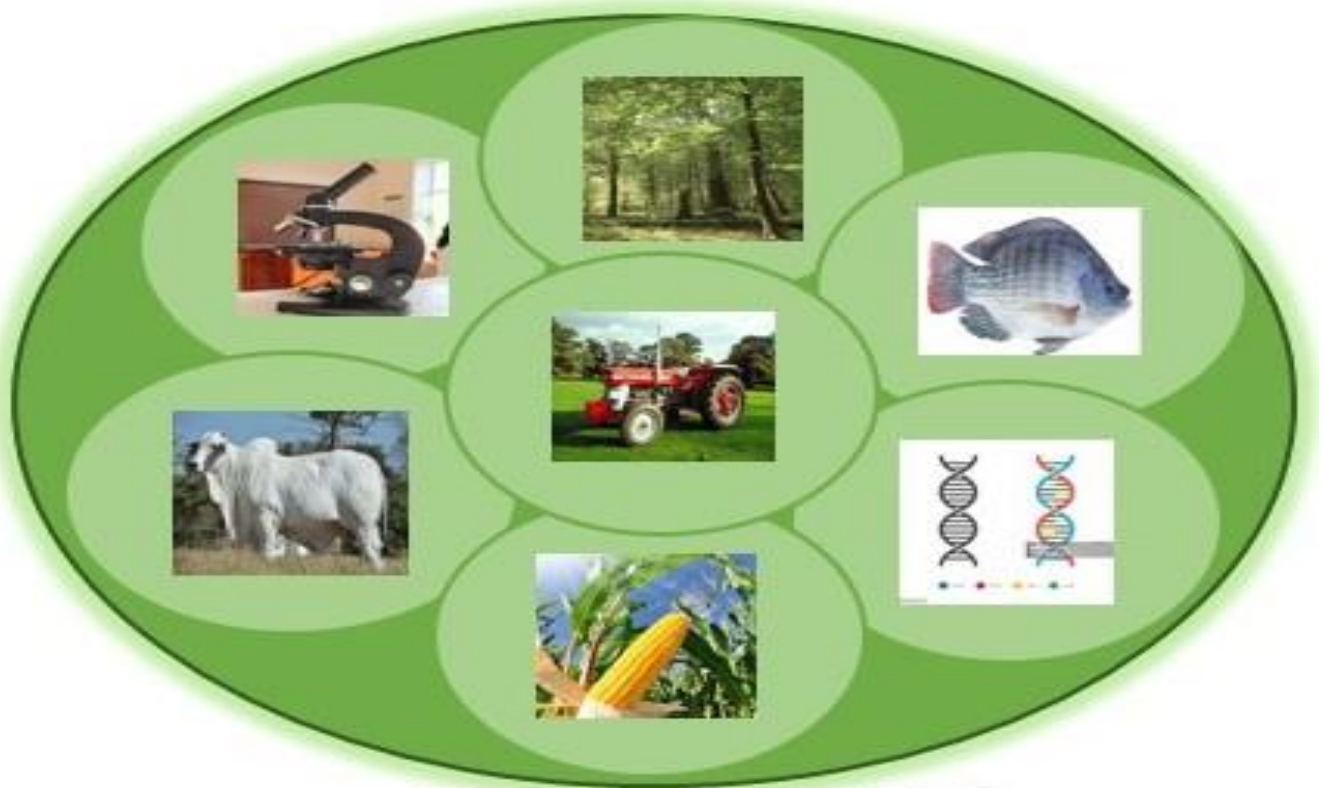




(KEJAANS)

KEBBI JOURNAL OF AGRICULTURE AND NATURAL SCIENCES

January, 2026, Vol. 2, issue 1



KEJAANS

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ISSN: 3122-0584



KEBBI JOURNAL OF AGRICULTURE AND NATURAL SCIENCES
(KEJAANS)

January, 2026; Volume 2, Issue 1

OFFICIAL JOURNAL OF THE
FACULTY OF AGRICULTURE
ABDULLAHI FODIO UNIVERSITY OF SCIENCE AND TECHNOLOGY,
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This official scientific publication of the Faculty of Agriculture, Abdullahi Fodio University of Science and Technology Aliero, is a non-profit, open access, double-blind peer-reviewed Journal publishing four issues (January, April, July and October) per annum. The Journal is a platform open to collaborations with researchers, authors, institutions, research agencies and private companies related to Agriculture. The Mission of the Journal is to disseminate scientific knowledge through the publication of original research articles, research notes, book reviews, letters to the editor and reviews of Literature, representing a contribution to scientific and technological knowledge in respective areas covered by the Journal. The Kebbi Journal of Agriculture and Natural Sciences seeks to validate and disseminate new knowledge, making it public in order to strengthen the human capacity, constitute a link in the scientific community to the society and encouraging the expansion of University and academic researches.

Scope of Kebbi Journal of Agriculture and Natural Sciences (KEJAANS)

The Kebbi Journal of Agriculture and Natural Sciences has the sole aim of providing an intellectual platform and ideas for scholars, by promoting interdisciplinary studies related to agriculture and natural science through publishing the latest scientific research findings that are of direct policy implications and beneficial to the research community. Consequently, the journal covers all aspects of Crop Science, Animal Science, Agricultural Economics, Agricultural Extension and Rural Development, Food Science, Fisheries and Aquaculture, Biotechnology, Soil Science and Agricultural Engineering, Forestry and Environment, Wildlife, Agricultural Education, Agro-allied Industries as well as all Natural Science researches related to Agriculture.

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GROWTH AND YIELD OF CUCUMBER (*Cucumis sativus* L.) INFLUENCED BY INTRA-ROW SPACING AND TRELLISING IN SUDAN SAVANNA OF KEBBI STATE, NIGERIA

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ABSTRACT

Cucumber (*Cucumis sativus* L.) is one of the oldest cultivated fruit vegetables of the Old World and is valued for its nutritional quality and economic importance. However, Cucumber productivity in the Sudan Savanna of Nigeria remains low, largely due to inappropriate plant spacing and trellising systems. Two field trials were conducted during the 2023/2024 and 2024/2025 dry seasons at the Fadama Teaching and Research Farm of Abdullahi Fodio University of Science and Technology, Aliero, located in Jega Kebbi State, Nigeria. Treatments consisted of four intra-row spacing's (0.5, 1.0, 1.5, and 2.0 m) and two training methods (trellised and un-trellised), arranged in a factorial combination using a Randomized Complete Block Design (RCBD) with three replications. Data on growth, flowering, yield, and fruit quality were collected and subjected to Analysis of Variance (ANOVA). Results showed that intra-row spacing significantly ($P \leq 0.05$) affected most growth and yield parameters. Moderate spacing (1.0 m) enhanced plant height, leaf development, early flowering, and fruit quality, while closer spacing (0.5 m) produced the highest fresh fruit yield per hectare due to increased plant population. Trellised plants consistently outperformed un-trellised plants in vegetative growth, yield, and proportion of marketable fruits, due to improved light interception, better canopy aeration. Cucumber grown at 1.0 m intra-row spacing x trellising provided the best balance between yield, fruit quality, and plant vigor and is recommended for sustainable dry season production in the Sudan Savanna.

Key words: Cucumber, Growth, Intra-Row Spacing, Trellising and Yield

Introduction

Cucumber (*Cucumis sativus* L.) is one of the most important fruit vegetables crop cultivated for its edible fruit that highly nutritious and economic value. In terms of economic importance, it ranks fourth in Asia, after tomatoes, cabbage, and onion (Saed, 2024). It is a tropical and subtropical plant grows well in specific environmental conditions. It grows

well in temperatures ranging from 18.3°C to 23.9°C, with a minimum temperature of 15.6°C and a maximum of 32.2°C. Soil temperatures between 15.6°C and 35°C are ideal for germination, although temperatures below 15.6°C significantly impede this process (Hamedalla *et al.*, 2022). The crop prefers light-textured, well-drained soils high in organic matter, with a pH between 6.0 and 6.8,

though it can tolerate acidic soils down to pH 5.5. Cucumber fruits are usually harvested when immature and can be prepared into pickles, eaten as a cooked vegetable, or used in curries (Kumar and Rajkumar., 2022). Global cucumber production had seen significant increase in recent years. As of 2017, the total world production was estimated at 688,824,643 tons, with China alone producing 77% of the world total 83,753,861 tons while to 91,258,272 metric tons in 2019. Egypt led production in Africa with 591,858 tones (Akinwole *et al.*, 2019) leading production in Africa, while Nigeria recorded produced only 40,000 tons (Afe, 2022) which were significantly low compared to leading countries. Sudan savanna characterized by moderate rainfall and high sunlight intensity it is favorable environment for cucumber production. Use of local agronomic practices is one of the primary causes of low yield particularly in Sudan savanna of Kebbi State. Adoption of proven scientific techniques such as trellising, optimum spacing, pruning and mulching enhance growth and yield in cucumber production. Spacing for instance it is necessary for managing competition for resources among plants. Intra-Row Spacing refers to the deliberate process of creating distance between individual plants within the row. It is an important factor influencing crop yield, plant health, resource utilization, and overall farm efficiency. Closer spacing coupled with humid microclimate promotes fungal diseases, overcrowding of vines, high insect damage to fruits high disease infestation and lower fruit quality, overcrowding reduces fruit size and uniformity, complicates harvesting, and pest control, high number of unmarketable fruit. Conversely, wider spacing results in lower yields per unit area, increased weed growth, damaging of vine and flower, underutilized land and resources (Umeh and Okoye, 2021). Aim of the study to examine the

growth and yield of cucumber as influenced by intra-row spacing. This study provides practical, low-cost agronomic recommendations that can enhance cucumber productivity in the Sudan Savanna of Nigeria. Identification of optimum intra-row spacing and the benefits of trellising offers farmers an effective means to increase marketable yield, improve fruit quality, and reduce losses during dry-season production. Adoption of these practices can raise farm income and livelihood resilience. At the national level, improved cucumber production supports food and nutritional security, stabilizes market supply, and promotes efficient land use. The findings also provide evidence based guidance for extension services and policymakers to strengthen sustainable vegetable production systems.

Materials and Methods

Experimental Site

The field trial was conducted during the dry season of 2023/2024 at Fadama Teaching and Research Farm of Kebbi State University of Science and Technology, located in Jega, in the Sudan Savanna ecological zone of Kebbi State (Lat. 12°12.99' N; long. 40°21.90' E; 197m above sea level). The area has a long dry season characterized by cool dry air (Harmattan) that prevails from November to February, and hot dry air extending from March to May. The location used for the cultivation of vegetable and cereal crops (Muhammad *et al.*, 2018). The treatment consist 4 levels of intra-row spacing (0.5m, 1.0m, 1.5m and 2.0m) which had been laid-out in a Randomized Complete Block Design (RCBD) with three replications. The experimental site had cleared, ploughed, harrowed, and leveled. The total plots of 24 were layout in three replications, with eight (8) plots per each replication. The total gross plot was 78 x 24m (1872m²). Variety Poinsett 76

sourced from the National Institute of Horticultural Research (NIHORT), Bagauda sub-station, Kano. The seed was sown two seeds per hole at the depth of 1-2cm. Surface irrigation system had been employed to supply water to the field at 4 days intervals using tube well and pump machine. Weeding was done manually using hand hoe at 2 and 5WAS and hand picking was done occasionally, insect pest had been control as regular application of pesticide at 4 days interval, Compound fertilizer (N.P.K. 15:15:15) had been applied at 2 and 4WAS at the rate of 120kg/ha. The fruits been harvested manually using a sharp disinfected knife at interval of 4 to 6 days. Five (5) plants had selected within the net plot and tagged as sample of the study.

Data collection and data analysis

Key data collected included: vine length, leaf number, leaf dimensions (length and width), leaf area index (LAI), days to 50% flowering, fruit number per plant, fruit length, fruit diameter, fruit weight, and yield ($t\ ha^{-1}$). Vegetative traits were measured at 3, 6, and 9 WAS. Reproductive traits were average per plant and per plot as described. The data collected were analyzed using the Analysis of variance (ANOVA) using SAS (GLM) and means separated by Duncan's test at 5% significance.

Leaf Area Index (LAI): Determined non-destructively using the regression equation from Peter *et al.* (2024) with an empirical coefficient of 0.73 (validated for Sudan Savanna cucumber): $LA\ (cm^2) = 0.73 \times (\text{Leaf Length} \times \text{Leaf Width})$.

$$LAI = \frac{(LA \times \text{Leaves per plant}^{-1} \times \text{Plants per plot}^{-1})}{}$$

Fresh Fruit Yield ($t\ ha^{-1}$):

Calculated using the formula:

$$\text{Yield (t ha}^{-1}\text{)} = \frac{\text{Yield (kg plot}^{-1}\text{)} \times 10,000}{\text{Plot area 1000}}$$

Percentage of marketable Fruit was determined through visual observation of the health status of the fruits.

Percentage of non-marketable fruits =

$$\frac{\text{Total number of unmarketable fruit per plot} \times 100}{\text{Total number of fruits harvested per plot}}$$

Results and Discussion

Vegetative Growth of Cucumber as Influenced by Intra-row Spacing and Trellising Plant Height

Intra-row spacing significantly ($P < 0.05$) influenced plant height at the early stages of vegetative growth (Table 1). Cucumber plants spaced at 1.0 m produced significantly taller plants compared with those grown at others intra-row spacing. Trellised cucumber plants consistently exhibited taller vines than un-trellised plants attributed to improved light penetration and vertical growth orientation. This observation agrees with Muhammad *et al.*, (2023), who reported that trellised cucumber plants produced significantly longer vines than un-trellised plants.

The interaction between trellising and 1.0m spacing resulted in the tallest cucumber plants (18.50 and 13.88cm), possibly due to optimal light interception, reduced inter-plant competition, and improved resource availability. In contrast, the widest spacing (2.0m) produced the shortest plants (36.63cm). Similarly, un-trellised cucumber plants at 2.0m spacing recorded the lowest plant heights (table 1.a and 1.b), which may be attributed to excessive exposure to environmental stress under Sudan Savanna conditions. These findings are consistent with reports by Ansa and Garjila (2019) and Peter *et al.*, (2024).

Table 1: Effect of trellising and spacing on plant height of cucumber during 2023/2024 and 2024/2025 dry seasons and combined data at Jega Sudan Savanna of Kebbi State

Spacing (m)	Plant height (m)								
	3 WAS			6 WAS			9 WAS		
	2023	2024	Combine	2023	2024	Combine	2023	2024	Combined
0.5	10.39	9.42 ^b	9.90 ^{ab}	29.61	25.22	27.41	40.94	35.69	38.31
1.0	9.66	13.98 ^a	11.83 ^a	29.73	26.84	28.28	40.02	33.33	36.67
1.5	9.08	9.68 ^b	9.38 ^b	27.60	29.11	28.35	40.30	36.78	38.53
2.0	9.50	8.92 ^b	9.21 ^b	27.41	26.15	26.78	39.89	33.37	36.63
SE±	1.098	2.330	2.434	4.910	5.413	5.247	3.552	6.085	5.553
Trellising									
Trellised	9.49	12.05 ^a	10.77	30.62 ^a	30.45 ^a	30.535 ^a	43.71 ^a	36.76 ^a	40.24 ^a
Un-trellised	9.83	8.94 ^b	9.39	26.55 ^b	23.22 ^b	24.88 ^b	36.86 ^b	32.82 ^a	34.84 ^b
SE±	2.266	3.295	3.444	6.944	7.655	7.41	4.390	8.725	7.854
Interaction									
S x T	NS	*	*	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a column in each treatment are not significantly different at 5% using DMRT. *= Significant at 5%, NS= not significant. WAS= Weeks after sowing

Table 1a: Interaction intra-row spacing x trellising on plant height of cucumber at 3 WAS 2024/2025 dry season data at Jega Sudan Savanna of Kebbi State

Trellising	Intra row spacing (m)			
	0.5	1.0	1.5	2.0
T0	9.27 ^{bc}	9.41 ^{bc}	8.59 ^c	8.47 ^c
T1	9.57 ^{bc}	18.5 ^a	10.76 ^b	9.34 ^{bc}
SE±	4.532			

Means followed by the same letter(s) within a treatment group are not significantly different at 5% level of significance using DMRT

Table 1b: Interaction intra-row spacing x trellising on plant height of cucumber at 3 WAS in the combined data at Jega Sudan Savanna of Kebbi State.

Trellising	Intra row spacing (m)			
	0.5	1.0	1.5	2.0
T0	10.02 ^b	9.77 ^{bc}	9.02 ^c	8.76 ^d
T1	9.18 ^c	13.88 ^a	9.74 ^{bc}	9.66 ^{bc}
SE±	1.860			

Means followed by the same letter(s) within a treatment group are not significantly different at 5% level of significance using DMRT

Number of Leaves

The results presented in Table 2 indicate that cucumber plants grown at the closest intra-row spacing (0.5m) produced a significantly ($P < 0.05$) more number of leaves compared with wider spacing's (2.0m). The increased leaf production at closer spacing attributed to reduced soil moisture loss through evaporation and the creation of a favorable microclimate that promotes vegetative growth in the Sudan Savanna. This observation aligns with the findings of Nweke *et al.*, (2013) and Peter *et al.*, (2024), who reported higher leaf numbers under closer spacing.

Trellised cucumber plants also produced a significantly greater number of leaves than un-trellised plants, likely due to improved light interception and enhanced photosynthetic efficiency. This finding supports the work of Ansa and Garjila (2019), who observed significantly higher leaf counts in trellised cucumber plants. Furthermore, cucumber spaced at 1.0 m in combination with trellising produced the highest number of leaves (Tables 2a and 2b). This result contrasts with earlier reports by Ansa and Garjila (2019) and Umeh and Okoye (2021), who observed higher leaf counts under wider spacing.

Table 2: Effect of trellising and spacing on number of leaves per plant of cucumber during 2023/2024 and 2024/2025 dry seasons and combined data at Jega Sudan Savanna of Kebbi State

Spacing (m)	Number of leaves per plant								
	3 WAS			6 WAS			9 WAS		
	2023	2024	Combine	2023	2024	Combi ned	2023	2024	Combined
0.5	4.92	6.00	5.46 ^{ab}	6.74 ^a	7.22 ^b	6.98	7.82	10.87 ^a	9.34 ^a
1.0	4.75	5.65	5.20 ^{ab}	6.70 ^a	7.73 ^{ab}	7.30	8.00	9.55 ^{ab}	8.78 ^{a^b}
1.5	5.03	6.20	5.62 ^a	6.92 ^a	7.80 ^{ab}	7.36	7.72	9.07 ^b	8.39 ^b
2.0	4.48	5.78	5.13 ^b	5.96 ^b	7.97 ^a	6.97	8.05	9.58 ^{ab}	8.82 ^{ab}
SE±	0.448	0.632	0.752	0.58	0.51	0.928	0.62	1.070	1.021
Trellising									
Trellised	4.81	5.65 ^b	5.49	6.77	8.17	7.47 ^a	7.95	10.38 ^a	9.17 ^a
Un-trellised	4.78	6.17 ^a	5.22	6.47	7.19	6.83 ^b	7.85	9.15 ^b	8.50 ^b
SE±	0.634	0.894	0.532	0.83	0.718	0.657	0.88	1.513	1.444
Interaction									
S x T	NS	NS	NS	NS	*	*	NS	NS	NS

Means followed by the same letter(s) within a column in each treatment are not significantly different at 5% using DMRT. *= Significant at 5%, NS= not significant. WAS= Weeks after sowing

Table 2a: Interaction intra-row spacing x trellising on number of leaves of cucumber at 6 WAS 2024/2025 data dry season data at Jega Sudan Savanna of Kebbi State

Trellising	Intra row spacing (m)			
	0.5	1.0	1.5	2.0
T0	5.93	5.13	6.07	5.47
T1	6.07	6.17	6.33	6.1 n
SE±	1.860			

Means followed by the same letter(s) within a treatment group are not significantly different at 5% level of significance using DMRT

Table 2b: Interaction intra-row spacing x trellising on number of leaves of cucumber at 6 WAS combined data dry season data at Jega Sudan Savanna of Kebbi State.

Trellising	Intra row spacing (m)			
	0.5	1.0	1.5	2.0
T0	6.83	6.6	7.87	7.47
T1	7.6	8.67	7.73	8.47
SE±	2.840			

Means followed by the same letter(s) within a treatment group are not significantly different at 5% level of significance using DMRT

Leaf Area Index (LAI)

The closest intra-row spacing (0.5m) produced the highest leaf area index (LAI), while the widest spacing (2.0m) recorded the lowest LAI throughout the sampling periods (Table 3). As spacing increased, LAI consistently declined. This trend is consistent with the findings of Umeh and Okoye (2021) and Peter et al. (2024), who reported higher LAI at closer spacing, likely due to increased plant population, improved soil moisture retention, and favorable microclimatic conditions.

Ansa and Garjila (2019) also noted that closer spacing resulted in greater LAI, suggesting enhanced canopy development. Trellised cucumber plants consistently recorded higher LAI than un-trellised plants across all sampling stage attributed to improved light interception, better air circulation, and enhanced photosynthetic activity. These results are in agreement with previous studies by Ansa and Garjila (2019), Pradhan et

al.,(2021), Muhammad et al., (2023), and Peter et al.,(2024).

Yield and Yield Components of Cucumber as Influenced by Intra-row Spacing and Trellising

Days to 50% Flowering

Intra-row spacing significantly ($P < 0.05$) influenced days to 50% flowering (Table 4). Moderate spacing enhanced efficient resource utilization and promoted earlier flowering, whereas the widest spacing (2.0m) significantly delayed flowering possibly due to the attributed to excessive exposure of plants to environmental stress typical of the Sudan Savanna. These findings support those of Peter et al.,(2024), who reported earlier flowering in moderately spaced cucumber plants.

Trellising had no significant effect on days to 50% flowering; however, un-trellised cucumber plants reached 50% flowering slightly earlier than trellised plants. This may be due to increased soil moisture retention

resulting from vine contact with the soil, which may have acted as natural mulch and reduced evaporation. The interaction between trellising

and 1.0m spacing resulted in the earliest attainment of 50% flowering (Table 4a).

Table 3: Effect of trellising and spacing on leaf area index (LAI) of cucumber during 2023/2024 and 2024/2025 dry seasons and combined data at Jega Sudan Savanna of Kebbi State

Spacing (m)	Leaf Area Index (LAI)								
	3 WAS			6 WAS			9 WAS		
	2023	2024	Combine d	2023	2024	Combine d	2023	2024	Combine d
0.5	1.80 ^a	2.25 ^a	2.03 ^a	3.09 ^a	5.39 ^a	4.24 ^a	5.82 ^a	11.57 ^a	8.70 ^a
1.0	0.92 ^b	1.24 ^a b	1.08 ^b	1.69 ^b	2.90 ^b	2.30 ^b	3.37 ^b	5.28 ^b	4.33 ^b
1.5	0.72 ^b	0.88 ^b	0.80 ^{bc}	1.10 ^b	2.27 ^b	1.69 ^c	2.33 ^b c	3.71 ^c	3.02 ^c
2.0	0.54 ^c	0.47 ^c	0.51 ^c	0.81 ^c	1.63 ^c	1.22 ^c	1.71 ^c	3.02 ^c	2.31 ^c
SE±	0.41	0.39	0.51	0.55	0.97	0.850	0.50	1.89	0.841
Trellising									
Trellised	1.11 ^a	1.19 ^a	1.16 ^a	1.78 ^a	3.49 ^a	2.63 ^a	3.41 ^a	6.34 ^a	4.74 ^a
Un-trellised	0.67 ^b	1.21 ^a	0.94 ^a	1.56 ^a	2.81 ^a	2.19 ^a	3.12 ^a	5.28 ^a	4.11 ^a
SE±	0.15	0.2	0.15	0.15	0.24	0.152	0.15	0.253	0.154
Interaction									
S x T	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a column in each treatment are not significantly different at 5% using DMRT. *= Significant at 5%, NS= not significant. WAS= Weeks after sowing

Fresh Fruit Yield per Hectare (t ha⁻¹)

The closest spacing (0.5m) produced the highest fresh fruit yield per hectare (23.29 t ha⁻¹), while the widest spacing (2.0m) recorded the lowest yield (3.84 t ha⁻¹) combined data, possibly due to the plant population. This result is consistent with the findings of Ansa and Garjila (2019) and Falodun and Emede (2019), who reported higher yields at closer spacing.

Trellised cucumber plants produced significantly higher fruit yield (11.77 t ha⁻¹)

than un-trellised plants (7.60 t ha⁻¹). This yield advantage may be due to improved light interception, enhanced air circulation, and reduced disease incidence, which collectively promote efficient photosynthesis. These findings are consistent with earlier reports by Hamayoun et al. (2018), Ansa and Garjila (2019), Pradhan *et al.*(2021), Muhammad *et al.*,(2023), and Peter *et al.*,(2024).

Table 4: Effect of Trellising and Spacing on Days To 50% Flower, Number of Fruit and Fresh Fruit Yields Weight (t ha⁻¹) Of Cucumber During 2023/2024 And 2024/2025 Dry Seasons And Combined Data At Jega Sudan Savanna of Kebbi State

Spacing (m)	Days to 50% flower			No: of fruit			Fruit weight (t ha ⁻¹)		
	2023	2024	Combined	2023	2024	Combined	2023	2024	Combined
0.5	36.17 _b	28.67 ^b	32.42 ^b	7.56 ^a	7.47 ^a	7.52 ^a	20.19 _a	26.40 ^a	23.29 ^a
1.0	35.00 _b	29.67 ^{ab}	32.00 ^b	6.56 ^{ab}	7.01 ^a	6.79 ^a	6.80 ^b	11.63 ^b	9.22 ^b
1.5	39.83 _a	29.33 ^a	34.33 ^a	6.00 ^{ab}	5.89 ^b	5.85 ^b	3.84 ^c	6.19 ^c	5.0 ^c
2.0	39.83 _a	28.67 ^b	34.25 ^a	4.19 ^b	5.69 ^b	5.04 ^b	2.45 ^d	5.23 ^d	3.84 ^d
SE±	1.429	0.299	1.035	1.200	0.884	1.17	0.308	0.211	0.314
Trellising									
Trellised	37.17	29.00	33.08	6.62 ^a	7.53 ^a	7.07 ^a	9.15 ^a	14.39 ^a	11.77 ^a
Un-trellised	38.00	28.83	33.42	5.54 ^b	5.50 ^b	5.52 ^b	5.66 ^b	9.94 ^b	7.60 ^b
SE±	2.025	1.423	1.464	1.698	1.25	1.654	0.440	0.443	0.462
Interaction									
S x T	NS	NS	*	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a column in each treatment are not significantly different at 5% using DMRT. *= Significant at 5%, NS= not significant. WAS= Weeks after sowing

Table 4a: Interaction Intra-Row Spacing x Trellising on 50% Flower Initiation of Cucumber Combined Data at Jega Sudan Savanna Kebbi State Nigeria.

Trellising	Intra row spacing (m)			
	0.5	1.0	1.5	2.0
T0	37.00 ^b	35.00 ^b	39.33 ^a	40.47 ^a
T1	35.33 ^b	35.00 ^b	39.33 ^a	39.00 ^a
SE±	1.072			

Means followed by the same letter(s) within a treatment group are not significantly different at 5% level of significance

Fruit Length

Fruit length was significantly (P < 0.05) influenced by spacing. The longest fruits were obtained from cucumber plants spaced at 1.0m (14.73cm). Trellised plants generally produced

longer fruits than un-trellised plants, although the differences were not statistically significant. Additionally, cucumber plants spaced at 0.5 m in combination with trellising produced the longest fruits, indicating that

vertical growth enhances light penetration, ventilation, and fruit elongation.

The shortest fruits recorded at 2.0m spacing (13.41cm), possibly due to excessive exposure, reduced microclimate stability, and environmental stress associated with the Sudan Savanna. These results agree with the findings of Falodun and Emede (2019) and Peter *et al.*,(2024).

Fruit Diameter

Fruit diameter was significantly ($P < 0.05$) influenced by intra-row spacing (Table 5). Cucumber plants spaced at 0.5 m produced the largest fruit diameter (6.31cm), likely due to reduced evaporation, efficient nutrient uptake, and improved microclimatic conditions. The smallest fruit diameter (6.18cm) was recorded at 2.0 m spacing. These findings are consistent with those of Ansa and Garjila (2019) and Falodun and Emede (2019), who reported increased fruit girth under closer spacing.

Trellised cucumber plants produced larger fruits than un-trellised plants, further supporting the role of trellising in enhancing fruit development. These results corroborate earlier findings by Hamayoun *et al.*,(2018), Ansa and Garjila (2019), Pradhan *et al.*,(2021), Muhammad *et al.*,(2023), and Peter *et al.*,(2024).

Percentage of Non-marketable Fruits

Intra-row spacing significantly ($P < 0.05$) influenced the proportion of non-marketable

fruits (Table 5). Cucumber plants spaced at 1.0m recorded the lowest percentage of non-marketable fruits (3.05%) in the combined data. Wider spacings (1.5 and 2.0m) produced a higher proportion of non-marketable fruits, possibly due to excessive exposure to environmental stress conditions prevalent in the Sudan Savanna.

Although plants spaced at 0.5m produced higher total yields, they also recorded a higher percentage of non-marketable fruits compared with those spaced at 1.0m. This may be attributed to high humidity and overcrowding at closer spacing, which likely favored disease development and pest infestation, leading to increased fruit spoilage. Thus, while closer spacing enhances yield, it may compromise fruit quality under certain conditions.

Trellised cucumber plants produced a lower proportion of non-marketable fruits (5.68%) by minimizing fruit–soil contact and reducing disease incidence. Similar observations were done by Muhammad *et al.*,(2023) and Peter *et al.*,(2024). Although minor fruit abrasions occasionally occurred due to wind-induced contact with trellis supports, trellised plants generally produced superior fruit quality and higher marketable yield. Overall, spacing at 1.0 m combined with trellising provided the most favorable balance between yield and fruit quality, likely due to the creation of an optimum microclimate that supported vigorous growth and high productivity.

Table 5: Effect of Trellising and Spacing on Fruit Length, Fruit Diameter and Un-Marketable Fruit of Cucumber during 2023/2024 and 2024/2025 Dry Seasons and Combined Data at Jega Sudan Savanna of Kebbi State

Spacing (m)	fruit length (cm)			Fruit diameter (cm)			Non-marketable (%)		
	2023	2024	Combi ned	2023	2024	Combi ned	2023	2024	Combi ned
0.5	14.82	13.98 ^{ab}	14.40 ^{ab}	6.38 ^a	6.24 ^a	6.31 ^a	5.29 ^{bc}	8.03 ^b	6.70 ^b
1.0	14.85	14.7 ^a	14.73 ^a	6.27 ^a	5.99 ^{ba}	6.13 ^{ab}	3.05 ^c	3.05 ^c	3.05 ^c
1.5	13.74	13.65 ^b	13.69 ^{bc}	6.08 ^a	5.92 ^b	6.00 ^b	6.67 ^b	10.19 ^a	8.43 ^a
2.0	13.05	13.76 ^b	13.41 ^c	6.31 ^a	6.06 ^{ab}	6.18 ^{ab}	9.55 ^a	7.03 ^b	8.29 ^a
SE±	1.387	0.634	1.123	0.308	0.21	0.314	0.08	0.16	0.51
Trellising									
Trellised	15.15 ^a	14.64 ^a	14.90 ^a	6.41 ^a	6.17 ^a	6.41 ^a	6.04 ^b	5.31 ^b	5.68 ^b
Un-trellised	13.09 ^b	13.36 ^b	13.22 ^b	5.88 ^b	5.93 ^b	5.91 ^b	10.83 ^a	14.55 ^a	12.69 ^a
SE±	1.961	0.897	1.588	0.436	0.297	0.444	0.569	0.467	0.539
Interaction									
S x T	NS	*	NS	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a column in each treatment are not significantly different at 5% using DMRT. *= Significant at 5%, NS= not significant. WAS= Weeks after sowing

Table 5 a: Interaction intra-row spacing x trellising on fruit length of cucumber during 2024/2025 dry season at Jega Sudan savanna Kebbi state Nigeria.

Trellising	Intra row spacing (m)			
	0.5	1.0	1.5	2.0
g				
T0	12.54b	14.61ab	12.85ab	13.43ab
T1	15.41a	14.61ab	14.46ab	14.1ab
SE±		1.267		

Means followed by the same letter(s) within a treatment group are not significantly different at 5% level of significance

Conclusion

The findings of this study demonstrated that both trellising and intra-row spacing significantly influenced the growth and yield performance of cucumber under dry season conditions in Jega, Kebbi State. Trellising consistently enhanced key vegetative and yield parameters such as vine length, number of leaves, leaf area index (LAI), number of

branches, number of flowers and fruit yield per plant, when compared to the non-trellised treatment. Among the various spacing treatments, a moderate spacing of 1.0 m generally resulted in better growth and higher yield components, including fruit length, fruit circumference, and total yield per hectare, due to optimal resource utilization and reduced plant competition.

The interaction between trellising and spacing was also notable in influencing several growth parameters, with trellised plants spaced at 1.0 m or 1.5 m often showing superior performance, particularly during the later stages of growth (6 and 9 WAS). These results underscore the agronomic importance of adopting improved cultural practices such as vertical trellising and appropriate intra-row spacing to maximize cucumber productivity in the Sudan Savanna environment

Recommendations

Based on the study outcomes, the following practices are recommended for cucumber farmers in the Sudan Savanna (Kebbi State):

Adopt 1.0 m intra-row spacing: This spacing balanced vegetative vigor with fruit production. It promoted early flowering and long fruits, while limiting excessive competition. Farmers can achieve high yields without the severe disease losses seen at 0.5 m spacing.

Adopt trellising widely: Training cucumber vines on sturdy supports should be standard practice. Trellises improve light and air flow, boosting growth and fruit set. They also keep fruits clean, markedly reducing losses. If possible, use flexible netting or avoid overly abrasive supports to minimize fruit scars.

Avoid extreme spacing: Very close spacing (0.5 m) should be used cautiously. If chosen for maximum yield, it must be coupled with vigilant pest and disease management (e.g., fungicides, good sanitation) due to high humidity in the canopy. Very wide spacing (≥ 2.0 m) is not recommended for intensive production, as it greatly reduces yield.

Manage microclimate: In the dry savanna, evaporation stress is an issue, especially at wider spacing. Implementing mulching, drip irrigation, or other moisture-conserving measures can help mitigate this. Maintaining some canopy cover (neither too sparse nor too

dense) will conserve soil moisture and regulate temperature around the plants.

Further research: Future trials should explore the interaction of spacing with water management. For example, testing drip irrigation at different densities could optimize both water use and yield. Economic analyses are also needed to weigh the cost of disease control at high densities versus the value of increased yield. Additionally, experimenting with improved trellis designs (e.g., tensioned nets) might reduce fruit damage while retaining support benefits.

By following these guidelines especially a 1.0 m spacing with trellising smallholder cucumber growers in Kebbi State and similar regions can potentially boost productivity and fruit quality. Agricultural extension services should incorporate these findings into training programs to help farmers achieve better yields and incomes from cucumber cultivation.

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