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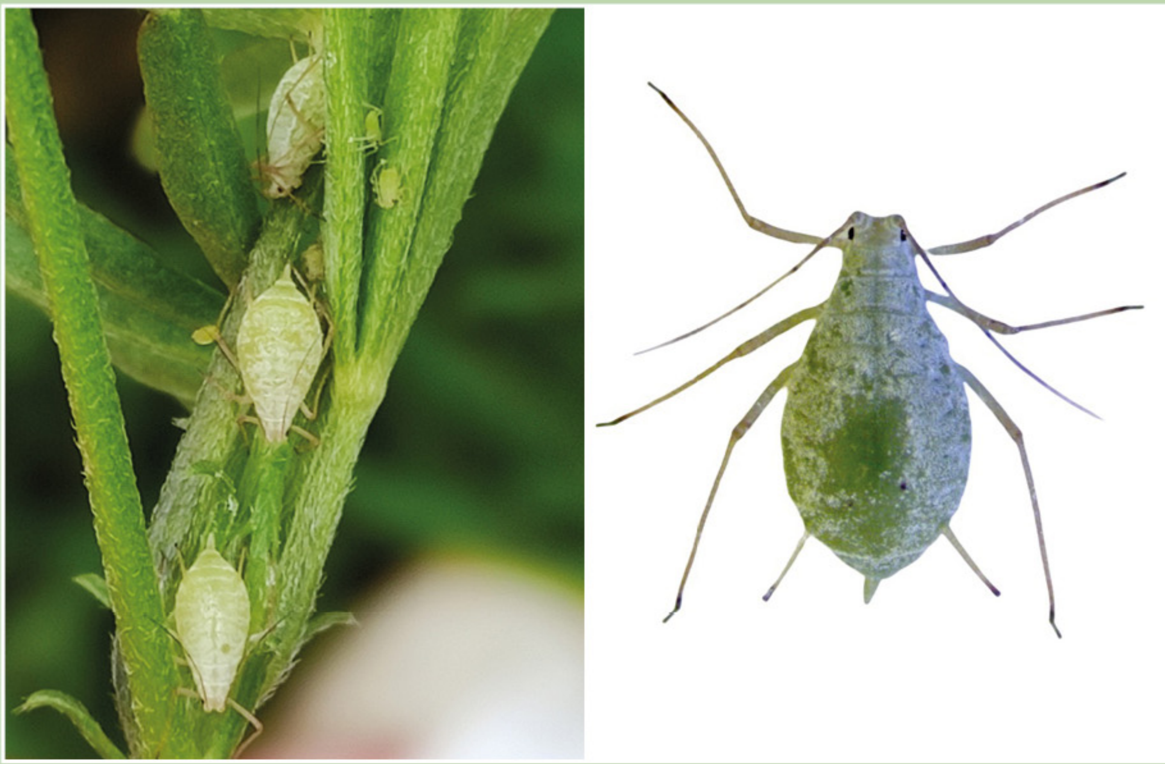

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Full-text article

ASSESSING THE PHYTOSOCIOLOGICAL CHARACTERISTICS OF WEED COMPLEX IN OKRA FIELD UNDER DIFFERENT CONTROL STRATEGIES

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Weed diversity is crucial for supporting ecological services, but weed control methods significantly influence weed species dominance and diversity. The present study was conducted in southwestern Nigeria's rainforest-savanna transitional agro-ecological zone during the 2017 and 2018 rainy seasons. Different weed management techniques were assessed, including applying cyanide-containing cassava effluent (CE@3WAS), pendimethalin (P), and hoe weeding (HW@3WAS), as well as repeated applications of HW and CE (HW@3&5WAS, CE@3&5WAS), and integrated approaches (P + CE@5WAS, P + HW@5WAS, CE@3WAS + HW@5WAS). A control treatment, where the weeds were left unmanaged, was also included. The experiment followed a randomized complete block design with three replications. Weed samples were collected using 25 cm x 25 cm quadrats placed randomly along the plot diagonals. Weed diversity was assessed using the Shannon-Wiener index and descriptive statistics. Results indicated that the control methods influenced weed species composition. Specifically, the presence of broad-leaf weeds was prominent in the P + HW@5WAS (2017) and P + CE@5WAS (2018) treatments, while grasses dominated in the weedy check (2017) and HW@3WAS (2018), suggesting that these strategies favour specific morphological groups of the weeds. Weed diversity decreased across various management practices, with the rankings in ascending order: CE@3&5WAP, CE@3WAP, P+CE@5WAS, CE@3WAP + HW@5WAP, P + HW@5WAP, Pendimethalin, HW@3WAP, and HW@3&5WAP. These findings underscore the importance of selecting weed management strategies based on weed ecological significance. Integrated weed management emerged as a more ecologically sustainable approach for okra fields compared to sole herbicide application or manual weeding.

Keywords: Ecological services, weed diversity, weed management, weed group, weed shift

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Introduction

Weeds play a dual role in agricultural settings, being detrimental to crop production while simultaneously serving as a resource for higher trophic groups (Gharde et al., 2018; Kati, Karamaouna, 2023). Consequently, there is a need for innovative weed management strategies that strive to enhance weed-related biodiversity while mitigating the adverse effects of weeds on agricultural productivity. The existence of neutral weed communities in crop production, where weed populations coexist with the crops without negatively affecting crop yield and quality compared to weed-free conditions (Esposito et al., 2023), reduces the requirement for intensive weeding. This, in turn, regulates crucial ecological services, which are the beneficial roles that weeds play in the environment, such as crop pollination (Kati, Karamaouna, 2023), soil erosion reduction (Moreau et al., 2020), and improvement of crop profitability by enhancing crop quality (Gibson et al., 2017).

Weed management aims to establish neutral weed communities, minimizing yield losses and supporting the ecological services. Additionally, it promotes the weed community transition from undesirable to desirable weed complex. Weed management practices, commonly recognised for their tendency to reduce weed diversity (Guerra et al., 2022), warrant a closer examination of their specific impacts, particularly in the light of weed species shift and dominance of particular morphological groups of weeds. Diverse weed flora provides for the ecological services delivery (Singh et al., 2022). Conversely, in low-biodiversity fields, a small number of highly competitive weed species often dominate, posing significant challenges to effective crop protection (Storkey, Neve, 2018).

A common characteristic of some weed management practices is the selective weed control, indicating their ability to negatively affect specific weed species while sparing the others. This attribute favours the dominance of a particular morphological group of weeds such as grasses, broadleaf weeds, sedges, and spiderwort (Kobayashi et al., 2003; Storkey, Neve, 2018), which are known for their distinct influence on weed-crop interactions. Hence, the phytosociological survey of weed communities in arable crop production with different weed management strategies may provide useful insights for practical outcomes of agriculture.

In arable crop production, chemical weed control stands out among commonly employed weed management strategies. The utilization of herbicides has contributed to heightened yields, and their ease of application has led to widespread adoption in both small- and large-scale farming. However, Nath et al., 2018 demonstrated that pendimethalin, a widely used dinitroaniline herbicide, can reduce the biodiversity of weeds.

The lowering of weed biodiversity is not limited to chemical weed management; weeding has also been found to modify weed richness, eliminating minor populations (Richard et al., 2020). In addition, biological weed control with plant extract such as cassava effluent reduces the number of weed species by selectively suppressing some weed species (Ayodele, 2020). For sustainable agricultural production and ecological concern, the rating of weed management practices should focus on its impact on weed biodiversity. Hence, this study aims to investigate the impact of pendimethalin, hoe weeding, and cassava effluent, both individually and in integrated weed management, on weed biodiversity in okra fields. This research is motivated by the economic significance of okra in Nigeria and the imperative for sustainable production.

Materials and Methods

Experimental site

Field trials were conducted at the research facility of the Institute for Agricultural Research and Training Ibadan (7°38’ N 3°84’ E), situated in the agroecological transition zone between rainforest and savanna in southwestern Nigeria. The trial site remained fallow for a year, showcasing predominant vegetation such as *Mimosa pudica*, *Panicum maximum*, and *Mitracapus villosus*. Field experiments were conducted during the rainy season (May–August) of 2017 and 2018, receiving total rainfall of 770 mm and 610 mm, respectively. Land preparation activities, including ploughing and harrowing, were conducted once at the experimental site. Before sowing in the 2017 trial, soil samples were collected from a depth of 0–15 cm using a soil auger. These samples were subsequently bulked, air-dried, sieved, and analysed for physicochemical properties, following standard procedures outlined by the Association of Official Analytical Chemists (AOAC, 2012). The soil’s physicochemical properties are detailed in Table 1, highlighting its composition as an acidic clay loam. The experimental site featured a layout of plots measuring 2 m x 2 m, with alley spacing set at 50 cm between plots and 100 cm between blocks.

Experimental materials

For the trials, Okra seeds (v 35) were procured from the Seed Store at the Institute of Agricultural Research and Training, Ibadan. The herbicide Missile®, a water-soluble concentrate (WSC) of pendimethalin by Wacot Limited Company, was sourced from a reliable agrochemical store. Fresh cassava effluent was gathered from the cassava processing unit at the International Institute of Tropical Agriculture, Ibadan. Obtained through pressing unfermented macerated cassava mash, the effluent was collected in a black container. Using the Ninhydrin-based spectrophotometric method outlined by Surleva et al. (2013), the cyanide concentration in the cassava effluent was determined. Subsequently, the cassava effluent was promptly applied at a rate of 24 g cyanide (CN)/ha, using a calibrated knapsack sprayer.

Table 1. Physicochemical properties of soil at the experimental site

Таблица 1. Физико-химические свойства почвы на экспериментальном участке

pH (H_20)	OC	Total N		Available P		Ca	Mg	K	Na		Sand	Silt	Clay
	(g/kg)			(mg/kg)		(Cmol/ kg)					(g/kg)		
4.9	18	1.5		11.4		1.9	1.3	11.4	0.2		328	239	383

Experimental treatments and design

The study involved nine weed management strategies, namely:

i. Pendimethlin at 1.2 kg a.i./ha applied at sowing (P)
ii. Cassava effluent at 24 g cyanide/ha applied at 3 weeks after sowing (CE@3WAS)
iii. Hoe-weeding at 3 weeks after sowing (HW@3WAS)
iv. Hoe-weeding at 3 and 5 weeks after sowing (HW@3&5WAS)
v. Cassava effluent at 3 weeks after sowing and hoe-weeding at 5 weeks after sowing (CE@3WAS + HW@5WAS)
vi. Cassava effluent applied at 3 and 5 weeks after sowing (CE@3&5WAS)
vii. Pendimethalin and cassava effluent applied at 5 weeks after sowing (P + CE@5WAS)
viii. Pendimethalin and hoe-weeding at 5 weeks after sowing (P + HW@5WAS)
ix. Weedy check

These experimental treatments were arranged in a Randomised Complete Block Design and replicated three times.

Sowing of okra seeds

At the onset of the study, three okra seeds were sown on the flat at 1 cm depth, with a plant spacing of 40 cm x 50 cm. Subsequently, okra seedlings were thinned to a plant per stand at 2 weeks after sowing (WAS).

Data collection

Data on weed density were collected at 9 WAS. Samplings were done using 25 cm x 25 cm quadrats that were randomly fixed at two spots along the diagonals of the plot. Weed samples collected from each plot were identified using the Handbook of West African Weeds by Akobundu and Agyakwa (1998) and counted based on weed species. The relative densities for weed species and morphological groups (further refererred to as “groups”) were determined as follows:

$$\text{Relative Density of Weed Species (\%)} = \frac{\text{Density of a Species}}{\text{Total Density of All Species}}$$

$$\text{Relative Density of Weed Group (\%)} = \frac{\text{Density of a Group}}{\text{Total Density of All Groups}}$$

Also, the biodiversity of weeds in each plot was determined using the Shannon-Weiner species diversity index calculated as follows:

$$H = -\Sigma p_i * ln(p_i)$$

Where Σ: sum, *ln*: natural log, p_i: proportion of the entire community made up of species i.

Data analysis

The data underwent descriptive analysis using SPSS software to ascertain average values and percentages of weed species density and weed group density across various weed management practices.

Results

During the 2017 and 2018 trials, a total of twenty-two weed species belonging to twelve families were identified on the okra field (Table 2). Specifically, eleven weed species were identified in the 2017 trial, while twenty weed species were observed in the 2018 trial. Notably, the 2017 trial exclusively featured two weed species, and the 2018 trial had eleven unique weed species. Meanwhile, both trials shared a common set of nine weed species. The family *Fabaceae* recorded the highest number of observed weed species, followed by *Asteraceae, Euphorbiaceae*, and *Poaceae*, the latter two possessing the same number of species.

Based on the relative density of the weedy check, the prominent weed species in the 2017 trial included *Brachiaria deflexa, Cyperus rotundus, Oldenlandia corymbosa,* and *Tridax procumbens* (Table 3). The weedy check plots exhibited the highest weed species diversity, with nine species, while P + HW@5WAS plots had the lowest weed species diversity among the weed management practices. Remarkably, *B. deflexa and T. procumbens* were found in all the treatments. Weedy check exhibited the highest relative density of *B. deflexa* of 27.1%, while the pendimethalin treatment had the lowest rate of 4%. The highest relative density of *T. procumbens* was found in P + HW@5WAS (66.7%), while HW@3&5WAS exhibited the lowest rate of 4.6%. Additionally, *Tithonia diversifolia* was absent in all weed control treatments, unlike weedy check where it showed 1.7% relative density.

When the groups of weeds in the 2017 trial were analysed, it was observed that the P + HW@5WAS treatment had the highest proportion of broad-leaf weeds, constituting 83.3% of the weed composition, while CE@3WAS exhibiting 27.5% had the lowest rate (Table 4). Weedy check plots showed the highest grass proportion of 27.12%, while pendimethalin plots exhibited the lowest grass rate of 4%. Additionally, the CE@3WAS treatment had the highest proportion of sedges constituting 52.9%, unlike P + HW@5WAS which had none. Pendimethalin had the highest percentage of spiderwort of 8%, while HW@3WAS, HW@3&5WAS, CE@3&5WAS, and P + HW@5WAS had none.

In the 2018 trial, the frequent weed species in terms of relative density in the weedy check comprised *B. deflexa*, *Euphorbia heterophylla*, *C. rotundus*, and *M. villosus* (Table 5). Remarkably, *T. procumbens* and *Senna obtusifolia*, which were not prominent in the weedy check, became predominant in the CE@3&5WAS and pendimethalin treatments. The weedy check and P + CE@5WAS treatments exhibited the highest weed species diversity, reaching eleven, while the HW@3&5WAS treatment had the lowest weed diversity of four species. Notably, *E. heterophylla* was recorded across all treatments, with its relative densities ranging from 55% in the HW@3&5WAS treatment to 3.3% in CE@3&5WAS. *Aspilia africana, O. corymbosa*, and *Malvastrum coromandelianum* were absent in the weedy check, but were identified in not less than two weed control treatments.

Analysing the weed groups in the 2018 trial (Table 6) reveals that the P+CE@5WAS treatment displayed the highest proportion (89.47%) of broad-leaf weed species, whereas the one-time hoe-weeding (HW@3WAS) treatment exhibited the lowest percentage (43.75%). Sedge weeds were most prevalent in weedy check plots, constituting 31.5%, while CE@3WAS+HW@5WAS plots had the least at 2.2%. The highest density of grass weeds was recorded in one-time hoe-weeding (53.13%), while pendimethalin had the lowest (1.96%). Additionally, spiderwort was exclusively observed in plots treated with pendimethalin, constituting 5.5% of the overall composition.

Measuring biodiversity within the ecological communities established by the experimental treatments, the weedy check demonstrated the highest Shannon-Wiener index (H') among the treatments in 2017, while the P+CE@5WAS treatment recorded the highest H' in 2018 (Table 7). Conversely, the P+HW@5WAS and HW@3&5WAS treatments exhibited the lowest H' values in 2017 and 2018, respectively. For both years, the average H' values for the treatments decreased in the order of weedy check, CE@3&5WAS, CE@3WAS, P+CE@5WAS, CE@3WAS+HW@5WAS, P+HW@5WAS, pendimethalin, HW@3WAS, and HW@3&5WAS.

Discussion

The results from the 2017 and 2018 trials, identifying a total of twenty-two weed species across twelve families, carry significant implications for weed management and crop productivity. The observed increase in the number of weed species from eleven in 2017 to twenty in 2018 may suggest evolving weed dynamics influenced by factors such as climate (Malarkodi et al., 2017), soil conditions (Govindasamy et al., 2021), or agronomic practices (Terzi et al., 2021).

The presence of exclusive weed species in each trial year underscores the variability in weed composition, emphasizing the need for tailored and adaptive weed control strategies. The shared set of nine weed species in both trials may indicate persistent or stable weed species across different growing seasons. The dominance of the Fabaceae family in terms of the highest number of weed species highlights the need for targeted interventions against weeds from this family. The comparable numbers of weed species in the Asteraceae, Euphorbiaceae, and Poaceae families suggest that these families also play a substantial role in the weed population.

Table 2. Taxonomic composition and characteristics of weeds in 2017 and 2018 trials
Таблица 2. Таксономический состав и характеристики сорных растений в экспериментах 2017 и 2018 гг.

Trials	Weed species	Family	Group	Life cycle
a	*Talinum fruticosum* (L.) Juss	*Portulacaceae*	Broadleaf	Annual / Perennial
a	*Tithonia diversifolia* (Hemsl.) A. Gray.	*Asteraceae*	Broadleaf	Annual
ab	*Ageratum conyzoides* L.	*Asteraceae*	Broadleaf	Annual
ab	*Boerhavia diffusa* L.	*Nyctaginaceae*	Broadleaf	Annual / Perennial
ab	*Brachiaria deflexa* (Schumach.) C.E. Hubb. ex Robyns	*Poaceae*	Grass	Annual
ab	*Commelina benghalensis* L.	*Commelinaceae*	Broadleaf	Annual / Perennial
ab	*Cyperus rotundus* L.	*Cyperaceae*	Sedge	Perennial
ab	*Mitracapus villosus* (Sw.) DC.	*Rubiaceae*	Broadleaf	Annual
ab	*Oldenlandia corymbosa* L.	*Rubiaceae*	Broadleaf	Annual
ab	*Megathysus maximum* Jacq.	*Poaceae*	Grass	Perennial
ab	*Tridax procumbens* L.	*Asteraceae*	Broadleaf	Annual
b	*Cynodon plectostadyus* (K.Schum.) Pilg.	*Poaceae*	Grass	Annual
b	*Calopogonium mucunoides* Desv.	*Fabaceae*	Broadleaf	Annual / Perennial
b	*Centrosema pubescens* Benth.	*Fabaceae*	Broadleaf	Perennial
b	*Euphorbia heterophylla* L.	*Euphorbiaceae*	Broadleaf	Annual
b	*Euphorbia hirta* L.	*Euphorbiaceae*	Broadleaf	Annual
b	*Ipomoea involucrata* P. Beauv.	*Convolvulaceae*	Broadleaf	Annual / Perennial
b	*Malvastrum coromandelianum* (L.) Garcke	*Malvaceae*	Broadleaf	Annual / Perennial
b	*Mimosa pudica* L.	*Fabaceae*	Broadleaf	Annual / Perennial
b	*Phyllanthus amarus* Schumach. & Thonn.	*Euphorbiaceae*	Broadleaf	Annual
b	*Spigelia anthelmia* L.	*Loganiaceae*	Broadleaf	Annual / Perennial
b	*Senna obtusifolia* (L.) H.S. Irwin & Barneby	*Fabaceae*	Broadleaf	Annual / Perennial

a = 2017 trial; ab = 2017 and 2018 trials; b = 2018 trial

Table 3. Effect of weed management strategies on weed species composition and relative density 9 weeks after sowing in 2017
Таблица 3. Влияние стратегии борьбы на видовой состав и соотношение сорных растений через 9 недель после посева в 2017 г.

Weed species	Relative Density (%)								
	HW @3WAS	HW @3&5WAS	CE @3WAS	CE@3WAS +HW@5WAS	CE @3&5WAS	P	P+ HW@5WAS	P+ CE@5WAS	Weedy Check
Ageratum conyzoides L.	-	-	-	4.4	-	-	16.7	8.3	1.7
Boerhavia diffusa L.	2.9	-	-	-	2.6	-	-	-	1.7
Brachiaria deflexa (Schumach.) C.E. Hubb. ex Robyns	11.9	18.2	17.7	13.0	19.7	4.0	16.7	8.3	27.1
Commelina benghalensis L.	-	-	2.0	4.4	-	8.0	-	4.2	-
Cyperus rotundus L.	9.5	45.5	52.9	13.0	11.1	20.0	-	20.8	13.6
Mitracapus villosus (Sw.) DC.	4.8	9.1	-	4.4	2.6	8.0	-	8.3	10.2
Oldenlandia corymbosa L.	61.9	22.7	3.9	34.8	43.6	24.0	-	-	33.9
Megathysus maximum Jacq.	-	-	-	4.4	0.9	-	-	-	-
Talinum fruticosum (L.) Juss.	2.4	-	3.9	-	2.6	-	-	-	1.7
Tithonia diversifolia (Hemsl.) A. Gray	-	-	-	-	-	-	-	-	1.7
Tridax procumbens L.	7.1	4.6	19.6	21.7	17.1	36.0	66.7	50.0	8.5

WAS = weeks after sowing, HW@3WAS = hoe weeding at 3 WAP, HW@3&5WAS = hoe-weeding at 3 WAS and 5 WAS, CE@3WAS = Cassava effluent of 24 g CN/ha applied at 3 WAS, CE@3WAS+HW@5WAS = Cassava effluent of 24 g CN/ha applied at 3 WAS and 1 hoe-weeding at 5 WAS, CE@3&5WAS= Cassava effluent of 24 g CN/ha applied at 3 and 5 WAS, P = Pendimethalin of 1.2 kg a.i ha^{-1} applied at planting, P+HW@5WAS = Pendimethalin of 1.2 kg a.i ha^{-1} applied at planting, and hoe-weeding at 5 WAS, P+CE@5WAS = Pendimethalin of 1.2 kg a.i ha^{-1} applied at planting and cassava effluent of 24 g CN/ha applied at 5 WAS, Weedy check = No weeding treatment.

Table 4. Effect of weed management strategies on relative density of weed groups 9 weeks after sowing in 2017
Таблица 4. Влияние стратегии борьбы на соотношение групп сорных растений через 9 недель после посева в 2017 г.

Weed groups	HW @3WAS	HW @3&5WAS	CE @3WAS	CE@3WAS +HW@5WAS	CE @3&5WAS	Pendimethalin (P)	P+ HW@5WAS	P+ CE@5WAS	Weedy Check
Broad-leaf (%)	78.6	36.4	27.5	65.2	68.4	68.0	83.3	66.7	59.3
Grass (%)	11.9	18.2	17.7	17.4	20.5	4.0	16.7	8.3	27.1
Sedge (%)	9.5	45.5	52.9	13.0	11.1	20.0	0.0	20.8	13.6
Spiderwort (%)	0.0	0.0	2.0	4.4	0.0	8.0	0.0	4.2	0.0

Abbreviations as in Table 3.

Table 5. Effect of weed management strategies on weed species composition and relative density 9 weeks after sowing in 2018

Таблица 5. Влияние стратегии борьбы на видовой состав и соотношение сорных растений через 9 недель после посева в 2018 г.

Weed Species	Relative Density (%)								
	HW @3WAS	HW @3&5WAS	CE @3WAS	CE@3WAS +HW@5WAS	CE @3&5WAS	P	P+ HW@5WAS	P+ CE@5WAS	Weedy Check
Aspilia africana L.	-	-	-	-	2.2	7.8	3.2	28.7	-
Boerhavia diffusa L.	-	-	-	-	-	-	-	-	1.9
Brachiaria deflexa (Schumach.) C.E. Hubb. ex Robyns	53.1	-	21.5	33.3	23.8	2.0	6.5	5.3	21.7
Calopogonium mucunoides Desv.	-	-	-	-	2.2	-	-	1.8	-
Centrosema pubescens Benth.	-	-	-	-	-	-	-	-	-
Commelina benghalensis L.	-	-	-	-	-	5.9	-	-	-
Cynodon plectostadyus (K.Schum.) Pilg.	-	20.0	-	-	-	-	-	-	-
Euphorbia heterophylla L.	9.4	50.0	26.6	11.1	3.3	11.8	25.8	14.4	13.4
Euphorbia hirta L.	-	-	1.27	-	-	-	-	-	-
Ipomoea involucrata P. Beauv.	-	-	-	-	-	-	-	1.8	-
Cyperus rotundus L.	3.1	-	3.8	11.1	2.2	9.8	19.5	5.3	31.5
Malvastrum coromandelianum (L.) Garcke	-	-	1.3	-	-	-	9.7	-	-
Mimosa pudica L.	-	-	-	-	1.1	-	-	-	2.2
Mitracapus villosus (Sw.) DC.	25.0	-	21.5	22.2	13.2	-	-	3.5	17.4
Oldenlandia corymbosa L.	-	-	1.3	-	-	2.0	12.9	-	-
Panicum maximum	-	-	-	-	-	-	-	-	2.2
Phyllanthus amarus Schumach. & Thonn.	-	10.0	-	-	1.1	-	3.2	1.8	1.9
Spigelia anthelmia L.	-	-	-	-	-	-	-	3.5	2.2
Tridax procumbens L.	6.3	20.0	5.6	22.2	27.5	7.8	-	28.7	6.5
Senna obtusifolia (L.) H.S. Irwin & Barneby	3.1	-	17.7	-	24.2	52.9	19.4	7.2	1.9

Abbreviations as in Table 3.

Table 6. Effect of weed management strategies on the relative density of weed groups 9 weeks after sowing in 2018

Таблица 6. Влияние стратегии борьбы на соотношение групп сорных растений через 9 недель после посева в 2017 г.

Weed groups	HW @3WAS	HW @3&5WAS	CE @3WAS	CE@3WAS +HW@5WAS	CE @3&5WAS	Pendimethalin (P)	P+ HW@5WAS	P+ CE@5WAS	Weedy Check
Broad-leaf (%)	43.75	80.00	74.68	74.73	55.56	82.35	74.19	89.47	44.57
Grass (%)	53.13	20.00	21.52	23.08	33.33	1.96	6.45	5.26	23.91
Sedge (%)	3.13	0.00	3.80	2.20	11.11	9.80	19.35	5.26	31.52
Spiderwort (%)	0.00	0.00	0.00	0.00	0.00	5.88	0.00	0.00	0.00

Abbreviations as in Table 3.

Table 7. Effect of weed management strategies on Shannon-Wiener Indexes *(H')* of weed biodiversity in 2017 and 2018

Таблица 7. Влияние стратегии борьбы на индекс Шеннона-Винера *(H')* биоразнообразия сорных растений в 2017 и 2018 гг.

	HW @3WAS	HW @3&5WAS	CE @3WAS	CE@3WAS +HW@5WAS	CE @3&5WAS	Pendimethalin (P)	P+ HW@5WAS	P+ CE@5WAS	Weedy Check
2017	-1.30	-1.15	-1.29	-1.37	-1.56	-1.16	-0.87	-1.09	-1.71
2018	-1.29	-1.22	-1.77	-1.52	-1.77	-1.54	-1.87	-1.95	-1.92
Average	-1.30	-1.18	-1.53	-1.44	-1.66	-1.35	-1.37	-1.52	-1.82

Abbreviations as in Table 3.

The notable presence of *B. deflexa* and *C. rotundus* in both years of the trial, coupled with the high occurrence of *O. corymbosa* and *T. procumbens* in the weedy check of the 2017 trial, as well as *E. heterophylla* and *M. villosus* in the weedy check of the 2018 trial, highlights the prevalence of these weed species in unmanaged environments of rainforest-savanna transitional regions in Ibadan. Prominently, in the 2018 trial, *T. procumbens* and *S. obtusifolia*, previously inconspicuous in the weedy check, became prominent in the CE@3&5WAS and pendimethalin treatments. This indicates that certain weed control methods might inadvertently promote weed shift. This finding is consistent with the observations of Chaniago *et al.* (2023), underscoring the importance of thoughtful consideration when choosing and implementing weed management practices.

The highest weed species diversity observed in the weedy check plots in the trials, as also reported by Naeem et al. (2022), signifies the varied weed composition between treated and untreated conditions, emphasizing the potential for diverse weed communities in the absence of management interventions. However, P + CE@5WAP in 2018 trial that had same number of weed species as the weedy check underscores the complexity of weed communities in this integrated weed management practice. The relatively lower weed species diversity in P + HW@5WAS and HW@3&5WAS plots in the 2017 and 2018 trial respectively, indicates a potential impact of these specific weed management practices in reducing overall weed diversity.

The consistent occurrence of *B. deflexa* and *T. procumbens* across all treatments in the 2017 trial accentuates their resilience and adaptability as reported by Waheed et al. (2022) and Olayinka et al. (2020). The dispersal corridor for the seeds of these weeds plays a major role in their persistence suggesting that they may require targeted management strategies. The variation in the relative density of *B. deflexa* and *T. procumbens* among treatments, with notable differences in the weedy check and P + HW@5WAS, further emphasizes the influence of management practices on specific weed species. Similarly, the persistence of *E. heterophylla* across all treatments in 2018 trial, with varying relative densities, suggests its adaptability and resilience to different weed control methods. The wide range of relative densities, from 55% in the 2 hoe-weeding treatment to 3.3% in CE + CE, further emphasizes the influence of specific management practices on the abundance of this particular weed species.

The absence of *T. diversifolia* in all weed control treatments in the 2017 trial, in contrast to its presence in the weedy check, points towards the potential effectiveness of the applied weed control methods in restricting the growth of this particular species. These findings align with Woghiren et al. (2021) and Amosun *et al*. (2021) that *T. diversifolia* can effectively be managed. The outcome provides a foundation for refining weed control strategies, with potential implications for improving crop yield and sustaining agricultural ecosystems.

The absence of *A. africana, O. corymbosa*, and *M. coromandelianum* in the weedy check of the 2018 trial, in contrast to their presence in the weed-managed plots, suggests that certain weed management practices might unintentionally facilitate the introduction or promotion of particular weed species. This observation emphasizes the importance of understanding the potential consequences of weed control methods on the broader weed community.

The high proportion of broad-leaf weeds in the P + HW@5WAS (2017) and P + CE@5WAS (2018) treatment suggests that these specific weed management strategies favour the growth of broad-leaf species. In contrast, CE@3WAS (2017) and HW@3WAS (2018) treatments which exhibited the least proportion of broad-leaf weeds indicate a potential impact of these particular weed control methods in limiting the dominance of broad-leaf species.

The observation from the 2017 trial that weedy check plots displayed the highest grass composition at 27.12% aligns with the general understanding that untreated or less managed conditions often lead to an increase in grassy weed species. This tallies with the findings of Tuesca *et al*. (2001) that grassy annual populations increased in undisturbed soil. The highest percentage of grassy weeds recorded by HW@3WAS in 2018 trial suggests its ineffectiveness in managing grassy weeds. This outcome may be attributed to the presence of underground structures that may have been disrupted, sliced, and subsequently re-established (Avav, 2000; Mashingaidze et al., 2009). Conversely, pendimethalin plots exhibited the lowest grass composition in both trials, suggesting the effectiveness of pendimethalin in suppressing the growth of grassy weeds. This corroborates Yadav et al. (2017) that pre-emergence application of pendimethalin is effective in controlling grasses. The variation in grass composition among different treatments underscores the importance of selecting appropriate weed control measures based on the prevalent weed species.

The high proportion of sedge weeds found in CE@3WAS treatment in the 2017 trial and weedy check in 2018, highlights the specificity of certain weed management strategies in influencing the prevalence of particular weed types. Notably, P + HW@5WAS showed no presence of sedge weeds in 2017, indicating its potential efficacy in suppressing this weed group. The noteworthy reduction in sedge weed composition observed in the 2018 trial within the CE@3WAS+HW@5WAS plots suggests a potential impact of this combined control approach on minimizing the growth of sedge weeds. This observation and that of 2017 suggest that supplementary weeding after herbicide or plant extract application seems effective in reducing the growth of sedge weeds.

The highest percentage of spiderwort observed in the pendimethalin treatment in the 2017 trial implies that this herbicide may be promoting the growth of spiderwort. The exclusive observation of spiderwort in plots treated with pendimethalin in the 2018 trial further corroborates this view. The absence of spiderwort in HW@3WAS, HW@3&5WAS, CE@3&5WAP, and P + HW@5WAS treatments suggests that disturbance of the soil by hoe-weeding and repeated application of cyanide might have prevented the establishment of spiderwort.

The assessment of weed biodiversity using the Shannon-Wiener index (H') in the context of this study provides valuable insights into the ecological dynamics and the effectiveness of different weed management strategies. The weedy check demonstrating the highest H' in 2017 suggests that untreated conditions promote greater diversity within weed communities. In 2018, the recording of the highest H' by P + CE@5WAS treatment indicates that this integrated weed management approach promotes diverse weed community.

The observed lowest H' values in the P + HW@5WAS and HW@3&5WAP treatments in 2017 and 2018, respectively, suggest that these weed management practices may lead to a reduction in overall weed species diversity. This finding suggests that there may be negative impact on the ecological services supported by weed diversity in these weed management practices compared to unmanaged field (Singh et al., 2022).

The average H' values for weed management practices in both years provide a comprehensive ranking of treatments based on their impact on weed diversity. The decreasing diversity trend from the weedy check, CE@3&5WAP, CE@3WAP, P+CE@5WAS, CE@3WAP + HW@5WAP, P + HW@5WAP, Pendimethalin, HW@3WAP to the HW@3&5WAP treatment is suggestive of decreasing ability of these weed management practices in supporting ecological services. However, their suppressive potentials for weed species is increasing in this order.

Conclusion

Weed control methods evaluated significantly altered the weed flora composition in the okra plots permitting the emergence of some new weed species but decreasing the overall weed diversity. However, integrated weed management methods involving hoe-weeding and cassava effluent had more weed diversity compared to sole pendimethalin and hoe weeding. Hence, for ecologically sustainable weed management in okra field, integrated weed management is preferred to the sole use of herbicides and weeding.

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Полнотекстовая статья

ОЦЕНКА ФИТОЦЕНОЛОГИЧЕСКИХ ХАРАКТЕРИСТИК КОМПЛЕКСА СОРНЫХ РАСТЕНИЙ В ПОСЕВАХ БАМИИ ПРИ РАЗЛИЧНЫХ СТРАТЕГИЯХ БОРЬБЫ

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Разнообразие сорных растений критически важно для поддержки экологических взаимосвязей. Методы борьбы с сорными растениями существенно влияют на их доминирование и разнообразие. В данном исследовании, проведенном в юго-западной переходной агроэкологической зоне дождевого леса и саванны в Нигерии в сезон дождей 2017 и 2018 гг. Были опробованы различные средства и способы борьбы с сорными растениями, включая сточные воды от отходов маниоки, содержащих цианид из расчёта 24 г/га (CE@3WAS), пендиметалин, 1.2 кг/га (P) и прополку мотыгой (HW@3WAS), повторные обработки HW и CE (HW@3&5WAS, CE@3&5WAS), а также интегрированные подходы (P + CE@5WAS, P + HW@5WAS, CE@3WAS + HW@5WAS). В контрольном варианте сорняки не подвергались обработке. Эксперимент проведен по схеме полной рандомизации в трёх повторениях. Образцы сорных растений были собраны с рандомизированных участков по диагонали участка с помощью рамок 25x25 см. Их разнообразие оценивалось с помощью индекса Шэннона-Винера и описательной статистики. Результаты показали, что методы борьбы повлияли на видовой состав сорных растений. В частности, присутствие двудольных сорных растений было заметным в вариантах P + HW@5WAS (2017) и P + CE@5WAS (2018), тогда как злаковые преобладали в контроле (2017) и HW@3WAS (2018), указывая на то, что эти подходы благоприятствуют определенным биологическим группам. Разнообразие сорных растений снижалось в ряду обработок в следующем порядке: CE@3&5WAP, CE@3WAP, P+CE@5WAS, CE@3WAP + HW@5WAP, P + HW@5WAP, Pendimethalin, HW@3WAP и HW@3&5WAP. Эти наблюдения подчеркивают важность выбора стратегий борьбы с сорными растениями в зависимости от их экологической значимости. Интегрированные методы борьбы представляются более надежным подходом для посевов бамии по сравнению с применением отдельных гербицидов и ручной прополкой.

Ключевые слова: экологические функции, разнообразие сорных растений, борьба с сорными растениями, группы сорных растений, смена состава сорных растений

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