Allelopathic Effects of Aqueous Extracts of *Mucuna Pruriens* (L.) DC (Velvet Bean) on Seed Germination and Plant Growth of *Amaranthus Cruentus L.* in Ibadan, Nigeria

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Abstract

Allelopathy is useful in facets of plant ecology such as occurrence, dominance, diversity and plant productivity. *Mucuna pruriens* is characterised as one of the strongest allelopathic plants Therefore, the effects of aqueous extracts of *M. puriens* extract on seed germination and plant growth of *Amaranthus cruentus* L. were investigated in Ibadan, Nigeria. Aqueous Shoot Extract-ASE and Aqueous Root Extract-ARE of 8-week-old *Mucuna pruriens* at 0, 25, 50, 75 and 100% concentrations were applied to *Amaranthus cruentus* seeds (n=50) in Petri dishes and Germination Percentage (GP) was determined at day seven. Also, the treatments were applied to *Amaranthus cruentus* plants in pots, and Plant Height (PH; cm) and Leaf Area (LA; cm^2) were determined at six Weeks After Sowing. All experiments were arranged in completely randomized design (r=3). Data were analysed using ANOVA at $\alpha_{0.05}$. The GP of *Amaranthus cruentus* seeds ranged from 13.3±1.67% (100ASE) to 31.7±1.67% (25ASE), and from 13.3±3.33% (100ARE) to 28.3±1.67% (50ARE), which were significantly lower than control (68.3±1.67%). The *A. cruentus* plants treated with 100ASE and 100ARE had PH of 30.93±1.32 cm and 30.46±0.70 cm respectively, and LA of 48.07±0.67 cm^2 and 50.48±3.08 cm^2 respectively, which were significantly higher than control (PH2-2.20±2.05 cm and LA-38.54±1.62 cm^2). Aqueous extracts of *Mucuna pruriens* inhibited seed germination but stimulated the growth of *Amaranthus cruentus* plants.

Keywords: Weed management, Inhibition, Stimulation, Legume, Velvet bean, Extracts

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INTRODUCTION

Allelopathy refers to any chemical facilitated interaction among plants and microbes. This interaction can be inhibitory or stimulatory. According to Cheng and Cheng (2015), allelopathy is a branch under chemical ecology that studies how plants produce biochemical substances that affect the life of other plants (Cheng and Cheng, 2015).

These biochemical compounds are called allelochemicals (Abbas et al., 2017) and are released from plant parts through leachation, decomposition of crop residues, volatilization, root exudates, and from pollen of some crop plants (Khanh et al., 2005). Examples of plants with allelopathic potentials are *Alternanthera brasiliana* (Owoseni and Awodoyin, 2013), *Bidens pilosa* (Awodoyin and Akande, 2014) and *Mucuna pruriens* (Ochekwu and Udensi, 2015).

Velvet bean (*Mucuna pruriens* (L.) DC.) is a twining annual plant that belongs to the Fabaceae family. The legume is distributed in tropical and sub-tropical regions of the world (Lucia et al., 2011). Ortiz-Ceballos et al. (2012) characterized *Mucuna pruriens* as one the strongest allelopathic plants. Levodopa or L-DOPA (L-3,4-dihydroxyphenylalanine), an amino acid derived from leaves and roots, has been linked to its allelopathic activity (Adler and Chase, 2007). The L-DOPA has been demonstrated to selectively decrease seed germination in a number of experiments (Adler and Chase, 2007).

Amaranthus cruentus L. is a leafy vegetable that can thrive throughout the year, with irrigation (Shu'aib et al., 2017). It is cultivated mostly in peri-urban centres across Nigeria (Ojo et al., 2011). The vegetable is consumed in various parts of Nigeria and poor Nigerian households utilize it to complement their nutritional needs and economic well-being (Awe and Osunlola, 2013).

Allelopathy has been found to be important in crop production. It is useful in various researches aimed at weed management, soil quality enhancement and formulations of organic pesticides from allelochemicals (Xuan et al., 2004). It is important to establish the possible allelopathic potential of a plant to be used as green manure and living mulch in a cropping system or in the establishment of agroforestry. Therefore, the allelopathic effect of aqueous extracts of *Mucuna pruriens* on seed germination and plant growth of *Amaranthus cruentus* were investigated in Ibadan, Nigeria.

MATERIALS AND METHODS

Experimental site and materials

The bioassay was conducted at the Ecology Research Laboratory of the Department of Crop Protection and Environmental Biology, Faculty of Agriculture, University of Ibadan, Ibadan, Nigeria. The Laboratory stands on latitude 7^o27`1.17576``N and longitude $3^o$53`49.16436``E and an elevation of 692 m above sea level.

The pot experiment was conducted at the Crop Garden of the Department of Crop Protection and Environmental Biology, University of Ibadan, Ibadan, Nigeria. The Crop Garden lies on latitude 7^o27`3.18636``N and longitude $3^o$53`48.95088``E and an elevation of 692 m above sea level. Seeds of *Mucuna pruriens* were obtained from the International Institute of Tropical Agriculture, Ibadan. The duration of the study was six months (June 2020 to November 2020).

Allelopathic effects of aqueous extracts of *Mucuna puriens* on the germination of *Amaranthus cruentus seeds*

The experiment was carried out in two trials. The experiment that had nine treatments in three replicates followed a completely randomized design (CRD). The nine treatments were:

1. Control (0%)
2. 25% aqueous shoot extract (25-ASE)
3. 50% aqueous shoot extract(50-ASE)
4. 75% aqueous shoot extract(75-ASE)
5. 100% aqueous shoot extract (100-ASE)
6. 25% aqueous root extract (25-ARE)
7. 50% aqueous root extract (50-ARE)
8. 75% aqueous root extract (75-ARE)
9. 100% aqueous root extract (100-ARE)

Fresh biomass of matured *M. pruriens* was separated into shoot and root and each component was cut into tiny pieces. One hundred (100) g of each plant part was crushed to form slurry using household electric grinder (Ochekwu and Udensi, 2015). The crushed part was filtered with muslin cloth after soaking in one litre of distilled water for 24 hours. The filtrate obtained was the stocked solution at 100% concentration. The extracts were ratio diluted with distilled water to obtain 75%, 50% and 25%. The extracts were stored in a regulated cooled incubator at 4°C to prevent degradation of the allelochemicals that may be present. A total of 50 seeds of *A. cruentus* were evenly placed on each Petri dish (9cm) lined with Whatman No.1 filter paper. The Petri-dishes were randomly arranged on the laboratory bench at room temperature (26-28°C). Two (2) ml of each treatment was applied to the appropriate Petri-dish using syringe. The setup was observed for seven consecutive days for the emergence of radicle which indicated germination.

The percentage of germinated seeds was determined as:

$$\text{Germination (\%)} = \frac{\text{Number of seeds that germinated}}{\text{Total number of seeds in Petri-dish}} \times 100 \quad (1)$$

Effects of aqueous extracts of *Mucuna pruriens* L. (DC) on *Amaranthus cruentus* seedling growth

The above nine treatments replicated three times were used in a completely randomized design (CRD) for the experiment.

A total of 27 experimental pots (each has 20 cm top diameter and 22 cm depth) were each filled with 5 kg (dry weight) of soil. Seeds of *A. cruentus* were sown in each pot and watered daily. Emerged seedlings were thinned to five seedlings per pot at 2 weeks after sowing (WAS). Treatments dose application of 200 ml of each extract of shoot and root of *M. pruriens* was added to each appropriate pot once in five days. The control pots received water application only.

Data were collected on the following growth parameters at 6 WAS;

1. Plant height (cm) using a meter rule
2. Leaf area (cm^2): Leaf area of sampled plants was determined by measuring the individual leaf length and width and multiply by 0.64 (Kolawole and Sarah, 2009).

Data analysis

Statistical analysis was carried out using DSAAT software. The data obtained were analysed using Analysis of Variance (ANOVA) at 5% level of significance. Means were separated using Tukey HSD test at 5% level of significance.

RESULTS AND DISCUSSION

Effects of aqueous extracts of *Mucuna pruriens* on *Amaranthus cruentus* L. seed germination

In the first trial, the highest percentage germination was observed in control and the lowest in 100-ARE treatment. The percentage germination in all treatments were significantly lower (P≤0.05) than control (Table 1.). Similarly, results obtained in the second trial showed that the control had the highest percentage germination while 100-ASE and 100-ARE treatments had the lowest percentage germination. All the treatments significantly (P≤0.05) reduced the germination of seeds as compared to the control (Table 1).

Table 1. Effect of aqueous *Mucuna pruriens* extract (shoot and root) on germination percentage of *Amaranthus cruentus* seeds at seven days after sowing

Treatment	Trial 1 (%)	Trial 2(%)
Control (0%)	68.33±1.67c	78.33±1.67e
25-ASE	31.66±1.67b	46.66±1.67d
50-ASE	30.00±0.00b	40.00±0.00cd
75-ASE	21.66±1.67ab	25.00±2.89ab
100-ASE	13.33±1.67a	20.00±0.00a
25-ARE	26.66±1.67b	38.33±4.41cd
50-ARE	28.33±1.67b	35.00±0.00bc
75-ARE	15.00±2.89a	25.00±2.89ab
100-ARE	13.33±3.33a	20.00±0.00a

Means followed by the same letter in a column are not significantly different (P <0.05) Turkey HSD
ASE25%=25% aqueous shoot extract, ASE50%=50% aqueous shoot extract, ASE75%=75% aqueous shoot extract, ASE100%=100% aqueous shoot extract, ARE25%=25% aqueous root extract, ARE50%=50% aqueous root extract, ARE75%=75% aqueous root extract, ARE100%=100% aqueous root extract

Results obtained from the bioassay study is in consonant with Galon et al. (2021), that the germination of *Solanum americanum* seeds were inhibited by 97% and 99% when treated with shoot extracts of velvet bean at 75% and 100% concentrations respectively. Similarly, in an allelopathic study of green manure cover crops in Zimbabwe, extracts of velvet bean reduced significantly the germination of seeds and biomass production of *Bidens pilosa*, *Eleusine indica* and *Pennisetum glaucum* (Runzika et al., 2013). The inhibitory influence of shoot and root extracts of velvet bean on germination of *A. cruentus* seeds showed that allelopathy potentials are not limited to certain parts of velvet bean. This supports the reports of Ochekwu and Udensi (2015) that all parts of velvet bean exhibited inhibitory allelopathy on the growth of spear grass. The presence of allelochemicals in velvet bean may be responsible for the inhibition of germination in *Amaranthus cruentus* seeds.

Allelopathic effects of aqueous extracts of *Mucuna pruriens* on growth of *Amaranthus cruentus*

In both trials, the highest plant height was observed in 100-ASE treatment and the lowest in the control. In the first trial, the plant height in 100-ASE and 100-ARE treatments alone was significantly higher ($P \leq 0.05$) than control (Table 2.), but it was not significantly ($P \geq 0.05$) different from control in any of the treatments in the second trial (Table 2).

Table 2. Effect of aqueous *Mucuna pruriens* extract (shoot and root) on plant height of *Amaranthus cruentus* seedlings

	Plant Height (cm)	
Treatment	Trial 1 (%)	Trial 2(%)
Control (0%)	22.20±2.05a	22.66±2.72a
25-ASE	24.93±0.99ab	24.43±2.70a
50-ASE	26.10±1.50ab	28.33±2.95a
75-ASE	26.30±1.47ab	25.96±0.99a
100-ASE	30.93±1.32b	30.56±1.53a
25-ARE	28.23±0.55ab	28.03±0.92a
50-ARE	27.73±0.44ab	28.76±0.29a
75-ARE	27.06±1.08ab	25.9±4.30a
100-ARE	30.46±0.70b	27.3±3.80a

Means followed by the same letter in a column are not significantly different ($P <0.05$) Turkey HSD
ASE25%=25% aqueous shoot extract, ASE50%=50% aqueous shoot extract, ASE75%=75% aqueous shoot extract, ASE100%=100% aqueous shoot extract, ARE25%=25% aqueous root extract, ARE50%=50% aqueous root extract, ARE75%=75% aqueous root extract, ARE100%=100% aqueous root extract

The highest leaf area was observed in 100-ARE treatment and the lowest in 25-ASE treatment (Table 3) in the first trial. Furthermore, the leaf area in 100-ASE and 100-ARE treatments were significantly higher (P≤0.05) than control (Table 3.). In the second trial, the highest leaf was observed in 100-ASE treatment and lowest in 25-ASE, nevertheless, it was not significantly different (P≥0.05) from the control (Table 3).

Table 3. Effect of aqueous *Mucuna pruriens* extract (shoot and root) on leaf area of *Amaranthus cruentus* seedlings

	Leaf Area (cm^2)	
Treatment	**Trial 1 (%)**	**Trial 2(%)**
Control (0%)	38.54±1.62ab	35.37±4.44a
25-ASE	31.91±1.18a	31.49±0.80a
50-ASE	38.57±1.21ab	35.84±3.68a
75-ASE	38.87±1.26ab	37.16±4.28a
100-ASE	48.07±0.67c	47.81±2.82a
25-ARE	39.11±0.71ab	37.61±4.10a
50-ARE	39.10±0.48ab	42.62±3.50a
75-ARE	39.13±0.80ab	39.21±1.69a
100-ARE	50.48±3.08c	35.37±5.72a

Means followed by the same letter in a column are not significantly different (P <0.05) Turkey HSD
ASE25%=25% aqueous shoot extract, ASE50%=50% aqueous shoot extract, ASE75%=75% aqueous shoot extract, ASE100%=100% aqueous shoot extract, ARE25%=25% aqueous root extract, ARE50%=50% aqueous root extract, ARE75%=75% aqueous root extract, ARE100%=100% aqueous root extract

In the study, application of velvet bean extracts stimulated the growth of *A. cruentus* plants. Similar result was obtained in a growth study by Rugare et al. (2020) where velvet bean extracts stimulated chlorophyll content and plant height of maize. However, application of velvet bean extracts inhibited the growth of goose grass plants (Rugare et al., 2020). Ibrahim et al. (2018) also stated that goose grass was severely inhibited from growing after being exposed to velvet bean aqueous extracts. In an allelopathic study between velvet bean and speargrass, aqueous extract of velvet bean parts reduced the biomass of speargrass significantly (Ochekwu and Udensi, 2015). Travlos et al. (2018) also stated that rigid ryegrass's height, number of leaves, and biomass were all substantially decreased by velvet bean residues. Similarly, Runzika et al. (2013) also discovered that extracts of velvet bean inhibited significantly the growth of pearl millet and hairy biggarticks (Runzika et al., 2013). While stimulatory allelopathy of velvet bean on *A. cruentus* seedlings was observed in the study, other researchers reported its inhibitory effects on the survival of other plants especially weeds. This shows that the allelopathic potentials of *M. pruriens* on plants maybe species specific. Nekonam et al. (2013) suggested that the degree of phytotoxic damage as a result of secondary metabolites from plants might be species-specific. Cruz-Silva et al. (2016) stated that allelochemicals from plants may have favourable or unfavourable impacts on the occurrence, health and populations of other plants.

The allelopathic (inhibitory and stimulatory) potentials of velvet bean observed from the study can be utilized in crop production. Xuan et al. (2004) emphasized the importance of allelopathy in weed management, soil fertility enhancement and formulations of organic pesticides. Allelochemicals from plants can be explored for the formulation of pesticides with less negative impact on the ecosystems. However, a lot of research on the efficacy and specificity of allelochemicals as it influences seed germination and performance of plants are essential.

CONCLUSION

The aqueous extracts of *M. pruriens* had inhibitory effect on seed germination and stimulatory effect on plant growth of *Amaranthus cruentus*, which indicates the potential of the legume as a pre-emergence herbicide and as a bio-fertilizer.

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