INNSPUB

International Journal of Agronomy and Agricultural Research (IJAAR)

ISSN: 2223-7054 (Print) 2225-3610 (Online)

http://www.innspub.net

Vol. 13, No. 2, p. 63-70, 2018

RESEARCH PAPER

OPEN ACCESS

Response of maize (*Zea mays* L.) against aqueous extracts of *Diodia scandens* and *Croton hirtus* weed species

Dan David Quee*[1], Johnny Ernest Norman[2], Musa Decius Saffa[2]

[1]Njala Agricultural Research Centre (NARC)/Sierra Leone Agricultural Research Institute (SLARI), Freetown, Sierra Leone

[2]Crop Protection Department, School of Agriculture, Njala University, Freetown, Sierra Leone

Article published on August 04, 2018

Key words: Maize, Aqueous extracts, *Croton hirtus*, *Diodia scandens*, Concentrations.

Abstract

The response of maize against *Diodia scandens* and *Croton hirtus* aqueous extracts were carried out under laboratory conditions. The importance of this study was to create consciousness in maize farmers about the allelopathic effect of *Diodia scandens* and *Croton hirtus*, if not properly controlled will cause economic losses in maize production. The phytotoxic properties of these weeds can also be used as a tool for controlling weeds in crops as the technology is easily transferable to farmers in low-input maize farming systems. The experiment consisted of six concentration levels and two aqueous extracts, laid out as a 2 × 6 factorial arranged in completely randomized design (CRD) with three replicates. The aqueous extracts showed considerable inhibitions with increase in concentration on germination percentage, number of seedling growth, root and shoot lengths, and seedling dry biomass compared with distilled water treated control. The results acquired proved that the degree of retardation in all growth parameters appeared to be more pronounced in maize seeds treated with *Croton hirtus* aqueous extracts. Statistical analysis ($P < 0.05$) revealed that there were significant differences in germination %, number of seedling growth, root and shoot lengths of maize treated with different concentrations of both aqueous extracts when compared to the values obtained from the control experiment. While other concentrations (10, 20, 40 and 50 grams) in the seedling dry biomass showed no significant difference between both aqueous extracts. Field trials are suggested for further clarifications of allelopathic activity of *Diodia scandens* and *Croton hirtus* on maize.

* **Corresponding Author:** Dan David Quee ✉ dandavidquee@yahoo.com

Introduction

Maize (*Zea mays* L.) an annual plant belonging to the Gramineae family is the most important cereal crop produced in Sierra Leone after rice.

The average annual grain production of maize in Sierra Leone is about 79 metric tonnes with a growth rate of 19.3% compared to the world average productivity of about 4.94 t/ha (IMF, 2011).

In Sierra Leone, maize is purposely utilized as human food and livestock feed (Memon *et al.*, 2011), but can also be utilized in other areas as bread, cake and porridge; forage stalks for cattle; used for making plastics, cellophane, photographic films, dying of clothes, soaps, vanishes and paints (Mupangwa *et al.*, 2007; Bukhsh *et al.*, 2008). Weeds adversely affect crop growth through the release of allelochemicals in the form of vapours, leachates, exudates or decomposition products from the aerial parts, usually emancipating from roots, stems, leaves, rhizome, flowers, fruits and seeds (Batish *et al.*, 2007; Asgharipour and Armin, 2010; Farooq *et al.*, 2011a).

The negative or positive effect of different plants on another plants via a chemical released is termed as "allelopathy (Zimdahl, 2007).

The readily visible effects of these allelochemicals include retard germination rate, seeds darkening and swelling, reduced root and shoot extension, swelling of root tips, curling of the root axis, discolouration, lack of root hairs, reduced dry weight accumulation, and lowered reproductive capacity (Turk and Tawaha, 2003).

During a field survey, it was observed that *Croton hirtus* and *Diodia scandens* are the most obnoxious weeds of maize crop in southern Sierra Leone. These weed species not only occupies space and share available growth resources in maize fields, but also release toxic chemicals that reduce maize plant height, leaf area, crop growth rate and crop biomass (Randhawa *et al.,* 2009). Most weed species are found to be deleterious in different cultivated crops which cause losses in crops yield through various ways such as competition and allelopathic effects on seed germination and seedlings growth of economically important crop plants (Mulatu *et al.*, 2009; Sajjad *et al.*, 2007; Majeed *et al.*, 2012).

The significant of this study was to create awareness in maize farmers about the allelopathic effect of *Diodia scandens* and *Croton hirtus*, if not properly controlled will cause economic losses in maize production. In addition, the phytotoxic properties of these weeds can be used as a tool for controlling weeds in crops, thus the technology can be easily transferable to farmers in low-input maize farming systems.

The information available on allelopathic potential of *Diodia scandens* and *Croton hirtus* on maize crop is limited in Sierra Leone, therefore the present study was designed to evaluate the effect of aqueous extracts of *Diodia scandens* and *Croton hirtus* at different concentrations on germination and early growth of maize.

Materials and methods

Study area

The laboratory experiment was conducted in the Environmental Management Quality Control (EMQC) Laboratory, Njala University to evaluate the response of maize against aqueous extracts of *Diodia scandens* and *Croton hirtus* weed species.

The Njala University (N 08.06, W 12.06 and altitude of 63m) is located about 200 km from the capital city of Freetown, along the banks of River Taia in the Kori Chiefdom of Moyamba District in southern Sierra Leone (Fig. 1).

The dominant land form of Njala University is drainage depressions, undulating plains, low plateau, and hills, with predominant secondary bush vegetation. The climatic condition is not different from the rest of the country with two distinct seasons, rainy season (May-October) and dry season (November-April).

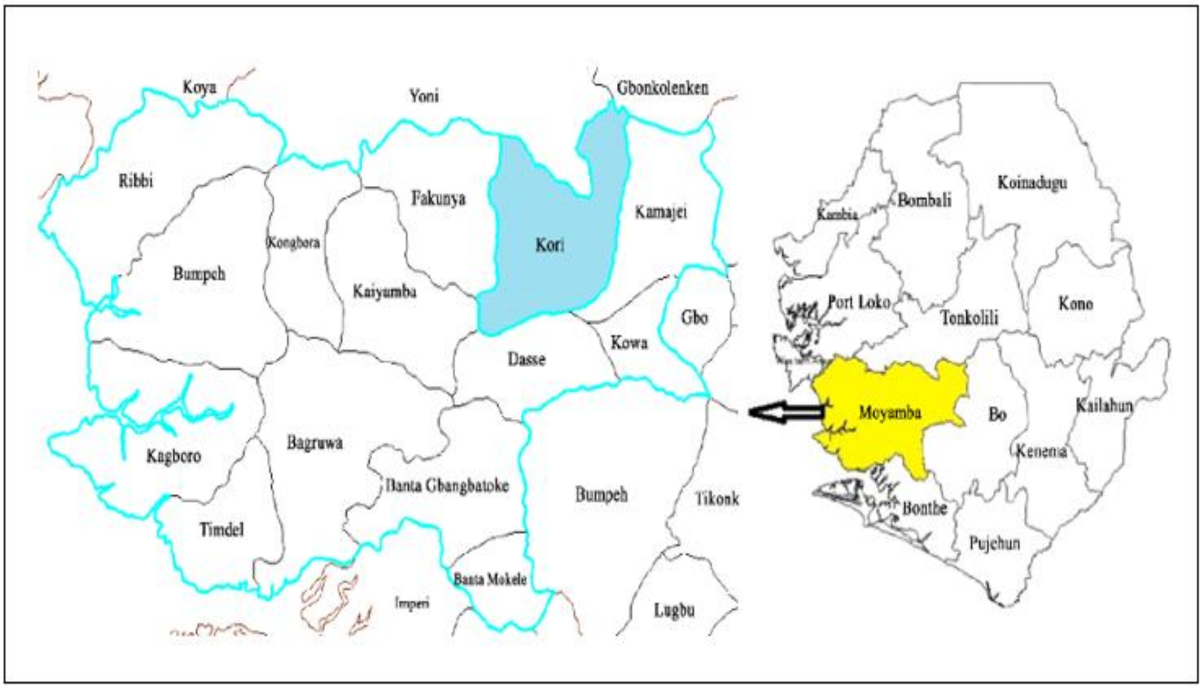

Fig. 1. Map of Sierra Leone showing Moyamba District (Highlighted yellow) and Kori chiefdom (highlighted blue). Source: Mansaray *et al.* (2015).

Preparation of aqueous extracts

Improved maize seeds (DMR-ESR-Yellow) were obtained from the Department of Crop Science, while matured *Croton hirtus* and *Diodia scandens* were harvested from the experimental farm of the School of Agriculture, Njala University in June 2017. The harvested *Croton hirtus* and *Diodia scandens* were thoroughly washed with tap water in order to remove dust and soil. These weed species were separately shredded into pieces and air-dried for three days prior to grinding into fine powder using 250 x 250-indiamart hand grinding mill. Different concentrations of 10, 20, 30, 40 and 50 grams of each ground *Diodia scandens* and *Croton hirtus* were weighed using scientific digital balance (JJ300Y, China). Each of these concentrations was soaked into 100 ml of distilled water in 500ml conical flasks. The mixtures were shaken intermittently using a Vortex shaker and allowed to stand for two weeks so that the contents will be properly extracted.

The aqueous extracts was filtered through a separating funnel stuffed with cotton wool to remove debris and the filtrates considered as original stock solution and stored in a refrigerator at 4°C for further usage.

Treatments and experimental design

The experiment consisted of six concentrations (0, 10, 20, 30, 40 and 50 grams) and two aqueous extracts from *Diodia scandens* and *Croton hirtus* weed species given a total of 12 treatments. Ten sterilized maize seeds were placed at equal spacing in each of the 36 petri-dishes (9 cm) containing two layers of Whitman number 1 filter papers. Each petri-dish was soaked with 10 ml of different concentrations of aqueous extracts prepared as stock solution using syringe and needle, and for comparison, 10 ml of distilled water was used as control (0 gram). All the Petri-dishes were arranged on the laboratory shelves at room temperature between 25–30°C and irrigated every 2 days. The experiment was laid out as a 2 x 6 factorial arranged in completely randomized design (CRD) with three replicates.

Data collection

Germination percentage, root and shoot length, number of seedling growth and seedling dry biomass was recorded for ten days after the establishment of experiment. Germination percentage was determined by counting seeds after 2 days of sowing using this formula: $Gp = Ng/Nt \times 100$.

Where: Ng = final number of emerged seeds, Nt = total number of seeds sown.

The root and shoot growth elongations were recorded at 24 hrs interval. Shoot and root length measurements were taken from the stem joint to the tip of the terminal leaf, while root length measurements were taken from the root joint to the tip of the main root. Seedling dry biomass of maize (g) was weighed after oven dried at 65˚C for 24 hours, using scientific digital balance (JJ300Y, China).

Data analysis

The data was subjected to analysis of variance (ANOVA) using the Gen Stat 12th edition. Least Significant Difference (LSD) test was used to compare treatment means at 5% level of probability. Also, Excel 2010 was used for analyzing number of seedling growth and seedling dry biomass.

Results and discussion

Concentrations of aqueous extracts on maize

Analysis of variance showed that germination, root and shoot lengths of maize crop was significantly affected by various concentrations of *Diodia scandens* and *Croton hirtus* aqueous extracts. Among the tested aqueous extracts for allelopathy, *Croton hirtus* demonstrated the highest degree of phytotoxicity affecting germination, root and shoot lengths of maize. Results showed that *Croton hirtus* decreased germination by 13.5% of *Diodia scandens*. In addition, different concentrations of both aqueous extracts significantly ($p<0.05$) affected seed germination, root and shoot lengths of maize in distinctly dissimilar ways (Table 1).

Table 1. Effects of aqueous extracts and concentrations on germination, root and shoot lengths of maize.

Treatment	Germination (%)	Root length (cm)	Shoot length (cm)
Aqueous extract			
Croton hirtus	59.40	5.48	8.84
Diodia scandens	68.80	5.66	13.16
LSD (5%)	4.26	0.72	1.28
Concentration (gram)			
0	89.40	12.37	19.17
10	69.70	9.92	14.12
20	65.30	5.32	12.18
30	60.00	2.60	8.42
40	57.80	1.94	6.67
50	42.50	1.28	5.42
LSD (5%)	7.37	1.24	2.22
CV (%)	9.6	18.7	16.9

For both aqueous extracts, concentration at50 gram recorded the highest inhibitory effects on germination (42.5%), root length(1.28 cm) and shoot length (5.42 cm) of maize, while at 0 gram (control), thes eparameters showed little or no inhibitory effects on the maize crop. Thus concentration at 50 gram reduced seed germination by 72.59%, root length by 89.65% and shoot length by 71.72% of the control (0 gram).

The increased inhibitory effect at higher concentration of both aqueous extract on germination characteristics may be due to increase in the concentration of allelochemicals like flavonoids, phenolic and coumaric acid compounds (Mousavi *et al.*, 2011).

Results from this study revealed reduced germination percentage, which could be attributed to the suppressive effects of allelochemicals present in *Diodia scandens* and *Croton hirtus*.

The inhibitory effect of these extracts was found to increase with increase in the concentration of the aqueous extracts which were in accordance with preceding researches (Sisodia and Siddiqui, 2009).

Fig. 2-3. Effect of 50g aqueous extracts concentration on maize.

The result also affirmed the report of Al-Watban and Salama (2012) that aqueous extracts of Asteraceae family affect germination percentage negatively as the concentration increases. Furthermore, Oyun (2006) reported that extracts from *Gliricidia sepium* caused a prolonged delay in maize seed germination.

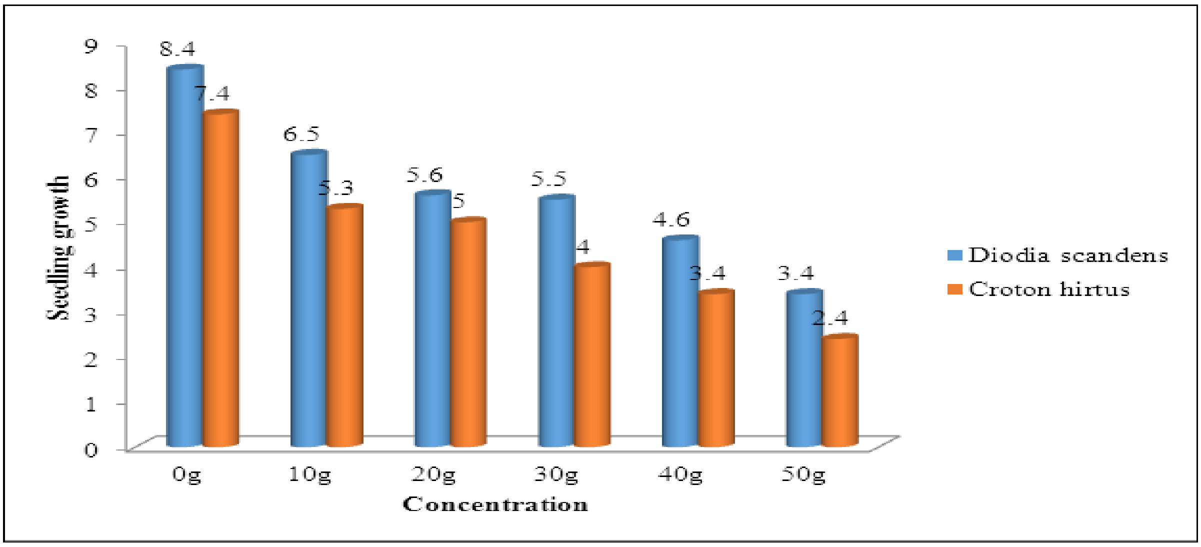

Fig. 4. Effects of aqueous extracts concentrations on seedling growth of maize.

For root and shoot lengths, concentrations of30, 40 and 50 grams statistically did not show any significant difference. But pronounced inhibitory effect on root and shoot lengths of maize were observed with increase in the concentration of the aqueous extracts which suggests that the effects of aqueous extracts were concentration dependent. Maize roots exposed to both aqueous extracts appeared chromatic, indicating localized death of the root tips, curling of root axis, lack of root hairs, and seed darkening.

This might be due to the fast inhibiting effect on respiration of root tips which might eventually lessen its length. Similar results were reported by Nazim *et al.* (2005) and Komal (2011). Thus, it can be affirmed from Table 1 that aqueous extracts of *Croton hirtus* had inhibitory effects on root length (5.48 cm) in comparison with extracts of *Diodia scandens* (5.66 cm). The effects different concentrations of both aqueous extracts on shoot length might have resulted from the occurrence of primary events caused by allelochemicals.

This observation suggested that the different weed aqueous extracts prepared in different concentrations are responsible for the inhibitory effects shown on reduced shoot lengths. These findings confirmed the work of Oyun (2006) who reported that the root and shoot length and seedling vigour of maize were decreased with the increasing concentration of *Gliricidia sepium*. Similarly, Salam *et al.* (2009) reported that extracts from rice hulls significantly reduced root and shoot elongation of *Echinochloa Crus-galli*. The practical implication of this study was that these chemicals (allelochemicals) have harmful effects on the maize, in the form of reduced and delayed germination, root and shoot lengths in Fig. 2 and 3.

Number of Seedling growth and biomass

The number of seedling growth in various concentrations of aqueous extracts responded differently (Fig. 4). The general inhibitory effect on number of seedling growth was found to be higher in *Croton hirtus* (2.4 plant^{-1}) than *Diodia scandens'* extract (3.4 plant^{-1}). Thus higher concentrations had more noticeable inhibitory effect on seedling growth compared with lower concentrations. Also, both aqueous extracts showed strong inhibitory effects at 50 gram concentration (2.9 Plant^{-1}) compared to control (7.9 Plant^{-1}). Results unfurled that when concentration of *Diodia scandens* and *Croton hirtus* increased, the number of seedling growth simultaneously decreased. Chandra *et al.* (2011) similarly verified inhibitory effect of aqueous plant extract of *Achyranthes aspera* on germination and seedling growth of broad bean (*Vicia faba* L.) at its higher concentration.

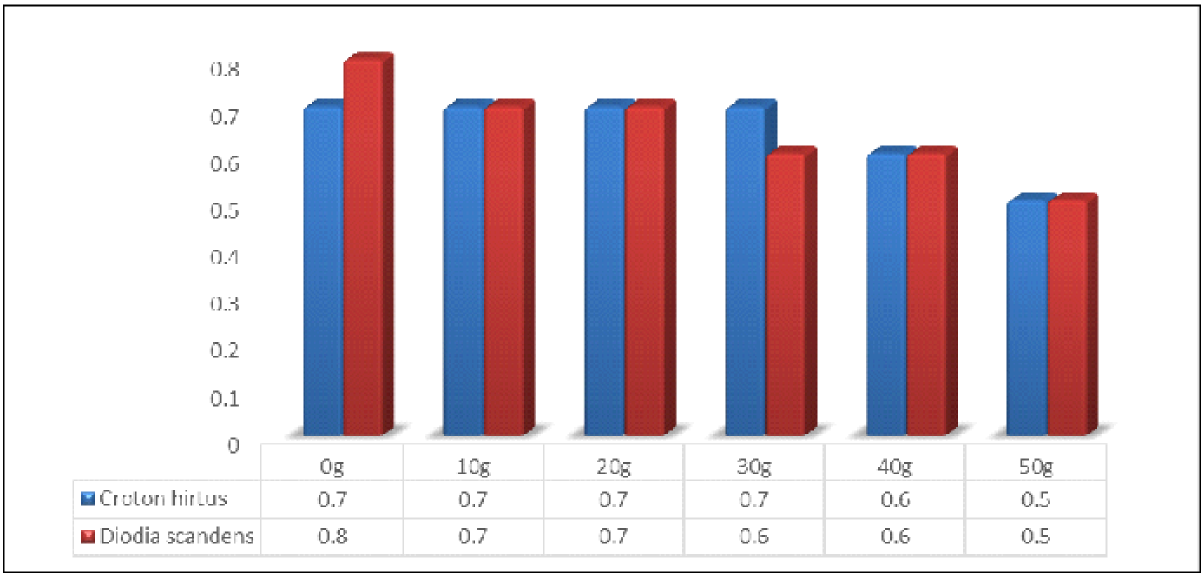

Fig. 5. Effects of aqueous extracts concentrations on maize seedling dry biomass.

Aqueous extracts with different concentrations significantly reduced seedling dry biomass of maize (Fig. 5). Both aqueous extracts showed equal seedling dry biomass (0.5 gram) of maize, while in the control treatment (0 gram), significant difference was recorded between *Diodia scandens* (0.8 gram) and *Croton hirtus* (0.7 gram). In addition, there were no significant differences between both aqueous extracts at 10, 20, 40 and 50 grams concentration. This result was in conformity with Anjum and Bajwa (2010) who reported that different concentrations of aqueous extracts of sunflower significantly decreased biomass of four wheat varieties showing strong allelopathic activity of sunflower. Khaliq *et al.* (2013) similarly affirmed that different aqueous extracts of sunflower and other plants reduced biomass accumulation.

Conclusion

The results from this study concluded that *Diodia scandens* and *Croton hirtus* aqueous extracts contain allelochemicals that negatively affected the germination, root and shoot lengths, number of seedling growth and seedling dry biomass of maize.

The results proved that the degree of retardation in all growth parameters appeared to be more pronounced in maize seeds treated with *Croton hirtus* aqueous extracts. Therefore, field trials are suggested for further clarifications of allelopathic activity of *Diodia scandens* and *Croton hirtus* on maize.

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