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COMPARATIVE ANALYSIS OF HERBICIDE BIOACTIVITY FOR WEED MANAGEMENT IN COWPEA CULTIVATION WITHIN LAPAI, NIGERIA

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SUMMARY

Field study was carried out in 2022 and 2023 rainy seasons at the Teaching and Research Farm of Ibrahim Badamasi Babangida University, Lapai, Niger State to evaluate the efficacy of pre and post emergence herbicides against weed species on the performance of three varieties of cowpea (*Vigna unguiculata* L). The experiment consisted of three Cowpea varieties (Kananado (Local), SAMPEA 11 [IT – 89-288] and SAMPEA 12 [IT-89-391]) including six weed control methods (application of Paraquat at 1.5 kg a.i. ha^{-1}(Pre); Paraquat at 1.0 kg a.i. ha^{-1} (Pre) followed by (fb) Diuron at 1.5 kg a.i. ha^{-1}(post); pendimethalin at 1.5 kg a.i. ha^{-1}(pre) only; pendimethalin at 2.0 kg a.i. ha^{-1} (pre) fb imazathapyr at 1.5 kg a.i. ha^{-1} (post); 2, 4-D at 2.0 kg a.i. ha^{-1} fb Diuron at 1.5 kg a.i. ha^{-1} (post) and Control. The experiment was laid out in a Randomize Complete Block Design (RCBD) replicated three times. Data that were collected include weed (weed density and weed control efficiency), growth and yield parameters of cowpea and were subjected to analysis of variance (ANOVA) using statistical analysis software GENSTAT 17th Edition and Duncan's Multiple Range Test (DMRT) was used for mean separation at 5% level of probability. Results showed that SAMPEA 11 had the highest number of leaves and leaf area. Weed species were suppressed more with SAMPEA 11 which also indicated that SAMPEA 11 recorded the highest weed control efficiency (WCE). Application of pendimethalin at 2.0 kg a.i. ha^{-1} fb imazathapyr at 1.5 kg a.i ha^{-1} recorded the tallest plant with highest number of leaves and branches of cowpea including the highest dry pod yield. From the result, SAMPEA 11 with application of pendimethalin at 2.0 kg a.i. ha^{-1} followed by imazathapyr at 1.5 kg a.i. ha^{-1}is therefore recommended for the production of Cowpea varieties in the study area.

Keywords: Varieties, herbicides, cowpea, weed, beans, pendimethalin

INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp.) is an important legume in Nigeria's agricultural landscape and has a long history of domestication and cultivation in many places. It is well-known for its adaptability to a variety of conditions as well as its high nutritional content. Nigeria, a significant producer and consumer of cowpeas, depends on them for food security and money production. Phillip *et al*. (2019) reported that cowpea was originated in Africa and the main producing countries are

in Africa. West Africa contributes for 95% of global output with Nigeria being the leading producer and user (Rivas *et al*., 2016; Phillip *et al*., 2019). While Nigeria and Niger are Africa's largest producers of cowpea, Burkina Faso, Cameroon, Ghana, Kenya, Uganda and Tanzania also produce cowpea. According to FAOSTAT (2023), Nigeria had the largest cowpea output in 2021, totaling 3.63 million metric tons (MT) across 4.7 million hectares. With the world population predicted to expand by up to 70% by 2050, the global society is faced with the constraint of supplying safe and secure food supplies to an increasing number of people (Omomowo and Babalola, 2021). These constrains that are posing threats to improvement in agricultural productivity need to be addressed to devise novel and workable solutions to achieve sustainable means of enhancing productivity in terms of agro-products and their nutritional composition. Such threats include climatic change, loss of fertile agricultural land, inappropriate use of herbicides for weed control, low-yielding cowpea seed cultivars including challenges ofmicrobial pathogens and pests such as weeds.

Despite the significant importance of cowpea as a food source in Nigeria, its yield is often low. The cowpea varieties IT89KD-288 (now SAMPEA-11) and IT89KD-391 (now SAMPEA-12) were developed by scientists at the International Institute of Tropical Agriculture (IITA) in collaboration with the Institute for Agricultural Research (IAR) The cultivars outperform the local kinds in terms of yield, with a yield advantage of at least 80% over the local varieties, particularly the IT89KD-288 variety. The low performance of some cwpea varieties may be due to a combination of factors, including poor soil fertility, inadequate weed control, the use of inferior seed varieties, and susceptibility to pests and diseases. Identifying cowpea varieties grown on smallholder farms would serve as an indicator of the degree to which improved varieties have been adopted and how they have performed against pests and diseases (Baoua*et al*., 2021).

Weeds compete for nutrients, space, and light, lowering crop production quality and quantity if not controlled. Akobundu (1987) defines weed control as acts aimed at limiting the spread of weeds and reducing their population in a certain area. It is a necessary component of crop productivity and therefore weed removal is essential for efficiently using disrupted natural ecosystems for food, fiber, shelter, and entertainment. Manual weed removal is effective but limited due to manpower shortages and high costs. Gupta *et al*. (2016) suggest that integrated weed management may be more effective in minimizing weed-related yield losses in cowpea crops. Chemical weed control, such as the use of herbicides, is the most feasible, successful and cost-effective method for controlling plants and weeds (Yadav *et al*., 2017).Herbicides disrupt weeds' biochemical and physiological processes, resulting in their death or significant growth retardation (Monteiro *et al*., 2012). Herbicides increase production, improve product quality, reduce labor-intensive hand weeding, and reduce soil erosion and topsoil loss by requiring less cultivation and tillage (which reduces fossil fuel use). Herbicide is excellent for controlling weeds in arable fields.The objective of this study was therefore to compare the effects of different herbicides as weed control techniques on the performance of cowpea varieties in order to make appropriate recommendation for weed management system in this agro-ecological zone.

MATERIALS AND METHODS

Description of the Study Site

Fields trials were conducted in the Southern Guinea Savanna agro-ecological zone of Nigeria in 2022 and 2023 cropping seasons at the Teaching and Research Farm of Ibrahim Badamasi Babangida University, Lapai, Niger State to evaluate the efficacy of pre and post emergence herbicides on weed control in three varieties of cowpea (*Vigna unguiculata* L). Lapai is positioned at Latitude 9^{O} 2′N and Longitude 6^{O} 34′E at 37 m above sea level). The region receives less than 1000mm of rainfall per year, with a wet season from April to September and peak periods from October to March. The temperature in Lapai varies depending on the season. During the dry season, temperatures range from 30^{o}C to 36^{O} from December to April. During the rainy season, temperatures range from 26^{O}C to 30^{O}C with the highest temperatures occurring at midday between May and July.

Land Preparation and Collection of Soil Samples

Soil samples were collected across the experimental site for physical and chemical analysis of the soil. This was done after the land was cleared of bushes, shrubs and previous year's crop residues. Initial weed species composition observed at the experimental site were *Cleome viscosa* L, *Hyptis suaveolens* Poir., *Digitaria horizontalis* Willd., *Cyperus esculentus* Linn., *Cyperus rotundus* L, *Commelina benghalensis* L., and *Phyllanthus amarus* Schum. & Thonn. Tractor-mounted disc plough and ridgerwas used for the tillage operation. The plot size was 3 m × 3 m (9 m^2). The leeway between plots was 1 m and each replicate was separated by 1 m. Planting of cowpea was done by planting two seeds per hole at intra-row spacing of 30 cm and inter-row spacing of 75cm.

Treatment and experimental design

The experimental setup comprised of three varieties of cowpea, [Kananado (Local), SAMPEA 11 and SAMPEA 12] and six weed control methods (application of paraquat at 1.5 kg a.i. ha^{-1} (Pre) at one day after planting (1 DAP); Paraquat at 1.0 kg a.i. ha^{-1}(1 DAP); (Pre-emergence as folia applied to kill all current weeds that were not covered to give the crop a clean start) followed by (fb) diuron at 1.5 kg a.i. ha^{-1} (post) at three weeks after sowing (3 WAS); pendimethalin at 1.5 kg a.i. ha^{-1} (pre) only at 1 DAP; pendimethalin at 2.0 kg a.i. ha^{-1} (pre) at 1 DAP, fb imazathapyr at 1.5 kg a.i. ha^{-1} (post) at 3 WAS; 2, 4-D at 2.0 kg a.i. ha^{-1} at 1 DAP, fb diuron at 1.5 kg a.i. ha^{-1} (post) 3 WAS and Control making a total of 18 treatment combinations. CP 15 Knapsa sprayer was used for applying herbicide treatments. These treatments were arranged in a Randomized Complete Block Design (RCBD) and replicated three times. Each plot measured 3m x 3m, with a 1m pathwayeach within and between plots. Two seeds were planted per hole, those seed that could not germinate at two weeks after planting were supplied. Application of herbicides as weed control methods wascarried out based on the treatment allocation. In the case of pest insect control during flowering, Cypermethrin 10% EC formulation was uniformly applied at the rate of 1.5 kg a.i. ha^{-1} to control insects fortnightly.

Data Collection

In each plots,5 plant stands were randomly selected and tagged in the net plot (4.5 m^2) for data collection. Data were collected on cowpea plant height, number of leaves, number of branches and leaf area at 3 and 6 WAS, and grain yield parameters such as grain yield, 100 seed weight, harvest index and shelling percentage after harvesting. Weed parameters were determined on weed

density, weed cover, weed control efficiency and weed dry matter 0.5m × 0.5m randomly placed within each plot at 3 and 6 WAS.Weeds within each quadrat were harvested, separated into three broad morphological groups (grasses broadleaves and sedges) for computation of relative density of each weed species.

Weed density

Weed density was determined in each plot at 3 and 6 WAS by counting the number of each weed species within the **quadrat** and recorded. Weed density,Weed density was therefore calculated using the formula below as expressed by Mahajan and Fatima (2017).

Weed density =

$$\frac{\text{Total number of individual weed species in all quadrats}}{\text{Total number of quadrats studied}} \times 100$$

Relative frequency

The degree of dispersion of individual species in an area in relation to the number of all the species occurred is termed as relative frequency. It is calculated as below as developed by Rana and Kumar (2014).

Relative frequency=

$$\frac{\text{Total number of occurrence of the species}}{\text{Number of occurrence of all the species}} \times 100$$

Relative weed density

Relative density is the study of numerical strength of a species in relation to the total number of individuals of all the species. The process was done by observing the frequencies, identifying and classifying predominant weedsfound in the experimental site during the growing season. The classification was based on morphology (Grasses, Broad leaves and Sedges weeds). It was calculated based on the formular developed by Rana and Kumar (2014).

Relative density =

$$\frac{\text{Total number of individuals of the species}}{\text{Number of individuals of all the species}} \times 100$$

Weed control efficiency (WCE) (%)

Weed control efficiency (WCE) refers to the magnitude of weed reduction achieved through weed control procedures. It was calculated using the formula proposed by Mani *et al*. (1973) and expressed in percentage as shown below;

WCE (%) =

$$\frac{\text{Weed density in control plots–weed density in treated plots}}{\text{Weed density in control plots}} \times 100$$

Data analysis

The data was analyzed using the GenStat Discovery 17 edition software package, and significant means were separated using the Duncan Multiple Range Test at the 5% level of probability.

RESULTS

Soil physical and chemical properties for the 2022 and 2023croping seasons is shown in Table 1. The soil at the experimental site was sandy loam in both years, with pH values of 5.7 in 2022 and 5.4 in 2023. According to the NSPFS (2005) soil rating assessment, organic carbon, total nitrogen, and the distribution of available P in the soil were all low both years. The exchangeable base was high in terms of K^{+2} and Na^{+2}, whereas Ca^{+2} and Mg^{+2} were low and medium in the soil, respectively. In 2022 and 2023, the soil showed high cation exchange capacity (CEC) values of 72.4 and 74.5 C mol kg^{-1}

Table 1: physical and chemical analysis of soil of the experimental site in 2022 and 2023 in rainy season in Lapai

	Physical properties				Chemical properties				Exchangeable base (Cmol kg^{-1})				
	Sand %	Clay %	Silt %	Textural class	pH in water	OC %	Total N. %	Avail. P. (Mg kg^{-1})	Ca^{+2}	Mg^{+2}	K^{+2}	Na^{+2}	CEC
Soil 2022	75. 8	13.7	10. 5	Sandy loam	5.7	4. 55	1.84	0.86	1.59	0.35	7.83	1.77	72.4
Soil 2023	73.7	14.2	12.1	,,	5.4	4. 64	1.81	0.90	1.43	1.32	8.71	1.83	74.5

Weed species composition of the experimental field

Weed species of the experimental field during 2022 rainy season consisted of 23 weed species comprising of 6 grasses, 13 broadleaves and 4 sedges; and 6 grasses, 16broadleaves and 4 sedges in 2023. The weed species found in the experimental plots belongs to 12 families of which Family Poaceae had 6 species; Cyperaceae 4 species; Euphorbiaceae 3 species; Asteraceae 2; Leguminoceae 2 species; Lamiaceae 2 species; Amaranthaceae 1 specie; Urticaceae 1 specie; Cleomaceae 1 specie; Commelinaceae 1 species; Nyctaginaceae 1 specie; Solanaceae 1 specie; and Rubiaceae had 1 species.

Relative density and relative frequency of weed species composition in the experimental field.

Relative Densities and Relative Frequencies of weed species in the experimental field in 2022 and 2023 rainy season is shown in Table 2. In 2022 at 3 WAS, the highest relative weed density was *Hyptis suaveolens (*78. 15 %) which was followed by *Tridex procumbens* (76.24 %). Similar result was observed at 6 WAS where *Hyptis suaveolens* (70. 25 %) recorded the highest relative weed density followed by *Tridex procumbens* (69.87 %). Relative weed frequency at 3 WAS in 2022 indicates that *Imperata cylindrica* (92.33) recorded the highest relative weed frequency followed by *Hyptis suaveolens* (87.55) and *Tridax Procumbens* Linn (87. 66) while at 6 WAS, *Cyperus amabilis*(86.66) recorded the highest relative weed frequency followed by *Hyptis suoveolense* (85.72) and *Tridax Procumbens*(84.33) while *Imperata cylindrical* recorded 53.33. In 2023 at 3 WAS, *Tridex procumbens* (74.24) recorded the highest relative weed density and followed by *Hyptis suaveolens*(70. 85 %), while at 6 WAS, weed relative weed density has reduced which shows that *Hyptis suaveolens* (64.54) and *Tridex procumbens* (62.58) were the highest relative weed density respectively. At 3 WAS in 2023, *Imperata cylindrical* (93.33) recorded the highest relative weed frequency which was followed by *Tridex procumbens* (87.64) and *Hyptis suaveolens*(84.25). It was observed that at 6 WAS*Tridexprocumbens* (82.55) recorded the highest relative weed frequency followed by *Cyperus amabilis* (77. 67) and *Hyptis suaveolens* (71.12) including *Imperata cylindrica* (50.33) respectively.

Weed density, Weed control efficiency and weed dry matter as affected by Bioactivities of herbicides on Cowpea varieties

Weed density, weed control efficiency and weed dry matter were significantly ($p<0.05$) affected with the application of both pre and post herbicides in 2022 and 2023 rainy seasons in Lapai (Table 3). In both years, plots planted with kananado recorded the highest weed density which was statistically similar with plots planted with SAMPEA 12 while SAMPEA 11 recorded the lowest weed density. Conversely in 2022, application of pendimethalin at 2.0 kg a.i. ha^{-1} fb imazathapyr at 1.5 kg a.i. ha^{-1} recorded the lowest weed density in both years and was statistically lower than other treatments all of which in turn were lower than the weedy check Weed control efficiency was significantly ($p<0.05$) affected by cowpea varieties and the use of Herbicide types. Highest weed control efficiency was observed under SAMPEA 11 in comparison with kanabadoand SAMPEA 12 which were statistically similar recording the lowest weed control efficiency in both years. In 2022, pendimethalin at 2.0 kg a.i. ha^{-1} fb imazathapyr at 1.5 kg a.i. ha^{-1} recorded the highest weed control efficiency, which

Table 2: Relative density and Relative frequency of weed species on the experimental field in 2022 and 2023raining seasons at Lapai, Niger State.

Name of weed	Family name	2022 Relative density (%)		2022 Relative frequency (%)		2023 Relative density (%)		2023 Relative frequency (%)	
GRASSES		3 WAS	6 WAS	3 WAS	6 WAS	3 WAS	6 WAS	3 WAS	6 WAS
Andropogon tectorum (Linn)	Poaceae	0	0.22	0	3.33	0.12	0.26	0.78	3.33
Brachiari alata(Schumach Ce. Hubbard)	”	0.43	0.44	6.66	6.66	0.35	0.32	6.66	5.66
Cynodon dactylon(Linn)	”	0.21	0	3.33	0	0.24	0	2.23	0
Digitaria horinzontalis(Willd)	”	0.43	0.66	6.66	10	0.45	0.66	5.66	10
Imperata cylindrical (Linn)	”	13.82	3.57	92.33	53.33	24.28	13.57	93.33	50.33
Paspalum scrobiculatum (SW)	”	0.43	1.78	6.66	26.66	0.55	1.88	5.56	24.66
BROADLEAF									
Acalypha segetalis (Shum & Thom)	Euphorbiaceae	0.64	0	10	0	0.48	0	10	0
Boerhavia diffusa L	Nyctaginaceae	0	0.22	0	3.33	021	0.24	0	1.33
Cleome viscosal L	Cleomaceae	1.72	0	26.66	0	1.47	0	23.33	5
*Commelina benghalensis*L	Commelinaceae	0.86	2.76	13.33	40	0.82	1.76	14.43	42
Daniellia oliveru(Rolfe)	Leguminoceae	0.21	1.34	3.33	20	0.32	1.34	4.33	18
Euphorbia hirta (Linn)	Euphorbiaceae	0.43	0	6.66	0	0.25	0	4.66	12
Gomphrena celosioides Mart.	Amaranthaceae	-	-	-	-	0.56	0	13.33	20
*Hyptis suaveolens*Poit.	Lamiaceae	78.15	70.25	87.55	85.72	70.85	64.54	84.25	71.12
Laportea aestuans(Linn)	Urticaceae	0	3.34	0	50	0.24	3.34	0	48
Leucas martinicensis(Jacq.) W.T. Aiton	Lamiaceae	-	-	-	-	0	0.55	0	12.10
Oldenlandia herbacea(Linn) Roxb	Rubiaceae	0	0.22	0	3.33	0.45	0.17	0	2.33
Phyllantus nirur(Schun & Thonn)	Euphorbiaceae	0.21	0	3.33	0	0.23	0	2.33	0.21
Physalis micrantha (Linn)	Solanaceae	0	1.1	0	26.66	0	1.3	0	23.33
Senna obtusifolia(L) Irwin & Barneby	Leguminoceae	-	-	-	-	0	0.22	0	10
Vicoale ptociads (Webb)	Asteraceae	0.21	0	3.33	0	0.22	0	2.35	0.22
Tridax procumbens (Linn)	”	76.24	69.87	87.66	84.33	74.24	62.58	87.64	82.55
SEDGES									
Cyperus amabilis (Vahl)	Cyperaceae	1.51	5.80	23.33	86.66	1.62	5. 68	33.33	77.67
Cyperus rutundus (Linn)	”	2.59	0.89	40	13.33	3.88	0. 68	48	15.53
Kyllingaerecta Schumach Thorn. Ex vahl	”	0	3.34	0	50	0.34	5.44	4.64	50
Mariscuslongi brateatus(Sw dc)	”	0	0.89	0	13.33	0	0.89	0	15.33

was higher ($p<0.05$) than paraquat alone and weedy check. In 2023, all the herbicide treatments recorded similar highest weed control efficiency with highest observation in pendimethalin at 2.0 kg a.i. ha^{-1} fb imazathapyr at 1.5 kg a.i. ha^{-1} while weedy check was least (Table 3).

Weed dry matter was significantly affected by cowpea varieties only in 2022 and herbicide types in both years (Table 3). In 2022, SAMPEA 11 and 12 recorded lowest weed dry matter which was significantly lower than kananado. In both years, pendimethalin at 2.0 kg a.i. ha^{-1} fb imazathapyr at 1.5 kg a.i. ha^{-1} treatments had the lowest weed dry matter which was significantly higer than both paraquat treated plots in 2022 and other treatments in 2023. Weedy check recorded the highest weed dry matter. Interaction of cowpea varieties and herbicide types was observed on weed dry matter in 2023 (Table 3).

Interaction of cowpea variety and herbicide types on weed dry matter

The interaction of cowpea varieties and herbicide type for weed control on weed dry matter at 6

WAS in 2023 as presented in Table 4 shows that SAMPEA 11 in combinations with pendimethalin alone and pendimethalin at 2.0 kg a.i. ha^{-1} fb imazathapyr at 1.5 kg a.i. ha^{-1} recorded the lowest weed dry matter compared with other treatments.

Table 3. Weed density, weed control efficiency and weed dry matter as affected bybioactivities of herbicides on cowpea varieties during 2022 and 2023 rainy seasons at Lapai

	Rate (Kg a.i. ha^{-1})	Weed density Plants/m^2		Weed control efficiency (%)		Weed dry matter (g)	
		2022	2023	2022	2023	2022	2023
VARIETIES							
. . . . .		32.50a	31.72a	58.79b	60.73b	5.586a	5.314
SAMPEA 11 – IT -89 – 288		28.83b	25. 61b	69.55a	70.24a	4.744b	4.750
SAMPEA 12 – IT – 89-391		29.56ab	29.94a	59.71b	56.20b	4.901b	4.896
. . .		1.090	1.261	2.33	2. 669	0.237	0.193
WEED CONTROL							
Paraquat alone	1.5	23.00b	20.89b	69.92b	70.15a	5.133b	4.878b
Paraquat + Diuron	1.0 + 1.5	16.89c	16.11b	75.74ab	75.15a	4.211b	4.078c
Pendimethalin alone	1.5	17.44c	17.56b	75.24ab	73.65a	3.128c	3.039d
Pendimethalin + imazathapyr	2.0 + 1.5	10.67d	10.44c	82.35a	81.27a	2.202c	2.080e
2, 4-D + Diuron	2.0 +1.5	19.56bc	17.00b	72.85ab	74.13a	2.989c	2.956c
Weedy check		94.22a	92.56a	0.00c	0.00b	12.800a	12.889a
SE±		1.541	1.784	3.30	3.774	0.335	0.273
INTERACTION							
VAR × WC		NS	NS	NS	NS	NS	*

Means followed by the same letter(s) across the column are not significantly different at 5% level of probability using DMRT. NS = not significant, *= significant at 5% level, **= highly significant at 1% level

Table 4. Interaction of cowpea variety and weed control methods on weed dry matter at 6 WAS during 2023 rainy season at Lapai

	1	2	3	4	5	6
Kananado – Local	4.867de	4.500def	3.300fgh	2.567ghi	3.100f-i	14.583a
SAMPEA 11–IT -89–288	4.333def	4.100d-g	3.200fgh	1.507i	2.767ghi	10.900c
SAMPEA 12–IT–89-391	5.433d	3.633e-h	2.617ghi	2.167hi	3.000f-i	13.183b
SE±			0. 669			

Means followed by the same letter(s) across the column are not significantly different at 5% level of probability using DMRT. **Note: 1.**Paraquat alone (1.5 kg a.i. ha^{-1}), **2**. Paraquat + diuron (1.0 + 1.5 kg a.i. ha^{-1}), **3.** pendimethalin only (1.5 kg a.i. ha^{-1}), **4.** pendimethalin + imazathapyr (2.0 +1.5 kg a.i. ha^{-1}), **5.** 2, 4-D + diuron (2.0 + 1.5 kg a.i. ha^{-1},**6**Weedy check

Effect of the bioactivities of herbicides on growth parameters of cowpea varieties

Effect of cowpea varieties and bioactivities of herbicides on cowpea plant height, number of leaves and leaf area are presented in Table 5. Plant height at 3 and 6 WAS in 2022 was not significantly ($p<0.05$) affected by cowpea varieties. Considering effect of weed management on plant height, significant ($p<0.05$) difference was observed at 6 WAS in 2022 in which plots applied with pendimethalin at 2.0 kg a.i. ha^{-1} plus imazathapyr at 1.5 kg a.i. ha^{-1} recorded the tallest plant which was significantly taller than plots sprayed with 2,4-D at 2.0 kg a.i. ha^{-1} plus Diuron at 1.5 kg a.i. ha^{-1} and weedy check. In 2022 at 3 WAS cowpea number of leaveswas significantly influenced by cowpea varieties in which SAMPEA 11 and SAMPEA 12 recorded the highest number of leaves compared to kananado – local, but number leaves was not significantly affected by cowpea varieties at 6 WAS. The use of pendimethalin at 1.5 kg a.i. ha^{-1} recorded the highest number of leaves at 3 WAS and was significantly higher than paraquat alone. Weedy check at 3 WAS recorded the least number of leaves. At 6 WAS in 2022, number of leaves was significantly ($p<0.05$) higher than other treatments when pendimethalin at 2.0 kg a.i. ha^{-1} plus imazathapyr at 1.5 kg a.i. ha^{-1} was applied, while the least number of leaves was recorded under plots with weedy check. Leaf area was significantly ($p<0.05$) affected by cowpea varieties. SAMPEA 11 recorded the largest leaf area at 3 and 6 WAS, however, the result was statistically similar with SAMPEA 12 at 3 WAS and kananado at 6 WAS, while kananado at 3 WAS and SAMPEA 12 at 6 WAS in 2022 recorded the smallest leaf area (Table 5). Similarly, application of pendimethalin at 1.5 kg a.i. ha^{-1} at 3 WAS recorded the largest leaf area, which was similar with plots that were sprayed with pendimethalin at 2.0 kg a.i. ha^{-1} plus imazathapyr at 1.5 kg a.i. ha^{-1}, while other treatments recorded similar leaf areawhich was wider than weedy check. At 6 WAS, similar leaf areawas observed in all the tretments compared to weedy check (Table 5).

In 2023, plant height was not significantly ($p<0.05$) affected by cowpea varieties at 3 and 6 WAS. Likewise, plant height was not affected by weed control methods at 3 WAS, however at 6 WAS, significanttlytaller plants ($p<0.05$) which shows that application of pendimethalin at 2.0 kg a.i. ha^{-1} plus imazathapyr at 1.5 kg a.i. ha^{-1} recorded the tallest plants compared to other treatments and weedy check treatmentrecorded the shorterplants. Number of leaves was significantly ($p<0.05$) affected by cowpea varieties at 3 and 6 WAS where SAMPEA 11 recorded that highest number of leaves at 3 WAS, but statistically similar with plots planted with SAMPEA 12 at 3 and 6 WAS. Kananado recorded the lowest number of leaves at 3 and 6 WASwhich was similar with the result obtained in plots planted with SAMPEA 11 at 6 WAS.Leaf area at 3 WAS in 2023 was not affected by cowpea varieties, however, at 6 WAS similar leaf area was observed in kananado and SAMPEA 11 which was significantly higher ($p<0.0.5$) than SAMPEA 12. In weed control treatments, at 3 WAS, application of pendimethalin at 2.0 kg a.i. ha^{-1} plus imazathapyr at 1.5 kg a.i. ha^{-1} recorded similar leaf area, all of which were significantly higher than weedy check except plots sprayed with 2,4-D at 2.0 kg a.i. ha^{-1} plus Diuron at 1.5 kg a.i. ha^{-1}.

Table 5. Growth parameters of cowpea varieties as affected by bioactivities of herbicides at the experimental site in Lapai

	Rate (Kg a.i. ha^{-1})	Plant height (cm)		Number of leaves		Leaf area (cm)		Plant height (cm)		Number of leaves		Leaf area (cm)	
			2022		2022		2022		2023		2023		2023
		3WAS	6 WAS	3WAS	6 WAS	3WAS	6 WAS	3WAS	6 WAS	3WAS	6 WAS	3WAS	6 WAS
VARIETIES													
. . . . .		8.13	25.73	25.72b	87.83	13.02b	57.96a	7.79	25.84	26.03b	84.59b	13.23	51.28a
SAMPEA 11 – IT -89 – 288		10.47	27.89	29.93a	95.92	13.95a	60.13a	9.07	25.40	28.05a	86.66b	13.70	52.30a
SAMPEA 12 –IT– 89-391		15.14	26.38	28.76a	87.83	13.68a	47.92b	15.15	26.41	28.79a	91.74a	13.68	40.47b
. . .		3.06	1.009	0.840	3.15	0.190	3.00	3.06	0.732	0.544	1.568	0.524	2.441
WEED CONTROL													
Paraquat alone	1.5	9.97	27. 69ab	27.62bc	90.82b	13.28b	53.95a	9.13	25.62b	27.57b	82.58c	13. 64ab	51.51a
Paraquat + Diuron	1.0 + 1.5	9.36	28.93ab	28.72abc	86.23b	13.64b	61.82a	8.66	25.52b	27.17b	82.66c	12.85ab	50.02a
Pendimethalin alone	1.5	9.78	26.70ab	31.51a	97.76b	14.42a	58.47a	9.66	26.36b	29.10b	95.77b	13.93ab	48.02a
Pendimethalin + imazathapyr	2.0 + 1.5	9.96	29.18a	30.86ab	112.31a	15.02a	65.65a	9.84	30.59a	31.51a	106.87a	14.88a	55.18a
2, 4-D + Diuron	2.0 +1.5	9.76	25.04bc	26.36cd	90.46b	13.14b	55.97a	9.38	25.41b	27.06b	87.21c	12.85ab	46.05ab
Weedy check		7.67	21.83c	23.77d	73.18c	11.82c	36.15b	7.36	21.78c	23.34c	70.91d	11.98b	37.30b
SE±		4.33	1.427	1.188	4.45	0.269	4.24	4.33	1.035	0.769	2.217	0.741	3.452
INTERACTION													
VAR × WC		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) across the column are not significantly different at 5% level of probability using DMRT. NS = not significant, *= significant at 5% level, **= highly significant at 1% level

Effect of the bioactivities of herbicides on yield parameters of cowpea varieties

The effect of cowpea varieties and weed control methods on yield parameters such as 100 seed weight and dry pod yield is presented in Table 6. In both years, SAMPEA 12 100 seed weight was significantly heavier ($p<0.05$) than SAMPEA 11. Similarly, application of pendimethalin at 2.0 kg a.i. ha^{-1} plus imazathapyr at 1.5 kg a.i. ha^{-1} recorded significantly heavier seed weight in both years than other treatments.

Dry pod yield of okra was significantly ($p<0.05$) affected by cowpea varieties in 2023 only. Highest dry pod was observed I SAMPEA 12 which was significantly higher ($p<0.05$) than SAMPEA 11 and kananado. In the weed control treatments, application of pendimethalin at 2.0 kg a.i. ha^{-1} and imazathapyr at 1.5 kg a.i. ha^{-1} recorded the highest dry pod yield in both years which was significantly higher than other treatments except paraquat at 1.0 kg a.i. ha^{-1}plus Diuron at 1.5 kg a.i. $ha^{-1}$and pendimethalin at 1.5 kg a.i. ha^{-1}alone in 2022.

Table 6: Growth parameters of cowpea varieties as affected by bioactivities of herbicides at the experimental site during 2022 and 2023 rainy seasons at Lapai

		100 seed weight (g)		Dry pod yield (Kg ha^{-1})	
	Rate (Kg a.i. ha^{-1})	2022	2023	2022	2023
VARIETIES					
Kananado – Local		4.339ab	4.383ab	1304	1211b
SAMPEA 11 – IT -89 – 288		3.806b	3.911b	1438	1191b
SAMPEA 12 – IT – 89-391		4.489a	4.478a	1348	1348a
SE±		0.199	0.186	55.8	24.3
WEED CONTROL					
Paraquat alone	1.5	3.744cd	3.889cd	1249b	1125c
Paraquat + Diuron	1.0 + 1.5	3.922bcd	3.878cd	1413ab	1334b
Pendimethalin alone	1.5	4.733ab	4.700b	1479ab	1360b
Pendimethalin + imazathapyr	2.0 + 1.5	5.478a	5.467a	1547a	1466a
2, 4-D + Diuron	2.0 +1.5	4.300bc	4.278.bc	1539a	1353b
Weedy check		3.089d	3.333d	953c	860d
SE±		0..281	0.263	79.0	34.4
INTERACTION					
AR × WC		NS	NS	NS	NS

Means followe d by the same letter(s) across the column are not significantly different at 5% level of probability using DMRT. NS = not significant, *= significant at 5% level, **= highly significant at 1% level

DISCUSSION

Intensive farming practice employed in the experimental site has left the land with low nutrient in terms organic carbon, total nitrogen, available P, including low cation exchange capacity. This result is in agreement with the report of Aleminew and Alemayehu (2020) who stated that, the major causes of soil depletion are inadequate fertilizer use, complete crop residues removal, continuous cropping system, climate and soil.Common weeds that are more close in association with cowpea include*v Hyptis suaveolens* Poit, *Tridax procumbens, Imperata cylindrica* and *Cyperus amabilis* (Vahl) were among weed species that had high relative weed density and relative weed frequency. In the work of Garba, *et al.* (2023) *Hyptis suaveolens, Tridax procumbens*

Boerhaviaerecta, Digitaria horizontalis, Brachiari alata and Cleome viscosa were of higher infestation in the experimental site.

Varietal differences in cowpea have shown that some of its characteristics possess a greater ability to suppress weeds in terms of weed, growth and yield parameters. In this research,S AMPEA 11 (IT -89 – 288) significantly reduced weed density, weed dry matter and highest weed control efficiency. This suggests that canopy and growth habit of SAMPEA 11 could have played a greater role in weed control compare to Kananado and SAMPEA 12 (IT – 89-391). This result contradicts the report of Nwagu*et al*. (2022) who reported that greater reduction of weed density was linked to plots planted with Kananado and had superior weed control ability over SAMPEA 11 and SAMPEA 12. Wider leaf area of SAMPEA11 and 12cowpea were statistically similar and greater than Kananado, this which could be attributed to their genetic makeup and growth habitat, which may be a key agronomic trait that influences the varieties wider leaf area compared to other varieties.SAMPEA 12 produced heavier seed weight and highest dry pod yield which was superior to other varieties studied. This could be that, the variety responded positively to the good timely agronomic practices employed such as land preparation among others. It was reported by Nwagu*et al*. (2022) that, combination of SAMPEA 12 with ploughing and harrowing produced the highest seed yield.

The use of herbicides significantly plays a greater role in the control of weeds in cowpea field, offering a crucial alternative to traditional methods like hand weeding. Application of pendimethalin at the rate of 2.0 kg a.i. ha^{-1} supplemented with imazathapyr at 1.5 kg a.i. ha^{-1} consistently recorded the lowest weed density, weed dry matter and highest weed control efficiency compared to other weed control methods. The combination of pendimethalin supplemented with imazathapyr has shown high effective strategy for weed control in cowpea. This could be attributed to the bioactivities of the herbicides for inhibiting the enzyme acetolactate synthesis (ALS) which is crucial for the synthesis of essential amino acid. This result corroborate the report of Walia and Kumar (2020) who stated that imazathapyr is effective against most of the grasses and broadleaved weeds by inhibiting root and shoot growth of susceptible weed species through disruption of protein and DNA in comparison to other herbicides.Patel *et al*. (2023) also indicated thatpre-emergence application of pendimethalin and imazathapyr eventually provided weed free and congenital environment as the consequence of enhanced weed control efficiency of cowpea.Taller plants, higher number of leaves and wider leaf canopy were as a result of the combination of pendimethalin at the rate of 2.0 kg a.i. $ha^{-1}$with imazathapyr at 1.5 kg a.i. ha^{-1}. This could be attributed to activities of the two combined herbicides which could have inhibited the germination and growth of weeds that could have competed with cowpea. This result is in line with the report of patel*et al*. (2023) who reported that inhibition of germination and growth of weeds as a result of pre-emergence application of pendimethalin resulted inreduced weed growth through arresting different metabolic activities and thus causing mortality of weeds. Heavier seed weight and dry pod yield of cowpea was achieved when pendimethalin at the rate of 2.0 kg a.i. ha^{-1}plus imazathapyr at 1.5 kg a.i. ha^{-1} which could have been as a result of the efficiency and effectiveness of the

combined herbicides that reduce weed competition with the target crop. This result is in close conformity with the report of Kumar*et al*. (2025) who stated that application of pendimethalin plus imazathapyr significantly controlled the mixed flora of weeds that resulted in significant growth and yield of cowpea.

CONCLUSION

These fields study shows that cowpea varieties are susceptible to weed infestation and competition. *Tridax procumbens*, *Hyptissuaveolens*, *Cyperus amabilis, Imperata cylindrica* were the most common and dominant weed species in the experimental field at Lapai. The two factors (Cowpea varieties and weed control methods) employed in this study was to evaluate efficacy of herbicides (pre and post) on the control of weed species composition in cowpea fields. Cowpea variety "SAMPEA 11" has the highest ability to suppresses weeds and recorded the highest weed control efficiency.However, the application of pendimethalin at the rate of 2.0 kg a.i. ha^{-1} as pre-emergence and supplemented with imazathappyr at 1.5 kg a.i ha^{-1}6 WAS recorded taller plants, highest number of leaves and branches with highest pod yield. The use of paraquat herbicide as pre-emergence in this study was folia applied to kill all current weeds that were not covered to give the crop a clean start.Based on the result obtained in this study, it will be concluded that, the use of SAMPEA 11 in combination of pendimenthalin at 2.0 kg a.i. ha^{-1} supplemented with imazathapyr at the rate of 1.5 kg a.i. $ha^{-1}$is appropiriate for better yield and thereforeit is recommended for farmers in the study area for better control of weedsand yield of the cowpea variety in the study area.

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