SCREENING OF SOME ARABLE CROP PLANTS FOR TOLERANCE TO CASSAVA EFFLUENT USED FOR WEED CONTROL

Olatunde Philip Ayodele[1]* and Johnson Adedayo Adetumbi[2]
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ABSTRACT

The advocacy for allelopathic weed control has justified that phytotoxicity of allelochemicals on crops be investigated since crop injury is an associated challenge of chemical weed control. A laboratory experiment was conducted to evaluate the effect of cassava effluent (CE) concentrations on germination of kenaf (Hibiscus cannabinus L.), cowpea (Vigna unguiculata (L) Walp.), okra (Abelmoschus esculentus (L.) Moench), maize (Zea mays L.), rice (Oryza sativa L.) and tomato (Lycopersicon esculentum Mill.). The experiment comprised four CE concentrations (120, 240, 360 and 480 g CN ha^{-1}) and a control (no CE) as treatments. These were laid out in a completely randomized design with three replicates. A follow-up screen-house experiment was conducted to investigate the effect of CE on growth and yield of okra using the same experimental treatments. The results showed that germination percentage decreased with increasing CE concentration in all the crops tested. Kenaf seed had germination inhibition percentage as high as 73% in the least CE concentration whereas okra seed had the least germination inhibition in CE concentrations that impacted most on other crops. CE did not significantly reduce the number and weight of okra pods compared to control treatment. Hence, it is recommended that the selective use of CE for weed control is feasible in okra since its yield was not reduced.

Keywords: Cassava effluent; germination inhibition; okra yield

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[1]Department of Agronomy, Adekunle Ajasin University Akungba-Akoko, Ondo State, Nigeria.
[2] Institute of Agricultural Research and Training, Obafemi Awolowo University, PMB 5029, Moor Plantation, Ibadan, Nigeria.
*E-mail of the Corresponding Author: olatunde.ayodele@aaua.edu.ng

INTRODUCTION

Indiscriminate use of synthetic herbicides for weed control has generated lots of environmental, health and weed resistance concerns. Hence, attention is being given to the use of plant derived-organic substances as an alternative to inorganic herbicides for weed control (Arif *et al.,* 2015). The use of allelopathic water extract for weed suppression has been reported to be effective in many previous studies (Farooq *et al.,* 2017; Khan *et al.,* 2017; Mahmood *et al.,* 2018). Pre-emergence application of allelopathic extract on soil for weed control is premised on its ability to impact negatively on weed seed bank. Since weeds and crops grow together in the field**,** it is necessary to evaluate the effect of allelopathic extracts on the germination of untargeted crop seeds.

The allelopathic nature of different parts of the cassava plant has been studied. Huang *et al*. (2010) reported that water leachates from cassava leaves inhibited seed germination in radish (*Raphanus sativus*) and ryegrass (*Lolium perenne*), decreased their root vigour and chlorophyll content. Cheng *et al.* (2013) reported that four concentrations of cassava leaf extracts differentially inhibited germination and seedling growth of weeds in a dose-related manner. Ogundola and Liasu (2007) studied the effects of effluent from cassava tuber on a weed species. It was reported that cassava effluent (CE) caused a reduction in the growth performance of *Chromolaena odorata.* Also, maize seedling watered with CE was reported to have stunted growth (Nwakaudu *et al.,* 2012). Therefore, it could be inferred from these studies that CE may be used to exert biocontrol of weeds.

Kremer and Souissi (2001) reported that the presence of cyanide in CE is responsible for its phytotoxic nature. Also, Burns *et al.* (2012) studied the cyanogenic content of cassava varieties across locations. It was reported that the concentration of cyanide varied based on the cultivar, plant part, and location where it was grown. Since cassava plants have been reported to have allelopathic effect and cyanide is responsible for associated phytotoxicity, it becomes important to understand how to positively utilise the herbicidal effect of CE without deleterious effect to non-target crops. Hence, this study aimed at investigating the effect of CE concentration based on cyanide (CN) on the germination, growth, and yield of a selected arable crop plant.

MATERIALS AND METHODS

Two experiments were conducted in this study in which, the second one was a follow-up experiment.

Experiment 1, Effect of different concentrations of CE on germination inhibition of some selected arable crop seeds

Experimental site

This experiment was conducted in the Seed Testing Laboratory, Institute of Agricultural Research and Training (IAR&T), Ibadan, Nigeria.

Collection of materials

Seeds of different crops including Kenaf (Ifeken D-1-400), Cowpea (Ife-Brown), Okra (V35) and Maize (DMR-LSR-Y) were obtained from Seed Processing and Storage Unit, Institute of Agricultural Research and Training, Ibadan, Nigeria, while seeds of Rice (Faro-44) and Tomato (NG/AA/SEP/09/042) were collected from Genetic Resources Unit, African Rice and National Centre for Genetic Resources and Biotechnology (NACGRAB), Ibadan Nigeria. Cassava effluent (CE) was obtained from Cassava Processing Unit, International Institute of Tropical Agriculture (IITA) Ibadan, Nigeria where cassava tubers were peeled, ground and pressed within a day to expel the effluent. Fresh effluent was collected on the day of application. Hence, it was not stored.

Experimental design and treatments

The experiment was laid out in a completely randomized design with three replicates. Treatments comprised four CE concentrations (120, 240, 360 and 480 g CN ha^{-1}) along with control (no effluent).

Preparation of cyanide concentration from CE

The equivalent volume of CE with desired CN concentration required as treatment was determined using the Ninhydrin-based spectrophotometric method (Surleva *et al.,* 2013). Different volumes of CE with corresponding CN concentrations needed for the experiment were diluted with water and made up to the same volume of 250 L ha^{-1}.

Planting and application of CE

Twenty-five seeds of each crop were sown separately in fifteen plastic germination trays that were filled with sterilised river sand. Distilled water was applied to the sand up to the saturation point. CE concentrations of 120, 240, 360 and 480 g CN ha^{-1} were separately and uniformly applied with knapsack sprayer to different marked-out plots within the laboratory to simulate field application of herbicide. Each treated plot area had germination trays of the six test crops randomly laid out and replicated three times. Control treatment was incorporated into the study by excluding the germination trays within the fifth plot from the CE application.

Data collection

Data were obtained on germination percentage (GP) as follows:

$$GP = \frac{\text{Number of germinated seeds at final count}}{\text{Number of seeds planted}} x\,100$$

Percentage germination inhibition (PI) was calculated using the formula proposed by Pati and Chowdhury (2015):

$PI = 100 - \frac{E2\times100}{E1}$ _where E_1=Response in control, E_2=Response in treatment plant_

Data analysis

Data were subjected to analysis of variance (ANOVA) using SPSS software (George and Mallery, 2016). Fisher's least significant difference (LSD) test was used to separate significant means at 5% probability level.

Experiment 2. Effect of different concentrations of CE on growth and yield of okra.

Experimental site

The experiment was carried out in a screen-house within Institute of Agricultural Research and Training, Ibadan, Nigeria.

Collection of materials

Topsoil (0-15 cm) was collected from arable crop farmland within the Institute of Agricultural Research and Training, Ibadan, Nigeria. The soil was air-dried, sieved and homogenized. Thereafter, forty-five (45) pots were each filled with 5 kg of soil. The pots were arranged in the screen-house for treatment application and each pot was irrigated with 250 ml of water on alternate days.

Experimental design and treatments

The experiment was laid in a completely randomized design with three replicates. The treatments comprised four CE concentrations viz.; 60, 120, 180 and 240 μg CN kg^{-1} soil. Control treatment where CE was not applied was also included in the experiment. The same concentrations of CE were used in this experiment as in Experiment 1, based on the assumption that one hectare of land has 2,000,000 kg soil available for plants to root (Brady and Weil, 2002).

Application of CE and planting of okra

Cassava effluent concentrations (60, 120, 180 and 240 μg CN kg^{-1} soil) were determined using the Ninhydrin-based spectrophotometric method (Surleva *et al.,* 2013). The CE equivalent of each CN concentration was diluted with water and made up to the same volume to facilitate equal spread when applied to the potted soil. The application of CE was done by drenching the soil in three pots with each of the CE concentrations. Two okra seeds were sown in a hole of 1 cm depth in all pots on the same day. Seedlings were thinned to one plant per pot at one week after planting (WAP).

Data collection

The number of leaves was taken by counting leaves on a plant at 3, 6 and 9 WAP. Plant height was measured with meter rule, measuring the distance between the soil level and the uppermost part of the stem which excludes flowers and pods at 3, 6 and 9 WAP. Butt girth was taken by measuring the diameter of the stem at about 5 cm above the soil level with Vernier calliper at 3, 6 and 9 WAP. The number of nodes was recorded as a numerical count of the nodes on plant at 9 WAP. Leaf area was estimated from the midrib length of leaf as described by Abdullahi and Jasdanwala (1991) at 9 WAP. At maturity, pods were harvested at a 3-day interval when the pods were at about 2-3 cm long. The harvesting period was from 9 to 12 WAP. Number of pods per plant and fresh weight of pods per harvest per pot were recorded and added to get the total number of pods and weight per pot.

Data analysis

Data were analysed as done in Experiment 1.

RESULTS

Effect of CE concentration on seed germination of some arable crops.

Cassava effluent concentration has a significant effect on percent germination of okra, maize, tomato, cowpea, kenaf and rice (Table-1). Maize had the highest germination percentage (100%) in the control treatment while kenaf had the least (50%). Germination percentage decreased with increasing CE concentration in all the crops tested. All the CE concentrations reduced germination in the test crops compared to the control treatment except in okra and tomato. The application of CE at 360 g or 480 g CN ha^{-1} resulted in germination that was not significantly different in all the test crops. CE concentrations of 360 g CN ha^{-1} and 480 g CN ha^{-1} significantly reduced germination in all the test crops.

Table 1. Effect of CE concentration on seed germination of some arable crops.

	Germination (%)					
CE (g CN ha^{-1})	Okra	Maize	Tomato	Cowpea	Kenaf	Rice
120	81.33a	73.33b	93.33a	66.67b	13.33b	68.67b
240	77.33a	23.33c	84.00a	44.33c	3.33b	31.00c
360	44.00b	0.00d	20.00b	26.66d	0.00b	11.00c
480	32.00b	0.00d	10.67b	15.67d	0.00b	4.67c
Control	82.66a	100.00a	94.66a	89.00a	50.00a	95.33a
LSD	14.91	15.58	12.18	17.15	19.37	26.39

Means followed by a common letter(s) in the same column are non significantly different according to Fisher's Protected LSD test at P > 0.05.

Effect of CE concentration on germination inhibition of some arable crops.

Cassava effluent concentration had significant inhibition on germination in all tested crops (Table-2). Application of 360 g and 480 g CN ha^{-1} resulted in germination inhibition percentages that were comparable in all the test crops. Cassava effluent concentration of 120 g CN ha^{-1} had reduced germination inhibition compared to 360 g CN ha^{-1} and 480 g CN ha^{-1} in all the crops. Kenaf seed had poor tolerance to CE with respect to germination. Its germination inhibition percentage was as high as 73% in the least CE concentration. Okra had good tolerance to CE with respect to germination. It had less germination inhibition in CE concentrations that impact most on other crops. Germination inhibition for different crops was in the following decreasing order in the highest CE concentration applied: kenaf (100%), maize (100%), rice (95%), tomato (89%), cowpea (70%) and okra (61%).

Table-2. Effect of CE concentration on germination inhibition in some arable crops.

	Germination inhibition (%)					
CE (g CN/ha)	Okra	Maize	Tomato	Cowpea	Kenaf	Rice
120	2.01a	26.67a	1.75a	25.09a	73.33a	28.24a
240	6.83a	76.67b	11.56a	50.06b	93.33ab	67.59b
360	46.99b	100c	78.95b	82.52c	100b	88.43b
480	61.45b	100c	88.77b	70.04c	100b	95.37b
LSD	19.6	18.03	13.54	21.93	24.31	32.58

Means followed by a common letter(s) in the same column are non significantly different according to Fisher's Protected LSD test at P > 0.05.

Effect of CE concentration on growth and yield of okra.

Cassava effluent treatments did not significantly affect the number of okra leaves at 3 and 9 WAP (Table 3). However, CE concentrations of 120, 180 and 240 µg CN kg^{-1} soil significantly reduced number of okra leaves at 6 WAP. The number of leaves of okra in potted soil treated with 60 µg CN kg^{-1} soil was comparable to that of the control treatment at 6 WAP. CE concentration had a significant effect on plant height of okra at 3, 6 and 9 WAP. Plant heights were significantly different among the treatments throughout the experiment. CE concentrations greater than 60 µg CN kg^{-1} soil significantly reduced plant height at 3 WAP. Height of okra in potted soil treated with CE was not reduced at 6 and 9 WAP (Table 3), while it was significantly higher in potted soil treated with 180 µg CN kg^{-1} soil at 6 WAP. The height of okra in potted soil treated with 180 µg or 240 µg CN kg^{-1} soil was significantly higher than that of control treatment at 9 WAP.

Stem girth of okra in pots differed significantly at 3, 6 and 9 WAP (Table 3). The girth in potted soil treated with 60 or 120 µg CN kg^{-1} soil was significantly less than control treatment at 3 WAP. In contrast, CE concentration had a non-significant adverse effect on stem girth measured at 6 or 9 WAP. Concentration of CE as high as 240 µg CN kg^{-1} soil resulted in girth that was significantly higher than control treatment at 3 and 6 WAP.

The effect of CE concentration on the number of nodes of okra was significant. The nodes counted at 9 WAP were significantly less in potted soil treated with 120, 180 or 240 µg CN kg^{-1} soil compared to control which had the maximum number of nodes (Table-3). However, the numbers of nodes among CE treatments were not significantly different.

The effect of CE concentration on leaf area was not significant. Leaf areas measured at 9 WAP among treatments were not significantly different. Okra in potted soil treated with 180 µg CN kg^{-1} soil showed maximum leaf area, while those treated with 120 µg CN kg^{-1} soil had the least.

Concentrations of CE did not significantly reduce the number and weight of okra pods compared to control treatment (Table-4). Okra in potted soil treated with CE at 240 µg CN kg^{-1} soil had significantly increased number and weight of pods, whereas those treated with CE at 60 µg CN kg^{-1} soil had the least.

Table-3. Effect of CE concentration on some growth parameters of okra.

CE (µg CN kg^{-1})	No of Leaves			Plant Height (cm)			Butt Girth (mm)			No of Nodes	Leaf Area (cm^2)
	WAP			WAP			WAP			WAP	WAP
	3	6	9	3	6	9	3	6	9	9	9
60	4.0a	7.1ab	6.6a	7.0ab	13.2ab	45.3ab	1.9c	4.0b	12.7b	11.4ab	180.3a
120	4.1a	6.4cd	6.7a	6.5bc	12.8ab	46.0ab	1.9c	4.1b	13.0b	10.3b	165.3a
180	4.1a	6.1d	6.7a	6.1bc	14.3a	48.0a	2.5b	4.9a	15.6a	10.2b	219.9a
240	4.1a	6.8bc	7.1a	5.6c	12.7ab	49.0a	2.7a	5.0a	14.9ab	10.0b	197.0a
Control	4.0a	7.4a	7.4a	7.6a	12.4b	41.3b	2.4b	3.8b	13.6ab	12.1a	192.5a
LSD	0.39	0.74	0.92	1.22	1.72	6.59	0.3	0.49	2.1	1.72	53.59

Means followed by a common letter(s) in the same column are non significantly different according to Fisher's Protected LSD test at P > 0.05.

Table-4. Effect of CE concentration on the yield of okra

CE (µg CN kg^{-1})	No of pods	Weight of pod (g pot^{-1})
60	2.0b	15.0b
120	2.1b	18.3ab
180	2.3b	19.3ab
240	3.0a	22.8a
Control	2.1b	15.4b
LSD	0.6	6.5

Means followed by a common letter(s) in the same column are not significantly different according to Fisher's Protected LSD test at P > 0.05.

DISCUSSION

Reduction in the germination of maize, rice, tomato, cowpea, okra and kenaf seeds with increasing concentration of CE was observed in this study. It is suggested that this might be safer to adopt the use of low CE concentrations for weed control when crop seeds are to be planted. The study showed that the germination inhibitory action of CE is CN concentration-dependent. CE at 120 g CN ha^{-1} and 240 g CN ha^{-1} did not significantly reduce germination of okra and tomato seeds, whereas higher concentrations (360 and 480 g CN ha^{-1}) significantly reduced the germination of these crops. This result agrees with that of Mullick and Chatterji (1967) who reported that cyanide at low concentration (1 – 20 ppm) did not significantly affect imbibition, germination, and growth of early seedling of *Clitoria ternatea*, whereas application of 500 - 1000 ppm had an inhibitory effect.

The differential response of test crops to concentrations of CE is an indication that crops differ in their susceptibility to effluent. The study showed that amongst crops used for the germination test, okra had the least germination inhibition in CE concentrations that impact most on other crops. This corroborates the report of Owokotomo and Afuye (2007) that *Gliricidia sepium* extract inhibited germination of crop seeds such as maize and cowpea. Similarly, Olabode *et al.* (2010) reported that *Tithonia diversifolia* extract inhibited the germination of soybean (*Glycine max*) and had no definite effect on okra. Hence, the phytotoxic effect of CE seems feasible for weed control in the okra field, since it minimally affects its germination. However, the application of CE at 480 g CN ha^{-1} is not advisable at the seed stage of maize and kenaf to avoid crop failure.

The germination inhibition that increased with increasing concentration of CE from 120 g CN to 480 g CN ha^{-1} is suggestive that germination inhibition is CE concentration related. Many studies have also reported that germination inhibition is concentration related to the allelochemical involved (Sun *et al.,* 2012; Islam and Kato-Noguchi, 2014; Shrivastava and Jha, 2016).

The pre-plant application of CE to the soil that had a significant effect on plant height, butt girth and number of nodes of okra, even at 9 WAP was an indication of the persistent effect of CE on okra growth till the flowering stage. Similarly, Orhue *et al.* (2014) reported that the application of CE to soil had a significant effect on the growth fluted pumpkin (*Telfairia occidentalis*) even at 56 days after planting. The study showed that CE had both positive and negative effects on plant height and butt girth at different stages of okra growth and CE concentrations, whereas it had only negative effect on the number of leaves when its effect was significant. This result does not agree with the report of Farooq *et al.* (2014) that an allelochemical caused an increase in the number of leaves of maize and mungbean. It rather suggests that plant parts may have a differential responses to the same allelochemical.

Growth of okra in control treatment that was not significantly superior to the CE treatments with respect to some growth parameters at 3, 6 or 9 WAP could be responsible for the comparable quantity of okra pods that resulted from control treatment and CE treatments. It can be deduced from this study that pre-plant application of CE at concentrations of 60, 120, 180 or 240 µg CN kg^{-1} soil for weed control may slightly influence the growth of okra, but it is not capable of reducing yield significantly.

CONCLUSION

The differential inhibition of seed germination in arable crops in response to CE applied to the soil makes it imperative that the cyanide tolerance ability of crops should be evaluated before CE is adopted for weed control in crop-weed environment, to avoid reduced number of crop stands or total crop failure. Okra germination was found to be moderately tolerant to cyanide. The adoption of pre-plant CE application of 60, 120, 180 or 240 µg CN kg^{-1} soil for weed control in okra may slightly influence its growth but the yield is not reduced. Hence, the use of these CE concentrations to exert biocontrol on weed associates of okra is recommended.

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