integrity Research Journals

Journal of Bioscience and Biotechnology Discovery
Volume 9(3), pages 47-60, August 2024
Article Number: 4708D57C2
ISSN: 2536-7064
https://doi.org/10.31248/JBBD2024.213
https://integrityresjournals.org/journal/JBBD

Full Length Research

Impact of weed control methods and staking on the growth, yield, and weed response of cucumber (*Cucumis sativus* L.) in Kano, Sudan Savanna, Nigeria

Shittu, E. A.[1]*., Bassey, M. S.[2] and Racha, V. N.[3]

[1]Department of Agronomy, Bayero University Kano, P.M.B 3011, Kano, Nigeria.
[2]National Cereals Research Institute, P.M.B. 8, Bida, Nigeria.
[3]Bio-Resourse Development Centre, Kano Office, BUK.

*Corresponding authors. Email: seabraham.agr@buk.edu.ng

Received 10th June 2024; Accepted 25th July 2025

ABSTRACT: Cucumber growing is becoming increasingly popular in Nigeria's Sudan savanna region due to its health benefits and minimal impact on the soil. However, weed infestation is a major challenge that can significantly reduce yields, by up to 45-95%. In view of this, two trials were conducted at the Teaching and Research farm of the Faculty of Agriculture and the net house of the Centre for Dryland Agriculture of the Bayero University Kano to examine the effects of weed control and staking on cucumbers during the 2021 dry season. The trial consisted of eight weed control treatments and two staking methods which were arranged in a split plot design with three replicates, with staking assigned to the main plot while weed control was assigned to the sub plots. The study analyzed data on growth and yield, using Genstat (17th edition) and significantly different means were separated using the Student Newman-Keuls Test (SNK) at a 5% level of probability. Results showed a higher composition of grass and broadleaf weeds in open fields compared to controlled net house environments. Weed Control Efficiency (WCE) was greater in weed-free plots, but Butachlor and metolachlor significantly outperformed other treatments, providing higher WCE. The herbicidal treated plots significantly resulted in longer days to 50% emergence than other treatments, while it also resulted in a shorter number of days to 50% flowering and fruiting than weedy check. The vine length, number of leaves, leaf area, and chlorophyll content were highly significant ($p<0.01$) in weed free, butachlor at 1.5 + Imazethapyr 1.5 kg a.i.ha^{-1} post emergence (POE) and metolachlor at 1.5 + Imazethapyr 1.5 kg a.i.ha^{-1} POE. Similarly, yield and yield attributes followed the same pattern as obtained in growth components. Staking of vines on the other hand significantly resulted in greater growth and yield of cucumber. Based on these findings, farmers in the study area are advised to grow cucumber staked with the application of Butachlor at 1.5 + Imazethapyr 1.5 kg a.i.ha^{-1} POE and metolachlor at 1.5 + Imazethapyr 1.5 kg a.i.ha^{-1} POE for sustainable weed management.

Keywords: Cucumber, growth, staking, weed control efficiency, yield-related characters.

INTRODUCTION

The family Cucurbitaceae includes cucumber (*Cucumis sativus* L.) as one of its members. According to Pandey and Kujur (2022), it is a noteworthy vegetable that is being domesticated all over the world. Cucumber is currently the fourth most extensively grown vegetable, behind tomatoes, cabbage, and onions (Jamir *et al.,* 2014). It is characterized by a creeping vine with broad leaves that form a canopy over the cylindrical fruits (Molaei and Ghatrehsamani, 2022). It is grown in nearly every agro-ecological zone in Nigeria, from the coastal to the savanna zones (Enujeke, 2013), and is quickly gaining popularity among local households (Okafor and Yaduma*,* 2021).

Cucumber has a wide range of functions, ranging from culinary to therapeutic and cosmetic (Mukherjee *et al.,* 2013; Muruganantham *et al.,* 2016; Oboh *et al.,* 2017). According to Fraire-Velázquez and Balderas-Hernández (2013), cucumber growth may be impacted by a variety of stresses, both biotic and abiotic. Weed invasion, insect pests, and diseases are among the biotic stressors that become much more common, lowering cucumber yield and quality (Arogundade *et al*., 2021). Both weeds and crops respond to the same environmental growth resources, such as carbon dioxide, nitrogen, water, soil nutrients and light which are used for their growth and development (Daramola *et al.,* 2021).

The kind of weed species present, their density, and the length of weed-crop interaction all play a role in determining the degree of crop damage and yield loss caused by weeds (Chauhan *et al.,* 2020). In addition to directly competing for scarce growth resources, weeds act as alternate habitats for insect pests and disease pathogens that infest cucumber and other horticultural crops (Abraham *et al*., 2020). If used, the management strategy of staking can help to control weeds and other pest infestations. In their study of the impact of staking and pruning on the development and production of cucumber. Pradhan *et al*. (2021) discovered that the non-staked treatment produced more vine length, flowers, total fruits, and non-marketable fruits while the staked treatment produced more marketable fruits, weight, length, and diameter.

Therefore, it is necessary to checkmate the weed threat by lowering their population density through effective control measures. This research was carried out to evaluate how cucumber growth, yield, and weed qualities respond to various weed control techniques and staking.

MATERIALS AND METHODS

Experimental site

Two separate trials were carried out at the Research and Teaching Farm (Orchard) of the Faculty of Agriculture, Bayero University, Kano (11°59'N; 8°25'E; 466 m above sea level) and the net house of the Center for Dryland Agriculture, BUK (11°98'N and 8°415'E; 466 m asl), both situated within the Sudan Savannah ecological zone of Nigeria (Figure 1) during the 2021 dry season to assess how the weed control method and staking affected the growth, yield, and weed characters of cucumber.

Treatments and experimental design

The experiment comprised eight weed control treatments (weed free, weedy check, Butachlor at 1.5 kg a.i. ha, Metolachlor at 1.5 kg a.i. ha^{-1}, Butachlor at 1.5 kg a.i. ha^{-1} + S.H.W. at 6 WAS, Metolachlor at 1.5 kg a.i. ha^{-1} + S.H.W at 6 WAS, Butachlor at 1.5 kg a.i. ha^{-1} + Imazethapyr at 1.5 kg a.i. ha^{-1} POE and Metolachlor at 1.5 kg a.i. ha^{-1} + Imazethapyr at 1.5 kg a.i. ha^{-1} POE.) and two stakings (staked and unstaked) which were replicated three times in a split plot design. The staking was assigned to the main plot while weed control was assigned to the sub plots.

Crop variety

The Poinsett variety of cucumber was utilized in the experiment; it was purchased from Technisem-Agritropic Ltd. in Nigeria. It is a slicing hybrid cultivar with a 99% emergence rate, an average time to emergence of 5 to 10 days, and a 55 to 65 days maturation duration at temperatures above 20°C. The fruits are round, 17.5–20 cm long, and 5-6.5 cm in diameter. They are straight, dark green, and not bitter.

Field layout, treatment application and crop husbandry

The experimental field was harrowed twice to a fine tilt before sowing. A plot measuring 3 x 3 meters was mapped out, with subplots, main plots, and replications separated by 0.5, 1.0, and 1.5 meters, respectively. Two seeds were sown per hole which were later thinned to one plant per stand.

Herbicides were applied one day after sowing using a 16-litre capacity knapsack sprayer fitted with a green deflector poly jet nozzle calibrated at a pressure of 2.1 kg m^{-2} to give a spray volume of 250 litres per hectare. Herbicides were applied on a treatment basis. Based on the recommendation, the fertilizer was applied at a rate of 200 kg/ha using NPK 15:15:15 at 3 WAS, with N applied in two split doses using Urea at 6 WAS.

The application of a broad-spectrum insecticide, Ampligo, was carried out across all treatments at 4, 6, and 9 WAS at a dosage of 30 g per 16 litres of water to control phytophagous insects. Regular weeding was done on weed-free (positive check) plots, and supplementary hoe weeding was done on plots that needed it. Weedy check plots were left unweeded for the duration of the experiment as the control (negative check).

Observation and data collection

Weed characters

Weed species harvested from the 1m^2 quadrant placed randomly in each plot were harvested and identified using a Book and other standard procedures described by Akobundu *et al.* (2016) and Rana and Rana (2018), respectively. Those that could not be positively identified are packaged and transported to the herbarium section of the Department of Plant Science at Bayero University in Kano, Nigeria.

From the harvested weed biotypes, their densities,

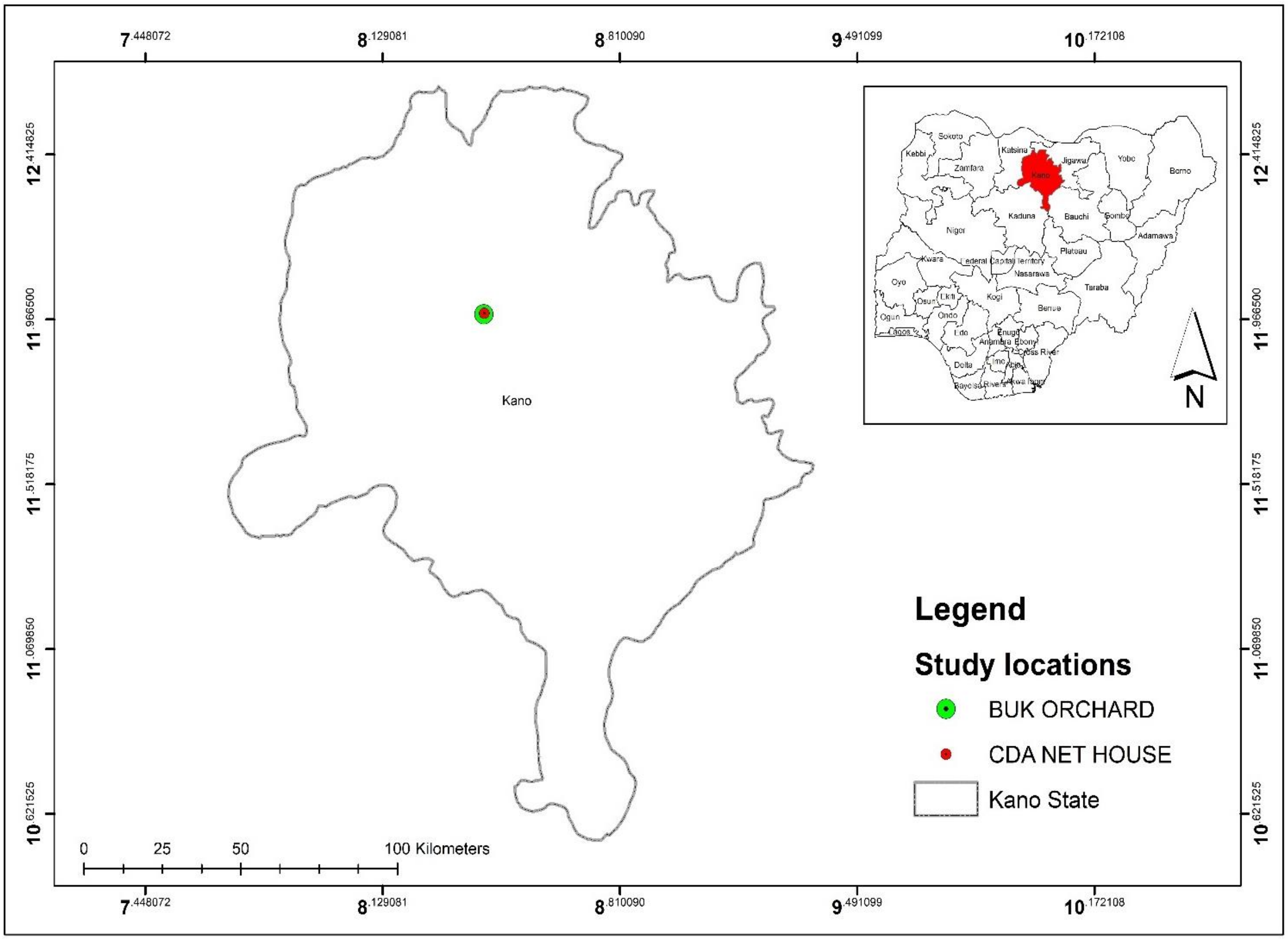

Figure 1. Map showing the study area.

species composition (grasses, broadleaves and sedges) and lifecycle were determined. Furthermore, the harvested weeds were oven-dried at 80°C for 48 hours and biomass was determined using a sensitive digital weighing balance (Metlar MT-2000) with a precision of 1 mg and recorded as weed dry weight. Parameters such as weed dry weight and weed control efficiency were also estimated according to the formula described by Mani *et al.* (1976) for weed control efficiency follows:

$$\text{Weed control efficiency} = \frac{total\ dry\ weigh\ in\ weedycheck - total\ dry\ weight\ treatment}{total\ weed\ dry\ weight\ in\ weedy\ check} \times 100\ldots \quad (1)$$

Crop growth and yield charactes

The growth and yield-related characters of three (3) tagged plants from the net plots were identified. Data were collected on growth characters including the number of days to 50% emergence, 50% flowering and fruiting, vine length, number of leaves plant^{-1}, leaf area and chlorophyll content while yield characters include the number of fruits plant^{-1}, fruit diameter, fruit length, fruit yield plot^{-1} and total fruit yield (t ha^{-1}). The growth and yield data were collected using standard agronomic procedures. The number of days to 50% emergence, flowering and fruiting was determined by counting the number of days from sowing to when the crop must have emerged, flowered and set fruit by 50% of the total population per treatment plot. The number of leaves per plant was determined by counting the number of leaves on three (3) tagged plants and the average was considered as number of leaves per plant. The leaf area was calculated by multiplying the length and the weight of the crop with its crop factor. Thus, leaf area is given as:

$$LA = L \times B \times CF\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where, LA = Leaf area, L= Length of leaf (cm), B= Breadth of leaf (cm) and C= Crop factor.

Similarly, the number of fruits per plant and per plot was determined by physical counting of the fruits. The fruit length was determined by measuring the length of the fruit

Table 1. Weed species composition of cucumber as affected by weed control and staking grown during 2021 dry season at BUK at the open field and net house condition.

Weed biotypes	Common names	Family	Life cycle	Level of occurrence	
				Open field	Net house
Grasses					
Cynodon doctylon Pers	Bermuda grass	Poaceae	Perennial	***	*
Digitaria ciliaris	Crab grass	Poaceae	Annual	*	*
Echinochloa colona (L.) Link	Jungle rice	Poaceae	Annual	*	*
Eragrostis cilianensis ex Janchen	Gray love grass	Poaceae	Annual	**	*
Eragrostis unioloides (Retz.) Neos ex Steud	Chinese love grass	Poaceae	Annual	**	-
Polypogon monspeliensis (L) Desf	Rabbit foot grass	Poaceae	Annual	*	-
Broad leaf					
Amaranthus spp (L)	Spiny pigweed	Amaranthaceae	Annual	***	**
Chenopodium murals (L)	Nettle-leaved goosefoot	Chenopodiaceae	Annual	*	*
Commelina benghalensis K. Schumann	Tropical spiderwort	Commelinaceae	Annual	**	**
Leucas martinicensis (Jacq) R.Br.	White wort	Lamiaceae	Annual	***	-
Phyllanthus virgatus G. Forst	Narrow piss weed	Euphorbiaceae	Annual	*	-
Portulaca oleracea (L)	Common purslane	Portulacaceae	Annual	*	**
Pseudognaphaliumluteo_album (L.) Hillard & B.L.Burt	Cotton weed	Asteraceae	Annual	*	*
Rungiapectinata (L) Nee	Comb rungia	Acanthaceae	Annual	*	-
Sedges					
Cyperus esculentus (L)	Yellow nutsedge	Cyperaceae	Perennial	*	**
Cyperus rotundus (L)	Purple nutsedge	Cyperaceae	Perennial	*	*
Fimbristylis miliacea (L) Vahi	Hoorah grass	Cyperaceae	Perennial	*	*

* = Low infestation 1–29%; ** = Moderate infestation 30–59%; *** = High infestation ≥ 60. - = Not available.

with a meter rule while the fruit diameter was obtained using a vernier calliper. Fruit yield per plot was determined by weighing the fruits per plot using a sensitive weighing balance (Metlar MT-2000) and weights obtained were converted to kg per hectare and subsequently to tons per hectare.

Data analysis

The data collected from the field were tested for normality and further subjected to analysis of variance (ANOVA) using GENSTAT (17th edition). Means showing significant differences were separated using the Student Newman-Keuls Test (SNK) at a 5% level of probability.

RESULTS

Effect of weed control methods and staking on weed species composition, weed covers score, weed dry weight and weed control efficiency

Based on the species composition of the grasses, broadleaf weeds, and sedges present in the open field conditions, a total of seventeen (17) weed biotypes were identified (Table 1). There were six different species of grasses, eight different species of broadleaf weeds, and three different species of sedges. Based on the lifecycle distribution of the weeds, 13 of them are annuals (76.47%), while 4 of them are perennials (22.53%). The Poaceae family contains six weeds, whereas the Cyperaceae family has three. The Amaranthacea, Asteraceae, Acanthaceae, Chenopodiaceae, Commelinaceae, Euphorbiaceae, Lamiaceae, and Portulacacea families each have one appearance.

Table 2. Weed covers score, weed density, weed dry matter and weed control efficiency of cucumber as affected by weed control and staking at BUK grown during the dry season of 2021 in the open field and net house condition.

Treatment	Open field				Net house			
	WCS	WD (n m^{-2})	WDW (g)	WCE (%)	WCS	WD (n m^{-2})	WDW (g)	WCE (%)
Weed control (W)								
Weed free	0.00^{f}	2.50e	0.11^{d}	91.67^{a}	0.00^{e}	2.08^{e}	0.11^{d}	92.83^{a}
Weedy check	4.00^{a}	84.50^{a}	47.00^{a}	1.67^{e}	3.80^{a}	78.50^{a}	42.48^{a}	2.90^{e}
Butachlor at 1.5 kg a.i.ha^{-1}	3.00^{b}	45.67^{b}	25.17^{b}	45.83^{d}	2.82^{b}	41.33^{b}	22.33^{b}	46.58^{d}
Metolachlor at 1.5 kg a.i.ha^{-1}	2.83^{b}	45.17^{b}	23.50^{b}	45.50^{d}	2.72^{b}	40.83^{b}	20.97^{b}	46.72^{d}
Butachlor at 1.5 kg a.i.ha-1 + SHW at 6 WAS	1.67^{c}	22.33^{c}	12.12^{c}	61.33^{c}	1.67^{c}	20.83^{c}	10.38^{c}	62.23^{c}
Metolachlor at 1.5 kg a.i.ha-1 + SHW at 6 WAS	1.67^{cd}	23.00^{c}	11.95^{c}	62.50^{c}	1.65^{c}	19.83^{c}	10.05^{c}	63.47^{c}
Butachlor at 1.5 + Imazethapyr 1.5 kg a.i.ha^{-1}POE	1.33^{c}	13.00^{d}	6.82^{cd}	80.00^{b}	1.33^{cd}	11.67^{d}	6.00^{c}	81.10^{b}
Metolachlor at 1.5 + Imazethapyr1.5 kg a.i.ha^{-1}POE	1.00^{e}	11.67^{d}	6.45^{cd}	79.17^{b}	1.00^{d}	10.67^{d}	5.87^{c}	80.00^{b}
P. value	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
S.E (±)	0.109	1.788	2.237	0.623	0.126	1.635	1.533	0.967
Staking (S)								
Staked	1.83^{b}	30.38	16.47	58.12	1.74	27.15	14.49	59.11
Unstaked	2.04^{a}	31.58	16.81	58.79	2.01	29.29	15.06	59.62
P. value	0.011	0.188	0.537	0.442	0.148	0.207	0.638	0.464
S.E(±)	0.118	0.621	0.384	0.597	0.083	0.825	0.737	0.401
Interaction								
W x S	0.186	2.177	2.365	1.347	0.076	0.814	0.999	0.027

Mean (s) followed by common superscript (s) in a column are significantly different at 5% (SNK). WAS = Weeks after sowing, POE= Post emergence. WCS= Weed cover sore (on scale of 1-5, with 5 as full weed cover); WD= Weed density; WDW= Weed dry weight; WCE= Weed control efficiency.

In comparison to the remaining species, *Cynodon dactylon*, *Amaranthus spp*., and *Leucas martinicensis* were shown to be the most prevalent in the open field experimental areas.

On the other hand, different species make up the net house. Twelve (12) distinct weed biotypes were found, broken down into three categories: grasses (4), broadleaf (5), and sedges (3). Based on life cycle distribution, annuals make up the majority (75%) of plants. The Poaceae family has four appearances, whereas the other families Acanthaceae, Euphorbiaceae, and Lamiaceae have one occurrence each. But Amaranthus species, *Commelina benghalensis*, *Portulaca oleracea*, and *Cyperus esculentus* are the dominants in the net home. Additional research revealed that the open field had a higher diversity of grass and broad-leaved weed species than the net house (Table 1).

Weed control and staking were highly significant (p<0.001) due to Weed Cover Score (WCS), Weed Density (WD), weed Dry Weight (WDW), and Weed Control Efficiency (WCE) (Table 2). Weedy check significantly produced the highest WCS, WD, and WDW compared with the rest of the treatments which resulted in lower values. However, WCE was significantly higher with weed-free conditions, closely followed by the application of Butachlor at 1.5 + Imazethapyr 1.5 kg a.i.ha^{-1} POE and Metolachlor at 1.5 + Imazethapyr 1.5 kg a.i.ha^{-1} POE among the herbicidal treatments at both the open field and the net house conditions. On the other hand, unstaked cucumber was highly

Table 3. Number of days to 50% emergences, 50% flowering and 50% fruiting of cucumber as affected by weed control and staking at BUK grown during dry 2021 season at the open field and net house condition.

Treatment	Open field			Net house		
	Days to 50% emergence	Days to 50% Flowering	Days to 50% fruiting	Days to 50% Emergence	Days to 50% flowering	Days to 50% Fruiting
Weed control (W)						
Weed free	10.00^{b}	53.50^{b}	64.83^{b}	9.52^{c}	51.33^{c}	62.00^{c}
Weed check	10.17^{a}	62.00^{a}	73.50^{a}	9.60^{c}	58.83^{a}	69.50^{a}
Butachlor at 1.5 kg a.i.ha^{-1}	10.83^{ab}	55.83^{b}	67.33^{b}	9.88^{bc}	53.83^{bc}	64.67^{bc}
Metolachlor at 1.5 kg a.i.ha^{-1}	11.67^{b}	56.33^{b}	67.83^{b}	10.73^{ab}	56.00^{b}	65.17^{bc}
Butachlor at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS	11.33^{b}	57.00^{ab}	68.67^{ab}	10.60^{ab}	54.83^{bc}	65.50^{bc}
Metolachlor at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS	11.83^{a}	56.33^{ab}	67.50^{b}	11.00^{a}	54.33^{bc}	65.50^{bc}
Butachlor at 1.5 + Imazethapyr 1.5 kg a.i.ha^{-1} POE	11.50^{a}	58.00^{ab}	69.17^{ab}	10.67^{ab}	54.17^{bc}	67.00^{ab}
Metolachlor at 1.5 + Imazethapyr1.5 kg a.i.ha^{-1} POE	12.17^{a}	57.83^{ab}	69.33^{b}	11.33^{a}	55.83^{ab}	66.33^{ab}
P. value	<.001	0.015	0.016	<.001	0.001	<.001
S.E (±)	0.2912	1.237	1.262	0.2628	0.968	0.929
Staking (S)						
Staked	11.38	55.92^{b}	66.46^{b}	10.56	53.92^{b}	63.75^{b}
Unstaked	11.37	58.29^{a}	70.58^{a}	10.28	55.88a	67.67^{a}
P. value	0.051	0.001	<.001	0.310	0.209	0.045
S.E(±)	0.125	0.425	0.368	0.1487	0.757	0.609
Interaction						
W x S	0.679	1.501	0.758	0.700	0.753	0.646

Mean (s) followed by common superscript (s) in a column are significantly different at 5% (SNK). WAS = Weeks after sowing, POE= Post emergence.

significant (p <0.001) and produced higher WCS, WD, WDW, and WCE than staked cucumber. The interaction between weed control and staking was, however, not significant (P > 0.05) on the above parameters (Table 2).

Effects of weed control methods and staking on growth characters

Table 3 presents the number of days to 50% emergence, 50% flowering, and 50% fruiting of cucumber as affected by weed control and staking at BUK during the dry 2021 season in the open field and net house conditions. Results reveal that weed control and staking showed a high level of significance (p <0.001) on 50% emergence, 50% flowering, and 50% fruiting, while the interaction between weed control and staking was not significant (p>0.05). Across all the treatments in the experiment, weed-free and weedy check plots had the least number of days to 50% emergences compared to herbicidal-treated plots, which were at par with having the highest numbers of days to 50% emergence in both open field and net house. On the number of days to 50% flowering and 50% fruiting, the weedy check was highly significant (p≤0.01) and took a longer number of days to flowering and fruiting compared to weed-free and herbicidal-treated plots that resulted in lower values, respectively. On the other hand, staking methods were highly significant (p≤0.01) at 50% flowering and 50% fruiting, and staked vines significantly resumed flowering and fruiting earlier than unstaked vines across both growing conditions.

Table 4. Vine length of cucumber at 6, 8 and 10 WAS as affected by weed control and staking at BUK grown during 2021 dry season at the open field and net house condition.

Treatment	Vine Length (cm) [Weeks After Sowing (WAS)]					
	Open field			Net house		
	6	8	10	6	8	10
Weed control (W)						
Weed free	11.60[a]	44.38[a]	48.17[a]	11.60[a]	51.50[a]	53.67[a]
Weedy check	7.07[b]	13.10[c]	19.65[c]	7.07[b]	17.60[c]	23.33[c]
Butachlor at 1.5 kg a.i.ha^{-1}	10.17[ab]	25.23[b]	30.17[bc]	10.17[ab]	29.60[b]	33.50[bc]
Metolachlor at 1.5 kg a.i.ha^{-1}	8.92[ab]	29.98[ab]	35.00[ab]	8.92[ab]	34.60[ab]	40.17[ab]
Butachlor at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS	11.03[ab]	32.85[ab]	37.50[ab]	11.03[ab]	37.33[ab]	41.83[ab]
Metolachlor at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS	9.60[ab]	36.93[ab]	41.50[ab]	9.60[ab]	44.00[ab]	48.83[ab]
Butachlor at 1.5 + Imazethapyr 1.5 kg a.i.ha^{-1} POE	12.62[a]	40.00[ab]	44.83[ab]	12.62[a]	45.00[ab]	49.00[ab]
Metolachlor at 1.5 + Imazethapyr 1.5 kg a.i.ha^{-1} POE	10.75[ab]	37.52[ab]	42.75[ab]	10.75[ab]	41.83[ab]	45.33[ab]
P. value	0.018	<.001	0.002	0.018	<.001	0.002
S.E (±)	0.891	3.690	3.624	0.891	3.839	3.910
Staked	11.52[a]	34.53[a]	39.48[a]	11.51[a]	40.43[a]	44.38[a]
Unstaked	8.92[b]	30.47[b]	35.4[b]	8.93[b]	34.94[b]	39.54[b]
P. value	<.001	0.005	0.012	<.001	<.001	<.001
S.E(±)	0.273	0.895	1.011	0.273	0.568	0.582
W x S	1.045	4.102	4.150	0.733	0.740	0.727

Mean (s) followed by common superscript (s) in a column are significantly different at 5% (SNK). WAS = Weeks after sowing, POE= Post emergence.

The vine length of cucumber as affected by weed control and staking at BUK during the 2021 dry season at the open field and net house conditions are shown in Table 4. Weed control and staking were highly significant (p<0.001) on the vine length of cucumber at 6, 8, and 10 WAS. Weedy check significantly had the shortest vine length throughout the sampling periods compared to weed-free and herbicidal-treated plots, which, though at par, produced longer vines in both the open field and net house, respectively. Stakedcucumber, on the other hand, significantly (p<0.001) produced longer vines compared to the unstaked. The interaction between weed control and staking on vine length was, however, not significant (p>0.05) throughout the sampling periods across both locations.

Table 5 shows the number of leaves per plant of cucumber as affected by weed control and staking at BUK during the dry 2021 season in the open field and net house conditions. Results indicated that weed control and staking were highly significant (p<0.01) and affected the number of leaves across all the sampling periods and locations. Weed free produced the highest number of leaves, though statistically similar to other herbicidal treatments, while weedy check resulted in producing a smaller number of leaves at 6 WAS. A similar trend of results was also obtained at 8 and 10 WAS, respectively. Conversely, compared to unstaked cucumbers, which yielded fewer leaves per plant, staked cucumbers substantially (p<0.001) generated more leaves. The interaction between weed control and staking on the number of leaves was, however, not significant throughout the sampling periods.

Leave chlorophyll content and leaf area per plant of cucumber as affected by weed control and staking at BUK during the dry 2021 season in the open field and net house conditions are presented in Table 6. Results indicated that weed control and staking were highly significant due to chlorophyll content at 8 and 10 WAS as well as leaf area at 10 WAS at both locations. The application of weed-free and Butachlor at 1.5 + Imazethapyr at 1.5 kg a.i. ha^{-1} POE significant (p<0.001) produced the highest chlorophyll content, although statistically similar with other herbicidal treatments compared to weedy check that resulted in producing lower

Table 5. Number of leaves per plant of cucumber as affected by weed control and staking on grown at 6, 8 and 10 WAS grown during dry season of 2021 at BUK at open field and net house condition.

Treatment	Number of leaves plant^{-1} [Weeks after sowing (WAS)]					
	Open field			Net house		
	6	8	10	6	8	10
Weed control (WC)						
Weed free	7.950^{a}	14.70^{a}	22.77^{a}	7.95^{a}	17.90^{a}	35.8^{a}
Weedy check	5.383^{b}	9.07^{b}	13.33^{e}	5.38^{d}	11.73^{a}	21.8^{b}
Butachlor at 1.5 kg a.i. ha^{-1}	6.500^{ab}	12.80^{a}	18.50^{a-d}	6.50^{cd}	16.12^{a}	30.7^{a}
Metolachlor at 1.5 kg a.i. ha^{-1}	6.883^{ab}	14.48^{a}	20.77^{ab}	6.88^{abc}	18.05^{a}	29.5^{a}
Butachlor at 1.5 kg a.i. ha^{-1} + SHW at 6 WAS	6.967^{ab}	14.47^{a}	21.60^{a}	6.96^{abc}	18.38^{a}	34.6^{a}
Metolachlor at 1.5 kg a.i. ha^{-1} + SHW at 6 WAS	6.633^{ab}	14.25^{a}	19.33^{a-d}	6.63^{bc}	17.00^{a}	33.7^{a}
Butachlor at 1.5 + Imazethapry 1.5 kg a.i. ha^{-1} POE	7.733^{a}	14.12^{a}	20.55^{abc}	7.73^{ab}	17.27^{a}	39.2^{a}
Metolachlor at 1.5 + Imazethapry 1.5 kg a.i. ha^{-1} POE	7.283^{a}	13.98^{a}	19.33^{a-d}	7.28^{abc}	16.93^{a}	34.3^{a}
P. value	0.011	0.013	0.034	0.011	0.021	0.062
S.E (±)	0.393	0.939	1.616	0.391	1.130	3.252
Staking method (S)						
Staked	7.84^{a}	18.06^{a}	23.75^{a}	7.84^{a}	21.70^{a}	39.0^{a}
Unstaked	6.00^{b}	8.91^{b}	15.30^{b}	6.00^{b}	11.64^{b}	25.9^{b}
P. value	<.001	<.001	<.001	<.001	<.001	<.001
S.E (±)	0.221	0.754	1.286	0.222	0.912	2.161
Interaction						
W x S	0.592	1.777	3.038	0.691	0.790	0.952

Mean (s) followed by common superscript (s) in a column are significantly different at 5% (SNK). WAS = Weeks after sowing, POE= Post emergence.

chlorophyll content at 8 and 10 WAS, respectively. A similar trend of results was also obtained for leaf area at 10 WAS, respectively. On the other hand, staked cucumber significantly ($p<0.001$) produced higher chlorophyll content at 8 and 10 WAS as well as larger leaves compared to unstaked ones that gave smaller values. The interaction between weed control and staking on the number of chlorophyll contents and leaf area was, however, not significant throughout the sampling periods.

Effect of weed control methods and staking on yield and yield related characters

In the open field and net house circumstances of the dry 2021 season at BUK, Table 7 shows the number of fruits per plant, fruit length, fruit diameter, fruit yield per plot, and fruit production per hectare as impacted by weed management and staking. The above yield and yield-related characteristics demonstrated a significant degree of significance for weed control and staking, according to the results. In comparison to other treatments that yielded fewer fruits, the weed-free plots and those treated with Butachlor at 1.5 + Imazethapyr at 1.5 kg a.i.ha^{-1} POE significantly ($p<0.001$) produced the greatest number of fruits per plant, while the weedy check produced the lowest value. Likewise, weed-free significantly yielded longer, broader, and higher fruit yield per plot and per hectare, which was closely followed by

Table 6. Chlorophyll content at 8 and 10 WAS and Leaf area of cucumber at 10 WAS as affected by weed control and staking at BUK during dry 2021 season at the open field and net house.

	Open field			Net house		
	Chlorophyll content (SPAD)		Leaf area (cm^2)	Chlorophyll content (SPAD)		Leaf area (cm^2)
	[Weeks after sowing (WAS)]					
	8	10	10	8	10	10
Weed control (W)						
Weed free	60.67[a]	68.33[a]	85.83[a]	64.83[a]	92.43[a]	82.72[a]
Weedy check	28.50[d]	34.47[d]	50.00[b]	31.00[d]	38.40[c]	47.40[b]
Butachlor at 1.5 kg a.i.ha^{-1}	41.17[c]	48.17[c]	76.83[a]	45.12[c]	61.90[b]	73.97[a]
Metolachlor at 1.5 kg a.i.ha^{-1}	41.83[c]	48.67[c]	77.83[a]	45.62[c]	64.98[b]	74.55[a]
Butachlor at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS	44.17[bc]	51.83[bc]	81.17[a]	48.35[bc]	66.67[b]	78.42[a]
Metolachlor at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS	44.83[bc]	52.33[bc]	77.83[a]	48.92[bc]	69.00[b]	75.18[a]
Butachlor at 1.5 + Imazethapyr 1.5 kg a.i.ha^{-1} POE	60.67[a]	63.00[ab]	82.83[a]	59.72[ab]	81.27[ab]	77.77[a]
Metolachlor at 1.5 + Imazethapyr 1.5 kg a.i.ha^{-1} POE	55.50[ab]	58.83[abc]	82.50[a]	55.55[abc]	82.45[ab]	79.70[a]
P. value	<.001	<.001	<.001	<.001	<.001	<.001
S.E (±)	3.02	2.99	4.08	3.26	5.98	3.90
Staking (S)						
Staked	49.1[a]	56.8[a]	78.1[a]	53.2	69.6	75.7
Unstaked	43.0[b]	49.6[b]	74.9[b]	46.5	69.7	71.8
P. value	0.029	0.011	0.301	0.157	0.291	0.611
S.E(±)	1.78	1.76	2.29	2.15	4.45	4.64
Interaction						
W x S	4.68	4.62	6.14	0.329	0.597	0.577

Mean (s) followed by common superscript (s) in a column are significantly different at 5% (SNK). WAS = Weeks after sowing, POE= Post emergence.

the application of butachlor at 1.5 + imazethapyr 1.5 kg a.i.ha^{-1} POE and metolachlor at 1.5 + imazethapyr 1.5 kg a.i.ha^{-1} POE compared to weedy check, which resulted in lower values for fruit yield per plot and fruit yield per hectare, respectively, in both locations.

On the other hand, staked cucumber significantly ($p<0.001$) produced a higher number of fruits per plant, fruit length, fruit diameter, fruit yield per plot, and frit yield per hectare, respectively, than unstaked cucumber. The interaction between weed control and staking on the number of fruits per plant is significant at the net house and is presented in Table 8, where the weed-free plots significantly produced a higher (14.51) number of fruits per plot, which was closely followed by the application of butachlor at 1.5 + imazethapyr at 1.5 kg a.i.ha^{-1} POE (13.83) and metolachlor at 1.5 + imazethapyr at 1.5 kg a.i.ha^{-1} POE (13.77) compared with the rest of the interactions that resulted in lower values. moreover, the same pattern of interaction was equally discovered in fruit yield per plot and hectare (Tables 10 and 11). The interaction between weed control and staking on fruit diameter in open fields and net houses is significant and shown in Table 9. The application of weed-free Metolachlor at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS and Butachlor at 1.5 +

Table 7. Number of fruits per plant, fruit length, fruit diameter, fruit yield per plot, fruit yield per hectare of Cucumber as affected by weed control and staking at BUK during 2021 dry season.

Treatment	Open field					Net house				
	NFP	FL	FD	FYP	FYH	NFP	FL	FD	FYP	FYH
Weed control (W)										
Weed free	9.17^{a}	15.50^{a}	5.43^{a}	6.88^{a}	12.12^{a}	10.30^{a}	17.00^{a}	6.42^{a}	7.58^{a}	12.64^{a}
Weedy check	4.55^{d}	10.50^{d}	2.82^{e}	3.43^{e}	6.32^{e}	5.83^{e}	10.95^{d}	4.18^{d}	4.35^{e}	6.30^{e}
Butachlor at 1.5 kg a.i.ha^{-1}	6.58^{c}	13.17^{c}	3.45^{d}	5.18^{d}	9.23^{d}	7.40^{d}	14.33^{c}	4.27^{d}	5.77^{d}	9.52^{d}
Metolachlor at 1.5 kg a.i.ha^{-1}	6.62^{c}	13.00^{c}	3.67^{d}	5.22^{d}	9.30^{d}	7.43^{d}	14.37^{c}	3.46^{e}	5.80^{d}	9.58^{d}
Butachlor at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS	8.22^{b}	14.17^{b}	4.77^{bc}	6.02^{c}	10.66^{c}	9.03^{c}	15.22^{b}	5.47^{c}	6.57^{c}	11.05^{c}
Metolachlor at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS	8.10^{b}	14.17^{b}	4.47^{c}	5.98^{c}	10.51^{c}	8.85^{c}	15.12^{b}	5.20^{c}	6.26^{c}	10.99^{c}
Butachlor at 1.5 + Imazethapry 1.5 kg a.i.ha^{-1} POE	8.97^{a}	14.67^{b}	5.03^{b}	6.65^{b}	11.62^{b}	9.78^{b}	15.45^{b}	5.85^{b}	7.10^{b}	12.21^{b}
Metolachlor at 1.5 + Imazethapry 1.5 kg a.i.ha^{-1} POE	8.15^{b}	14.50^{b}	4.60^{c}	6.62^{b}	11.57^{b}	8.97^{c}	15.42^{b}	5.38c	7.07^{b}	12.15^{b}
P. value	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
S.E(±)	0.077	0.190	0.111	0.037	95.7	0.141	0.218	0.112	0.127	61.1
Staking (S)										
Staked	8.17^{a}	15.13^{a}	4.76^{a}	6.44^{a}	11.32^{a}	9.16^{a}	16.33^{a}	5.55^{a}	6.97^{a}	11.83^{a}
Unstaked	6.92^{b}	12.29^{b}	3.80^{b}	5.05^{b}	9.01^{b}	7.63^{b}	13.14^{b}	4.50^{b}	5.65^{b}	9.28^{b}
P. value	<.001	<.001	<.001	<.001	0.005	0.034	0.014	0.005	0.005	<.001
S.E(±)	0.138	0.122	0.046	0.015	1.105	0.205	0.269	0.059	0.069	2.551
Interaction										
W x S	0.540	0.594	0.003	0.540	<.001	0.002	0.055	0.050	0.002	<.001

Mean (s) followed by common superscript (s) in a column are significantly different at 5% (SNK). WAS = Weeks after sowing; POE= Post emergence. NFP=Number of fruits plant^{-1}; FL= Fruit length (cm); FD= Fruit diameter (cm); FYP= Fruit yield plot (Kg ha-^{1}); FYH= Fruit yield (t ha^{-1}).

Imazethapry at 1.5 kg a.i.ha^{-1} POE to staked cucumber significantly ($p<0.001$) resulted in producing the widest fruit in the open field and net house compared with the rest of the interaction effects.

DISCUSSION

Effect of weed control methods on weed characters

The higher abundance of both broad-leaved and grass weed species in the open field compared to the controlled environment of the net house could be attributed to variation in the weed seed bank at the two sites, as reported by Travlos *et al*. (2018) and Schumacher *et al*. (2020). The predominance of *Cynodon doctylon, Amaranthus spp., and Leucas martinicensis in the open field and Amaranthus spp., Commelina benghalensis, Portulaca oleracea,* and *Cyperus esculentus* in the net house compared with the rest of the weed biotypes in cucumber plots could be attributed to the noxiousness of these weeds, as earlier reported by Daramola (2021) to be associated with cucumber in all ecologies of the world. Heap (2019) also affirms that *Amaranthus spp*. is resistant to certain herbicides, hence its noxiousness.

The low weed cover scores, weed density, and weed dry weight were achieved by the application of Metolachlor at 1.5 + Imazethapyr at 1.5 kg a.i.ha^{-1} POE, Butachlor at 1.5 + Imazethapyr at 1.5 kg a.i.ha^{-1} POE, Butachlor at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS, and Metolachlor at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS. This resulted in a 51.92% increase in the fruit yield of cucumber compared to the weedy

Table 8. Interaction between weed control and staking on number of fruits plant^{-1} of cucumber at BUK during 2021 dry season at the net house condition.

Weed control	Number of fruits plant^{-1}	
	Staked	Unstaked
Weed free	11.67^{a}	8.93^{de}
Weedy check	5.76^{h}	5.00^{h}
Butachlor at 1.5 kg a.i.ha^{-1}	8.00^{ef}	6.80^{g}
Metolachlor at 1.5 kg a.i.ha^{-1}	8.00^{ef}	6.87^{g}
Butachlor at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS	10.00^{c}	8.06^{f}
Metolachlor at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS	9.53^{cd}	8.17^{f}
Butachlor at 1.5 kg a.i.ha^{-1} + Imazethapry 1.5 kg POE	10.67^{b}	8.90^{de}
Metolachlor at 1.5 kg a.i.ha^{-1} + Imazethapry 1.5 kg POE	9.66^{cd}	8.27^{f}
SE (±)	0.277	

Mean (s) followed by common superscript (s) in a column are significantly different at 5% (SNK). WAS = Weeks after sowing, POE= Post emergence.

Table 9. Interaction between weed control and staking on fruit diameter (cm) of cucumber at BUK during 2021 dry season at open field and net house condition.

Weed control	Open field		Net house	
	Staked	Unstaked	Staked	Unstaked
Weed free	5.83^{a}	5.03^{b}	6.77^{a}	6.06bc
Weedy check	2.93^{f}	2.70^{f}	3.63^{f}	3.13^{g}
Butachlor at 1.5 kg a.i.ha^{-1}	3.90^{e}	3.00^{f}	4.63^{e}	3.80^{f}
Metolachlor at 1.5 kg a.i.ha^{-1}	4.33^{cd}	3.00^{f}	5.73^{c}	4.67^{e}
Butachlor at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS	4.97^{b}	3.97^{de}	6.07^{bc}	5.20^{d}
Metolachlor at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS	5.60^{a}	3.93^{de}	6.30^{b}	4.90^{de}
Butachlor at 1.5 + Imazethapry 1.5 kg a.i.ha^{-1} POE	5.57^{a}	4.50^{c}	6.50^{ab}	4.97^{de}
Metolachlor at 1.5 + Imazethapry 1.5 kg a.i.ha^{-1} POE	4.93^{b}	4.27^{cde}	5.80^{c}	4.63^{e}
SE (±)	0.145		0.159	

Mean (s) followed by common superscript (s) in a column are significantly different at 5% (SNK). WAS = Weeks after sowing, POE= Post emergence.

Table 10. Interaction between weed control and staking on number of fruit yield plot^{-1} (Kg) of cucumber at BUK during 2021 dry season at the net house condition.

Weed control	Fruit yield plot^{-1}	
	Staked	Unstaked
Weed free	7.90^{a}	3.93^{h}
Weedy check	3.93^{h}	2.93^{i}
Butachlor at 1.5 kg a.i.ha^{-1}	5.70^{e}	4.67^{g}
Metolachlor at 1.5 kg a.i.ha^{-1}	5.67^{e}	4.77^{g}
Butachlor at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS	6.63^{c}	5.40^{f}
Metolachlor at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS	6.67^{c}	5.30^{f}
Butachlor at 1.5 kg a.i.ha^{-1} + Imazethapry 1.5 kg POE	7.53^{b}	5.77^{de}
Metolachlor at 1.5 kg a.i.ha^{-1} + Imazethapry 1.5 kg POE	7.50^{b}	5.73^{de}
SE (±)	0.048	

Mean (s) followed by common superscript (s) in a column are significantly different at 5% (SNK). WAS = Weeks after sowing, POE= Post emergence.

check plots. This finding is in line with those of Kalhapure *et al*. (2013), who reported low weed density due to effective weed management of onions due to the preemergence application of pendimethalin and SHW at 40 DAT. In another development, Aliyu *et al*. (2019) reported lower weed dry weight and higher weed control

Table 11. Interaction between weed control and staking on fruit yield (t ha^{-1}) of cucumber at BUK during 2021 dry season at the open field and net house condition.

Weed control	Open field		Net house	
	Staked	Unstaked	Staked	Unstaked
Weed free	13.79^{a}	10.45^{d}	14.51^{a}	10.77^{d}
Weedy check	7.23^{i}	5.41^{j}	7.22^{h}	5.38^{i}
Butachlor at 1.5 kg a.i.ha^{-1}	9.93^{def}	8.52^{h}	10.42^{e}	8.57^{g}
Metolachlor at 1.5 kg a.i.ha^{-1}	9.99^{def}	8.58^{h}	10.41^{e}	8.75^{g}
Butachlor at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS	11.73^{c}	9.60^{fg}	12.18^{c}	9.91f
Metolachlor at 1.5 kg a.i.ha^{-1} + SHW at 6 WAS	11.71^{c}	9.28^{g}	12.24^{c}	9.93^{f}
Butachlor at 1.5 kg a.i.ha^{-1} + Imazethapry 1.5 kg POE	13.10^{b}	10.19^{de}	13.83^{b}	10.59^{de}
Metolachlor at 1.5 kg a.i.ha^{-1} + Imazethapry 1.5 kg POE	13.05^{b}	10.05^{e}	13.77^{b}	10.53^{de}
SE (±)	0.681		0.670	

Mean (s) followed by common superscript (s) in a column are significantly different at 5% (SNK). WAS = Weeks after sowing, POE= Post emergence.

efficiency in cucumber due to the application of pendimethalin at 1.0 kg combined with fluazifop at 1.0 kg ai/ha. Similarly, Fufa and Etagegnehu (2016) and Soltani *et al.* (2014) demonstrated 98 and 85% decreases in weed density in haricot and kidney beans, respectively, owing to effective weed control. Besançon *et al*. (2020) affirm the potency of pre-emergent metolachlor applied to summer squash and cucumber.

Effect of weed control methods on growth and yield characters of cucumber

The growth and yield-related characters showed a significant increase in line with the varying degrees of herbicidal treatments employed at both the open field and at the screen house. The significant increase in days to 50% emergence of the herbicidal--treated plots could be attributed to the physiological interruption of the germination process compared to weedy check and weed-free plots, which resulted in a shorter number of days to 50% emergence. Studies by Shittu and Abdullahi (2022 a, b) and Shittu *et al.* (2023) back up this finding, where they independently reported an increase in days to 50% emergence of sorghum and roselle due to pre-emergence herbicide application.

The significant increase in growth and yield parameters such as vine length, number of leaves plant^{-1}, chlorophyll content, number of fruits plant^{-1}, fruit yield, fruit diameter, and fruit length could be attributed to effective weed management achieved in weed-free areas, which is on par with Butachlor at 1.5 kg + Imazethapry at 1.5 kg a.i. ha^{-1} POE and Metolachlor at 1.5 kg + Imazethapry at 1.5 kg a.i. ha^{-1} POE. Effective weed control enables crops to utilize the available growth resources for the translocation of assimilates from the source to the sink for adequate dry matter production. This finding agreed with those of Shittu and Bassey (2023) and Shittu (2023), who reported similar findings in cowpea and tomatoes, respectively. Further findings were also corroborated by Wiro and Iyagba (2020a, b) and Daramola *et al*. (2020) in cucumber and chilli pepper.

Effect of staking on growth and yield of cucumber

When compared to unstaked cucumbers, staked cucumbers exhibited a significant increase in leaves per unit area, vine length, chlorophyll content, number of pods per unit area, pod length, pod diameter and pod yield. This increase may have been caused by the vine staking effect, which allows the plant to take advantage of available sunlight for photosynthetic activities and generates more dry matter for pod production. Chukwudi and Agbo (2014) reported a similar outcome, claiming that staking a fluted pumpkin lengthens the vine and extends the harvest period. Nweke *et al*. (2013) reported that there was a notable difference in the growth and production of crops grown on stake compared to those that were not staked. According to Elesho *et al.* (2021), staking enhanced the vegetative phase, flowering, and yield of *T. occidentalis* and should therefore, be introduced as an agronomic practice in crops of the Cucurbitaceae family owing to the utilization of growth resources and sunlight, which are essential for photosynthetic activities.

Conclusion and Recommendation

Findings from the trial show that the application of weed control methods significantly improved the growth and yield characters of cucumber. Similarly, staked cucumbers significantly perform better than the unstaked in terms of growth and yield related characters in both the open field and net house condition. In different growing situations, the study emphasizes the value of staking and weed management (Butachlor at 1.5 + Imazethapyr 1.5 kg a.i.ha^{-1} POE and Metolachlor at 1.5 + Imazethapyr 1.5 kg a.i.ha^{-1}

POE) in improving cucumber growth, yield, and fruit quality. For the best cucumber production in the Sudan savanna ecology of Nigeria, growing cucumber on staked with the application of either Butachlor at 1.5 + Imazethapyr 1.5 kg a.i.ha^{-1} POE and Metolachlor at 1.5 + Imazethapyr 1.5 kg a.i.ha^{-1} POE for season long and sustainable weed management could be recommended to the farmers towards boosting their crop yield.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

REFERENCES

Abraham, P., Banwo, O. O., David Kashina, B., & Alegbejo, M. D. (2020). Survey for alternative weed hosts of tomato mosaic virus in field-grown tomato crops in Sudan Savanna, Nigeria. *Nigerian Journal of Weed Science*, 33 (1),16-30.

Akobundu, O., I. Ekeleme, F., Agyakwa, C. W., & Ogazie, C. A. (2016). A handbook of West African Weeds (3rd Edition). International Institute of Tropical Agriculture.

Aliyu, D., Muhamman, M.A., Ahmad, A.T., Muhammed, I.B., & Garko, M.S. (2019). Effect of variety and weed control methods on weed infestation on cucumber (*Cucumis sativus* L) in Sudan Savannah of Nigeria. *Iconic Research and Engineering Journals*, 2(10), 1-5.

Arogundade, O., Ajose, T., Matthew, J. O., & Osijo, I. A. (2021). Current and emerging pests and diseases of cucumber (Cucumis sativus L.) in Africa. *Cucumber Economic Values and Its Cultivation and Breeding*, *179*, 473-479.

Besançon, T. E., Wasacz, M. H., & Carr, B. L. (2020). Weed control and crop tolerance with S-metolachlor in seeded summer squash and cucumber. *Weed Technology*, *34*(6), 849-856.

Chauhan, B. S. (2020). Grand challenges in weed management. *Frontiers in Agronomy*, *1*(3), 1-4.

Chukwudi, U. P., & Agbo, C. U. (2014) Effect of trellis height and cutting frequency on leaf and fruit yield of fluted pumpkin (*Telfairia occidentalis* Hook F.) *Journal of Animal and Plant Science*, *24* (4), 264-267.

Daramola, O. S. (2020). Weed interference and management in cucumber (*Cucumis sativus* L.). In: Wang, H. (ed.). *Cucumber economic values and its cultivation and breeding*. Intechopen. Retrieved from https://www.intechopen.com/books/9704.

Daramola, O. S., Adigun, J. A., & Adeyemi, O. R. (2021) Efficacy and economics of integrated weed management in Chilli pepper. *Journal of Crop Improvement*, 35(1), 38-50.

Elesho, R. O., Aderemi, A. M., Aluko, A. K., & Aderemi, F. T. (2021). Effect of staking and spacing on the growth and yield of fluted pumpkin (*Telfairia occcidentalis* Hook. F.) in Ibadan, Southwest, Nigeria. *International Journal of Academic and Applied Research*, *5*(4), 21-25.

Enujeke, E.C. (2013). Growth and yield responses of cucumber to five different rates of poultry manure in Asaba area of Delta state, Nigeria. *International Research Journal of Agricultural Science and Soil Science*, *3*(11), 369-375.

Fraire-Velázquez, S., & Balderas-Hernández, V. E. (2013). Abiotic stress in plants and metabolic responses. In: Vahdati, K., & Leslie, C. (eds.). *Abiotic stress-plant responses and applications in agriculture* (pp. 25-48). (New York: InTech Open Science).

Fufa, A., & Etagegnehu, G.M. (2016). Effect of weed management on weeds and grain yield of haricot bean. *Ethiopian Journal of Agricultural Science*, *26*(2),1-9.

GenStat (2015). Release 16.3DE. VSN International, 5 The Waterhouse, Waterhouse Street, Hemel Hempstead, Hertfordshire HP1 1ES, UK.

Heap, I. (2019). *The international survey of herbicide resistant weeds*. Retrieved 20th November 2019 from www.weedscience.org.

Jamir, M., & Sharma, A. A. (2014). Sustainable production and marketing of cucumber crop in the hilly zone of Nagaland. TECHNOFAME-*A Journal of Multidisciplinary Advance Research*, 23(1), 61-66.

Kalhapure, A. H., & Shete, B. T. (2013). Effect of weed management practices on weed dynamics, weed control efficiency, bulb yield and economics in onion. *Journal of Agriculture Research and Technology*, *38*(2), 238-240.

Mani, V. S., Pandita, M. L., Gautam, K. C., & Bagwandas, B. (1973). Weed killing chemicals in potato cultivation. *Indian Farming,* 23, 7-13.

Molaei, F., & Ghatrehsamani, S. (2022). Kinematic-based multi-objective design optimization of a grapevine pruning robotic manipulator. *AgriEngineering*, 4(3), 606625.

Mukherjee, P. K., Nema, N. K., Maity, N., & Sarkar, B. K. (2013). Phytochemical and therapeutic potential of cucumber. *Fitoterapia*, *84*, 227-236

Muruganantham, N., Solomon, S., & Senthamilselvi, M. M. (2016). Anti-cancer activity of *Cucumis sativus* flowers against human liver cancer. *International Journal of Clinical Pharmacology Research*, *8*, 39-41.

Nweke, I. A., Orji, E. C., & Ijearu, S. I. (2013). The effect of Staking and Plant Spacing on the growth and yield of Cucumber (*Cucumis sativus* L.), *3*(4), 26-31.

Oboh, G., Ademiluyi, A. O., Ogunsuyi, O. B., Oyeleye, S. I., Dada, A. F., & Boligon A. A. (2017). Cabbage and cucumber extracts exhibited anticholinesterase, antimonoamine oxidase and antioxidant properties. *Journal of Food Biochemistry*, *41*(3), e12358.

Okafor, B. N., & Yaduma, J. J. (2021). Soil and agronomic management for cucumber production in Nigeria. In *Cucumber Economic Values and Its Cultivation and Breeding*. IntechOpen. Pp. 89-98

Pandey, S., & Kujur, S. N. (2022). Importance, distribution, botany and genetics. In: *The Cucumber Genome.* Springer International Publishing. Pp. 1-13.

Pradhan, R., Nayak, D.A., Rao, K. M., & Mohapatra, P. (2021). A critical review on the effect of trailing and staking on growth and yield of Curbitaceous crops. *Journal of Pharmacognosy and Phytochemistry, 10*(1), 2151-2154.

Schumacher, M., Dieterich, M., & Gerhards, R. (2020). Effects of weed biodiversity on the ecosystem service of weed seed predation along a farming intensity gradient. *Global Ecology and Conservation, 24*, e01316.

Shittu, E. A. (2023). Growth and performance of tomato (*Solanum lycopersicum* Mill.) under hoe weeding and butachlor application. *World Scientific News*, *180*, 94-104.

Shittu, E. A., & Abdullahi, S. Y. (2022a). Growth performance of sorghum (*Sorghum bicolor* L. Moench) as influenced by variety and weed control treatment in a semi-arid ecology of Nigeria. International Academic Research Consortium Journals (IARCJ), *International Journal of Agricultural Science and Technology*, 9 (6), 1-16.

Shittu, E. A., & Bassey, M. S. (2023). Weed persistence, crop resistance and herbicide phytotonic effects in cowpea (*Vigna unguiculata* [L] Walp) under various weed control treatments in Kano, Nigeria. *World News of Natural Sciences*, 48, 60-69.

Shittu, E. A., Bassey, M. S., & Dantata, I. J. (2023). Cultivar and weed control strategy influencing the productivity of roselle (*Hibiscus sabdariffa* L.) in a semi-arid environment of Nigeria. *Journal of Plant Development*, *30*, 119-128.

Shittu, E.A, & Abdullahi, S.Y. (2022b). Yield and yield attributes of sorghum varieties (*Sorghum bicolor* [L]. Moench) as influenced by weed control in Sudan and Northern Guinea Savanna Ecology of Nigeria. *International Academy Journal of Agribusiness and Agricultural Science Annals*, *6*(2), 1-14.

Soltani, N., Nurse, R. E., & Sikkema, P. H. (2014). Weed management in kidney bean with tank mixes of S-metolachlor, imazethapyr and linuron. *Agricultural Science*, *5*, 611-617.

Travlos, I. S., Cheimona, N., Roussis, I., & Bilalis, D. J. (2018). Weed-species abundance and diversity indices in relation to tillage systems and fertilization. *Frontiers in Environmental Science*, *6*, 11.

Wiro, K. O., & Iyagba, A. G. (2020a). Effect of Weeding Regime on the Performance of Cucumber (Cucumus sativus) In the South-South Rainforest of Nigeria. *American Journal of Multidisciplinary Research & Development*, *2*(7), 34-38.

Wiro, K. O., & Iyagba, A. G. (2020b). Influence of weeding frequency and poultry manure on the growth and yield of cucumber (*Cucumis sativus* L.) in the humid region of Nigeria. *International Journal of Advanced Scientific Research,* 5(5), 9-15.