



## RESEARCH ARTICLE

### Growth and yield of groundnut (*Arachis hypogaea* L.) as influenced by weed control and maize intercrop

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#### ABSTRACT

In tropical environments, groundnut is highly vulnerable to competitive interference from weeds. Failure to manage this competition for limited resources during the critical initial growth phase results in a significant yield decline. The field experiments were carried out at the Federal University of Agriculture, Abeokuta, Nigeria, to assess how various weed management strategies and intercropping arrangements influence groundnut growth and yield. The experimental setup employed a split-plot design within a randomized complete block framework, replicated three times. The main plot treatments consisted of two cropping patterns, including a mixture of groundnut with maize and sole groundnut. The subplots were made of eight weed control methods, including 4 different herbicide types, 3 different hoe-weeding methods, and a weedy check. Data were collected on groundnut growth and yield. The result showed that planting groundnut sole resulted in significantly higher groundnut stand, ground cover, dry matter and yield compared to the intercropped groundnut. Groundnut ground cover and number of pods were statistically similar among the weed control methods, but were significantly reduced in the untreated plots. In 2018, the plots with supplementary hoe weeding (SHW) resulted in the highest pod yields, while in 2020, pod yields were similar among the weed control methods but were significantly reduced in the weedy check. Every weed management approach significantly lowered weed dry matter by 10–81% relative to the untreated plots, with treatments incorporating supplementary hoe-weeding proving most effective. The study concluded that weed control methods evaluated improved groundnut performance and can be adopted by farmers.

**Keywords:** groundnut; intercrop; weed control; weedy check; yield.

## INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an important oilseed crop grown widely in humid and sub-humid regions for its edible kernels, oil extraction, and as a rich source of protein and energy in human diets (Paul et al., 2022). It is considered the king of oilseeds as virtually every part of the crop is of value in domestic and industrial sectors (Guchi, 2015; Biswas and Bhattacharjee, 2019). Nigeria ranks third globally in groundnut production, following China and India (Gabasawa, 2021; Vabi et al., 2019). Despite this, its yield remains below international benchmarks. One major factor limiting productivity is severe weed competition. Because groundnut grows slowly during its early stages, it creates favourable conditions for weed proliferation. Previous studies by Eni et al. (2012) and Osunleti et al. (2022) documented yield reductions of 51% and 83.4%, respectively, when weeds were left uncontrolled.

Weed management is, therefore, crucial for optimizing groundnut growth and yield. Various weed control methods suggested for use in crop production include cultural, chemical, biological and integrated, among others (Akobundu, 1987; Kasasian, 1989). Chemical weed control, according to Chikoye et al. (2005) and Osunleti et al. (2022a), is effective. However, their excessive use can lead to environmental concerns, such as soil degradation, herbicide resistance, and the loss of biodiversity. Therefore, integrated weed management which combines herbicides with other practices, such as intercropping, is essential to minimize these risks while improving crop productivity.

Growing two or more crops simultaneously on the same plot, known as intercropping, offers an effective approach to weed management in groundnut production. Specifically, intercropping groundnut with maize presents multiple advantages. Maize's fast growth and height can provide shade, and suppress weed growth. Intercropping enhances farm diversification and boosts productivity per unit area and time by optimizing the use of natural resources such as light, nutrients, water, and space (Ghosh, 2004; Dhima et al., 2007). The study was designed to evaluate how various weed management techniques, including different rates of two pre-emergence herbicides combined with intercropping, influence groundnut growth and yield.

## MATERIALS AND METHODS

### Experimental Site and Plant Material

Experiments were implemented during the 2018, 2019, and 2020 cropping seasons to assess how different weed management strategies combined with intercropping influence groundnut growth, yield, and weed incidence. These trials took place at the Teaching and Research Farms of the Federal University of Agriculture, Abeokuta, Ogun State, Nigeria. The experiments were carried out between May and September each year. Before planting each season, the field was initially ploughed and subsequently harrowed two weeks later. The field was then divided into various plots and subplots.

### Land preparation, treatments, and experimental design

The land was ploughed and harrowed at two-week intervals to achieve a fine, weed-free tilth. After clearing weed stumps and debris, plots were marked out for flat planting. Each year, the experiment followed a split-plot design within a Randomized Complete Block Design (RCBD) with three replications. Main plots featured three inter-cropping: sole groundnut at 50 cm × 25 cm, groundnut intercropped with maize at 100 cm × 25 cm and 100 cm × 37.5 cm spacing, and groundnut intercropped with maize at 75 cm × 25 cm and 75 cm × 50 cm spacing. Subplots included eight weed control treatments: Probaben® (prometryne + metolachlor) at 2.4 kg a.i./ha, 1.6 kg a.i./ha, and 1.6 kg a.i./ha followed by supplementary hoe-weeding; Super Union® (prometryne + acetochlor) at similar rates; two hoe-weeding at 3 and 6 WAP; and a weedy check. Maize (Oba Super 2) and groundnut (local variety Jawanda) seeds were sown three per stand and thinned to two plants at three weeks after planting. Pre-emergence herbicides were applied one day after planting at 230 L/ha using a CP3 knapsack sprayer, and hoe-weeding was performed as specified using a West African hand hoe.

### Data Collection and Statistical Analysis

Data collected on growth parameters of groundnut included: stand count, cover score, canopy height, and dry matter. Weed data included: weed cover score, and yield data included: number of pods and pod yield. Data collected on weed included weed cover score on a scale of 10 to 100, where 10 indicated no weed cover, 20 to 30 indicated minimal weed cover, 40 to 60 indicated moderate weed cover, 70 to 90 indicated acute weed cover, and 100 indicated absolute weed cover (Osunleti et al., 2024), as well as dry matter production. Data collected were analysed using GenStat software 18th Edition. Treatment means were compared using the Least

Significant Difference (LSD) test at a 5% probability level. The formula for calculating stand count is  $\text{Plants/ha} = [\text{plants counted in row length} / \text{measured row length (m)} \times 10,000 / \text{Row spacing (m)}]$ . Where the plants counted in row length represent the actual number of live plants recorded within the sample row. The measured row length (m) refers to the specific length of the row used for this sample count. Row spacing (m) indicates the distance between the center of one row and the center of the adjacent row, for example, 0.30 m corresponds to 30 cm spacing. Finally, the value 10,000 serves as the conversion factor for square meters to hectares, since 1 hectare is equal to 10,000 m<sup>2</sup>.

## RESULTS AND DISCUSSION

### Crop Parameters

The effect of cropping pattern on groundnut stand was statistically different at 9 and 12 WAP in all the trials (Table 1). Sole groundnut consistently produced the highest groundnut stand count, while those intercropped with maize at 100 x 37.5 cm gave the lowest count. Weed management treatments significantly influenced the stand count of groundnut. The plots treated with herbicides and hoe-weeded-twice outperformed the weedy check, especially at 12 WAP in 2019 (Table 1).

Groundnut cover score was significantly influenced by the cropping pattern (Table 2). Sole groundnut had the highest ground cover across all years (2018–2020), at 6, 9, and 12 WAP. Intercropping reduced ground cover, especially with maize at 100 x 37.5 cm spacing. Weed management practices significantly influenced groundnut cover score at 6 and 12 WAP in 2018, across all observation periods in 2019, and at 9 and 12 WAP in 2020 (Table 2). Plots treated with weed control methods recorded higher cover scores compared to the weedy check. Best results were from hoe weeding and Super Union® treatments; Probaben® was less effective. There was a significant effect of cropping pattern on plant height at 9 WAP in 2018, 2019 and 2020 (Table 3). Intercropping at 75 x 50 cm led to taller plants than sole planting or 100 x 37.5 cm in 2018 and 2020. In 2019, the sole groundnut was taller than the 100 x 37.5 cm intercrop, while the reverse was observed in 2020. Cropping arrangement significantly influenced groundnut dry matter accumulation at 9 WAP in 2019 and 2020 (Table 3). In both years, sole groundnut produced significantly higher dry matter compared to intercropped treatments, particularly those with maize at 75 x 50 cm and 100 x 37.5 cm spacing in 2019.

**Table 1.** Effects of cropping patterns and weed control treatments groundnut stand count at Abeokuta

Treatments	Stand Count of Groundnut ('000/ha)					
	9 WAP			12 WAP		
	2018	2019	2020	2018	2019	2020
<b>Cropping Pattern (CP)</b>						
75 x 50 cm Maize + Groundnut	33.05 <sup>b</sup>	43.30 <sup>b</sup>	38.66 <sup>b</sup>	31.65 <sup>b</sup>	38.01 <sup>b</sup>	38.66 <sup>b</sup>
Sole Groundnut	42.29 <sup>a</sup>	51.18 <sup>a</sup>	48.88 <sup>a</sup>	41.05 <sup>a</sup>	46.25 <sup>a</sup>	48.89 <sup>a</sup>
100 x 37.5 cm Maize + Groundnut	23.17 <sup>c</sup>	32.53 <sup>c</sup>	28.24 <sup>c</sup>	21.68 <sup>c</sup>	29.22 <sup>c</sup>	28.24 <sup>c</sup>
SE ± (CP)	0.401	0.6	0.179	0.403	0.959	0.179
<b>Weed Control Method (WC)</b>						
Probaben <sup>R</sup> at 2.4 kg a.i/ha	33.1	43.2	38.65	31.66	42.05 <sup>a</sup>	38.65
Probaben <sup>R</sup> at 1.6 kg a.i/ha	33.43	42.43	38.65	32	40.27 <sup>a</sup>	38.65
Probaben <sup>R</sup> at 1.6 kg a.i/ha fb <sup>3</sup> SHW <sup>4</sup>	33.94	43.38	38.56	32.25	42.23 <sup>a</sup>	38.56
Super Union <sup>®</sup> at 2.4 kg a.i/ha	33.77	43.21	38.65	32.33	42.06 <sup>a</sup>	38.65
Super Union <sup>®</sup> 1.6 kg a.i/ha	33.01	43.07	38.56	31.83	41.91 <sup>a</sup>	38.56
Super Union <sup>®</sup> 1.6 kg a.i/ha fb <sup>3</sup> SHW <sup>4</sup>	32.16	42.59	38.65	30.73	41.44 <sup>a</sup>	38.65

Hoe Weeding at 3 and 6 WAP <sup>5</sup>	32.76	40.11	38.1	31.83	38.04 <sup>a</sup>	38.1
Weedy Check	30.5	40.74	38.92	29.06	14.65 <sup>b</sup>	38.93
SE ± (WC)	7.647 <sup>ns</sup>	1.105 <sup>ns</sup>	0.220 <sup>ns</sup>	0.751 <sup>ns</sup>	1.567	0.220 <sup>ns</sup>
SE ± Interaction (WC x CP)	1.201	1.773	0.469	1.195	2.714	0.469

Means followed by the same letter(s) within a column are not significantly different according to Duncan's Multiple Range Test (DMRT) at  $p = 0.05$ .

**Table 2.** Effects of cropping patterns and weed control treatments groundnut cover score at Abeokuta

Treatments	Groundnut Cover Score								
	6 WAP			9 WAP			12 WAP		
	2018	2019	2020	2018	2019	2020	2018	2019	2020
Cropping Pattern									
75 x 50 cm Maize + Groundnut	3.3	4.10 <sup>b</sup>	2.00 <sup>b</sup>	5.6	5.70 <sup>b</sup>	5.80 <sup>b</sup>	4.70 <sup>a</sup>	4.30 <sup>c</sup>	6.60 <sup>b</sup>
Sole Groundnut	3.5	4.80 <sup>a</sup>	2.30 <sup>a</sup>	8.6	6.50 <sup>a</sup>	7.20 <sup>a</sup>	5.30 <sup>a</sup>	5.60 <sup>a</sup>	7.20 <sup>a</sup>
100 x 37.5 cm Maize + Groundnut	3.2	3.90 <sup>b</sup>	2.20 <sup>a</sup>	4.7	5.40 <sup>b</sup>	5.30 <sup>c</sup>	3.80 <sup>b</sup>	4.80 <sup>b</sup>	5.70 <sup>c</sup>
SE ± (CP)	0.11 <sup>ns</sup>	0.12	0.06	1.42 <sup>ns</sup>	0.16	0.15	0.27	0.17	0.16
Weed Control Method (WC)									
Probaben <sup>R</sup> at 2.4 kg a.i./ha	3.20 <sup>a</sup>	4.40 <sup>a</sup>	2.4	5.7	5.10 <sup>c</sup>	6.60 <sup>a</sup>	5.20 <sup>a</sup>	4.10 <sup>c</sup>	7.10 <sup>ab</sup>
Probaben <sup>R</sup> at 1.6 kg a.i./ha	3.40 <sup>a</sup>	4.70 <sup>a</sup>	2.3	11.8	5.70 <sup>bc</sup>	6.60 <sup>a</sup>	4.20 <sup>ab</sup>	4.90 <sup>bc</sup>	6.90 <sup>ab</sup>
Probaben <sup>R</sup> at 1.6 kg a.i./ha fb <sup>3</sup> SHW <sup>4</sup>	3.40 <sup>a</sup>	4.70 <sup>a</sup>	2.3	6.2	7.10 <sup>a</sup>	6.40 <sup>a</sup>	6.10 <sup>a</sup>	5.80 <sup>ab</sup>	7.50 <sup>a</sup>
Super Union <sup>®</sup> at 2.4 kg a.i./ha	3.60 <sup>a</sup>	4.30 <sup>a</sup>	2.2	5.7	6.30 <sup>ab</sup>	6.20 <sup>a</sup>	4.30 <sup>ab</sup>	5.30 <sup>ab</sup>	7.00 <sup>ab</sup>
Super Union <sup>®</sup> 1.6 kg a.i./ha	3.40 <sup>a</sup>	4.30 <sup>a</sup>	2	5.4	6.40 <sup>ab</sup>	6.10 <sup>a</sup>	4.10 <sup>ab</sup>	5.80 <sup>ab</sup>	6.20 <sup>b</sup>
Super Union <sup>®</sup> 1.6 kg a.i./ha fb <sup>3</sup> SHW <sup>4</sup>	3.30 <sup>a</sup>	4.60 <sup>a</sup>	2.2	5.6	7.00 <sup>a</sup>	6.10 <sup>a</sup>	5.30 <sup>a</sup>	6.10 <sup>a</sup>	7.10 <sup>ab</sup>
Hoe Weeding at 3 and 6 WAP <sup>5</sup>	3.60 <sup>a</sup>	4.20 <sup>a</sup>	2.3	6.3	6.60 <sup>ab</sup>	6.30 <sup>a</sup>	5.80 <sup>a</sup>	5.60 <sup>ab</sup>	7.60 <sup>a</sup>
Weedy Check	2.80 <sup>b</sup>	3.10 <sup>b</sup>	2.1	3.8	2.60 <sup>d</sup>	4.40 <sup>b</sup>	2.20 <sup>b</sup>	1.50 <sup>d</sup>	2.80 <sup>c</sup>
SE ± (WC)	0.13	0.21	0.09 <sup>ns</sup>	2.43 <sup>ns</sup>	0.36	0.24	0.68	0.32	0.35
SE ± Interaction (WC x CP)	0.28 <sup>ns</sup>	0.36	0.17	4.08 <sup>ns</sup>	0.52	0.41	0.94 <sup>ns</sup>	0.51 <sup>ns</sup>	0.52 <sup>ns</sup>

Means followed by the same letter(s) within a column are not significantly different according to Duncan's Multiple Range Test (DMRT) at  $p = 0.05$ .

**Table 3.** Effects of cropping patterns and weed control treatments groundnut canopy height and dry matter production at Abeokuta

Treatments	Groundnut Canopy Height (cm) at 9 WAP			Groundnut Dry Matter Production 9 WAP (g/plant)		
	2018	2019	2020	2018	2019	2020
Cropping Pattern (CP)						
75 x 50 cm Maize + Groundnut	32.9 <sup>a</sup>	49.3 <sup>a</sup>	30.7 <sup>a</sup>	10.8	17.30 <sup>b</sup>	10.00 <sup>b</sup>
Sole Groundnut	28.5 <sup>b</sup>	55.2 <sup>a</sup>	25.5 <sup>b</sup>	8.3	28.60 <sup>a</sup>	14.30 <sup>a</sup>

100 x 37.5 cm Maize + Groundnut	31.4 <sup>ab</sup>	42.5 <sup>b</sup>	30.4 <sup>a</sup>	8.1	16.20 <sup>b</sup>	13.60 <sup>a</sup>
SE ± (CP)	1.08	2.17	1.44	01.08 <sup>ns</sup>	1.39	1.19
Weed Control Method (WC)						
Probaben <sup>R</sup> at 2.4 kg a.i/ha	31.8	49.6	28.1	6.4	20.8	11.8
Probaben <sup>R</sup> at 1.6 kg a.i/ha	30.2	49.3	28.5	8.9	18.7	13.9
Probaben <sup>R</sup> at 1.6 kg a.i/ha fb <sup>3</sup> SHW <sup>4</sup>	29.6	50.3	28.5	6.4	20.2	11.6
Super Union <sup>®</sup> at 2.4 kg a.i/ha	31.3	46.3	27.7	8.9	20.6	13.6
Super Union <sup>®</sup> 1.6 kg a.i/ha	33.1	45.4	26.8	9.7	19.6	15.3
Super Union <sup>®</sup> 1.6 kg a.i/ha fb <sup>3</sup> SHW <sup>4</sup>	31.4	49.1	26.8	10.4	25.5	10.8
Hoe Weeding at 3 and 6 WAP <sup>5</sup>	31.7	43.8	28.7	11.8	25.9	14.7
Weedy Check	28.3	58.2	35.9	9.7	14.3	9
SE ± (WC)	1.90 <sup>ns</sup>	3.04 <sup>ns</sup>	2.04 <sup>ns</sup>	01.41 <sup>ns</sup>	02.38 <sup>ns</sup>	2.28
SE ± Interaction (WC x CP)	3.14	5.87	3.9	02.87 <sup>ns</sup>	04.00 <sup>ns</sup>	03.58 <sup>ns</sup>

Means followed by the same letter(s) within a column are not significantly different according to Duncan's Multiple Range Test (DMRT) at  $p = 0.05$ .

The effect of cropping pattern on groundnut pod yield and number was significant in all the years. Sole groundnut consistently resulted in higher number and yield of groundnut pods than those intercropped with maize at both spacings in all the trials except in 2018, when groundnut intercropped with maize at 75 x 50 cm performed comparably (Table 4). In 2019, 100 cm x 37.5cm intercropping produced a significantly higher pod yield compared to 75 cm x 50 cm intercropping. Furthermore, in 2019, application of Probaben<sup>®</sup> at 1.6 kg a.i/ha fb SHW and Super Union<sup>®</sup> at 1.6 and 2.4 kg a.i/ha alone resulted in pod number comparable to the best performing treatment (Super Union<sup>®</sup> at 1.6 kg a.i/ha fb SHW). These were higher than the pod number of those treated with Probaben<sup>®</sup> at both rates alone, and the hoe weeded twice (Table 4).

**Table 4.** Effects of cropping patterns and weed control treatments on number of pod and pod yield at Abeokuta

Treatments	Number of Pod ('000/ha)			Pod Yield (kg/ha)		
	2018	2019	2020	2018	2019	2020
Cropping Pattern (CP)						
75 x 50 cm Maize + Groundnut	152.59 <sup>a</sup>	171.67 <sup>b</sup>	538.22 <sup>b</sup>	145 <sup>a</sup>	237 <sup>c</sup>	665 <sup>z</sup>
Sole Groundnut	146.98 <sup>a</sup>	736.50 <sup>a</sup>	1137.87 <sup>a</sup>	106 <sup>a</sup>	1112 <sup>a</sup>	1478 <sup>a</sup>
100 x 37.5 cm Maize + Groundnut	71.26 <sup>b</sup>	202.04 <sup>b</sup>	455.25 <sup>b</sup>	51 <sup>b</sup>	403 <sup>b</sup>	588 <sup>b</sup>
SE ± (CP)	13.066	50.119	46.047	16.5	21.59	58.6
Weed Control Method						
Probaben <sup>R</sup> at 2.4 kg a.i/ha	135.56	265.89 <sup>b</sup>	721.68 <sup>a</sup>	111	387 <sup>f</sup>	951 <sup>a</sup>
Probaben <sup>R</sup> at 1.6 kg a.i/ha	90.37	335.00 <sup>b</sup>	767.65 <sup>a</sup>	59	507 <sup>e</sup>	936 <sup>a</sup>
Probaben <sup>R</sup> at 1.6 kg a.i/ha fb <sup>3</sup> SHW <sup>4</sup>	157.16	489.44 <sup>ab</sup>	820.91 <sup>a</sup>	119	748 <sup>c</sup>	1046 <sup>a</sup>
Super Union <sup>®</sup> at 2.4 kg a.i/ha	106.67	436.44 <sup>ab</sup>	698.05 <sup>a</sup>	88	568 <sup>de</sup>	871 <sup>a</sup>
Super Union <sup>®</sup> 1.6 kg a.i/ha	117.41	454.22 <sup>ab</sup>	645.33 <sup>a</sup>	106	636 <sup>d</sup>	840 <sup>a</sup>

Super Union® 1.6 kg a.i./ha fb <sup>3</sup> SHW <sup>4</sup>	148.1	628.67 <sup>a</sup>	806.39 <sup>a</sup>	125	933 <sup>b</sup>	1061 <sup>a</sup>
Hoe Weeding at 3 and 6 WAP <sup>5</sup>	172.47	339.00 <sup>b</sup>	870.62 <sup>a</sup>	158	1057 <sup>a</sup>	1122 <sup>a</sup>
Weedy Check	61.16	11.89 <sup>c</sup>	352.94 <sup>b</sup>	40	19 <sup>g</sup>	452 <sup>b</sup>
SE ± (WC)	25.252 <sup>ns</sup>	67.063	90.238	27.3 <sup>ns</sup>	35.2	118.7
SE ± Interaction (WC x CP)	39.358 <sup>ns</sup>	133.771 <sup>ns</sup>	139.468	47.0 <sup>ns</sup>	61.01 <sup>ns</sup>	180.0 <sup>ns</sup>

Means followed by the same letter(s) within a column are not significantly different according to Duncan's Multiple Range Test (DMRT) at  $p = 0.05$ .

Groundnut stand count, ground cover, dry matter production, number of pods and yield were higher in sole cropping than in intercrop, indicating that groundnut is highly sensitive to inter specific competition with the component tall growing maize in the mixture. The reduction in performance of intercropped groundnut compared with the sole crop in this study can be caused by the shading of the groundnut plants by the maize plants. Lagoke et al. (2014) obtained similar results of sole groundnut performing better than intercropped groundnut at the same location. Inal et al. (2007) reported that the dry matter of peanut were reduced by intercropping the plants, as compared to sole cropping. Masude et al. (2016) also reported similar findings.

Weed management practices significantly influenced groundnut growth, yield, and its yield components in this study. Groundnut canopy spread, cover score at 9 WAP, the number and yield of groundnut pods were similar and significantly higher on the plots with various weed control methods compared with those on weed infested plots. Groundnut cover score at 12 WAP, number of pod and pod yield was however higher on the supplementary hoe weeded plots than on those with herbicide application alone. Supplementary hoe-weeding at 6 WAP on plots previously treated with pre-emergence herbicides or initially weeded at 3 WAP extended the duration of weed-free conditions. This reduced the length of period of weed competition with the crop, thereby making soil nutrients available to the crop only, hence higher yield. These results confirm the effectiveness of the weed control treatments evaluated in controlling or reducing weed competition in intercropped and sole groundnut hence good growth and productivity. These results agree with Kalhapure (2013) and Sharma et al., (2015), who emphasized that weed-free conditions enhance flowering, peg initiation, pod formation, and ultimately boost groundnut yield. Similarly, the yield of groundnut has been established to be enhanced, where integrated weed control measures were used in groundnut production (Jat et al., 2011; Eni et al., 2021).

### Weed Parameters

In 2019, cropping pattern significantly influenced weed cover score at 12 WAP, with sole groundnut recording higher values than intercropped plots (Table 5). Weed control treatments also had a significant effect on weed cover scores at 3 and 12 WAP across all trials (Table 5). At 3 WAP, weed cover score on the plots treated with herbicide were significantly lower compared to hoe weeded plots and the weedy check. Similarly, weed cover score at 12 WAP on the herbicide-treated and hoe-weeded plots was significantly lower compared with that of the plots left weed-infested. At 12 WAP in all the trials, application of both herbicides fb SHW resulted in significantly lower weed cover score compared to application of Probaben® at 1.6 kg a.i./ha alone (Table 5). In 2019, cropping pattern significantly affected broadleaf weed dry matter at 9 WAP, with sole groundnut recording the highest values. Broadleaf and grass weed dry matter was significantly reduced by weed control methods compared with the plots left weed-infested at 9 WAP in all trials (Table 6). Plots hoe-weeded twice or combining herbicides with SHW consistently resulted in lower weed biomass than those treated with herbicides alone. Applying Super Union® at 1.6 kg a.i./ha without supplementary hoe-weeding proved less effective in lowering broadleaf weed dry matter during 2018 and 2020.

**Table 5.** Effects of cropping patterns and weed control treatments on weed cover score at Abeokuta

Treatment	Weed Cover Score					
	3 WAP			12 WAP		
	2018	2019	2020	2018	2019	2020

Cropping Pattern (CP)						
75 x 50 cm Maize + Groundnut	13	13	13	57	34 <sup>b</sup>	28
Sole Groundnut	13	13	14	59	51 <sup>a</sup>	30
100 x 37.5 cm Maize + Groundnut	15	14	14	65	36 <sup>b</sup>	31
SE ± (CP)	0.7 <sup>ns</sup>	0.5 <sup>ns</sup>	0.5 <sup>ns</sup>	2.9 <sup>ns</sup>	2.0	1.8 <sup>ns</sup>
Weed Control Method (WC)						
Probaben <sup>R</sup> at 2.4 kg a.i/ha	11 <sup>b</sup>	11 <sup>b</sup>	12 <sup>b</sup>	58 <sup>bc</sup>	41 <sup>b</sup>	34 <sup>bc</sup>
Probaben <sup>R</sup> at 1.6 kg a.i/ha	12 <sup>b</sup>	11 <sup>b</sup>	12 <sup>b</sup>	67 <sup>ab</sup>	38 <sup>bc</sup>	36 <sup>bc</sup>
Probaben <sup>R</sup> at 1.6 kg a.i/ha fb <sup>3</sup> SHW <sup>4</sup>	12 <sup>b</sup>	11 <sup>b</sup>	13 <sup>b</sup>	48 <sup>cd</sup>	27 <sup>de</sup>	18 <sup>e</sup>
Super Union <sup>®</sup> at 2.4 kg a.i/ha	11 <sup>b</sup>	10 <sup>b</sup>	12 <sup>b</sup>	69 <sup>ab</sup>	34 <sup>bcd</sup>	29 <sup>cd</sup>
Super Union <sup>®</sup> 1.6 kg a.i/ha	11 <sup>b</sup>	11 <sup>b</sup>	13 <sup>b</sup>	68 <sup>ab</sup>	34 <sup>bcd</sup>	39 <sup>b</sup>
Super Union <sup>®</sup> 1.6 kg a.i/ha fb <sup>3</sup> SHW <sup>4</sup>	12 <sup>b</sup>	11 <sup>b</sup>	13 <sup>b</sup>	45 <sup>cd</sup>	24 <sup>e</sup>	21 <sup>de</sup>
Hoe Weeding at 3 and 6 WAP <sup>5</sup>	24 <sup>a</sup>	23 <sup>a</sup>	21 <sup>a</sup>	43 <sup>d</sup>	29 <sup>cde</sup>	20 <sup>de</sup>
Weedy Check	24 <sup>a</sup>	24 <sup>a</sup>	22 <sup>a</sup>	81 <sup>a</sup>	76 <sup>a</sup>	78 <sup>a</sup>
SE ± (WC)	1.3	2.3	0.9	4.3	2.9	3.2
SE ± Interaction (WC x CP)	2.3 <sup>ns</sup>	2.7 <sup>ns</sup>	1.6 <sup>ns</sup>	8.8	6.0	5.7

Means followed by the same letter(s) within a column are not significantly different according to Duncan's Multiple Range Test (DMRT) at  $p = 0.05$ .

**Table 6.** Effects of cropping patterns and weed control treatments on weed dry matter at Abeokuta

Treatment	Broadleaf Weed Dry Matter Production (kg/ha) At 9 WAP			Grass Weed Dry Matter Production (kg/ha) At 9 WAP		
	2018	2019	2020	2018	2019	2020
Cropping Pattern (CP)						
75 x 50 cm Maize + Groundnut	452	171 <sup>b</sup>	163	129	405	72.0
Sole Groundnut	633	590 <sup>a</sup>	243	148	365	169
100 x 37.5 cm Maize + Groundnut	530	287 <sup>b</sup>	218	299	477	124
SE ± (CP)	90.7 <sup>ns</sup>	75.9	62.4 <sup>ns</sup>	99.9 <sup>ns</sup>	101.9 <sup>ns</sup>	69.9 <sup>ns</sup>
Weed Control Method (WC)						
Probaben <sup>R</sup> at 2.4 kg a.i/ha	464 <sup>c</sup>	727 <sup>a</sup>	295 <sup>bc</sup>	160 <sup>b</sup>	200 <sup>bc</sup>	55.0 <sup>b</sup>
Probaben <sup>R</sup> at 1.6 kg a.i/ha	549 <sup>bc</sup>	404 <sup>b</sup>	296 <sup>bc</sup>	85 <sup>b</sup>	223 <sup>bc</sup>	123 <sup>b</sup>
Probaben <sup>R</sup> at 1.6 kg a.i/ha fb <sup>3</sup> SHW <sup>4</sup>	372 <sup>c</sup>	225 <sup>b</sup>	206 <sup>c</sup>	63 <sup>b</sup>	59.0 <sup>c</sup>	80.0 <sup>b</sup>
Super Union <sup>®</sup> at 2.4 kg a.i/ha	550 <sup>bc</sup>	272 <sup>b</sup>	247 <sup>c</sup>	96 <sup>b</sup>	485 <sup>b</sup>	166 <sup>b</sup>
Super Union <sup>®</sup> 1.6 kg a.i/ha	844 <sup>ab</sup>	319 <sup>b</sup>	447 <sup>ab</sup>	141 <sup>b</sup>	224 <sup>bc</sup>	162 <sup>b</sup>
Super Union <sup>®</sup> 1.6 kg a.i/ha fb <sup>3</sup> SHW <sup>4</sup>	537 <sup>bc</sup>	123 <sup>b</sup>	241 <sup>c</sup>	96 <sup>b</sup>	121 <sup>bc</sup>	31.0 <sup>b</sup>

Hoe Weeding at 3 and 6 WAP <sup>5</sup>	342 <sup>c</sup>	239 <sup>b</sup>	215 <sup>c</sup>	66 <sup>b</sup>	92 <sup>bc</sup>	110 <sup>b</sup>
Weedy Check	954 <sup>a</sup>	662 <sup>a</sup>	608 <sup>a</sup>	719 <sup>a</sup>	1135 <sup>a</sup>	558 <sup>a</sup>
SE ± (WC)	99.2	83.5	56.9	104.7	119.0	75.8
SE ± Interaction (WC x CP)	259.6 <sup>ns</sup>	217.4 <sup>ns</sup>	174.5 <sup>ns</sup>	284.2 <sup>ns</sup>	294.7 <sup>ns</sup>	199.9 <sup>ns</sup>

Means followed by the same letter(s) within a column are not significantly different according to Duncan's Multiple Range Test (DMRT) at  $p = 0.05$ .

All weed control strategies in this study significantly reduced weed cover compared to the untreated plots, particularly during the early growth stages of the crop. Consistent lower weed cover scores recorded at 9 and 12 WAP in plots treated with herbicides followed by supplementary hoe weeding, and in plots hoe weeded twice, compared to sole application of herbicide, could be attributed to additional hoe weeding carried out at 6 WAP. This shows that supplementary hoe weeding at 6 WAP was still crucial to attain season-long weed control even after pre-emergence herbicide application. Several studies have shown that using only pre-emergence herbicides does not provide season-long weed control (Adeyemi et al., 2019; Lagoke et al., 2014; Osunleti et al., 2022; Yusuf et al., 2024). Janak and Grichar (2016) recommended supplementing pre-emergence herbicides with post-emergence applications, while Lagoke et al. (2014) advised incorporating hoe-weeding to effectively limit weed growth. Similarly, Osunleti and Lagoke (2024) reported an 85% reduction in weed infestation when post-emergence measures followed pre-emergence herbicide use.

### CONCLUSION

The study showed that planting groundnut sole, resulted in at least 100% increase in yield compared to when in intercrop with maize. It is therefore recommended for higher groundnut production. Every weed management approach significantly lowered weed infestation and enhanced groundnut growth and pod yield compared to untreated plots. Applying the two pre-emergence herbicides at 1.6 kg a.i./ha followed by supplementary hoe-weeding consistently provided season-long weed control and crop performance similar to two hoe-weeding. Application of the two pre-emergence herbicides at 1.6 kg a.i./ha fb SHW is therefore recommended for the production of groundnut, as it ensures minimum weed infestation with high groundnut yield.

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### AUTHORS CONTRIBUTION

Eni, E. I: The conceptualizing, methodology and writing the original manuscript. Onwudiwe, N: Writing, review and editing. Osunleti, S. O: Collection of data and analysis. Falade, A. A: Collection of data, review and editing. Adeyemi, O. R: Research supervision. All authors read and approved the final manuscript

### CONFLICT OF INTEREST

The authors declare no conflict of interest.

### ETHICAL APPROVAL

Not applicable.

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### CONSENT TO PUBLISH DECLARATION

Not applicable

### CONSENT TO PARTICIPATE DECLARATION

Not applicable

### AVAILABILITY OF DATA AND MATERIALS

All datasets analyzed and described during the present study are available from the corresponding author upon reasonable request.

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