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Weed control and cowpea yield under different tillage systems

Francis Nwagwu[1], Manthy Athanasius[2], Goddey Michael[3], Ekemini Obok[1]*, Ali Ibrahim[4]

[1]Department of Crop Science, Faculty of Agriculture, Forestry and Wildlife Resources Management, University of Calabar, PMB 1115 Calabar, Cross River State, Nigeria.
[2]Department of Crop Science, Taraba State College of Agriculture, Jalingo, Taraba State, Nigeria.
[3]Department of Agronomy, Taraba State University, Jalingo, Taraba State, Nigeria.
[4]Department of Soil Science, Faculty of Agriculture, Forestry and Wildlife Resources Management, University of Calabar, PMB 1115 Calabar, Cross River State, Nigeria.

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ABSTRACT

Field studies conducted in 2016 and 2017 in Calabar, Nigeria, evaluated the influence of tillage methods on weed control and yield of cowpea (*Vigna unguiculata* [L.] Walp). These were split-plot experiments laid out in a randomized complete block design with three replications; involving no-tillage, plough + harrow, hoe tillage and SAMPEA 11, SAMPEA 12 and "*Kanannado*" cowpea varieties. Analysis of variance indicated significant ($P \leq 0.05$) tillage, cowpea varieties and their interaction effects on weed control and yields of cowpea. Tillage system did not change the soil texture. The results obtained could not be attributed to environmental changes as the weather data for the 2 years were not unique, rather they followed a similar trend. Longer pods with the highest number of pods plant^{-1}, seeds pod^{-1}, and seed yield (kg) ha^{-1} of cowpea were produced in ploughed plus harrowed plots. "*Kanannado*" reduced weed dry matter by 50.32% and 49.39% over SAMPEA 12 and SAMPEA 11, respectively. "*Kanannado*" combined with no-tillage (92.00 kg ha^{-1}) was similar ($P > 0.05$) to SAMPEA 11 combined with no-tillage (101.50 kg ha^{-1}). However, the combination of SAMPEA 12 with ploughing and harrowing produced the highest seed yield (667.00 kg ha^{-1}) and was recommended for adoption based on outstanding yield and satisfactory weed control in cowpea production in the study area.

1. INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp) is an important, versatile legume crop grown primarily for seed across various agro-ecologies especially in the semi-arid tropics of the world [1]. Cowpea is the most important indigenous legume crop in West Africa, contributing about 40% of most people's daily protein requirements [2]. As a fast-growing, spreading/semi-determinate crop, cowpea aids in erosion control, smothers weeds, and being a legume, improve soil fertility through symbiotic nitrogen fixation [3,4], all making it an important component of intercropping systems with cereals and other food crops [5] among the predominantly small-scale farmers of sub-Saharan Africa. Globally, cowpea is cultivated on about 12.6 million hectares with a production of about 4.5 million tonnes annually [6]. Nigeria, the largest producer of cowpea, accounts for 2.4 million tonnes on about 5 million hectares annually [2]. However, Nigeria is the world's largest consumer and a net importer of cowpea [7], with a low yield of 0.52 tonnes/h on a 5-year average (2007–2011) [8]. Weed interference is prominent among problems militating against cowpea production in Nigeria and elsewhere [9,10], especially at the early growth stage [4], thereby causing significant reductions in grain yield [11]. Grain yield reductions due to uncontrolled weed growth ranged from 24.03% on a 2–year average [11] to 80% [12]. Weed seeds and debris contaminate the quality of produce when mixed with them; weeds also harbor pests and disease pathogens that attack the crop [10]. Improvements in crop growth and yield accruable from elite varieties and good cropping practices can be confounded if weeds are not adequately controlled in the field [13]. Tillage and crop variety are indispensable tools in non-chemical weed management and play vital roles in crop performance. Akinyemiju and Echendu [14] obtained more effective weed control and higher grain yield in conventionally-tilled and tilled and ridged plots, than minimum tillage under different herbicide treatments. Weed biomass was significantly higher in no-tillage with the herbicide-killed stubble left undisturbed relative to ploughing and harrowing, but pod and grain yield were unaffected by the tillage method [15]. Ewansiha *et al.* [16] reported superior cowpea grain yield on flat than no-tillage and ridge tillage with a 10% yield advantage over the two, while Ogban *et al.* [17] obtained 37.40% greater cowpea grain yield on tilled than no-tillage plots on a 2-year average. Elsewhere, disc ploughing followed by disc harrowing resulted in greater cowpea growth and yield compared with that under no-tillage [18]. The highest number of pods per plant and the most significant number of seeds per pod of cowpea were obtained from ploughed and harrowed plots against ploughing only, harrowing only, and no-tillage [19]. Reports have shown that cowpea varieties differ in their potential grain yield [20-22], in their responses to tillage methods [16,19], and their abilities to

**Corresponding Author:*
Ekemini Obok,
Department of Crop Science, Faculty of Agriculture, Forestry and Wildlife Resources Management, University of Calabar, PMB 1115 Calabar, Cross River State, Nigeria. E-mail: e.e.obok @ unical.edu.ng

control weeds/withstand weed competition [22,23]. However, there is a paucity of information on the contribution of tillage [2,24] and variety to weed control in cowpea production in the coastal humid rain-forest zone of Nigeria, where the crop has been demonstrated to produce satisfactory yields [11,17], especially in the late – cropping season [25]. The objective of this study was to evaluate weed control and the yield response of three cowpea varieties to different tillage methods in Calabar, South-eastern Nigeria.

2. MATERIALS AND METHODS

2.1. Description of Study Site

Fields trials were conducted in the humid rainforest agro-ecological zone of Nigeria; during the 2016 and 2017 late – cropping seasons (September–December) at the University of Calabar Teaching and Research Farm, Calabar (Latitude: 04° 45’ 30” and 05° 08’ 30” N; Longitude: 08° 11’ 21” and 08° 27’ 00” E, at 37 m above sea level). Calabar is a coastal town with up to 10 months (February–November) of high-intensity rainfall with a bimodal pattern ranging from 3000 to 3700 mm/annum. A short dry spell in August usually separates the early (longer) and late (shorter) cropping seasons. The annual temperature and relative humidity of the area usually range from 22.6 to 30.8°C and 70 to 100%, respectively [26]. Nonetheless, during the period of the study (August–December of 2016 and 2017), weather data were obtained from the World Weather Online directory for Calabar.

2.2. Land Preparation and Soil Samples Analysis

Representative pre-planting soil samples were obtained from the study site for physical and chemical soil properties analyses following suitable laboratory procedures. Predominant secondary vegetation at the experimental site included *Panicum maximum* Jacq., *Mimosa pudica* L., *Cyperus esculentus* L, *Cyperus rotundus* L, *Commelina benghalensis* L., and *Phyllanthus amarus* Schum. & Thonn. The thicket was manually cleared followed by respective tillage treatments– tractor-mounted disc plough and harrow and manual hand hoe tillage – at 1 week after bush clearing. Delsate® (N-(phosphomethyl) glycine (Canndel Company Ltd, Lagos, Nigeria) was applied to the plots to prevent pre-plant weed regrowth. This was done at the rate of 4 L ha^{-1} using a CP15 knapsack sprayer calibrated to deliver 200 L ha^{-1} spray volume in the no-tillage treatment.

2.3. Treatments, Experimental Design, Field Layout and Agronomic Practices

Treatments were arranged as split-plot and laid out in a randomized complete block design with three replications. Three tillage methods (i.e., no-tillage, plough + harrow, hoe tillage) were assigned the main plots while cowpea varieties (SAMPEA 11, SAMPEA 12, “*Kanannado”*) constituted the sub-plots. Each sub-plot measured 4 m × 4.5 m with 1 m spacing between sub-plots and 3 m path between main plots and between blocks (replications) to allow for tractor manoeuvrings. The total land area was 1, 296 m^2. Cowpea varieties, SAMPEA 11 and SAMPEA 12, were obtained from IITA, Ibadan, Nigeria and var. *Kanannado,* sourced from the seed unit of the Taraba State Agricultural Development Programme, Jalingo, Nigeria, were sown at the rate of three seeds per hill (2–3 cm depth) on 15 September 2016 and 17 September 2017 at 75 cm inter-row and 25 cm intra-row. Successfully emerged seedlings were thinned to two vigorous plants per stand at 2 weeks after sowing (WAS), giving populations of 75 stands per sub-plot and 106,667 plants ha^{-1}. Hoe weeding was done twice at 2 WAS and 5 WAS. The experiments were all conducted under rainfed field conditions.

2.4. Data Collection and Statistical Analyses

Weed density was determined at 2, 5 and 8 WAS using a 1 m × 1 m quadrat randomly placed within each plot. The enclosed weeds were harvested, separated into three broad morphological groups (broadleaves, grasses and sedges), pooled over the sampling periods [13], and recorded. Irrespective of morphological groupings, the harvested weeds were oven-dried at 72°C to a constant weight to obtain the weed dry matter (kg ha^{-1}). For yield assessment, dry pods from ten randomly tagged plants in the net plot (two middle rows) of each sub-plot were manually harvested by hand-picking at 2 days intervals and sundried for 1 week. The average number of pods per plant was recorded. Twenty pods were randomly selected from the sun-dried pods per treatment to determine pod length (cm), the number of seeds per pod and grain yield (kg ha^{-1}). These data were documented on a cumulative and an average basis. All data collected were subjected to a two-way analysis of variance (ANOVA) procedure using GenStat® for windows® version 8.1 (VSN International Ltd, Hamel Hempstead, UK). Differences among treatment means and interaction effects were compared using the Least Significant Difference method at a 5% level of probability [27].

3. RESULTS AND DISCUSSION

3.1. Weather Variation and Soil Properties

There was no change in the textural class of the soil in both years; however, soil pH was slightly lower in 2016 than in 2017 [Table 1] leading to a correspondingly lower and higher base saturation, respectively. Organic matter, organic carbon, total nitrogen, and available phosphorus slightly declined in 2017. The weather conditions in both years were relatively similar and followed the same trend. The only marked difference was in the amount of rainfall received in both years–2017 received almost double the amount received in 2016 – this raised the relative humidity in 2017. The duration of sunshine and the ultraviolet radiation index were similar. Overall, these data were not different from other reports [26].

3.2. Influence of Tillage and Cowpea Variety on Weed Morphological Groups Density

No-tillage and plough + harrow systems significantly decreased weed density among the three morphological groups compared with hoe tillage [Table 2]. Averaged over both years, no-tillage reduced the density of broadleaves, grasses and sedges by 26.54%, 56.74%, and 52.38%, respectively, relative to hoe tillage. The no-tillage system also decreased grass and sedge weeds populations by 22.01% and 31.67 %, respectively, compared with the plough + harrow system. The superior reduction in weed density obtained from no-tillage relative to hoe tillage and plough + harrow system, in respect of grasses and sedges, could be attributed to the initial bush clearing and packing of the trash before herbicide application to the early weed regrowth [15], and the effectiveness of the pre-plant herbicide (glyphosate) application. Glyphosate is a non-selective, systemic herbicide reported to be effective against sedges in particular, including *C. esculentus* and *C. rotundus* [28], which were visually observed to be the most predominant sedges in the field. This finding agrees with that of Nwagwu *et al.* [29], who observed that tilled plots tended to produce a greater weed population than no-tillage plots of okra in the same humid agroecology. In another development, weed density was highest in conventionally tilled plots compared to no-tillage and minimum tillage in the intercropped wheat field [30]. On the contrary, Akinyemiju and Echendu [14] obtained more effective weed control in conventionally-tilled and tilled and ridged plots than

Table 1: Soil properties and weather conditions at Calabar in 2016 and 2017 (August–December)

Soil property	Value	
	2016	2017
pH (H_2O)	5.0	5.4
Organic matter (%)	3.44	1.52
Organic Carbon (%)	1.99	0.88
Total Nitrogen (%)	0.17	0.07
Available *P* (mg kg^{-1})	24.56	22.97
Exchangeable base		
Ca^{2+} (cmol kg^{-1})	6.8	6.2
Mg^{2+} (cmol kg^{-1})	1.8	0.8
K^{+} (cmol kg^{-1})	0.08	0.09
Na^{+} (cmol kg^{-1})	0.06	0.06
Exchangeable acidity		
Al^{3+} (cmol kg^{-1})	0.72	0.64
H^{+} (cmol kg^{-1})	0.48	0.24
ECEC (cmol kg^{-1})	9.34	8.63
BS (%)	87.0	89.8
Particle size analysis (g kg^{-1})		
Clay	117	147
Silt	97	57
Sand	786	796
Textural class (USDA)	Sandy loam	Sandy loam
Weather conditions (range)*		
Rainfall (mm)	74.76–850.64	136.70–1326.10
Relative humidity (%)	73–88	75–92
Temperature (°C)	25–30	25–29
Sunshine (h)	120–346	124–372
UV radiation index	6–8	5–8

*1st August–31st December: Data provided by WorldWeatherOnline.com [https://www.worldweatheronline.com/calabar-weather-averages/cross-river/ng.aspx]. ECEC: Effective Cation Exchange Capacity; BS: Base Saturation; USDA: United States Department of Agriculture; UV: Ultraviolet

minimum tillage under different herbicide treatments. The plough + harrow tillage system had a similar density of broadleaf weeds with no-tillage and decreased the population of broadleaves, grasses, and sedges by 28.44%, 44.53%, and 30.31%, respectively, when compared with hoe tillage on the 2-year average. The superior weed control achieved in plough + harrow relative to hoe tillage is consistent with Amosun *et al.* [31] and Singh *et al.* [32] who reported that weeds were better suppressed as the intensity/depth of tillage increased. Thus, the greater depth of tillage achieved in the plough + harrow relative to hoe tilled plots could bury weed seeds and propagules in the soil to depths unsuitable for germination, regeneration and/or emergence, thereby inhibiting their growth. Furthermore, harrowing could break soil clods to finer tilth thereby exposing weed seeds, seedlings and propagules to possible desiccation by solarisation. Conversely, shallow depth of tillage accompanying hoe tillage could have brought weed seeds and propagules closer to the topsoil, triggering dormant weed seed germination and emergence through scarification and fragmentation of vegetative propagules [33]. When comparing plots sown to the elite cowpea varieties, SAMPEA 12 and SAMPEA 11, plots with the local variety, *Kanannado*, produced the lowest number ($P \leq 0.05$) of all weed morphological categories each year, except grass weeds in 2016, which had statistically similar values ($P > 0.05$) with SAMPEA 12 [Table 2]. Average over the years, *Kanannado* depressed the density of broadleaves by 37.41% and 33.98%, grasses by 21.26% and 23.16%, and sedges by 22.47% and 26.95%, relative to SAMPEA 12 and SAMPEA 11, respectively. The demonstrated superior weed control by the local cowpea variety *Kanannado* aligns with the observation that traditional cowpea varieties effectively suppress weeds due to their fast growth and spreading habit [3]. Results of the interaction indicated that no-tillage with *Kanannado* and plough + harrow with *Kanannado* plots tended to produce the lowest density of broadleaves, grasses and sedges. In contrast, hoe tillage plots either with SAMPEA 12 or SAMPEA 11 tended to produce the highest weed densities in each year.

3.3. Influence of Tillage and Cowpea Variety on Weed Dry Matter

Weed dry matter was consistently in the order: no-tillage < plough + harrow < hoe tillage [Table 2]. On a 2-year average, weed dry matter was lower by 42.17% in no-tillage and 24.78% in plough + harrow system, relative to hoe tillage. This trend can be ascribed to the differential reduction in weed density by the tillage methods earlier described. Consequently, no-tillage that produced the highest weed density reduction had the least weed dry matter, followed by plough + harrow, whereas hoe tillage with the highest weed density produced the highest weed dry matter. The results further demonstrate that precluding no-tillage where pre-plant herbicide is integrated, deeper tillage (plough + harrow) controlled weeds better than shallower (hoe) tillage, which agrees with the findings of [30,32]. *Kanannado* plots significantly reduced weed dry matter in contrast with the elite varieties each year, with an average of 50.32% and 49.39% less mean weed dry matter than SAMPEA 11 and SAMPEA 12 plots, respectively, over the 2 years. This finding can be linked to the greater reduction in weed density attained in the *Kanannado* plots and indicates that *Kanannado* had superior weed control ability over SAMPEA 11 and SAMPEA 12. Furthermore Asiwe and Kutu [22], reported differential reductions in weed biomass among four cowpea varieties in Vaalharts, Northern Cape Province of South Africa. On the other hand, weed dry matter was not significantly different between plots of SAMPEA 11 and SAMPEA 12, indicating similarity in their weed control abilities. In terms of interaction effects, whereas no-tillage with *Kanannado* produced the lowest weed dry matter similar ($P > 0.05$) to plough + harrow with *Kanannado*, the highest weed dry matter was obtained from plots sown to SAMPEA 12 and SAMPEA 11 that were prepared by hoe tillage. These results demonstrated that planting *Kanannado* on no-tillage or plough + harrow tillage systems provided superior weed control to other tillage-by-variety combinations evaluated in this study.

3.4. Influence of Tillage and Cowpea Variety on Yield and Yield Components of Cowpea

Plough + harrow tillage system maximized yield attributes of cowpea (number of pods $plant^{-1}$, pod length and number of seeds pod^{-1}), resulting in the highest grain yields of 379.00 kg ha^{-1} and 520.40 kg ha^{-1} in 2016 and 2017, respectively [Table 3]. On the 2-year mean, plough + harrow produced 146.41% and 276.32% greater grain yield than no-tillage and hoe tillage plots, correspondingly. This superior yield performance of cowpea in plough + harrow plots, despite better weed control in the no-tillage treatment, could be ascribed to possible improved soil conditions, through pulverization at the primary and

Table 2: Influence of tillage methods and cowpea varieties on weed density and weed dry matter in 2016 and 2017 cropping seasons

Treatment	Cumulative weed density based on morphological groupings (no. m^{-2})									Weed dry matter (g m^{-2})		
	Broadleaves			Grasses			Sedges					
	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean
Tillage												
Hoe tillage (HO)	6.18	15.51	10.85	7.82	10.53	9.18	62.90	59.50	61.19	9.77	50.06	29.92
Plough+Harrow (PH)	6.67	14.47	10.57	10.78	12.75	11.77	97.31	81.79	89.55	12.38	65.46	38.92
No-tillage (NT)	10.11	19.43	14.77	17.22	25.22	21.22	133.2	123.81	128.50	21.30	82.18	51.74
$LSD_{0.05}$	1.46	2.27	2.04	1.79	2.37	1.48	6.55	8.85	7.65	2.17	6.63	4.67
Variety												
SAMPEA 11 (V1)	8.85	17.81	13.33	13.37	17.37	15.37	112.72	96.23	104.48	15.95	81.34	48.65
SAMPEA 12 (V2)	9.34	18.79	14.06	11.89	18.09	15.00	101.58	95.31	98.44	15.72	79.80	47.76
Kanannado (V3)	4.78	12.82	8.80	10.56	13.04	11.81	97.10	73.54	76.32	11.79	36.56	24.17
$LSD_{0.05}$	1.46	2.27	2.04	1.79	2.37	1.48	6.55	8.85	7.65	2.17	6.63	4.67
Tillage×Variety												
HO×V1	6.87	16.41	11.64	6.45	11.83	9.14	68.00	64.37	66.19	11.16	66.99	39.08
HO×V2	7.00	17.30	12.15	9.67	11.87	10.77	73.70	64.36	69.03	11.60	54.14	32.87
HO×V3	4.67	12.82	8.75	7.34	7.89	7.62	46.97	49.72	48.35	6.56	29.04	17.80
PH×V1	8.00	14.62	11.31	14.32	14.33	14.33	130.33	82.19	106.26	13.86	80.29	47.08
PH×V2	9.34	17.04	13.19	9.34	13.94	11.64	89.30	93.84	91.57	14.59	82.13	48.36
PH×V3	2.67	11.74	7.21	8.67	9.99	9.33	72.30	69.33	70.82	8.70	33.95	21.33
NT×V1	11.66	22.40	17.03	19.33	25.96	22.65	139.73	142.14	140.94	22.83	96.73	59.78
NT×V2	11.67	22.01	16.84	16.67	28.64	22.59	141.73	127.71	134.72	20.97	103.13	62.05
NT×V3	7.00	13.90	10.45	15.66	21.25	18.46	118.03	101.56	109.80	20.10	46.68	33.39
$LSD_{0.05}$	2.52	3.93	3.54	3.09	4.11	2.57	11.34	15.33	13.25	3.75	11.49	8.09

Table 3: Influence of tillage methods and cowpea varieties on pod and seed yields of cowpea in 2016 and 2017 cropping seasons

Treatment	Pods plant^{-1} (no.)			Pod length (cm)			Seeds pod^{-1} (no.)			Seeds (kg) ha^{-1}		
	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean
Tillage												
Hoe tillage (HO)	8.29	11.34	9.82	10.89	12.25	11.57	9.07	9.77	9.42	138.70	226.30	182.50
Plough+Harrow (PH)	10.05	15.19	12.62	14.67	14.97	14.82	10.34	11.88	11.11	379.00	520.40	449.70
No-tillage (NT)	6.80	9.89	8.34	11.03	11.56	11.29	7.96	9.51	8.74	104.67	134.40	119.50
$LSD_{0.05}$	1.51	1.57	0.36	1.64	1.98	1.85	1.86	1.89	1.94	9.23	12.20	21.90
Variety												
SAMPEA 11 (V1)	8.22	11.97	10.10	12.12	13.33	12.73	9.16	9.99	9.58	200.30	298.40	249.38
SAMPEA 12 (V2)	11.85	15.78	13.82	14.39	15.07	14.73	10.80	12.44	11.62	297.00	413.00	355.00
Kanannado (V3)	5.07	8.67	6.87	10.08	10.37	10.22	7.41	8.73	8.07	125.00	169.70	147.30
$LSD_{0.05}$	1.51	1.57	10.06	1.64	1.98	1.85	1.86	1.89	1.94	9.23	12.20	21.90
Tillage×Variety												
HO×V1	8.95	11.30	10.13	11.43	12.83	12.13	9.03	9.52	9.28	134.00	205.00	169.50
HO×V2	10.63	14.57	12.60	11.47	14.25	12.86	10.70	11.27	10.99	178.00	288.00	233.00
HO×V3	5.30	8.15	6.73	9.77	9.67	9.72	7.47	8.51	7.99	104.00	186.00	145.00
PH×V1	9.10	15.18	12.14	13.73	14.62	14.18	10.17	11.34	10.76	371.00	582.00	477.15
PH×V2	15.17	20.26	17.72	18.77	17.34	18.06	12.32	14.76	13.54	581.00	753.00	667.00
PH×V3	5.87	10.14	8.01	11.50	12.96	12.23	8.50	9.54	9.02	185.00	225.00	205.00
NT×V1	6.60	9.42	8.01	11.20	12.53	11.87	8.27	9.10	8.69	96.00	107.00	101.50
NT×V2	9.76	12.51	11.14	12.93	13.6	13.12	9.33	11.28	10.31	132.00	198.00	165.00
NT×V3	4.03	7.73	5.88	8.97	8.47	8.72	6.27	8.14	7.21	86.00	98.00	92.00
$LSD_{0.05}$	2.62	2.73	1.84	2.84	3.42	3.20	3.22	3.27	3.36	53.41	21.13	37.93

secondary tillage operations, which could have enhanced water and nutrient absorption, and consequently cowpea growth and yield. This finding agrees with the suggestion that tillage could enhance crop yield through non-weed factors including improving essential soil physicochemical properties [31] and is consistent with [17-19]. However, our finding differs from that of Ikuenobe *et al*. [15] who found no significant influence of different land prepetition methods on cowpea grain yield. Although statistically similar, no-tillage plots produced generally higher values for all yield attributes except pod length in 2016 and gave significantly ($P \leq 0.05$) higher (52.72%) seeds (grain) yield than the hoe tilled treatment [Table 3]. The greater cowpea grain yield obtained from the no-tillage relative to hoe tillage treatment could be attributed to better weed control in the former through pre-plant herbicide, supplemented with hoe weeding, whereas only post-planting hoe weeding was done in the hoe tilled plots. Furthermore, Olaoye [34] obtained a higher number of pods per plant for cowpea grown on a no-tillage soil in contrast with tilled soils in the derived savannah agro-ecology of Nigeria. Among the different cowpea varieties, SAMPEA 12 produced the highest ($P \leq 0.05$) number of pods per plant, longest pods, the greatest number of seeds per pod and highest grain yield, followed by SAMPEA 11 [Table 3]. The superior yield performance of SAMPEA 12 relative to SAMPEA 11 and *Kanannado* indicates an inherently higher yield potential of the SAMPEA 12 over SAMPEA 11 and *Kanannado*. Ewansiha *et al.* [16], Augustine and Godfre [20], Mfeka *et al.* [21], and Asiwe and Kutu [22] reported variations in grain yield among different cowpea varieties and attributed these variations to mostly genotypic differences among the varieties tested. Statistically, the shortest pods, the lowest pods per plant, the least number of seeds per pod, and the lowest grain yield were obtained from *Kanannado*. Thus, despite being the most effective in weed control, *Kanannado* could not match the improved SAMPEA 12 and SAMPEA 11 in grain yield and yield attributes measured. The relatively low yield obtained from *Kanannado* in this study could be due to its possibly low inherent yield potential. It has been observed that low yields of local varieties are among the major limiting factors to cowpea production in Nigeria [35]. Interactively, significantly the highest number of pods per plant, pod length and number of seeds per pod were obtained from SAMPEA 12 variety on plough + harrow, culminating in the highest mean grain yield (667.00 kg ha^{-1}), followed by SAMPEA 11 with mean grain yield of 477.15 kg ha^{-1}. Conversely, *Kanannado* on hoe tilled plots produced the lowest pods per plant, pod length, number of seeds per pod and grain yield (92.00 kg ha^{-1}). Therefore, striking a balance between weed control potentials of the tillage methods and cowpea varieties in one hand, and the yield response of the different cowpea varieties to the tillage practices, on the other hand, the interaction results indicated that growing the SAMPEA 12 cowpea variety on plough + harrow seedbed, which controlled weeds satisfactorily and produced the highest number of pods per plant, longest pods, greatest number of seeds per pod and maximized grain yield was the most promising option for cowpea growers in the area of study.

4. CONCLUSIONS

Tillage and crop variety are indispensable tools in non-chemical weed management. From the findings of this research, it is evident that the tillage system, cowpea variety and their interactions influenced weed control and yield performance of cowpea although this did not change the soil texture. The results obtained could not be attributed to environmental changes as the weather data for the 2 years (August–December, 2016 and 2017) were not unique but followed a similar trend. Best weed control was achieved on no-tillage, followed by plough + harrow seedbeds, however, superior cowpea yield attributes and grain yield were attained in plough + harrow seedbeds across the varieties. Among tillage methods, the poorest weed control and lowest grain yield of cowpea were recorded in the hoe tillage treatment. *Kanannado* variety gave the best weed control, but produced the minimum pod length, number of pods per plant, seeds per pod, and grain yield, while SAMPEA 12 variety produced the best yield performance across tillage systems. Interactively, yield attributes and grain yield of cowpea were maximized in the SAMPEA 12 on plough + harrow seedbed; therefore, this combination could be recommended for farmers in the study area. The *Kanannado* variety that gave the best weed control but fell short of high grain yields could be further evaluated for fodder; however, it can be an effective cover crop for weed control in intercropping systems.

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6. AUTHOR CONTRIBUTIONS

All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval of the version to be published; and agree to be accountable for all aspects of the work. All the authors are eligible to be an author as per the international committee of medical journal editors (ICMJE) requirements/guidelines.

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The authors report no financial or any other conflicts of interest in this work.

9. ETHICAL APPROVALS

This study does not involve experiments on animals or human subjects.

10. DATA AVAILABILITY

All data generated and analyzed are included within this research article.

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