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PHYTOSOCIOLOGICAL CHARACTERISTICS OF THE PREDOMINANT WEEDS IN CALABAR AS INFLUENCED BY CASSAVA DENSITY AND SOIL SOLARIZATION DURATION

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ABSTRACT

Field experiments were conducted in the 2019 and 2020 early cropping seasons in the Teaching and Research Farm, Department of Crop Science Teaching and Research Farm, University of Calabar, to identify the predominant weeds and assess their responses to cassava population density integrated with pre-planting soil solarization duration. The experiment was a factorial combination of three crop densities of cassava: 17,778 plants ha^{-1} (0.75 m x 0.75 m), 13,333 plants ha^{-1} (0.75 m x 1 m) and 10,000 plants ha^{-1} (1 m x 1 m) and four pre-planting soil solarization durations (0, 4, 7 and 10 weeks), laid out in randomized complete block design (RCBD) with three replications. Data were collected on the phytosociological characteristics at four weeks intervals up to the 20th week. The relative density, frequency and abundance of the weed species varied across treatments in both years. *C. bicolor* consistently had the highest relative important value index reaching up to 57.2 % in the plot treated with 17,778 cassava plants ha^{-1} integrated with pre-planting soil solarization for 10 weeks, followed by *P. maximum, A. compressus* and *C. dactylon* in that order. *Aspillia bussei*, *A. conyzoides*, *P. amarus* and *T. rhomboidea* had zero percent important value index when soil solarization duration of 10 weeks was integrated with crop density of either 17,778 plants ha^{-1} or 13,333 plants ha^{-1} of cassava. The important value index of *C. bicolor* consistently increased as cassava density and solarization duration increased, while those of the other weed species tended to decline. The integration of cassava density at 17,778 plants ha^{-1} with soil solarization duration of 10 weeks effectively controlled most of the weed species in the area except *C. bicolor* and could be recommended for effective weed suppression.

Keywords: Predominant weeds; solarization; cassava density; phytosociological characteristics

INTRODUCTION

Weed remains a major biotic constraint to crop production around the world, leading to significant yield reductions in quality and quantity of crop produce (Cardoso *et al*., 2013;

Nedunchezhiyan *et al*., 2017; Onasanya *et al*., 2021). Weeds compete with cultivated food crops for limited growth resources such as nutrients, light and moisture (Nwagwu *et al*., 2016). The infestation of weeds in crop farms increase the cost of production as extra expenses would be incurred to checkmate them. Some weeds, especially the grasses constitute risk of fire hazards in forest reserves and plantation crops (Oudhia, 2004). Weed seeds can contaminate the grains of cereals and legumes, thereby causing reduction on their market value (Nwagwu *et al*., 2016). Some weeds can harbour disease pathogens and insect pests and can form barriers that obstruct harvesting operations (Adesina *et al*., 2012). Significant yield loses due to weed interference has been reported in several crops. In cassava, tuberous yield losses resulting from weed infestation have been reported to range from 46 % in Thailand (Melifonwu, 1994) to 95 % in Nigeria (Albuquerque *et al*. 2012). Soltani *et al*. (2020) reported 81 % yield loss in *Phaseolus vulgaris* L. (white beans) in North America. In other crops, yield losses due to weed infestation include, 25 % in maize (Oerke, 2006), 40 – 50 % in wheat (Oad *et al*., 2007), 70 % in peanut (Abudulai *et al*., 2017), and 31 % in soybean (Chauhan, 2020).

Crop yield losses as a result of weed interference depend on such factors as weed phytosociological characteristic, weed types present, time of the emergence of weeds relative to crops, crop type, the prevailing cultural practices and the period in which the crop and weeds coexisted (Silva *et al*., 2012). A 100 % crop yield loss could result if the coexistence period between crop and weeds remained unchecked (Chauhan, 2012; Llewellyn *et al*., 2016; Gharde *et al*., 2018). Therefore, identifying the weed species and finding the most dense and frequent species is necessary to understanding the species with the greatest potentials in the area and aggressively interfere with the cultivated crop.

Studies on weed phytosociological characteristics is very essential if we are to understand weed species mixture in a cropping environment and the behavior of each species to the prevailing cultural practice in the area, which will help in developing a sustainable weed management strategy (Chauhan, 2020). *According to Sinha* (2017*), Phytosociological study of weeds provides insight into the dynamics and relative importance of each weed species predominant in a particular Phyto-society or across Phyto-societies which is very important in understanding crop-weed ecosystem and provides a guide to taking effective weed management decisions.* Phytosociology also known as plant sociology is the study of groups of species of plant that are found together (Dengler *et al.*, 2008). The major phytosociological characteristics of weed species studied are absolute density, frequency, abundance; relative frequency, density, abundance and importance value index of each species component of the vegetation in the cropped area (Gomes *et al*., 2010). These phytosociological parameters show the species richness in the area and how each species relates with the others within the area, while the importance value index (IVI) indicates the species of utmost importance in the area under investigation (Dos Santos *et al.*, 2015). The absolute density measures the exact number of each species comprising the weed community in a unit area. Absolute frequency is the number of times each of the constituent species occur against the number of sampling or the rate of dispersal of each species (Sinha, 2017). Absolute abundance measures a species richness in each sampling unit that it occurred (Khan *et al.*, 2014). The relativity of the species indicates how each species relates to the other species in terms of density, frequency and abundance within the studied area. The relative values are expressed as percentages and could be determined by dividing the absolute value of each species by the sum of the absolute values of all the species comprising the weed community and multiplying the result by 100 (Maszura *et al*., 2018). Understanding the abundance, distribution and severity of each predominant weed species over time in a given cropping environment would be helpful in predicting changes in the weed community in response to cultural practices and agro-climatic conditions of the area (Nkoa *et al.*, 2015).

Cropping systems or patterns of arranging crop stands and the nature of crops have been reported to influence the presence and distribution of weed species in a cropped area (Sit *et al.*, 2007). Any strategy that utilizes crop arrangement to checkmate weed interference in cropped field can be regarded as a sustainable weed management technique. Such strategies increase the competitiveness of crops, thereby reducing the aggressiveness of weeds and the deleterious effects they would have on the cultivated crop (Gibson *et al*., 2002). The competitiveness of crops can be enhanced by using crop cultivars that are highly competitive, precisely applying nutrients where crops can access it faster than weeds, adjusting crop direction, increasing seed rate and reducing the spaces between crop stand (Chauhan, 2020). A crop cultivar that establishes very fast with profuse branching can significantly reduce the establishment of weed species and the negative effects they would have on the yield of the crop (Mashingaidze *et al*., 2009; Chauhan, 2012). However, these techniques need to be integrated with other environmentally friendly weed management methods such as solarization to achieve effective weed control (Chauhan, 2020).

High temperatures are inimical to living tissues and have been reported to alter physiological processes in plants leading to desiccation and death (Chauhan, 2020). There are several ways heat could be applied to kill weeds such as steam (Rask and Kristoffersen, 2007), electrocution (Chauhan, 2020), laser radiations (Mathiassen *et al*., 2006), direct flaming (Knezevic *et al*., 2011), microwaves (Brodie *et al*., 2007) and solarization (Nwagwu *et al*., 2016). Solarization which has been demonstrated to effectively reduce weed growth (Ashrafuzzaman *et al*., 2011; Horowitz *et al.*, 2017) and improve yield of many crops (Golzardi *et al.*, 2014; Nwagwu *et al*., 2016) could be integrated at pre- planting or at planting with other methods such as plant canopy management to enhance the efficacy, timeliness and cost-effectiveness of weed control. Soil solarization is a unique mulching precept, whereby a polythene film is used to cover a wet soil and allowed to be heated by the sun for many days (Nwagwu *et al*., 2016). It is employed in soil thermic sterilization, which is achieved when a wet soil is covered with polythene. This results in the production of a greenhouse effect, whereby the soil temperature increases to levels lethal or injurious to soil-borne organisms including weed seeds and seedlings (Pathel *et al.*, 2005). The impacts are higher in wet soils; therefore, the success is dependent on moisture for maximum heat transfer to soil borne microorganisms and weed seeds (Pokharel, 2010). This experiment was therefore conducted to identify the predominant weeds in cassava farm in Calabar and assess their responses to cassava population density integrated with preplanting soil solarization periods.

MATERIALS AND METHODS

Study Location

The experiment was conducted at the Teaching and Research Farm of the Crop Science Department, University of Calabar. Calabar is located in the southeastern rainforest agro-ecological zone of Nigeria (4.5^{0}N - 5.2^{0}N, 8.3^{0}E - 9.0E), about 39 m above sea level and has a bimodal annual rainfall distribution that ranges from 3,000 mm to 3,500 mm with mean annual temperature range of 27 to 35 ^{0} C and relative humidity of 75 to 88 % (Efiong, 2011). The experimental site was in secondary vegetation following a two-year fallow period having been previously used for cassava cultivation. The predominant weed species before land preparation were *Panicum maximum* Jacq., *Calapogonium mucunoides* Desv., *Ageratum conyzoides* L., *Caladium bicolor* Vent., *Triumfetta rhomboidae* Jacq and many shrubs. The existing vegetation was cleared with machete and the debris packed using rake. The field was tilled to a depth of 20 – 30 cm using spade and then demarcated into thirty-six (36) uniform experimental units to meet the design specifications.

Experimental Design and Layout

The experiment was a 3 x 4 factorial, consisting of three levels of crop densities of cassava: 17,778 plants ha^{-1} (0.75 m x 0.75 m), 13,333 plants ha^{-1} (0.75 m x 1 m) and 10,000 plants ha^{-1} (1 m x 1 m) and four levels of pre-planting soil solarization durations (0, 4, 7 and 10 weeks). The twelve treatment combinations were laid out in randomized complete block design (RCBD) and replicated three times, bringing the total number of plots to 36. Each experimental unit measured 4 m x 5 m with 0.5 m paths between experimental units and 1 m paths between blocks. An experimental area measuring 38 m x 29.5 m equaling 1121 m^2 was used for the trial.

Procedure for soil solarization: Polyethylene sheets measuring 5.5 m x 4.5 m were spread over the surface of already prepared seedbeds measuring 5 m x 4 m. The polyethylene sheets were applied at 333 kg ha^{-1}. The edges of the polyethylene sheets were buried 10 – 15 cm into the soil to prevent them from being blown away by the wind. The plots for 10 weeks solarization were laid with polyethylene sheet first, three weeks later, the 7 weeks solarization plots were covered, while the plots for the 4 weeks were covered at the beginning of the seventh week from the inception. Finally, on the tenth week, all the polyethylene sheet materials were removed, and the cassava cuttings planted. The unsolarized plots were not covered with polyethylene sheet. The solarization commenced on the 2nd of March and ended on the 11th of May in each year (2019 and 2020). Non branching cassava cultivar (TME 419) stem cuttings of 20 – 25 cm length with 4 – 7 nodes each were inserted in a slanting position into the soil, 1 m x 1 m, 1 m x 0.75 m and 0.75 m x 0.75 m apart according to treatments, immediately after the removal of the solarization materials on the 11th of May each year of planting. The cuttings were planted one cutting per stand giving a total of 20, 25 and 35 plants plot^{-1} respectively and 10,000; 13,333 and 17,778 plants ha^{-1}, accordingly. About 40, 53 and 71 bundles of 50 stems of cassava each were used per hectare, accordingly.

Data Collection and Analysis

Weed assessment was conducted every four weeks for a period of 20 weeks beginning from 4 weeks after planting (WAP). Sampling was achieved by placing a detachable wooden quadrat measuring 1 m x 1 m at random on two locations per treatment unit and the total number of weeds present within the quadrat were harvested, sorted into species and recorded. Weeds were botanically identified by analyzing their external morphological characteristics using a weed identification handbook by Akobundu *et al*. (2014). The total number of each weed species was recorded separately for each treatment unit at each sampling period and was used to determine the phytosociological attributes of each weed species at the end of the sampling period. The phytosociological structures of the weeds were assessed as outlined by Sinha and Banerjee (2016), and Sinha (2017) which included:

Absolute Density: This is the total number of individuals of a species per unit area (m^{-1}). This was determined by counting the total number of individuals of a species obtained in all quadrants thrown, divided by the number of throws and then multiplied by the area of the quadrant. It is mathematically expressed as:

$$\text{Absolute density} = \frac{\text{Total number of individuals of a species in all quadrats}}{\text{Total number of quadrants studied x area in m}^2\text{ of a quadrat}}$$

Relative Density (RD): This is the numerical strength of a species in relation to the total number of individuals of all species. It is expressed in percentage. It is mathematically expressed as:

$$\text{Relative density } (\%) = \frac{\text{Total number of individuals of a species in all quadrats}}{\text{sum of all absolute densities}}\ x\ 100$$

Absolute frequency: the absolute frequency of individual weed species was determined as the number of quadrats with a species presence divided by the total number of quadrats studied, mathematically expressed as:

$$\text{Absolute Frequency} = \frac{\text{Number of quadrats with species presence}}{\text{Total number of quadrats used}}$$

Relative frequency (RF): the relative frequency of individual weed species was determined as a species absolute frequency divided by the sum of all absolute frequencies multiplied by 100, mathematically expressed as:

$$\text{Relative Frequency } (\%) = \frac{\text{Species absolute frequency}}{\text{Sum of all absolute frequencies}}\ x\ 100$$

Absolute Abundance: The absolute abundance of individuals of the different weed species present per unit area of occurrence was determined as total number of each weed species comprising the flora in all quadrats divided by the total number of quadrats in which the species occurred:

$$\text{Absolute abundance} = \frac{\text{Total number of individuals of a species in all quadrats}}{\text{Total number of quadrats in which the species occurred}}$$

Relative Abundance (RA): This refers to the evenness of distribution of individuals among species in a community. It is mathematically expressed as:

$$\text{Relative Abundance } (\%) = \frac{\text{Species absolute abundance}}{\text{Sum of all absolute abundances}}\ x\ 100$$

Importance Value Index (IVI): The IVI is used to find the overall importance of each species in a biotic community. To obtain the IVI of each species, the relative density (RD), relative frequency (RF) and relative abundance (RA) are added up together. Thus, $\text{Importance Value Index} = \text{RD} + \text{RF} + \text{RA}$

RESULTS AND DISCUSSION

Relative Density

The relative densities of the predominant weed species in the cropped area as influenced by cassava density and pre-planting soil solarization duration in 2019 and 2020 cropping seasons are presented in Tables 1 and 2, respectively. The relative density of the weed species varied across treatments in both years. The relative density of *Caladium bicolor* consistently increased while that of the other weed species tended to decline as the solarization duration increased. *C. bicolor* maintained the highest relative density in both years with moderate status across treatments in 2019 to dense status in D_1S_{10} in 2020. *Axonopus compressus*, *C. bicolor, Cleome rutidosperma*, *Cynodon dactylon*, *Gloriosa superba*, *Kylinga bulbosa*, *Kylinga erecta,* and *Panicum maximum* were all moderate species with relative densities between 5 and 25 % across the treatments in both years. *Aspilia bussei*, *Ageratum conyzoides*, *Phyllantus amarus* and *Triumfetta rhomboidea* were rare species with relative densities less than 1 % in plots with cassava populations of 17,778 and 13, 3333 plants ha^{-1} solarized for 10 weeks pre-cropping in 2020, but occasional species in the other treatment combinations. *Calapogonium mucunoides*, *Eragrostis ciliaris*, *Euphorbia heterophylla*, *Ipomoea involuncrata*, *Mitracarpus villosus* and *Oldenlandia herbacea* attained between occasional and scattered status across the treatments.

The predominant weeds in the area were *A. conyzoides*, *A. bussei*, *A. compressus*, *C. bicolor*, *C. mucunoides*, *C. rutidosperma*, *C. dactylon*, *E. ciliaris*, *E. heterophylla*, *G. superba*, *I. involuncrata*, *K. bulbosa*, *K. erecta*, *M. villosus*, *O. herbacea*, *P. maximum*, *P. amarus* and *T. rhomboidea*. These weeds are similar to those earlier listed by Binang *et al*. (2016) and Shiyam *et al*. (2011) in the same cropping environment. The variation in the relative density of the weed species across the treatments in both years suggests that the weed species responded differently to the cassava density and pre-planting soil solarization treatments with some species being highly susceptible to heat stress. The less than 1 % relative density of some weed species such as *A. bussei*, *A conyzoides*, *P. amarus* and *T. rhomboidei* observed in plots with cassava populations of 17,778 and 13, 3333 plants ha^{-1} solarized for 10 weeks preplanting suggests that these weed species are highly susceptible to high cassava density and longer soil solarization duration. Similarly, Silva *et al.* (2012) observed reduced weed growth in higher cassava population and Mohanty *et al*. (2002) reported a total reduction of the seedlings of heat sensitive weed species by soil solarization. The relatively high density of up to 26 % *Caladium bicolor* observed in plots with high cassava populations of 17,778 and 13, 3333 plants ha^{-1} solarized for 10 weeks preplanting suggests that this weed species is not adequately suppressed by increasing the crop density and soil solarization duration. Similar to this observation, Gul *et al*. (2013), reported that some weed species were not affectively controlled by soil solarization.

Table 1: Predominant weed species relative density in 2019

S/N	Treatments		Relative density (%)											
	Weed species	Life cycle	D_1S_0	D_1S_4	D_1S7	D_1S_{10}	D_2S_0	D_2S_4	D_2S7	D_2S_{10}	D_3S_0	D_3S_4	D_3S7	D_3S_{10}
						Broadleaves								
1	*Ageratum conyzoides* L.	A	4.70	4.50	4.00	2.10	5.50	4.80	3.00	3.70	5.50	4.40	2.00	3.00
2	*Aspillia bussei* O. Hoff	A	4.20	3.40	2.70	1.10	4.30	4.80	2.50	1.80	4.20	4.20	3.00	1.50
3	*Caldum bicolor* Vent.	P	14.70	16.00	17.00	19.50	8.20	10.40	14.10	16.60	9.00	9.90	14.20	17.60
4	*Calapo mucunoides* Desv.	P	4.40	4.10	3.10	2.10	5.90	4.40	3.40	2.70	5.40	4.60	2.50	2.30
5	*Cleom rutidosperma* DC.	A	7.60	5.60	6.30	6.40	6.20	5.80	6.40	7.30	6.00	6.70	6.10	8.40
6	*Euphobia heterophylla* L.	A	4.80	4.70	4.50	2.10	4.80	4.60	3.90	2.70	4.80	4.70	2.50	1.50
7	*Gloriosa superba* L.	A	5.10	5.00	5.80	8.60	6.60	6.20	6.00	7.30	5.60	7.10	7.60	5.30
8	*Ipomoea involuncrata* P.	A	4.10	4.30	4.00	2.10	4.80	3.10	4.70	1.80	6.50	4.40	1.50	1.50
9	*Mitracarpos villosus* DC.	A	6.90	5.80	5.80	7.50	5.30	6.20	6.80	8.30	6.70	5.80	7.10	6.90
10	*Oldenladia herbacea* L.	A	4.60	4.30	3.50	4.20	4.70	5.00	3.90	2.70	5.50	5.30	3.50	5.30
11	*Phyllantus amarus* Schum.	A	4.20	3.60	3.50	2.10	4.80	3.90	3.00	1.80	5.10	4.20	3.50	1.50
12	*Triumfeta rhomboidea* Jac.	P	2.80	3.60	3.50	4.30	4.40	3.70	2.50	1.80	4.60	4.00	5.10	1.50
						Grasses								
13	*Axonopus compressus* Bea	P	5.40	7.70	6.70	8.60	6.80	5.60	7.70	8.30	2.80	5.30	5.60	9.20
14	*Cynodoon dactylon* L.	A	5.10	5.40	7.10	5.40	6.00	7.90	8.10	9.20	6.20	6.40	9.10	8.40
15	*Eragrostis ciliaris* L.	A	4.30	4.50	4.50	4.20	5.90	4.60	4.70	3.70	5.60	5.30	6.10	6.10
16	*Panicum maximum* Jac.	A	6.10	7.70	7.60	9.70	5.80	6.00	8.60	7.30	6.10	5.80	6.60	10.70
						Sedges								
17	*Kyllinga bulbosa* Bea.	A	5.20	5.00	6.70	4.30	5.30	6.20	5.60	4.60	5.30	5.50	6.10	3.80
18	*Kyllinga erecta* Schum.	A	5.70	5.00	5.80	4.30	5.00	6.80	5.10	8.30	5.10	6.00	8.10	5.30

Rating: < 1% = trace / rare; between 1 and 5% = low / occasional plants; between 5 and 25% = moderate / scattered plants; between 25 and 100% = high / fairly dense (Maszura *et al*., 2018)

KEY: A = annual; P = perennial; D_1 = cassava @ 17,778 plants ha^{-1}; D_2 = cassava @ 13,333 plants ha^{-1}; D_3 = cassava @ 10,000 plants ha^{-1}; S_0 = No solarization; S_4 = 4 weeks solarization; S_7 = 7 weeks solarization; S_{10} = 10 weeks solarization

Table 2: Predominant weed species relative density in 2020

S/N	Weed species	Life cycle	D_1S_0	D_1S_4	D_1S7	D_1S_{10}	D_2S_0	D_2S_4	D_2S7	D_2S_{10}	D_3S_0	D_3S_4	D_3S7	D_3S_{10}
	Broadleaves													
1	*Ageratum conyzoides* L.	A	5.90	3.60	1.10	0.00	6.50	4.00	2.30	0.00	3.90	4.20	3.00	1.80
2	*Aspillia bussei* O. Hoff	A	5.20	2.10	0.60	0.00	5.40	3.50	2.80	0.00	5.50	4.80	2.50	1.80
3	*Caldum bicolor* Vent.	P	10.10	13.30	14.90	26.30	7.70	11.00	14.50	21.80	8.00	9.70	12.0	22.30
4	*Calapo mucunoides* Desv.	P	3.70	2.30	1.60	1.20	4.90	3.00	2.30	1.00	5.10	3.20	3.00	1.80
5	*Cleom rutidosperma* DC.	A	5.90	7.40	6.60	5.00	6.00	6.10	7.00	3.00	6.00	6.50	6.40	5.50
6	*Euphoba heterophylla* L.	A	5.40	4.40	1.60	1.20	4.70	4.60	1.90	1.00	4.10	4.20	3.80	2.80
7	*Gloriosa superba* L.	A	5.20	7.10	8.80	3.70	6.00	5.90	7.00	6.90	6.50	5.70	8.50	4.60
8	*Ipomoea involuncrata* P.	A	4.90	5.00	1.10	1.20	5.50	3.00	2.30	1.00	3.30	3.60	1.30	3.60
9	*Mitracarpos villosus* DC.	A	6.10	6.20	7.70	5.00	6.00	6.40	7.50	2.00	3.60	6.70	3.40	5.50
10	*Oldenladia herbacea* L.	A	4.00	3.60	4.40	1.20	3.60	3.50	2.80	3.00	4.40	4.60	4.70	2.80
11	*Phyllantus amarus* Schum.	A	4.20	3.30	1.60	0.00	4.90	2.40	2.80	0.00	5.20	4.60	3.40	1.80
12	*Triumfeta rhomboidea* Jac.	P	3.70	2.10	1.60	0.00	4.60	3.60	2.80	2.00	4.10	2.90	2.10	1.80
	Grasses													
13	*Axonopus compressus* Bea.	P	5.20	7.40	9.90	11.30	6.20	6.20	7.00	14.90	6.70	7.40	9.40	11.10
14	*Cynodoon dactylon* L.	A	5.70	8.00	10.50	11.30	6.20	8.30	8.90	12.90	7.20	7.20	7.20	2.80
15	*Eragrostis ciliaris* L.	A	6.20	5.60	3.80	2.50	5.50	3.20	2.80	1.00	5.20	3.60	3.80	1.80
16	*Panicum maximum* Jac.	A	6.10	7.70	10.50	16.30	6.50	9.70	9.80	12.90	6.90	8.00	9.80	10.20
	Sedges													
17	*Kyllinga bulbosa* Bea.	A	5.70	5.00	6.60	7.50	4.90	8.60	7.50	7.90	6.90	5.50	7.20	10.20
18	*Kyllinga erecta* Schum.	A	6.60	5.90	7.10	6.20	4.90	6.70	7.90	9.00	6.20	5.90	8.50	7.40

Treatments: S/N, Weed species, Life cycle; Relative density (%): D_1S_0 – D_3S_{10}

Rating: < 1% = trace / rare; between 1 and 5% = low / occasional plants; between 5 and 25% = moderate / scattered plants; between 25 and 100% = high / fairly dense (Maszura *et al*., 2018)

KEY: A = annual; P = perennial; D_1 = cassava @ 17,778 plants ha^{-1}; D_2 = cassava @ 13,333 plants ha^{-1}; D_3 = cassava @ 10,000 plants ha^{-1}; S_0 = No solarization; S_4 = 4 weeks solarization; S_7 = 7 weeks solarization; S_{10} = 10 weeks solarization

Relative Frequency

The relative frequencies of the predominant weed species in the cropped area as influenced by cassava density and pre-planting soil solarization duration in 2019 and 2020 cropping seasons are presented in Tables 3 and 4, respectively. The relative frequency of the weed species varied across the treatments. In both cropping seasons, *C. bicolor* and *G. superba* had moderate frequent status across the treatments with relative frequencies of between 5 and 25 %, while most of the weed species were frequent or occasional across the treatments. The relative frequency of *C. bicolor* consistently increased as the solarization duration increased, while those of the other weeds tended to decline. In 2020, *A. bussei*, *A conyzoides, P. amarus* and *T. rhomboidea* were rare species with relative densities less than 1 % in plots with cassava population densities of 17,778 and 13,333 plants ha^{-1} solarized for 10 weeks.

The infrequent occurrence of *A. bussei*, *A conyzoides*, *P. amarus* and *T. rhomboidea* as cassava density and soil solarization duration increased showed progressive reduction of the species and suggests that they were effectively controlled by high cassava density and longer solarization period. Higher plant population density results in quicker row closure, which minimizes the rate with which light passes to the emerging weed seedlings below the crop canopy, while high temperatures as a result of soil solarization desiccated the weed propagules. This observation agrees with the reports of Begna *et al*. (2001) and Horowitz *et al.* (2017), that high crop density and soil solarization respectively, is effective in the management of many weed species. On the other hand, the relatively higher occurrence of *C. bicolor* and *G. superba* suggests that these species are not effectively controlled by high cassava density and soil solarization. Similarly, Pathel *et al.* (2005) averred that, though solarization is effective in managing many weed species, some species are not totally controlled.

Relative Abundance

The relative abundance of the predominant weed species in the cropped area as influenced by cassava density and pre-planting soil solarization duration in 2019 and 2020 cropping seasons are presented in Tables 5 and 6, respectively. The relative abundance of the various weed species varied across the treatments in both years. The highest relative abundance of 12.90 and 14.10 % were recorded on *C. bicolor* in D_1S_4 and D_1S_0 respectively in 2019. This was followed by *A. compressus* and *C. dactylon* with 12.20 % and 11.50 % relative abundance respectively in D_2S_{10}, and D_1S_{10} plots in 2020. All other weed species were occasional to moderately abundant in 2019. In 2020, *C. rutidosperma* had occasional status in D_2S_{10} treatment plot, while, *A. bussei, A conyzoides, P. amarus* and *T. rhomboidea* were ‘rare’ with relative abundance less than 1 % in plots with 17,778 and 13,333 cassava plants ha^{-1} solarized for 10 weeks.

The relatively higher abundance of *C. bicolour* across the treatments suggests that this weed species was tolerant to the integration of varying cassava density and pre-planting soil solarization. This could be attributed to such factors as the ability of *C. bicolor* seedlings to emerge from any part of the cormel that breaks off from the mother corm.

Table 3: Weed species relative frequency in 2019

Treatments			Relative frequency (%)											
			D_1S_0	D_1S_4	D_1S7	D_1S_{10}	D_2S_0	D_2S_4	D_2S7	D_2S_{10}	D_3S_0	D_3S_4	D_3S7	D_3S_{10}
S/N	Weed species	Life cycle												
							Broadleaves							
1	*Ageratum conyzoides* L.	A	5.90	4.90	4.30	4.10	5.80	4.60	2.70	4.10	6.00	5.60	4.60	5.70
2	*Aspillia bussei* O. Hoff	A	5.90	4.10	4.30	2.00	5.80	5.40	2.70	4.10	6.00	5.60	4.60	3.80
3	*Caldum bicolor* Vent.	P	5.90	7.40	13.00	12.20	5.80	7.00	12.30	8.20	6.00	6.30	9.20	13.20
4	*Calapo mucunoides* Desv.	P	5.90	4.10	4.30	4.10	5.80	4.60	3.70	6.10	6.00	4.20	4.60	3.80
5	*Cleom rutidosperma* DC.	A	5.90	5.70	4.30	6.10	5.80	5.40	5.40	8.20	6.00	6.30	4.60	5.70
6	*Euphoba heterophylla* L.	A	5.90	4.70	4.30	4.10	5.80	4.60	2.70	4.10	6.00	6.30	4.60	1.90
7	*Gloriosa superba* L.	A	5.90	7.40	8.60	6.10	5.80	7.00	6.70	6.10	6.00	5.60	9.20	5.70
8	*Ipomoea involuncrata* P.	A	5.90	4.90	4.30	4.10	5.80	3.10	3.70	4.10	6.00	5.70	3.10	3.80
9	*Mitracarpos villosus* DC.	A	5.90	6.50	5.70	6.10	5.80	7.00	5.40	6.10	6.00	5.60	4.60	5.70
10	*Oldenladia herbacea* L.	A	5.90	5.70	5.70	6.10	5.80	6.10	3.70	6.10	6.00	6.30	4.60	5.70
11	*Phyllantus amarus* Schum.	A	5.10	4.90	4.30	4.10	5.80	5.40	5.40	4.10	6.00	4.90	4.60	3.80
12	*Triumfeta rhomboidea* Jac.	P	5.10	4.90	4.30	6.10	5.80	5.40	5.40	4.10	5.30	4.90	6.10	3.80
							Grasses							
13	*Axonopus compressus* Bea.	P	5.90	6.50	5.70	6.10	4.50	5.40	8.10	6.10	3.30	4.90	6.20	7.50
14	*Cynodoon dactylon* L.	A	5.90	6.50	8.60	6.10	5.80	7.00	6.70	6.10	6.00	6.30	7.70	5.70
15	*Eragrostis ciliaris* L.	A	5.90	4.90	4.30	6.10	5.80	5.40	5.40	6.10	6.00	5.60	4.60	5.70
16	*Panicum maximum* Jac.	A	4.50	7.40	5.70	6.10	5.10	5.40	8.10	4.10	4.60	4.90	6.10	7.50
							Sedges							
17	*Kyllinga bulbosa* Bea.	A	4.50	4.90	4.30	4.10	4.50	4.60	5.40	6.10	4.60	5.60	4.60	5.70
18	*Kyllinga erecta* Schum.	A	4.50	4.90	4.30	6.10	4.50	7.00	5.40	6.10	4.60	4.90	6.10	5.70

Rating: < 1% = trace / rare; between 1 and 5% = low / occasional plants; between 5 and 25% = moderate/scattered plants; between 25 and 100% = high / frequent (Maszura *et al*., 2018).

KEY: A = annual; P = perennial; D_1 = cassava @ 17,778 plants ha^{-1}; D_2 = cassava @ 13,333 plants ha^{-1}; D_3 = cassava @ 10,000 plants ha^{-1}; S_0 = No solarization; S_4 = 4 weeks solarization; S_7 = 7 weeks solarization; S_{10} = 10 weeks solarization

Table 4: Weed species relative frequency in 2020

Treatments			Relative frequency (%)											
			D_1S_0	D_1S_4	D_1S7	D_1S_{10}	D_2S_0	D_2S_4	D_2S7	D_2S_{10}	D_3S_0	D_3S_4	D_3S7	D_3S_{10}
S/N	Weed species	Life cycle												
							Broadleaves							
1	*Ageratum conyzoides* L.	A	6.30	4.00	1.60	0.00	6.30	4.00	2.90	0.00	4.40	5.10	4.10	4.00
2	*Aspillia bussei* O. Hoff	A	4.80	3.00	1.60	0.00	6.30	5.00	2.90	0.00	6.60	5.10	2.70	4.00
3	*Caldum bicolor* Vent.	P	6.30	9.00	12.70	19.40	5.50	9.10	13.00	20.00	5.80	7.80	8.10	14.00
4	*Calapo mucunoides* Desv.	P	4.10	3.00	4.80	2.80	6.30	3.00	2.90	2.50	6.60	3.40	4.10	4.00
5	*Cleom rutidosperma* DC.	A	5.50	5.90	6.30	8.30	5.50	7.00	5.70	5.00	6.60	6.80	6.80	6.00
6	*Euphoba heterophylla* L.	A	6.30	4.90	1.60	2.80	5.50	5.00	2.90	2.50	4.40	5.10	4.10	6.00
7	*Gloriosa superba* L.	A	5.50	6.90	9.50	5.60	5.50	7.00	8.60	7.50	6.60	6.00	10.80	6.00
8	*Ipomoea involuncrata* P.	A	6.30	4.90	1.70	2.80	6.30	3.00	2.90	2.50	4.40	4.30	2.70	4.00
9	*Mitracarpos villosus* DC.	A	6.30	5.90	6.30	5.60	6.30	7.00	7.10	5.00	5.80	7.80	4.10	4.00
10	*Oldenladia herbacea* L.	A	4.80	4.90	4.80	2.80	5.50	3.00	4.30	5.00	6.60	6.00	4.10	6.00
11	*Phyllantus amarus* Schum.	A	4.80	4.90	3.20	0.00	6.30	4.00	4.30	0.00	6.60	5.10	4.10	4.00
12	*Triumfeta rhomboidea* Jac.	P	4.80	3.00	3.20	0.00	6.30	4.00	5.70	2.50	5.10	4.30	1.40	4.00
							Grasses							
13	*Axonopus compressus* Bea.	P	4.80	6.90	7.90	8.30	4.10	7.00	7.10	10.00	4.40	7.80	8.10	8.00
14	*Cynodoon dactylon* L.	A	6.30	7.90	7.90	8.30	6.30	8.00	7.10	10.00	6.60	6.80	9.50	4.00
15	*Eragrostis ciliaris* L.	A	6.30	5.90	4.80	2.80	5.50	3.00	4.30	2.50	6.60	4.30	4.10	4.00
16	*Panicum maximum* Jac.	A	4.80	6.90	9.50	13.90	4.10	6.00	7.10	10.00	4.40	6.80	5.40	6.00
							Sedges							
17	*Kyllinga bulbosa* Bea.	A	6.30	5.90	6.30	8.30	4.10	9.10	5.70	7.50	4.40	4.30	8.10	6.00
18	*Kyllinga erecta* Schum.	A	6.30	5.90	6.30	8.30	4.10	6.00	5.70	7.50	4.40	3.40	8.10	6.00

Rating: < 1% = trace / rare; between 1 and 5% = low / occasional plants; between 5 and 25% = moderate/scattered plants; between 25 and 100% = high / frequent (Maszura *et al*., 2018).

KEY: A = annual; P = perennial; D_1 = cassava @ 17,778 plants ha^{-1}; D_2 = cassava @ 13,333 plants ha^{-1}; D_3 = cassava @ 10,000 plants ha^{-1}; S_0 = No solarization; S_4 = 4 weeks solarization; S7 = 7 weeks solarization; S_{10} = 10 weeks solarization

Table 5: Weed species relative abundance in 2019

S/N	Weed species	Life cycle	D_1S_0	D_1S_4	D_1S7	D_1S_{10}	D_2S_0	D_2S_4	D_2S7	D_2S_{10}	D_3S_0	D_3S_4	D_3S7	D_3S_{10}
	Treatments		Relative abundance (%)											
			Broadleaves											
1	*Ageratum conyzoides* L.	A	4.50	5.30	5.30	3.30	5.10	5.80	6.20	5.30	4.60	4.40	2.50	3.30
2	*Aspillia bussei* O. Hoff	A	4.00	4.70	3.60	3.30	4.00	4.90	5.30	2.60	4.00	4.40	3.80	2.50
3	*Caldum bicolor* Vent.	P	14.10	12.90	7.50	9.80	7.60	5.80	6.40	11.80	8.30	8.70	8.80	8.20
4	*Calapo mucunoides* Desv.	P	4.20	5.70	4.10	3.30	5.50	5.30	4.70	2.60	5.00	5.20	3.10	3.70
5	*Cleom rutidosperma* DC.	A	7.20	5.60	8.30	6.50	5.80	6.00	6.60	5.30	5.60	6.00	7.60	9.10
6	*Euphoba heterophylla* L.	A	4.60	5.50	5.90	3.30	4.50	5.50	7.90	3.90	4.50	4.20	3.10	5.00
7	*Gloriosa superba* L.	A	4.80	3.90	3.80	8.70	6.10	5.00	4.90	7.00	2.70	7.10	4.70	5.80
8	*Ipomoea involuncrata* P.	A	3.90	5.00	5.30	3.30	4.50	5.60	6.40	2.60	6.00	4.40	1.80	2.50
9	*Mitracarpos villosus* DC.	A	6.50	5.10	5.80	7.60	4.90	5.00	7.00	7.90	6.20	5.80	8.80	7.50
10	*Oldenladia herbacea* L.	A	5.40	5.00	6.70	4.30	4.90	4.30	5.30	2.60	5.10	4.70	4.40	5.80
11	*Phyllantus amarus* Schum.	A	4.50	4.20	4.70	3.30	4.50	4.10	3.10	2.60	4.80	4.80	4.40	2.50
12	*Triumfeta rhomboidea* Jac.	P	3.00	4.20	4.70	4.30	4.10	3.90	2.60	2.60	4.80	4.60	4.70	2.50
			Grasses											
13	*Axonopus compressus* Bea.	P	5.20	6.70	6.70	8.70	7.80	5.90	5.30	7.90	5.10	6.00	5.20	7.50
14	*Cynodoon dactylon* L.	A	4.80	4.70	4.70	5.40	5.60	6.30	6.70	8.80	5.80	5.60	6.80	9.10
15	*Eragrostis ciliaris* L.	A	4.90	5.80	5.90	4.30	5.50	4.70	5.70	7.90	5.20	5.30	7.60	6.60
16	*Panicum maximum* Jac.	A	7.40	6.00	7.50	9.80	8.00	6.20	5.90	10.50	7.30	6.60	6.20	8.70
			Sedges											
17	*Kyllinga bulbosa* Bea.	A	5.30	5.30	4.70	6.50	5.60	7.50	4.80	4.40	6.30	5.50	7.60	4.10
18	*Kyllinga erecta* Schum.	A	5.60	5.00	4.70	4.30	6.00	5.50	5.30	3.50	6.20	6.90	7.60	5.80

Rating: < 1% = trace / rare; between 1 and 5% = low / occasional plants; between 5 and 25% = moderate/scattered plants; between 25 and 100% = high / abundant (Maszura *et al*., 2018).

KEY: A = annual; P = perennial; D_1 = cassava @ 17,778 plants ha^{-1}; D_2 = cassava @ 13,333 plants ha^{-1}; D_3 = cassava @ 10,000 plants ha^{-1}; S_0 = No solarization; S_4 = 4 weeks solarization; S_7 = 7 weeks solarization; S_{10} = 10 weeks solarization

Table 6: Weed species relative abundance in 2020

Treatments			Relative abundance (%)											
			D_1S_0	D_1S_4	D_1S7	D_1S_{10}	D_2S_0	D_2S_4	D_2S7	D_2S_{10}	D_3S_0	D_3S_4	D_3S7	D_3S_{10}
S/N	Weed species	Life cycle												
						Broadleaves								
1	*Ageratum conyzoides* L.	A	5.20	5.20	4.30	0.00	5.60	5.60	4.80	0.00	4.80	4.60	4.10	2.90
2	*Aspillia bussei* O. Hoff	A	5.90	4.10	2.20	0.00	4.60	3.90	5.60	0.00	4.60	5.30	3.60	2.90
3	*Caldum bicolor* Vent.	P	9.00	8.70	7.30	11.50	7.50	6.70	6.60	8.90	7.50	7.10	8.30	9.90
4	*Calapo mucunoides* Desv.	P	4.90	4.60	2.20	3.80	4.20	5.50	4.80	3.20	4.20	5.10	4.10	2.90
5	*Cleom rutidosperma* DC.	A	5.90	7.30	6.50	5.10	5.80	5.00	7.20	4.30	5.00	5.40	5.30	5.80
6	*Euphoba heterophylla* L.	A	4.80	5.20	6.50	3.80	4.60	5.10	3.80	3.20	5.10	4.60	5.30	2.90
7	*Gloriosa superba* L.	A	5.20	6.00	5.70	5.70	6.00	4.70	4.80	7.60	5.40	5.30	4.40	4.80
8	*Ipomoea involuncrata* P.	A	4.30	5.90	4.30	3.80	4.70	5.50	4.80	3.20	4.10	4.70	2.70	5.80
9	*Mitracarpos villosus* DC.	A	5.40	6.10	7.60	7.70	5.20	5.20	6.10	3.20	3.30	4.90	4.70	8.70
10	*Oldenladia herbacea* L.	A	4.60	4.20	5.70	3.80	3.50	6.50	3.80	4.90	3.60	4.40	6.50	2.90
11	*Phyllantus amarus* Schum.	A	4.80	3.80	3.20	0.00	4.20	3.40	3.80	0.00	4.30	5.10	4.70	2.90
12	*Triumfeta rhomboidea* Jac.	P	4.20	4.10	3.20	0.00	4.00	5.30	2.90	6.50	4.40	3.90	8.90	2.90
						Grasses								
13	*Axonopus compressus* Bea.	P	5.90	6.20	7.80	11.50	8.00	5.00	5.80	12.20	8.40	5.40	6.50	8.70
14	*Cynodoon dactylon* L.	A	5.10	5.90	8.20	11.50	5.30	5.80	7.30	10.50	6.00	5.90	4.30	4.30
15	*Eragrostis ciliaris* L.	A	5.50	5.50	5.00	7.70	5.40	6.00	3.80	3.20	4.30	4.70	5.30	2.90
16	*Panicum maximum* Jac.	A	6.90	6.50	6.80	10.00	8.40	9.00	8.10	10.50	8.60	6.60	10.20	10.60
						Sedges								
17	*Kyllinga bulbosa* Bea.	A	5.10	4.90	6.50	7.70	6.40	5.30	7.70	8.60	8.60	7.20	5.00	10.60
18	*Kyllinga erecta* Schum.	A	5.80	5.80	7.00	6.40	6.40	6.30	8.20	9.70	7.70	9.70	5.90	7.70

Rating: < 1% = trace / rare; between 1 and 5% = low / occasional plants; between 5 and 25% = moderate/scattered plants; between 25 and 100% = high / abundant (Maszura *et al*., 2018).

KEY: A = annual; P = perennial; D_1 = cassava @ 17,778 plants ha^{-1}; D_2 = cassava @ 13,333 plants ha^{-1}; D_3 = cassava @ 10,000 plants ha^{-1}; S_0 = No solarization; S_4 = 4 weeks solarization; S_7 = 7 weeks solarization; S_{10} = 10 weeks solarization

The corm is hardly destroyed and continues to sprout as long as the ground is moist, irrespective of how tiny the corm bits are. Mechanical weeding tends to fragment the corms and cormels, thereby aggravating the problem. This observation is in line with the report of Gul *et al*. (2013), who observed the resistance of some weed species to solarization. However, the rareness of *A. bussei*, *A. conyzoides*, *P. amarus* and *T. rhomboidea* in plots with high cassava population density of 13,333 – 17,778 plants ha^{-1} solarized for 10 weeks suggests that integrating high cassava density and long pre-planting soil solarization duration was effective in controlling these weeds. It also suggests that increasing the plant density of a non-branching cassava cultivar such as TME 419 to 17,778 plants ha^{-1} in combination with preplanting soil solarization of up to 10 weeks could result in a 100 % control of *A. bussei*, *A conyzoides*, *P. amarus* and *T. rhomboidea* weed species. Ashrafuzzaman *et al*. (2011), noted that soil solarization for nine weeks was effective in controlling more than 50% of weed species in chilli. Similarly, Mohanty *et al*. (2002) reported a complete control of all weed species by plastic mulch. Kapoor (2020), demonstrated that solarization up to 8 weeks stopped the emergence of weed seedlings. Moya and Furukawa (2000), reported that the growth of weed species were effectively controlled by soil solarization technique. In addition, Nwosisi *et al.* (2019) opined that plastic mulch is a preventive weed management method with the potentials of 100 % weed control, while Marenco and Lustosa (2000) reported that about 40 % of the weed community were not affected by soil solarization, thus, supporting the high occurrence of *C. bicolour* despite soil solarization in this present study.

Relative Important Value Index

The important value index of the predominant weed species in the cropped area as influenced by cassava density and pre-planting soil solarization duration in 2019 and 2020 cropping seasons are presented in Tables 7 and 8, respectively. The important value index of the weed species varied across the treatments. In both cropping seasons, *C. bicolor* consistently had the highest important value index, reaching up to 57.2 % of the entire weed species when treated with 17,778 cassava plants ha^{-1} integrated with preplanting soil solarization for 10 weeks, followed by *P. maximum*, *A. compressus* and *C. dactylon* in that order. *Aspillia bussei*, *A. conyzoides*, *P. amarus* and *T. rhomboidea* had zero percent important value index when soil solarization duration of 10 weeks was integrated with crop density of either 17,778 plants ha^{-1} or 13,333 plants ha^{-1} of cassava. The important value index of *C. bicolor* consistently increased as cassava density and solarization duration increased, while those of the other weed species tended to decline, which is an indication of survival of the fittest. The propagules of *C. bicolor* might have escaped the effects of pre-planting soil solarization and subsequent shading by quick canopy cover of high cassava density. This shows that this weed species is the most important in the area, with the least chances of being checked by crop canopy management and soil solarization duration, suggesting further investigation for suitable weed management approach for this weed species.

Table 7: Important value index (IVI) of the predominant weed species in 2019

Treatments			Important value index											
			D_1S_0	D_1S_4	D_1S7	D_1S_{10}	D_2S_0	D_2S_4	D_2S7	D_2S_{10}	D_3S_0	D_3S_4	D_3S7	D_3S_{10}
S/N	Weed species	Life cycle												
							Broadleaves							
1	*Ageratum conyzoides* L.	A	15.1	14.7	13.6	9.5	16.4	16.2	11.9	13.2	16.1	14.4	9.10	12.0
2	*Aspillia bussei* O. Hoff	A	14.1	12.2	10.6	6.4	15.2	15.1	10.5	8.50	12.2	14.2	11.4	7.8
3	*Caldum bicolor* Vent.	P	34.7	35.8	37.5	41.5	21.6	23.2	32.8	36.6	23.3	24.9	32.2	39.0
4	*Calapo mucunoides* Desv.	P	14.5	13.9	11.5	9.5	18.2	14.3	11.8	11.4	16.4	14.0	10.2	9.8
5	*Cleom rutidosperma* DC.	A	20.7	16.9	18.9	17.0	17.8	17.2	18.4	20.8	17.6	19.0	18.3	23.2
6	*Euphoba heterophylla* L.	A	15.3	14.9	14.7	9.5	15.1	14.7	14.5	10.7	15.3	15.2	10.2	8.4
7	*Gloriosa superba* L.	A	15.8	16.3	18.2	23.4	18.5	18.2	17.6	20.4	14.3	19.8	21.5	16.8
8	*Ipomoea involuncrata* P.	A	13.9	14.2	13.6	9.5	15.1	11.8	14.8	8.5	18.5	14.5	17.4	7.8
9	*Mitracarpos villosus* DC.	A	19.3	17.4	17.3	21.2	16.0	18.2	19.2	22.3	18.9	17.2	20.5	20.1
10	*Oldenladia herbacea* L.	A	15.9	15.0	15.9	14.6	15.4	15.4	12.9	11.4	16.6	16.3	12.5	16.8
11	*Phyllantus amarus* Schum.	A	13.8	12.7	12.5	9.5	15.1	13.4	11.5	8.5	15.9	13.9	12.5	7.8
12	*Triumfeta rhomboidea* Jac.	P	10.9	12.7	12.5	14.7	14.3	13	10.5	8.5	14.7	13.5	15.9	7.8
							Grasses							
13	*Axonopus compressus* Bea.	P	16.5	20.9	19.1	23.4	19.1	16.9	21.1	22.3	11.2	16.2	17	24.2
14	*Cynodoon dactylon* L.	A	15.8	16.6	20.4	16.9	17.4	21.2	21.5	24.1	18.0	18.3	23.6	23.2
15	*Eragrostis ciliaris* L.	A	15.1	15.2	14.7	14.6	17.2	14.7	15.8	17.7	16.8	16.2	18.3	18.4
16	*Panicum maximum* Jac.	A	18.0	21.1	20.8	25.6	18.9	17.6	22.6	21.9	18.0	17.3	18.9	26.9
							Sedges							
17	*Kyllinga bulbosa* Bea.	A	15.0	15.2	15.7	14.9	15.4	18.3	15.8	15.1	16.2	16.6	18.3	13.6
18	*Kyllinga erecta* Schum.	A	15.8	14.9	14.8	14.7	15.5	19.3	15.8	17.9	15.9	17.8	21.8	16.8

Rating: < 1% = trace / rare; between 1 and 5% = low / occasional plants; between 5 and 25% = moderate/scattered plants; between 25 and 100% = high / abundant (Maszura *et al*., 2018).

KEY: A = annual; P = perennial; D_1 = cassava @ 17,778 plants ha^{-1}; D_2 = cassava @ 13,333 plants ha^{-1}; D_3 = cassava @ 10,000 plants ha^{-1}; S_0 = No solarization; S_4 = 4 weeks solarization; S_7 = 7 weeks solarization; S_{10} = 10 weeks solarization

Table 8: Important value index (IVI) of the predominant weed species in 2020

Treatments			Important value index											
			D_1S_0	D_1S_4	D_1S7	D_1S_{10}	D_2S_0	D_2S_4	D_2S7	D_2S_{10}	D_3S_0	D_3S_4	D_3S7	D_3S_{10}
S/N	Weed species	Life cycle												
							Broadleaves							
1	*Ageratum conyzoides* L.	A	17.4	12.8	7.0	0.0	18.4	13.6	10.0	0.0	13.1	13.9	11.2	8.7
2	*Aspillia bussei* O. Hoff	A	15.9	9.2	4.4	0.0	16.3	12.9	11.3	0.0	16.7	15.2	8.8	8.7
3	*Caldum bicolor* Vent.	P	25.4	31.1	34.9	57.2	20.7	26.8	34.1	49.7	21.3	24.6	28.4	46.2
4	*Calapo mucunoides* Desv.	P	12.7	9.6	8.6	7.8	15.4	11.5	10.0	6.7	15.9	11.7	11.2	8.7
5	*Cleom rutidosperma* DC.	A	17.3	20.6	19.4	18.4	17.3	18.1	19.9	12.3	17.6	18.7	18.5	17.3
6	*Euphobia heterophylla* L.	A	16.5	14.5	9.7	7.8	14.8	14.7	8.6	6.7	13.6	13.9	13.2	11.7
7	*Gloriosa superba* L.	A	15.9	20	24	15	17.5	17.6	20.4	22	18.5	17	23.7	15.4
8	*Ipomoea involuncrata* P.	A	15.5	15.8	7.1	7.8	16.5	11.5	10.0	6.7	11.8	12.6	6.7	13.4
9	*Mitracarpos villosus* DC.	A	17.8	18.2	21.6	18.3	17.5	18.6	20.7	10.2	12.7	19.4	12.2	18.2
10	*Oldenladia herbacea* L.	A	13.4	12.7	14.9	7.8	12.6	13.0	10.9	12.9	14.6	15.0	15.3	11.7
11	*Phyllantus amarus* Schum.	A	13.8	12.0	8.0	0.0	15.4	9.8	10.9	0.0	16.1	14.8	12.2	8.7
12	*Triumfeta rhomboidea* Jac.	P	12.7	9.2	8.0	0.0	14.9	12.9	11.4	11.0	13.6	11.1	12.4	8.7
							Grasses							
13	*Axonopus compressus* Bea.	P	15.9	20.5	25.6	31.1	18.3	18.2	19.9	37.1	19.5	20.6	24.0	27.8
14	*Cynodoon dactylon* L.	A	17.1	21.8	26.6	31.1	17.8	22.1	23.3	33.4	19.8	19.9	21.0	11.1
15	*Eragrostis ciliaris* L.	A	18.0	17.0	13.6	13.0	16.4	12.2	10.9	6.7	16.1	12.6	13.2	8.7
16	*Panicum maximum* Jac.	A	17.8	21.1	26.8	40.2	19.0	24.7	25.0	33.4	19.9	21.4	25.4	26.8
							Sedges							
17	*Kyllinga bulbosa* Bea.	A	17.1	15.8	19.4	23.5	15.4	23.0	20.9	24.0	19.9	17.0	20.3	26.8
18	*Kyllinga erecta* Schum.	A	18.7	17.6	20.4	20.9	15.4	19.0	21.8	26.2	18.3	19.0	22.5	21.1

Rating: < 1% = trace / rare; between 1 and 5% = low / occasional plants; between 5 and 25% = moderate/scattered plants; between 25 and 100% = high / abundant (Maszura *et al*., 2018).

KEY: A = annual; P = perennial; D_1 = cassava @ 17,778 plants ha^{-1}; D_2 = cassava @ 13,333 plants ha^{-1}; D_3 = cassava @ 10,000 plants ha^{-1}; S_0 = No solarization; S_4 = 4 weeks solarization; S_7 = 7 weeks solarization; S_{10} = 10 weeks solarization

CONCLUSION

The predominant weeds in the cropped area were *A. conyzoides*, *A. bussei*, *A. compressus*, *C. bicolor*, *C. mucunoides*, *C. rutidosperma*, *C. dactylon*, *E. ciliaris*, *E. heterophylla*, *G. superba*, *I. involuncrata*, *K. bulbosa*, *K. erecta*, *M. villosus*, *O. herbacea*, *P. maximum*, *P. amarus* and *T. rhomboidea*. The integration of cassava density at 17,778 plants ha^{-1} with soil solarization duration of 10 weeks effectively controlled *A. bussei*, *A. conyzoides*, *P. amarus* and *T. rhomboidea* and lowered the severity of the other species except *C. bicolor*. The *C. bicolor* species is the most important weed species in the area and the control requires further investigation using other weed management approaches. Generally, for effective weed control in cassava farms at Calabar, nearby farming communities and areas with similar climate, a non-branching cassava cultivar such as TME 419 should be planted at 17,778 plants ha^{-1} integrated with 10 weeks pre-planting soil solarization duration.

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