Turkish Journal of Weed Science 23(2):2020:125-136

Available at: www.journal.weedturk.com

Turkish Journal of Weed Science

Araştırma Makalesi/ Research Article

Screen-House Evaluation of Weed Suppression Potential of Cassava Effluent at Varied Frequency of Application and Cyanide Concentration

Olatunde Philip AYODELE*

Department of Agronomy, Adekunle Ajasin University Akungba-Akoko, Ondo State, Nigeria
***Corresponding Author:** olatunde.ayodele@aaua.edu.ng

ABSTRACT

The suitability of cassava effluent (CE) for weed management required investigation due to the comparative advantage of biological weed control over other methods. Screen-house experiment comprising four levels of CE concentration (60, 120, 180, and 240 µg CN /kg soil) in factorial combination with four levels of application frequency (one, two, three, and four times) and a control treatment where no CE was applied, were laid out in a Completely Randomized Design and replicated three times. Data on weed weight, density, and flora composition were collected. The data were subjected to analysis of variance (ANOVA), and Duncan multiple range test (DMRT) was used to separate the treatment means at $P < 0.05$. The result showed that 240 µg CN /kg soil, applied four times, performed best in reducing weed density. The CE concentration and frequency of application had selective control on weed species. The density of *Mitracarpus hirtus* (L.) decreased, whereas *Panicum maximum* (L.) and *Cyperus rotundus* (L.) were tolerant. Therefore, the sole use of CE for non-selective control in the weed population of high heterogenicity is not advisable.

Key Words: Cassava effluent; Cyanide concentration; Weed composition; Weed control

INTRODUCTION

The increase in cassava production and processing has generated an enormous cassava effluent volume and caused its discharge to the environment (Nwaogu *et al.*, 2011). Cassava effluent (CE) adversely affects plants growing on its dumpsites (China-Cambodia-UNDP, 2015), and studies have suggested its potential for weed control (Eze and Onyilide, 2015; Fayinminnu *et al.*, 2013; Nwakaudu *et al.*, 2012). However, its phytotoxin concentration, frequency of application, and weed composition are vital factors influencing its weed control efficiency (Khan *et al.*, 2017; Naseem *et al.*, 2009).

The cyanide present in CE is responsible for its phytotoxic nature (Fayinminnu *et al*., 2013). It binds with the protein plastocyanin to block photosynthetic electron transfer (Kremer and Souissi, 2001). Thus, cyanide inhibits enzymes involved in plant processes such as carbon dioxide and nitrate assimilation and respiration. The cyanide content of cassava varies widely for cultivars and locations where they are grown (Burns *et al.*, 2012). Therefore, it is appropriate to evaluate CE's biocontrol potentials based on the applied cyanide concentration.

The concentration of the phytotoxic constituents of plant extract applied for weed control may affect weed control efficiency in different forms. For instance, low concentrations of phenolic phytochemicals such as caffeic, ferulic, protocatechuic, and vanillic acids stimulate plant growth, and high concentrations have an inhibitory effect (Sunar and Agar, 2017). In contrast, barnyard grass (Echinochloa crus-galli) biomass increased with increasing allantoin concentration from allelopathic rice cultivar (Sun *et al.*, 2012). Therefore, the relationship between the concentration of phytotoxic constituents of plant extract and weed growth is not inverse in all scenarios. Hence, the quest for information on the phytotoxic concentration of cyanide from CE is necessary for its effective use for weed control.

The suboptimal concentration of phytotoxins in plant extracts requires repeated application at days interval for significant herbistatic and herbicidal effects on weeds. The inhibitory effect of sunflower water extract on some weed species increased with increasing application frequency (Naseem *et al.*, 2009). Thus, the frequency of plant extracts application influences the weed control efficiency of some weed species. Also, it influences the cost incurred on weed control since it is an operation that requires labour (Negash and Mulualem, 2014). Therefore, it is economically reasonable to have information on the number of times that plant extracts are to be applied for effective weed control.

Plant extracts are selectively phytotoxic (Mangao *et al*., 2020). For this reason, the use of plant extracts for weed control is feasible in crop - weed environment with susceptible weed species. For instance, low concentrations of *Delonix regia* leaf extract are phytotoxic to field bindweed (*Convolvulus arvensis* L.), but to wheat (*Triticum aestivum* L.), it is safe (Perveen *et al*., 2019). Also, Khaliq *et al*. (2013) found that extract from winter cherry (*Withania somnifera*) reduced the root and the shoot length of purple nutsedge (*Cyperus rotundus*) and barnyard grass (*Echinochloa crus-galli*). However, it had no such effect on horse purslane (*Trianthema portulacastrum*). Thus, it is necessary to investigate the weed management potentials of plant extract based on weed species; this will avert weed-shift that may arise due to selective control (Hanson *et al*., 2014).

The effective use of plant extracts for weed control has been reported in many studies (Fayinminnu, 2014; Saif *et al.,* 2016: Iqbal *et al.,* 2020). Weed management generally seeks to lessen the negative effect of weeds. However, some weed management methods predispose human health and the environment to hazard (Caiati *et al*., 2020). The use of plant extracts for weed suppression is also gaining attention for their environmental friendliness compared to herbicides. Hence, this study seeks to evaluate CE for weed control potential based on the cyanide concentration applied and their application frequency.

MATERIALS AND METHODS

Experimental site

This study involved a screen-house experiment conducted at the Institute of Agricultural Research and Training, Ibadan (7° 31'N 3° 45'E), Nigeria. The screen-house temperature ranged between 24-33ºC during the study, and the relative humidity was 52-79%.

Materials

Cassava effluent and topsoil are the primary materials used for this study. The study used CE sourced from the Cassava Processing Unit, International Institute of Tropical Agriculture, Ibadan. Effluent from unfermented cassava tubers was expelled by pressing after peeling and grinding operations. It was collected in a black keg and taken to the screen-house for application on the same day. Before the application, its cyanide concentration content was analysed using the Ninhydrin-based spectrophotometric method (Surleva *et al.,* 2013). This analysis revealed CE volumes containing the cyanide concentrations required as the experimental treatments. These volumes were diluted with water to the same level to allow for equal spread within the soil when applied. The application of CE to the potting soil was repeated three times at a week interval. Hence, at each time of application, standardization of cyanide concentration was also repeated.

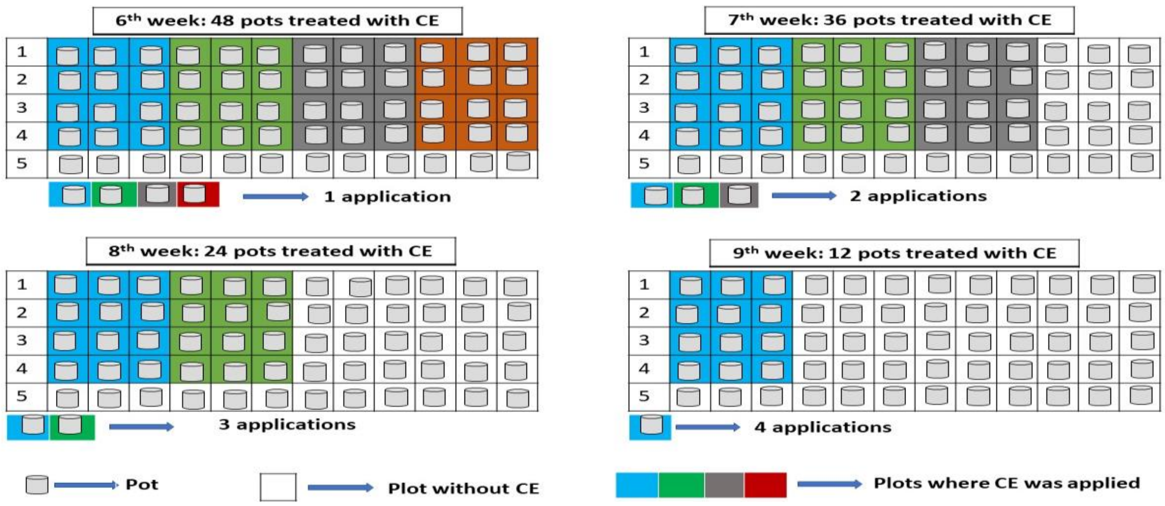
Topsoil from arable land in the Institute of Agricultural Research and Training (IART) Ibadan, located within the rainforest-savanna transition agro-ecological zone of Nigeria, was air-dried sieved with 2 mm mesh and homogenized. The textural class of the soil obtained is clay loam. It had 38% sand, 24% silt, and 38% clay.

Soil preparation for weed emergence

Sixty pots measuring 16.5 x 13.5 cm were each filled with 5kg soil. These were arranged in the screen-house and watered every other day. Excessively high moisture was avoided in the potting soil to allow oxygen diffusion and promote weed seeds germination (Dasberg and Mendel, 1971). The watering continued for five weeks to facilitate the natural emergence and growth of weeds.

Application of CE

From the sixth week, CE's application to the potting soil started according to the treatment plan. Presented in Figure 1 is a schematic illustration of the CE application. The application of CE to the potting soil was over four weeks, such that the same CN concentration was repeatedly applied to some potting soil at a week interval.



CE concentration applied per row: 1=60 µg CN/kg soil, 2= 120 µg CN/kg soil, 3=180 µg CN/kg soil, 4= 240 µg CN/kg soil, 5= 0 µg CN/kg soil (control).

Figure 1: Treatment application plan showing the order of CE post-emergence (soil) application and the corresponding number of weedy pots used.

Experimental treatments and design

The experimental treatments were four CE concentrations (60, 120, 180, and 240 µg CN /kg) in factorial combination with four application frequencies (one, two, three, and four times). Treatment with no CE application was added to the experiment to serve as a control. These were laid out in Completely Randomized Design and replicated three times.

Data collection

Data were taken on weed flora composition, weed density, and weed weights (fresh and dry) in the 12th week by destructive sampling. The entire weeds growing in each pot were carefully removed, bulked, weighed, counted based on species before they were oven-dried at 80°C for 48 h, and subsequently weighed to obtain the dry weight of the weeds. The weed flora composition was identified with a handbook on West African weeds authored by Akobundu and Agyakwa (1998). The relative weed density was estimated as the number of weeds of the same species in a treatment to the total number of weeds in the treatment. In the 16th week, another destructive weed sampling was done on the second flush of weeds that emerged, and the same weed parameters taken from the first flush were obtained.

Data analysis

For the statistical analysis of the data obtained, IBM SPSS Statistics 23 software was utilized (George and Mallery, 2016). The data collected were subjected to Analysis of Variance (ANOVA) or descriptive analysis, as appropriate. The treatment means were separated using Duncan Multiple Range Test (DMRT) as a follow-up test at $P < 0.05$.

RESULTS

Effect of CE concentration and frequency of application on weed flora composition

The predominant species of weed that emerged in the first flush of the potting soil are *Cyperus rotundus* (L.), *Mitracarpus hirtus* (L.), *Panicum maximum* (L.), and *Tithonia diversifolia* (Hemsl) (Table 1). For the second flush, *Oldenlandia corymbosa* (L.), *Ageratum conyzoides* (L.), and *Boerhavia diffusa* (L.) were the predominant weed species. The weeds that emerged from the potting soil belong to 22 species and 12 families.

Table 1. Effect of CE concentration on weed species composition and density

			Weed density (count /pots)									
			First flush					Second flush				
		Growth	CE concentration (µg CN /kg soil)					CE concentration (µg CN /kg soil)				
Weed species	**Family**	**form**	**Control**	**60**	**120**	**180**	**240**	**Control**	**60**	**120**	**180**	**240**
Ageratum conyzoides	Asteraceae	ABL	2	8	2	2	1	12	15	26	7	14
Boerhavia diffusa	Nyctaginaceae	ABL	0	0	1	0	0	3	21	28	19	8
Celosia leptostachya	Amaranthaceae	ABL	9	10	3	4	2	0	0	0	0	0
Commelina erecta	Commelinaceae	ABL	1	0	1	0	1	1	0	1	0	2
Cyperus rotundus	Cyperaceae	PS	12	24	13	14	17	2	3	2	1	3
Eragrostis tenella	Poaceae	AG	0	0	0	2	0	0	0	0	0	0
Euphorbia heterophylla	Euphorbiaceae	ABL	3	3	3	1	4	0	0	1	6	1
Mariscus alternifolius	Cyperaceae	PS	1	0	3	3	1	0	0	0	0	0
Mitracarpus hirtus	Rubiaceae	ABL	53	50	32	21	11	10	8	12	12	11
Oldenlandia corymbosa	Rubiaceae	ABL	0	0	0	0	0	92	64	76	56	46
Oldenlandia herbacea	Rubiaceae	ABL	1	4	8	4	0	0	0	4	0	0
Panicum maximum	Poaceae	PG	36	49	36	44	21	1	5	1	1	1
Phyllanthus amarus	Phyllanthaceae	ABL	3	5	2	2	5	2	7	6	4	1
Tanium triangulare	Portulacaceae	PBL	0	1	3	1	0	0	2	0	5	0
Tithonia diversifolia	Asteraceae	ABL	28	38	22	13	2	4	1	7	3	3
Tridax procumbens	Asteraceae	ABL	1	0	5	3	0	1	1	1	0	3
Digitaria horizontalis	Poaceae	AG	5	6	7	15	8	2	4	3	4	6
Acalypha fimbriata	Euphorbiaceae	ABL	0	2	1	0	0	0	4	3	13	3
Centrosema pubescens	Fabaceae	ABL	1	0	0	0	0	0	1	0	1	1
Cynodon dactylon	Poaceae	PG	0	0	0	0	0	0	1	0	0	0
Euphorbia hirta	Euphorbiaceae	ABL	0	0	0	0	0	1	0	0	0	0
Fluerya aestuans	Urticaceae	ABL	0	0	0	0	0	0	0	1	1	0

ABL= Annual Broad Leaf, PBL= Perennial Broad Leaf, AG= Annual Grass, PG= Perennial Grass, PS= Perennial Sedges

Table 2. Effect of CE concentration on the relative density of weed species

	Relative density (%)									
	First flush					Second flush				
	CE concentration (µg CN /kg soil)					CE concentration (µg CN /kg soil)				
Weed species	**Control**	**60**	**120**	**180**	**240**	**Control**	**60**	**120**	**180**	**240**
Ageratum conyzoides	1.3	4.0	1.4	1.5	1.4	9.2	11.0	15.1	5.3	13.6
Boerhavia diffusa	0.0	0.0	0.7	0.0	0.0	2.3	15.3	16.3	14.3	7.8
Celosia leptostachya	5.8	5.0	2.1	3.1	2.7	0.0	0.0	0.0	0.0	0.0
Commelina erecta	0.6	0.0	0.7	0.0	1.4	0.8	0.0	0.6	0.0	1.9
Cyperus rotundus	7.7	12.0	9.2	10.9	23.3	1.5	2.2	1.2	0.8	2.9
Eragrostis tenella	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0
Euphorbia heterophylla	1.9	1.5	2.1	0.8	5.5	0.0	0.0	0.6	4.5	1.0
Mariscus alternifolius	0.6	0.0	2.1	2.3	1.4	0.0	0.0	0.0	0.0	0.0
Mitracarpus hirtus	34.0	25.0	22.5	16.3	15.1	7.6	5.8	7.0	9.0	10.7
Oldenlandia corymbosa	0.0	0.0	0.0	0.0	0.0	70.2	46.7	44.2	42.1	44.7
Oldenlandia herbacea	0.6	2.0	5.6	3.1	0.0	0.0	0.0	2.3	0.0	0.0
Panicum maximum	23.1	24.5	25.4	34.1	28.8	0.8	3.7	0.6	0.8	1.0
Phyllanthus amarus	1.9	2.5	1.4	1.6	6.9	1.5	5.1	3.5	3.0	1.0
Tanium triangulare	0.0	0.5	2.1	0.8	0.0	0.0	1.5	0.0	3.8	0.0
Tithonia diversifolia	18.0	19.0	15.5	10.1	2.7	3.1	0.7	4.0	2.3	2.9
Tridax procumbens	0.6	0.0	3.5	2.3	0.0	0.8	0.7	0.6	0.0	2.9
Digitaria horizontalis	3.2	3.0	4.9	11.6	11.0	1.5	2.9	1.7	3.0	5.8
Acalypha fimbriata	0.0	1.0	0.7	0.0	0.0	0.0	2.9	1.7	9.8	2.9
Centrosema pubescens	0.6	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.8	1.0
Cynodon dactylon	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0
Euphorbia hirta	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0
Fluerya aestuans	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.8	0.0

In the first flush, *Mitracarpus hirtus* had the highest relative density in the control treatment and potting soil treated with 60 µg CN / kg soil (Table 2). The relative density of *Mitracarpus hirtus* was lesser in potting soil treated with CE compared to the control treatment. In contrast, the relative densities of *Panicum maximum* and *Cyperus rotundus* were lower in the control treatment compared to CE treatments. The relative densities of *Mitracarpus hirtus* and *Tithonia diversifolia* decreased with an increasing concentration of CE.

Regardless that *Oldenlandia corymbosa* was absent in the first flush, it had the highest relative density in the second flush. Its relative density was higher in control treatment compared to CE treated soil. The second flush composition further showed that the relative density of *Mitracarpus hirtus* increased with an increasing CE concentration. Also, *Boerhavia diffusa* and *Acalypha fimbriata* had higher relative densities in CE treated soil than the control. The relative weed densities of *Panicum maximum* and *Cyperus rotundus* were higher in potting soil treated with 60 or 240 µg CN / soil kg and lesser in potting soil treated with 120 or 180 µg CN / kg soil compared to the control.

The CE application frequency influenced the relative density of weed species (Table 3). In the first flush, *Mitracarpus hirtus* and *Tithonia diversifolia* had lesser relative densities in potting soil where CE was applied once or up to four times compared to the control. In contrast, *Cyperus rotundus* had higher relative density in potting soil treated with CE once or up to four times. The relative density of *Panicum maximum* decreased with increasing frequency of CE application. However, CE applied four times or less had a relative density of *Panicum maximum* higher than the control.

Table 3. Effect of frequency of CE application on the relative density of weed species

Weed species	Relative density (%)									
	First flush					Second flush				
	CE application frequency (times)					CE application frequency (times)				
	Control	1	2	3	4	Control	1	2	3	4
Ageratum conyzoides	1.3	0.7	1.5	6.3	0.8	9.2	1.8	8.5	19.1	18.0
Boerhavia diffusa	0.0	0.7	0.0	0.0	0.0	2.3	14.9	18.9	10.9	11.8
Celosia leptostachya	5.8	6.6	5.2	1.4	0.8	0.0	0.0	0.0	0.0	0.0
Commelina erecta	0.6	0.0	0.8	0.0	0.8	0.8	0.0	0.0	0.0	1.9
Cyperus rotundus	7.7	8.1	11.2	17.4	13.1	1.5	1.2	2.8	0.9	1.9
Eragrostis tenella	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0
Euphorbia heterophylla	1.9	0.7	3.0	1.4	3.1	0.0	0.6	0.9	1.8	2.5
Mariscus alternifolius	0.6	2.9	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0
Mitracarpus hirtus	33.9	18.4	23.9	21.5	20.0	7.6	5.4	12.3	10.9	5.6
Oldenlandia corymbosa	0.0	0.0	0.0	0.0	0.0	70.2	67.3	38.7	25.5	37.3
Oldenlandia herbacea	0.6	2.2	0.0	7.6	1.5	0.0	0.0	0.0	0.0	2.5
Panicum maximum	23.1	37.5	26.9	23.6	23.3	0.8	0.0	2.8	3.6	0.6
Phyllanthus amarus	1.9	2.9	1.5	2.1	3.9	1.5	1.8	5.7	5.5	1.9
Tanium triangulare	0.0	0.0	2.2	0.0	1.5	0.0	1.2	0.0	0.	3.1
Tithonia diversifolia	18.0	11.0	16.4	12.5	15.4	3.1	1.8	0.9	5.5	2.5
Tridax procumbens	0.6	0.0	2.2	1.4	2.3	0.8	0.0	0.9	2.7	0.6
Digitaria horizontalis	3.2	6.6	4.5	2.8	12.1	1.5	1.8	2.8	1.8	5.6
Acalypha fimbriata	0.0	1.5	0.8	0.0	0.0	0.0	2.4	3.8	10.9	1.9
Centrosema pubescens	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.9	0.6
Cynodon dactylon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.6
Euphorbia hirta	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0
Fluerya aestuans	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2

In the second flush, the relative density of *Oldenlandia corymbosa* was higher in the control treatment than those treated with CE once or up to four times. In contrast, *Boerhavia diffusa* had lesser relative density in the control treatment than those treated with CE once or up to four times.

Effect of CE concentration on weed growth

The CE concentration significantly affected density, number of species, fresh weight, and dry weight of the first flush of weeds (Table 4). Potting soil treated with 60 µg CN / kg soil resulted in significantly increased weed density. In contrast, potting soil treated with the highest CE concentration, 240 µg CN / kg soil, significantly reduced weed density. Similarly, the CE concentration of 240 µg CN / kg soil significantly reduced the number of weed species. In contrast, lesser CE concentrations had a number of weed species similar to the control treatment. Potting soil treated with 60 µg CN / kg soil and 240 µg CN / kg soil had the highest (5.4) and the least (3.5) number of weed species, respectively.

The highest weed fresh weight (37.8g) resulted from potting soil treated with 180 µg CN / kg, and it was significantly higher than the control treatment. Potting soil treated with 60 µg CN / kg soil had the least fresh weight (27.5). It was comparable to the control treatment. Similarly, potting soil treated with 180 and 60 µg CN / kg soil had the highest (9.7g) and the least (6.8 g) weed dry weight, respectively. However, the weed dry weight that resulted from 180 µg CN / kg soil was comparable to the control treatment, while 60 µg CN / kg soil resulted in significantly reduced weed dry weight compared to the control treatment.

CE concentration had no significant effect on density, number of species, and dry weight of weeds in the second flush. However, its effect was significant on weed fresh weight where potting soil treated with 180 µg CN / kg soil had the highest weed fresh weight (7.81g) and was significantly higher than the control treatment that had the least (2.72g).

Table 4. Effect of CE Concentration on the weed species number, density, and weight

CE (µg CN/ kg)	First flush				Second flush			
	Weed density (plant/pot)	No of species	Weed fresh weight (g/pot)	Weed dry weight (g/pot)	Weed density (plant/pot)	No of species	Weed fresh weight (g/pot)	Weed dry weight (g/pot)
60	16.7a	5.4a	27.5b	6.8c	11.4	4.3	6.9a	1.3
120	11.8b	5.2a	34.1ab	9.2ab	14.3	4.1	6.3ab	1.1
180	10.8b	4.3ab	37.8a	9.7a	11.1	4.0	7.8a	1.3
240	6.1c	3.6b	33.3ab	8.4ab	8.6	3.3	5.2ab	0.9
Control	13.0b	5.2a	29.3b	8.4ab	10.9	3.1	2.7b	0.6

Means in a column followed by the same letter are not significantly different, according to DMRT (P = 0.05)

Table 5. Effect of frequency of CE application on the weed species number, density, and weight

Frequency	First flush				Second flush			
	Weed density (plant/pot)	No of species	Weed fresh weight (g/pot)	Weed dry weight (g/pot)	Weed density (plant/pot)	No of species	Weed fresh weight (g/pot)	Weed dry weight (g/pot)
1	11.3	4.5	40.0a	10.7a	14.0	3.4ab	5.5ab	0.9ab
2	11.2	4.8	35.0ab	8.2ab	8.8	3.8ab	6.1ab	1.0ab
3	12.0	4.4	29.3b	6.8b	9.2	3.8ab	7.1a	1.2ab
4	10.9	4.8	28.4b	8.3ab	13.5	4.8a	7.6a	1.5a
Control	13.0	5.2	29.3b	8.4ab	10.9	3.1b	2.7b	0.6b

Means in a column followed by the same letter are not significantly different, according to DMRT (P = 0.05)

Table 6. Interaction of CE concentration and frequency of application on the weed species number, density, and weight

Treatments		First flush				Second flush			
CE (µg CN /kg)	Frequency	Weed density (plant/pot)	No of species	Weed fresh weight (g/pot)	Weed dry weight (g/pot)	Weed density (plant/pot)	No of species	Weed fresh weight (g/pot)	Weed dry weight (g/pot)
60	1	16.3ab	5.7ab	29.7b-f	5.5cd	7.0	4.3ab	6.6ab	1.9
60	2	12.7b-d	5.7ab	24.9d-f	6.7b-d	15.0	5.0ab	8.0ab	1.0
60	3	21.7a	4.7ab	26.6c-f	7.1b-d	13.0	4.3ab	9.2ab	1.7
60	4	16.0ab	5.7ab	28.8b-f	7.8b-d	10.7	3.7ab	3.9ab	0.8
120	1	9.7b-e	6.3a	33.6b-e	9.8bc	20.7	5.7a	6.2ab	1.8
120	2	11.7b-e	4.3ab	35.4b-d	10.0bc	6.0	3.3ab	6.3ab	1.1
120	3	10.7b-e	6.0ab	33.9b-e	7.4b-d	11.3	3.7ab	5.8ab	0.9
120	4	15.3ab	4.0ab	33.5b-e	9.6bc	19.3	3.7ab	6.9ab	1.2
180	1	10.0b-e	4.0ab	42.0b	12.0ab	14.0	5.0ab	12.1a	2.0
180	2	14.0a-c	4.7ab	39.5bc	7.9b-d	9.0	4.0ab	8.0ab	1.6
180	3	10.3b-e	4.3ab	38.4b-d	9.2b-d	5.3	2.7ab	3.0b	0.5
180	4	8.7b-e	4.3ab	31.5b-f	9.8bc	16.0	4.3ab	8.1ab	1.1
240	1	9.3b-e	3.0b	54.6a	15.4a	12.0	4.3ab	5.4ab	1.1
240	2	6.3c-e	3.0b	40.2bc	8.3b-d	6.7	2.7ab	6.1ab	1.0
240	3	5.3de	4.3ab	18.4f	3.8d	5.7	4.3ab	6.2ab	1.0
240	4	3.3e	4.0ab	19.9ef	6.0cd	10.0	2.0b	3.0b	0.4
Control		13.0b-d	5.2ab	29.3b-f	8.4b-d	10.9	3.1ab	2.7b	0.6

Means in a column followed by the same letter are not significantly different, according to DMRT (P = 0.05)

Effect of frequency of CE application on weed growth

The CE application frequency did not significantly affect the density of weed in the first and second flushes (Table 5). Its effect was also not significant on the number of weed species in the first flush but was significant in the second flush. The fresh and dry weights of weeds in the flushes were significantly affected by the CE application frequency.

In the first weed flush, CE applied once resulted in significantly increased weed fresh weight compared to the control treatment. However, weed fresh weights from a higher frequency of CE application were comparable to the control treatment. The CE application frequency did not significantly increase or decrease weed dry weight compared to the control treatment. Cassava effluent applied once had the highest weed dry weight (10.7g), while three applications had the least (6.9 g).

In the second flush, the CE application frequency did not significantly reduce the number of weed species. In contrast, CE applied four times resulted in a significant increase in the number of weed species compared to the control treatment. Similarly, the CE application frequency did not significantly reduce the fresh and dry weights of weeds. Cassava effluent applied four times resulted in significantly increased weed fresh and dry weights.

Interaction of CE concentration and frequency of application on weed growth

Interaction of CE concentration and frequency of application was significant on the number of species and fresh weight of the first and second flushes of weeds (Table 6). It was also significant on the density and dry weight of the first flush of weeds, unlike the second flush.

In the first flush, 60 µg CN / kg soil, applied three times, had the highest weed density (21.7). It had a weed density that was significantly higher compared to the control treatment. In contrast, 240 µg CN / kg soil, applied four times, had the least weed density (3.3). It had a weed density that was significantly lesser compared to the control treatment. Interaction of CE concentration and frequency of application did not significantly increase or decrease the number of weed species compared to the control treatment. The CE concentration of 120 µg CN/ kg soil, applied once, had the highest number of weed species (6.3), while 240 µg CN / kg soil, applied once or twice, had the least (3.0). Interaction of CE concentration and frequency of application did not significantly reduce the fresh and dry weights of weed compared to the control treatment. In contrast, CE concentration of 240 µg CN / kg soil, applied once, significantly increased weed fresh and dry weights. The study showed that 240 µg CN / kg soil, applied three times, had the least fresh and dry weed weights.

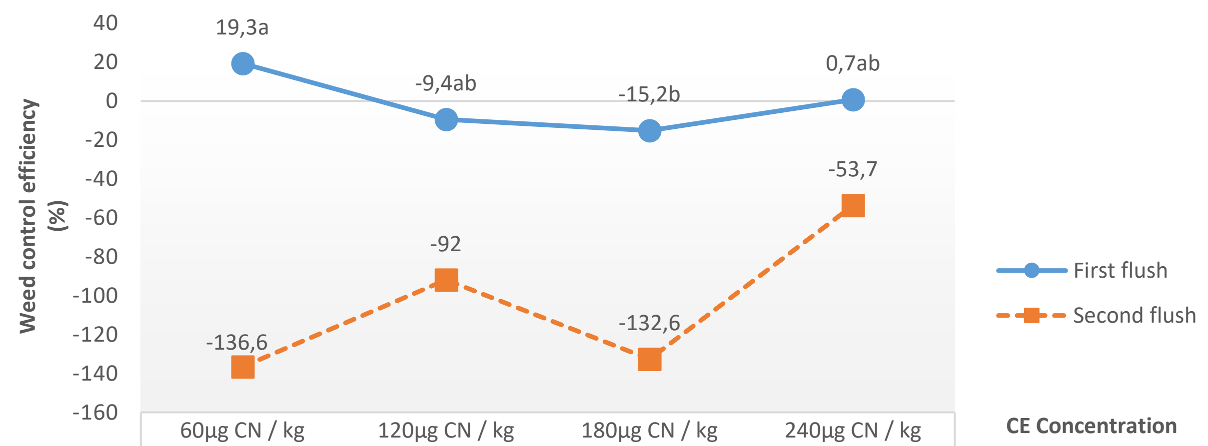
In the second flush, the interaction of CE concentration and frequency of application did not significantly increase or decrease the number of weed species. The result showed that 120 µg CN / kg soil, applied once, had the highest number of species (5.7), while 240 µg CN / kg soil, applied four times, had the least (2.0). Interaction of CE concentration and frequency of application did not significantly reduce weed fresh weight. In contrast, 180 µg CN / kg soil, applied once, had significantly increased weed fresh weight. Other treatment interactions of CE concentration and CE application frequency were similar to the control treatment for the weed fresh weight.

Effect of CE concentration and frequency of application on weed control efficiency (WCE)

Cassava effluent concentration significantly affected the WCE of the first flush of weeds (Figure 2). Potting soil treated with 60 or 240 µg CN / kg soil had positive WCE, while those treated with 120 or 180 µg CN / kg soil had negative WCE. The highest WCE resulted from potting soil treated with 60 µg CN / kg soil (19.3%), and it was significantly different from the treatment of 180 µg CN / kg soil that had the least (-15.15%). In the second weed flush, CE concentrations resulted in negative WCE and were not significantly different in this respect.

Similarly, the CE application frequency significantly affected the WCE of the first flush of weeds (Figure 3). CE applied once had negative WCE while an increase in the frequency of application up to four times resulted in positive WCE. Three applications of CE had the highest WCE (18.4%), while CE applied once had the least (-26.7%). In the second weed flush, the frequency of the CE application did not significantly influence the WCE. Cassava effluent applied four times or less resulted in negative WCE, which decreased with increasing CE application frequency.

The interaction of CE concentration and application frequency was significant on the WCE of the first flush of weeds. However, it was not significant on the WCE of the second flush of weeds (Figure 4). The cassava effluent concentration of 240 µg CN / kg soil, applied once and three times, had the least (-83.3%) and the highest (55.3%) WCE, respectively. In contrast, 240 µg CN / kg soil, applied once, had the highest WCE (26.8%) in the second flush. Cassava effluent of 180 µg CN / kg soil, applied twice, had positive WCE in both first and second weed flush.



	60µg CN / kg	120µg CN / kg	180µg CN / kg	240µg CN / kg
First flush	19,3	-9,4	-15,2	0,7
Second flush	-136,6	-92	-132,6	-53,7

Figure 2. Graph showing the effect of CE concentration on weed control efficiency
Means followed by the same letter are not significantly different, according to DMRT (P = 0.05)

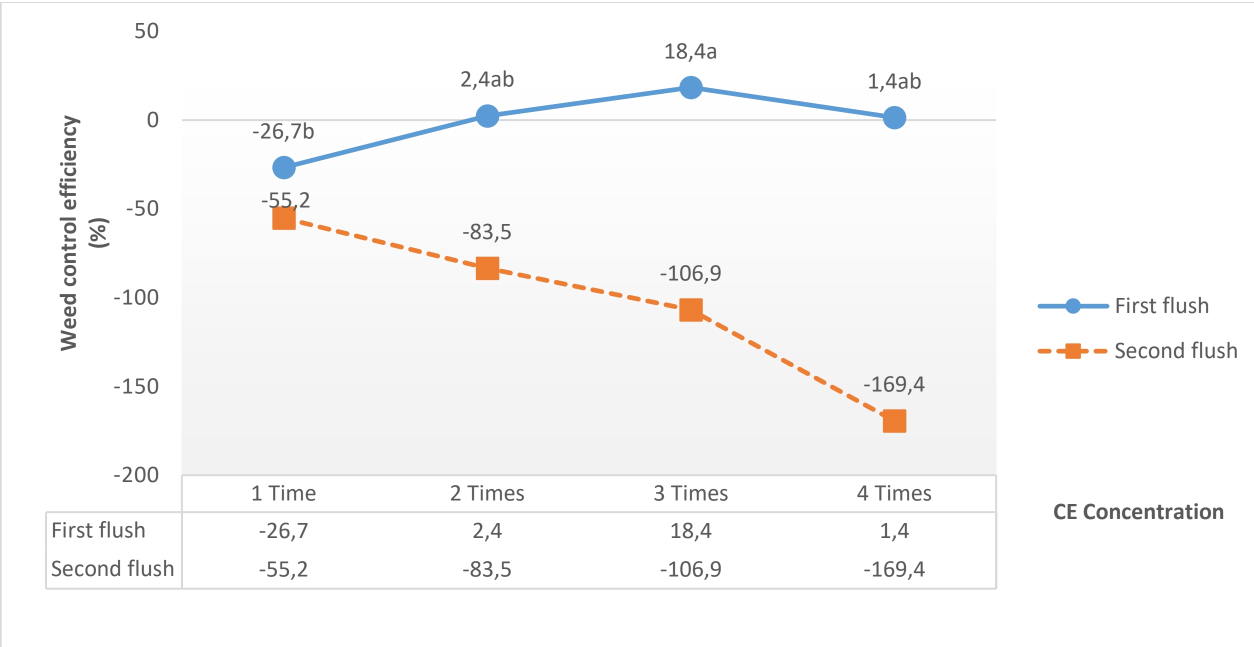


Figure 3. Graph showing the effect of frequency of CE application on weed control efficiency
Means followed by the same letter are not significantly different, according to DMRT (P = 0.05)

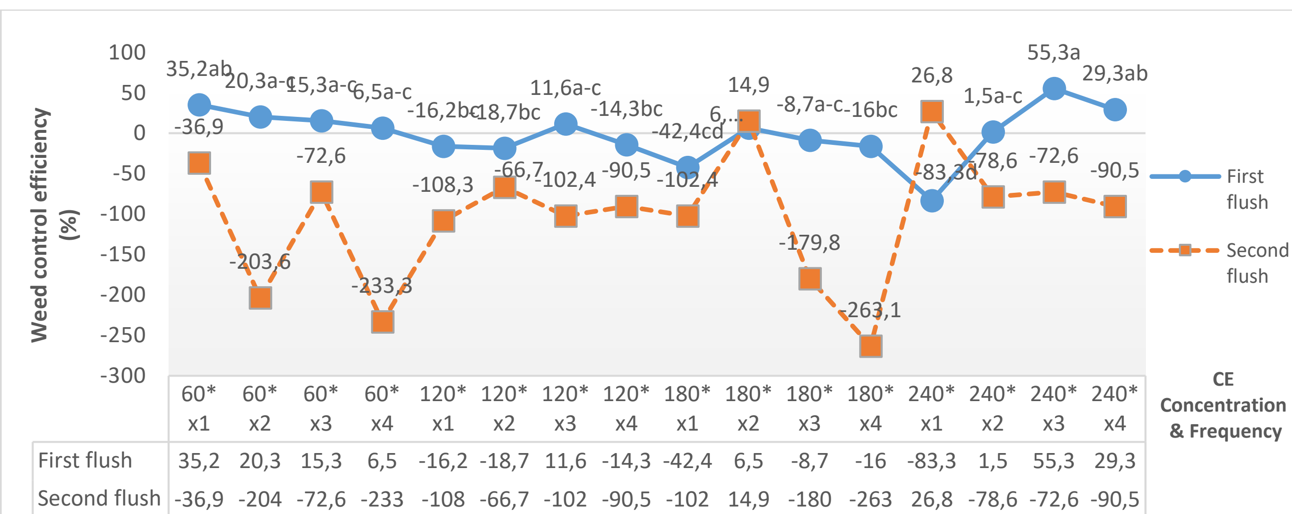


Figure 4. Graph showing the interaction of CE concentration and frequency of application on weed control efficiency
Means followed by the same letter are not significantly different, according to DMRT (P = 0.05). * = µg CN /kg soil

DISCUSSION

Effect of CE on weed flora composition

Previous studies reported the weed composition of the rainforest-savanna transition agro-ecological zone of Nigeria (Aluko *et al.*, 2015; Akadiri *et al.*, 2017). The emergence of weed species such as *Ageratum conyzoides*, *Boerhavia diffusa*, *Centrosema pubescens*, *Cyperus rotundus*, *Euphorbia hirta*, *Mariscus alternifolius*, *Panicum maximum*, *Phyllanthus amarus*, *Tanium triangulare*, and *Tridax procumbens* from the soil sourced from this zone aligned with earlier reports.

The reduced relative density of a weed species due to the CE application indicates that the prevailing concentration or application frequency can control the species. The relative density of *Mitracarpus hirtus* that decreased in the first flush with increasing CE concentration was an indication that the weed species is susceptible to the CE concentrations used in this study, and it can be effective for its control.

The increase in the relative weed densities of *Panicum maximum* and *Cyperus rotundus* in the first weed flush that emerged from the CE treated soil indicates that these species are tolerant of the CE concentrations applied. The increased relative weed densities could be due to increased density, a decrease in the susceptible weed species' density, or both. Hence, 60 to 240 µg CN/ kg soil was not effective in controlling these species. This finding agrees with Fayinminnu (2014) that CE's use was not effective in controlling *Panicum maximum*. This study further provided information that the earlier reported decrease in the weight of *Cyperus rotundus* resulting from the addition of CE (Fayinminnu, 2014) does not reduce its density at a concentration of 60 to 240 µg CN / kg soil. Hence, the continuous use of these CE concentrations on fields that have *Panicum maximum*, *Cyperus rotundus,* and susceptible weed species could lead to weed-shift over time (Liebman and Davis, 2000).

The absence of *Oldenlandia corymbosa* in the first flush and its subsequent emergence in the second flush indicate that its seeds were dormant in the soil (Lefebvre *et al*., 2018). The decrease in its relative density in CE treated soil was an indication that the pre-emergence application of CE concentrations used in this study was effective for its control. The relative density of *Mitracarpus hirtus* that increased with increasing CE concentration in the second flush did not follow the same trend with its density across the concentrations. Thus, this suggests that the influence of increasing CE concentration on the density of susceptible weed species may be responsible for the observed increase.

This study showed that post-emergent application of CE done once or up to four times could be adopted to reduce the density of *Mitracarpus hirtus* and *Tithonia diversifolia* since these application frequencies decreased the relative density of these weed species compared to the control. This finding agrees with Naseem et al. (2009) that allelopathic extracts application frequency significantly affects its weed control potentials. However, repeated CE application may not be justifiable for these weed species since their relative density in potting soil treated with CE once was less than those with repeated applications.

Pre-emergence application of CE done once or up to four times reduced the relative density of *Oldenlandia corymbose* in a manner that repeated application is justifiable, as it reduced the relative density of this species further. In contrast, CE applied one to four times was not effective in reducing the relative density of *Cyperus rotundus.* This finding corroborates the report of Fayinminnu (2014) that the weed control ability of CE is selective.

Considering that the relative density of *Panicum maximum* was lesser in the control treatment than the CE treatments, the reduction in the relative density of *Panicum maximum* resulting from increasing CE application frequency is inconsequential. The increased relative density of *Boerhavia diffusa* in the second flush suggests that CE concentration and application frequency may have the ability to break seed dormancy. The cyanide present in CE could be responsible for this attribute (Flematti *et al.*, 2011).

Effect of CE on weed growth

This study showed that CE applied to the soil at 60, 120, 180, and 240 µg CN / kg may not generally provide a reliable weed control since none of the CE concentrations reduced both the weeds' density and weight. This finding disagrees with the report of Fayinminnu (2014) that CE caused a reduction in both weed density and weed biomass. The disparity could be due to the emergence of different weed species and different CE concentrations in the studies. Hence, the sole use of CE for non-selective weed control is not advisable.

The second flush of weeds with comparable density, number of species, and dry weight across the CE concentrations and control treatment suggest that the CE concentrations have poor herbicidal persistence. The increase in weed fresh weight that resulted from the addition of 180 µg CN / kg soil suggests that this CE concentration modifies plant-water relations in the second flush. This attribute could be due to CE's ability to alter soil pH (Ayodele and Oladele, 2020). Moreso, soil pH plays a substantial role in plant water uptake (Long et al., 2017).

The first flush of weeds from all the CE application frequencies and the control treatment with a comparable number of species and density suggests that all the CE application frequencies evaluated in this study were ineffective for weed control. This finding disagrees with the report of Cheema and Khaliq (2000) that weed density reduced with increasing application of allelopathic extract.

Also, the weights of the first flush of weeds from all the CE application frequencies that were not lesser than the control treatment further corroborates the ineffectiveness of these application frequencies for weed control. Cassava effluent's inability to effectively control weed at these application frequencies could be due to modified soil nutrients (Ayodele and Oladele, 2020) and selective weed control (Fayinminnu, 2014), which promote the growth of non-susceptible weed species.

The significant interaction of CE concentration and application frequency on weed growth parameters implies that these factors can influence weed growth in a manner related to their combination level. For instance, a CE concentration of 240 µg CN / kg soil, applied four times, exercised control on the density of the first flush of weeds. However, the lack of concomitant decrease in the weight and absence of herbicidal effect on the second flush are the defects.

The highest WCE that resulted from CE application frequencies and concentrations that were 18.4% and 19.3%, respectively, are low. These may not be adequate to achieve high crop yield since the WCE and weed index relationship is inverse (Girothia and Thakur, 2006). The highest WCE (55.3%) from CE concentration and application frequency interactions obtained from 240 µg CN / kg soil, applied three times, may not have a comparative advantage over existing weed control methods with more WCE in a single application. However, it may serve as a complementary weed control approach where the cost of application is reasonable. The negative WCE obtained in the second flush, concerning CE concentration, frequency of application, and interactions, implies that CE may later promote weed growth.

CONCLUSION

Cassava effluent selectively controls weeds based on species. Hence, its use for non-selective control in a weed population of high heterogenicity is inappropriate. Weed species such as *Mitracarpus hirtus* and *Tithonia diversifolia* can be controlled effectively with increasing CE concentration and application frequency. Cassava effluent of 240 µg CN / kg soil, applied four times, effectively reduced weed density.

REFERENCE

Akobundu I.O. and Agyakwa C.W. (1998). *A Handbook of West African Weeds*. Ibadan. International Institute of Tropical Agriculture, Pp 162.

Akadiri M., Ayodele O. and Aladesanwa R. (2017). Evaluation of Selected Post-Emergence Herbicides for Weed Management in Maize at Different Agroecological Zones of Nigeria. *World Journal of Agricultural Research, 5*(5), 258-264.

Aluko O., Oyebola T. and Taiwo S. (2015). Effect of cultural practices on weed flora composition of selected field crops. *European Journal of Agriculture and Forestry Research,* 3(4): 29-37.

Ayodele O.P and Oladele S.O. (2020). Screening of cassava effluent-a proposed weed biocontrol agent for its effect on soil nutrients and microbial population. *Soil & Environment.* 39(1): 106-115.

Burns A.E., Gleadow R.M., Zacarias A.M., Cuambe C.E., Miller R.E. and Cavagnaro T.R. (2012). Variations in the chemical composition of cassava (*Manihot esculenta* Crantz) leaves and roots as affected by genotypic and environmental variation. *Journal of Agricultural and Food Chemistry,* 60(19): 4946-4956.

Caiati C., Pollice P., Favale S., and Lepera M. E. (2020). The herbicide glyphosate and its apparently controversial effect on human health: An updated clinical perspective. *Endocrine, Metabolic & Immune Disorders-Drug Targets* 20(4), 489-505.

Cheema Z. and Khaliq A. (2000). Use of sorghum allelopathic properties to control weeds in irrigated wheat in a semi-arid region of Punjab. *Agriculture, Ecosystems and Environment,* 79 (2-3): 105-112.

China-Cambodia-UNDP (2015). *Cassava Handbook.* China-Cambodia-UNDP Trilateral Cooperation Cassava Project Phase II, Phnom Penh, Cambodia. Pp 111.

Dasberg S., and Mendel K. (1971). The effect of soil water and aeration on seed germination. *Journal of Experimental Botany,* 22(4): 992-998.

Eze V.C. and Onyilide D.M. (2015). Microbiological and physicochemical characteristics of soil receiving cassava effluent in Elele, Rivers State, Nigeria. *Journal of Applied and Environmental Microbiology,* 3(1): 20-24.

Fayinminnu O. (2014). Phytotoxicity and mode of application of crude cassava water extract as a natural herbicide on weeds of cowpea (*Vigna unguiculata* (L.) Walp). *International Journal of Organic Agriculture Research and Development,* 9: 108-131.

Fayinminnu O.O., Fadina O.O. and Adedapo A.A. (2013). Screening of chemical composition of crude water extract of different cassava varieties. *Annals of West University of Timisoara, Ser. Biology,* 16(1): 61-66.

Flematti G.R., Merritt D.J., Piggott M.J., Trengove R.D., Smith S.M., Dixon K.W. and Ghisalberti E.L. (2011). Burning vegetation produces cyanohydrins that liberate cyanide and stimulate seed germination. *Nature Communications*, 2(360): 1-6.

George D. and Mallery P. (2016). *IBM SPSS statistics 23 step by step: A simple guide and reference*. 14th edition, Routledge, New York. Pp 400.

Girothia O. and Thakur H. (2006). Efficacy of post-emergence herbicides for weed management in soybean [*Glycine max* (L.) Merrill] in Vertisols. *Soybean Research* 4: 20-23.

Iqbal N., Khaliq A. and Cheema Z.A. (2020). Weed control through allelopathic crop water extracts and S-metolachlor in cotton. *Information Processing in Agriculture*, *7*(1), 165-172

Khaliq A., Matloob A., Khan M. and Tanveer A. (2013). Differential suppression of rice weeds by allelopathic plant aqueous extracts. *Planta Daninha*, *31*(1), 21-28.

Khan F., Khalil S., Rab A., Khan I. and Nawaz H. (2017). Allelopathic potential of sunflower extract on weeds density and wheat yield. *Pakistan Journal of Weed Science Research*, *23*(2): 221 -232.

Kremer R., and Souissi T. (2001). Cyanide production by rhizobacteria and potential for suppression of weed seedling growth. *Current microbiology*, 43(3): 182-186.

Lefebvre M., Leblanc M. L. and Watson A.K. (2018). Seed dormancy and seed morphology related to weed susceptibility to biofumigation. *Weed Science*, 66(2): 199-214.

Liebman M. and Davis A.S. (2000). Integration of soil, crop, and weed management in low-external-input farming systems. *Weed Research-Oxford*, *40*(1), 27-48.

Long A., Zhang J., Yang L., Ye X., Lai N., Tan L., Lin D. and Chen L. (2017). Effects of low pH on photosynthesis, related physiological parameters, and nutrient profiles of citrus. *Frontiers in plant science*, 8 (185) 1-8.

Naseem M., Aslam M., Ansar M. and Azhar M. (2009). Allelopathic effects of sunflower water extract on weed control and wheat productivity. *Pakistan Journal of Weed Science Research*, 15(1): 107-116.

Negash F., and Mulualem T. (2014). The effect of ploughing, fertilizer application, and weeding frequency on field pea (*Pisum sativum* L.) production at Angacha, South Ethiopia. *Time Journals of Agriculture and Veterinary Sciences*, 2(7): 125-31.

Nwakaudu M.S., Kamen F.L., Afube G., Nwakaudu A.A. and Ike I.S., 2012. Impact of cassava processing effluent on agricultural soil: A case study of maize growth. *Journal of Emerging Trends in Engineering and Applied Sciences*, *3*(5): 881-885.

Nwaogu L.A., Agha N.C., Alisi C.S. and Ihejirika C.E. (2011). Investigation on the effect of cassava effluent-polluted soil on germination, emergence, and oxidative stress parameters of *Telferia occidentalis*. *Journal of Biodiversity and Environmental Sciences*, 1(6): 104-111.

Mangao A. M., Arreola S. L., San Gabriel E.V. and Salamanez K.C. (2020). Aqueous extract from leaves of *Ludwigia hyssopifolia* (G. Don) exell as potential bioherbicide. *Journal of the Science of Food and Agriculture*, 100(3):1185-1194.

Perveen S., Yousaf M., Mushtaq M., Sarwar N., Khaliq A. and Hashim S. (2019). Selective bioherbicidal potential of *Delonix regia* allelopathic leaf extract on germination and seedling growth of field bindweed and wheat. *Applied Ecology and Environmental Research*, 17(1), 511-519.

Saif, H.B., Bari, M.N., Islam, M.R., and Rahman, M.A. (2016). Allelopathic potential of sunflower extract on weed control and wheat yield under subtropical conditions. *International Journal of Applied Agricultural Sciences*, 2 (4), p.44.

Sunar S. and Agar G. (2017). Allelopathic effect of *Convolvulus arvensis* L. extracts on the phytohormones and cytological processes of *Zea mays* L. seeds. *European Journal of Experimental Biology*, 7(3): 1-6.

Sun B., Kong C.-H., Wang P. and Qu R. (2012). Response and relation of allantoin production in different rice cultivars to competing barnyard grass. *Plant Ecology* 213: 1917 - 1926.

Surleva A., Zaharia M., Ion L., Gradinaru R.V., Drochioiu G. and Mangalagiu I. (2013). Ninhydrin-based spectrophotometric assays of trace cyanide. *Acta Chemica IASI*, *21*(1): 57-70.

Geliş Tarihi/ Received:Haziran/June, 2020
Kabul Tarihi/ Accepted: Ekim/October, 2020

To Cite : Ayodele OP. (2020). Screen-House Evaluation of Weed Suppression Potential of Cassava Effluent at Varied Frequency of Application and Cyanide Concentration. Turk J Weed Sci, 23(2):125-136.
Alıntı için : Ayodele OP. (2020). Screen-House Evaluation of Weed Suppression Potential of Cassava Effluent at Varied Frequency of Application and Cyanide Concentration. Turk J Weed Sci, 23(2):125-136.