | 5.6 |

L0 – Leachate from pots without *Bidens pilosa* seedlings **L1** – Leachate from pots with *Bidens pilosa* seedlings
Values are Mean ± SE, n = 3

Table 5: Effect of *Bidens pilosa* leachate on the root length (cm/plant) of soybean seedlings at 9 WAS

| Treatment | TRIAL 1 | | TRIAL 2 | |
|--------------|------------------------|--|------------------------|--|
| | Root length (cm/plant) | | Root length (cm/plant) | |
| L0 | 18.2 ± 3.5 | | 22.5 ± 0.1 | |
| L1 | 9.6 ± 0.5 | | 13.0 ± 0.8 | |
| LSD (P=0.05) | NS | | 8.9 | |
| CV (%) | 7.7 | | 22.0 | |

L0 – Leachate from pots without *Bidens pilosa* seedlings **L1** – Leachate from pots with *Bidens pilosa* seedlings;
Values are Mean ± SE, n = 3

Table 6: Effect of *Bidens pilosa* leachate on the dry weight of shoot and root (g/plant) of soybean seedlings

| Treatment | TRIAL 1 | | TRIAL 2 | |
|--------------|-----------|-----------|-----------|-----------|
| | Shoot | Root | Shoot | Root |
| L0 | 3.8 ± 0.8 | 0.3 ± 0.1 | 5.1 ± 0.7 | 0.9 ± 0.2 |
| L1 | 1.7 ± 0.1 | 0.2 ± 0.1 | 2.2 ± 0.1 | 0.3 ± 0.1 |
| LSD (P=0.05) | 2.1 | 0.3 | 1.9 | Ns |
| CV (%) | 32.9 | 52.2 | 22.4 | 45.4 |

L0 – Leachate from pots without *Bidens pilosa* seedlings **L1** – Leachate from pots with *Bidens pilosa* seedlings;
values are Mean ± SE, n = 3

Discussion

The result obtained from this study revealed that application of *Bidens pilosa* leachate to the seeds of soybeans, maize and tomato strongly inhibited germination efficiency at ten days after planting compared to the control. The composition of the extract may therefore contain inhibitors that suppressed the germination of the seeds and the growth of such plants. In addition, moisture absorption inhibition can benefit in an indirect correlation between decreased seed germination and allelopathic inhibition (Shapla *et al.*, 2011). This is in agreement with the report of Otunsanya *et al.* (2014) who confirmed that plant allelopathy has the ability to reduce or cause depression in the germination of seeds and growth of such plants. Usually, germination is sensitive to the allelopathic chemical than seedling growth, particularly root growth (Chandra *et al.*, 2012). Essentially, the activity of the chemical compounds present in *Bidens pilosa* leachate must have been responsible for the reduction in seed germination (Deba *et al.*, 2008). Several bioassay studies have also shown that various plants parts release phytotoxic compounds into soil that adversely affect the germination and growth of food crops (Nagabhushana *et al.*, 2001; Ferguson *et al.*, 2003).

As observed, the leachates of *Bidens pilosa* significantly inhibited seedling growth of soybean. This agrees with the findings of Bhatt *et al.* (2001) that observed a significant inhibition in germination, plumule, and radicle length of *Glycine max* treated with aqueous extracts of dried fresh leaves of *Bidens pilosa*. The toxicity increased as the concentration of extracts increased. The aqueous extracts of *Bidens pilosa* inhibited radicle length of *Glycine max* more than plumule length.

Bidens pilosa has been shown to possess inhibition of target plants through allelopathy,

competition, or both. In addition, germination, growth and development may be impaired when susceptible plants are exposed to allelochemicals. Germination and growth of leguminous species such as soybean has been observed to be more sensitive to inhibition by allelochemicals Bhatt *et al.* (2001). The most frequently reported distinct morphological effects on plants are suppressed or delayed seed germination, effects on coleoptile elongation, and effects on radicle, shoot, and root development.

In this present study the root length of soybean treated with allelopathic leachates was inhibited significantly. This shows the species' organ-based immunity to phytotoxic substances. This feature of greater root than shoot inhibition was also reported by previous studies (Tawaha and Turk, 2003; Mushtaq *et al.*, 2010). There are potential explanations why roots are the first to grow and are in close contact with extracts and are therefore exposed to peak times and phytotoxin concentrations. Khanh *et al.* (2005) suggested that when maximum phytotoxin levels correlate with the early phases of plant development, the highest level of allelopathic suppression may occur.

Conclusions

Bidens pilosa leachate had an inhibitory influence on all the parameters measured. The Maize > Tomatoes > Soybean pattern was accompanied by a pronounced reduction in the seed vigour index. The leachate of *B. pilosa* has had the most allelopathic effect on soybean germination percentage. The leachate of *B. pilosa* affected the phenology (plant height, number of leaves and root length) of soybean seedling.

Competing interests

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