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Effect of Cultivar and Agroecological Zones on Growth Parameters and Proximate Composition of Sesame

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Abstract: *Sesame (Sesamum indicum L.) is one of the oldest cultivated oilseed crops, valued for its high nutritional content and adaptability to diverse environmental conditions. In Nigeria, sesame is grown across different agroecological zones; however, there is limited research on how cultivar selection and environmental factors collectively affect its growth and nutritional properties. This study aimed to evaluate the growth performance and proximate composition of different sesame cultivars across varying agroecological conditions. Three sesame cultivars: White Benue, Cameroon White, and E8 were cultivated in two agroecological zones: The experiment was conducted in Ejigbo (a derived savanna) and Osogbo (rainforest) in 2023. Ejigbo is a town in Osun State that is part of the Derived savanna agroecological zone in southwest Nigeria. Osogbo is the capital city of Osun State and is part of a rainforest agro-ecological zone in south-west Nigeria. A randomized complete block design on a plot with four replicates was implemented. Growth parameters, including plant height, stem girth, number of leaves, and leaf area, were measured. Additionally, proximate composition (moisture content, ash, fibre, fat, protein, carbohydrate and calories) was analyzed. Data collected were analysed using Analysis of Variance and Duncan's Multiple Range Test (DMRT) at a 5% probability level. Results indicated that growth parameters such as plant height and stem girth increased by agroecological conditions, whereas proximate composition exhibited minimal variation across cultivars locations. The increase in plant heigh and stem girth shows that environmental conditions have a greater influence on sesame growth parameters than on its proximate composition. Cameroon White emerged as the most suitable sesame cultivar overall due to its consistently superior performance in plant height, stem girth, leaf number, leaf area, and nutritional content across both locations. Osogbo proved to be the more favorable location for sesame cultivation, as it consistently supported better vegetative growth and higher nutritional quality compared to Ejigbo. It is recommended that sesame farmers prioritize the cultivation of Cameroon White variety, particularly in the Osogbo agroecological zone or similar environments, to optimize plant growth, yield, and nutritional value.*

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Keywords: Cultivar, Agroecological Zones, Growth Parameters, Proximate Composition, Sesame

1. Introduction

Sesame (*Sesamum indicum* L.), one of the oldest known plant species in the world (Francis, 2013), is a member of the Pedaliaceae family. This upright annual plant can reach heights of 1 to 2 meters when planted early and in moist conditions, featuring bell-shaped flowers and opposite leaves. The sesame fruit is a capsule that is typically hairy, rectangular and grooved with a small triangular tip. The capsules length and width measures between 2 and 8 cm and 0.5 to 2 cm respectively, containing 4 to 12 loculi (Satyagopal *et al*., 2014). It is among the earliest oilseed crops used by humans due to its mild flavour and significant nutritional benefits. It possesses high agronomic benefits such as the ability to withstand drought, especially in the vegetative stage (Boureima *et al*., 2011) and great tolerance to different soil types but thrives excellently in rich, well-drained, medium-textured soils. However, its cultivation is limited since it does not grow well in clayey, heavy, or water-logged soils (Misganaw *et al*., 2015). Sesame grows in Guinea, Sudan, and the Sahel Savannah areas, as well as recently in Nigeria's forest savannah transition zone (Olowe, 2004).

Despite the extensive knowledge on sesame seeds, there is a notable lack of information and utilization related to sesame leaves. Since sesame cultivation primarily targets seed production, the leaves are often overlooked and treated as agricultural byproducts. Exploring their potential could add value and diversify the crop's uses, especially in regions like the Southwest where sesame thrives.

In various African regions, sesame leaves are utilized as a vegetable due to their nutritional content such as minerals, antioxidants and phytochemicals, including their proximate composition (Liu *et al*., 2012). In 2020, Egypt produced 38,000 tons of sesame from an area of 29,000 hectares (FAO, 2020). During the late flowering stage, the middle and lower leaves of a sesame plant making up about one-third of its height are ideal for consumption. Sesame leaves serve as a valuable vegetable resource, especially for low-income populations in developing countries, as they offer essential nutrients that support human health. Sesame (*Sesamum indicum* L.) is an important oilseed crop valued for its essential nutrients and economic significance. However, its productivity and quality are often influenced by genetic variation (cultivar differences) and environmental conditions such as soil properties, temperature, and rainfall.

In Nigeria, sesame cultivation varies across agroecological zones: the Sudan Savanna (500–800 mm rainfall), covering Katsina, Kano, Jigawa, Yobe, and Borno; the Northern Guinea Savanna (900–1200 mm), including Kaduna, Niger, Plateau, Benue, and Kwara; the Southern Guinea Savanna (1100–1500 mm), spanning Kogi, Nasarawa, and Taraba; while the Derived Savanna zone (1200–1600 mm), covering Oyo, Ekiti, Ogun, and Ondo. Additionally, sesame is found in the Rainforest Zone of southern Nigeria including parts of Lagos, Cross River, Rivers, Akwa Ibom, Bayelsa, Edo, Delta, Abia, Imo, Ebonyi, and Ondo which is characterized by high rainfall (1500–2500 mm annually), high humidity, and dense vegetation, yet there is limited research on how cultivar selection and environmental factors collectively impact growth performance and proximate composition. Farmers and agronomists often lack data-driven recommendations on the best cultivar-environment combinations for optimal productivity. The aim and objectives of the study were; to assess the growth performance of different sesame cultivars under varying agroecological conditions, to determine the proximate composition (moisture, protein, fat, fiber, ash, and carbohydrate content) of the selected sesame cultivars across different agroecological zones on sesame growth and proximate composition.

2. Materials and Methods

2.1 Experimental site

The experiment was conducted in Ejigbo (a derived savanna) and Osogbo (rainforest). Ejigbo is a town in Osun State that is part of the Derived savanna agroecological zone in southwest Nigeria (Shittu *et al.*, 2022). Derived Savanna represents a transitional ecological zone between the dense rainforest to the south and the open Guinea savanna to the north. It has emerged largely due to human activities such as farming and bush burning, which have reduced forest cover and encouraged grassland vegetation. This zone experiences moderate rainfall (1200–1500 mm annually) and a distinct wet and dry season, creating conditions suitable for a mix of forest and savanna crops. With relatively fertile soils and increasing sunlight exposure, it offers promising opportunities for adaptable crops like sesame, provided waterlogging is managed.

Osogbo is the capital city of Osun State and is part of a rainforest agro-ecological zone in south-west Nigeria (Aremu *et al.*, 2017). Nigeria's Rainforest Zone is characterized by high annual rainfall (1500–2500 mm), persistent humidity, and dense vegetation. Located primarily in the southern regions, it supports lush, multi-layered forests and year-round biological activity. While the ecosystem is rich and productive, the high moisture levels and heavy canopy cover present challenges for crops sensitive to excess water and low light. Nonetheless, with appropriate management practices such as selecting well-drained sites and drought-tolerant, short-cycle varieties limited crop diversification, including sesame, can be explored.

Teaching and Research Farm College of Agriculture, Ejigbo (7° 54' 0.00" N and 4° 18' 54.00" E) and the other location at Osogbo (7° 45' 10" N and 4° 31' 36" E), Osun State within Southwest Nigeria, and factors such as temperature, rainfall, relative humidity and soil type were considered. The experiment was conducted from August to November 2023.

2.2 Description of Sesame Varieties

i. White Benue: an extra-early maturing variety. The colour of the seed is naturally pearly white.

ii. Cameroon White: an early maturing variety. The seed is whitish brown.
iii. E-8: an early maturing, the colour of the seed is pearly white

2.3 Treatment and Experimental Design

Different sesame cultivars (White Benue, Cameroon White and E8) were collected from the National Cereals Research Institute Badeggi and implemented in a designated experimental plot size of 3 (m) ×3 (m) = 9 (m^2), the total number of plots was 12. The recommended seeding rate is 9 kg/ha which amounted to 8 g/plot. The selection of these cultivars was based on the availability and past work being done in the Southwest Nigeria (Olowe, 2009; Agele et al., 2015).

The treatments (C1 - White Benue, C2 - Cameroon White, C3 - E8) were arranged in a Randomized Complete Block Design (RCBD) with four replications in the two agroecological zones and the field experiments were conducted to evaluate the yield and nutritional compositions of sesame cultivars in the two agroecological zones (Aremu *et al.*, 2017; Shittu *et al.*, 2022).

2.4 Soil Analysis and Land Preparation

The soil samples were collected from a depth of 0-15 cm before planting and after harvest. The samples were analyzed to determine the pre-planting, physical and chemical properties of the soil, the land was thoroughly cleared. Determining the pre-planting physical and chemical properties of the soil helps assess its fertility status, texture, and structure, which are critical for supporting healthy crop growth. This analysis guides appropriate land preparation, amendment, and fertilization practices to optimize plant productivity.

Table 1: *Chemical Properties of Soil*

The soil analyses were carried out at the soil science laboratory at Osun state University, Ejigbo

Chemical Properties	**Method of Analysis**	**Derived Savanna**	**Rainforest**
Acidity/Alkalinity	Electrometric method	7.50 ± 0.09	6.86 ± 0.00
Sand (%)	Part of particle size analysis using hydrometer	72.87 ± 0.38	74.3 ± 0.44
Clay (%)	Hydrometer method	9.23 ± 0.07	9.6 ± 0.06
Silt (%)	Silt = 100% - (sand% + clay%).	15.57 ± 0.12	16.67 ± 0.15
B/D (g/cm^2)	Core method	1.5 ± 0.00	1.70 ± 0.01
Nitrogen (%)	Kjeldahl digestion method	0.02 ± 0.00	0.22 ± 0.00
Temperature (0^0c)	Soil thermometer	27.24 ± 0.14	26.17 ± 0.42
Conductivity (μs/cm)	EC meter in a 1:2 soil-to-water extract	51.42 ± 0.65	450 ± 0.00
Potassium (ppm)	Atomic Absorption Spectroscopy (AAS)	6079.10 ± 285.92	7.32 ± 0.01
Sodium (ppm)	Atomic Absorption Spectroscopy (AAS)	0.13 ± 0.02	1.13 ± 0.00

Magnesium (ppm)	Atomic Absorption Spectroscopy (AAS)	0.55 ± 0.02	1.50 ± 0.01
Phosphorus (ppm)	Olsen method	371.9 ± 4.51	10.10 ± 0.01
Calcium (ppm)	Atomic Absorption Spectroscopy (AAS)	206.2 ± 3.49	1.00 ± 0.02

2.5 The Two Agroecological zones: Climate data in 2023

Table 2: *Climate Data of Derived Savanna in 2023* (NIMETA, 2023)

MONTH	SUNSHINE HOURS (hour)	RAINFALL (mm)	MAXIMUM TEMP (°c)	MINIMUM TEMP (°c)	RELATIVE HUMIDITY (%)
JAN	7.0	9.1	34.9	19.5	62
FEB	6.7	14.2	36.3	22.3	64
MAR	6.7	62.7	34.1	22.5	81
APR	7.2	74.2	33.2	23.1	82
MAY	7.2	214.1	32.8	22.8	82
JUN	5.4	224.4	30.0	21.8	88
JUL	3.9	184.4	29.8	22.0	90
AUG	2.6	142.2	28.4	21.5	93
SEP	3.2	206.1	29.5	21.5	90
OCT	6.3	255.1	30.9	21.8	87
NOV	7.9	40.7	32.3	22.2	85
DEC	7.3	0.0	34.4	19.2	63

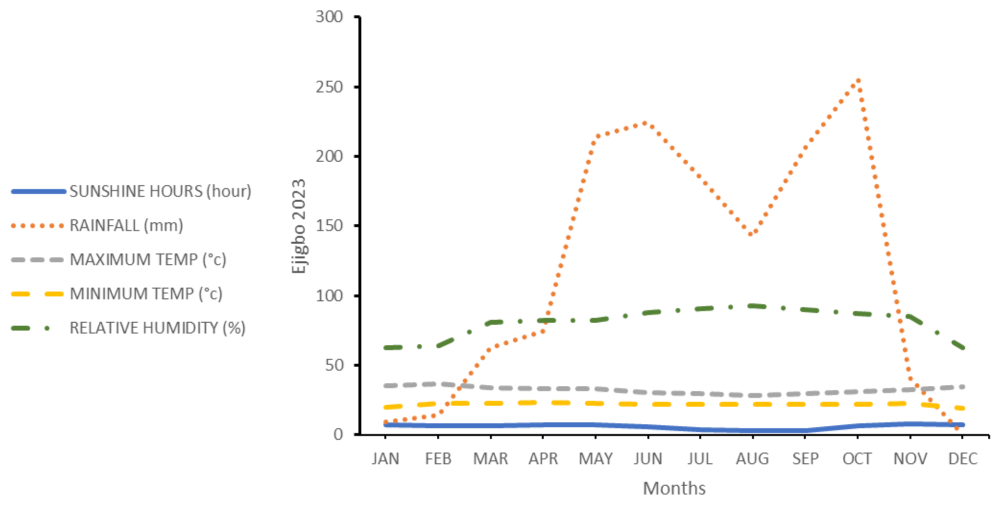

Figure 1. Climate Data of Derived Savanna in 2023 (NIMETA, 2023)

Table 3. *Climate Data of Rainforest in 2023*

MONTH	SUNSHINE HOURS (hour)	RAINFALL (mm)	MAXIMUM TEMP (°c)	MINIMUM TEMP (°c)	RELATIVE HUMIDITY (%)
JAN	7.2	1.4	35.1	18.7	60
FEB	6.7	55.1	36.2	21.9	65
MAR	6.4	75.1	33.3	21.6	79
APR	6.3	123.2	32.5	22.4	81
MAY	6.5	101.5	32.0	22.1	84
JUN	5.3	135.3	29.2	21.1	88
JUL	2.9	158.6	29.2	21.4	90
AUG	1.3	93.1	28.4	20.9	91
SEP	2.7	132.9	29.4	21.0	91
OCT	3.2	334.2	30.6	20.9	88
NOV	5.5	111.4	32.1	21.6	81
DEC	4.4	0	35.0	18.0	74

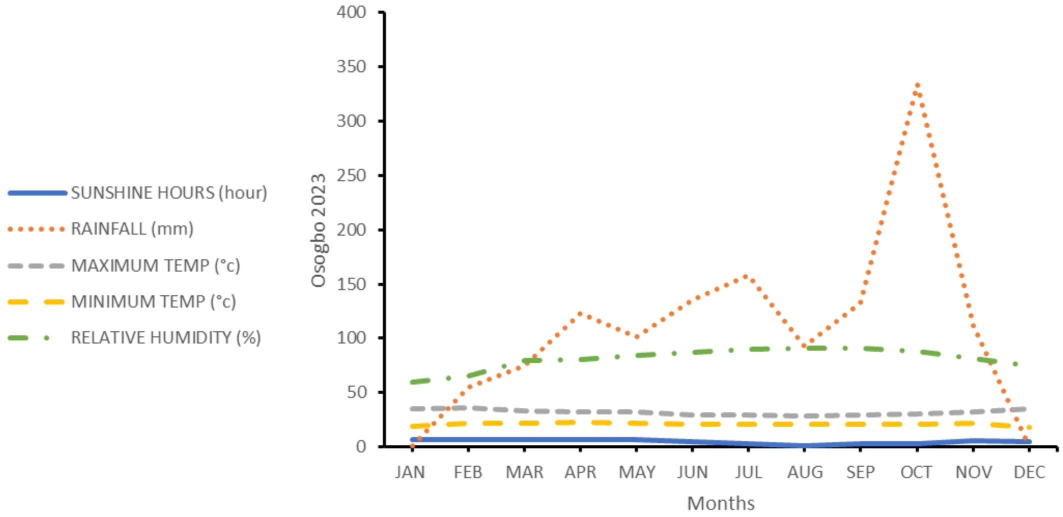

Figure 2. Climate Data of Rainforest in 2023 (NIMETA, 2023)

2.6 Weeding

Manual weeding was performed one week after sowing, 2nd WAS, 4th WAS, 6th WAS, 8th WAS, 10th WAS, and 12th WAS.

WAS – Weeks After Sowing

2.7 Growth Parameters

Ten plants were randomly chosen from each plot and tagged to collect growth parameters, which include:

a. Stem height (cm)

Primary stem length was measured from the ground level to the tip of sample plants at 3- 6 WAS (Miao *et al.*, 2021).

b. Stem girth (cm)

The girth measurement was taken at 3 -6 WAS.

c. Leaf area (cm^2)

The leaf area was determined per plant at 3 -6 WAS using the mathematical formula:

Leaf Area (LA) = L × W × k

Where:

L = Leaf length (cm)

W = Maximum leaf width (cm)

k = Correction factor (typically between 0.65 and 0.75 for sesame leaves; a value of 0.70 is commonly adopted)

d. Number of leaves

The number of leaves on the sample plant was counted at 3 – 6 WAS (Oloniruha *et al.*, 2021).

2.8 Laboratory Assays

The method of analysis used was the Association of Official Analytical Chemists (AOAC) (2023) determination method.

Proximate analysis i.e., carbohydrates, moisture, ether extract, crude fibre, crude ash and protein.

Table 4. *Proximate Method of Analyses*

Parameter	Method	Calculation Formula
Moisture Content	5g of sample placed in a pre-weighed petri dish, oven-dried at 105°C for 2 hrs, cooled in desiccator, reweighed until constant weight.	%Moisture = (W2 − W3) / (W2 − W1) × 100 Where: W1 = weight of empty dish, W2 = weight of dish + sample (before drying), W3 = after drying
Ash Content	5g of sample in a pre-weighed crucible, ashed at 550°C in a furnace for 6 hrs, cooled in desiccator, and reweighed.	%Ash = (W3 − W1) / (W2 − W1) × 100 Where: W1 = empty crucible, W2 = crucible + sample, W3 = crucible + ash
Crude Fibre	2g of ether-extracted sample boiled in 1.25% H_2SO_4 and then 1.25% NaOH, washed, dried at 130°C, ignited at 600°C, and weighed.	%Crude Fibre = (W2 − W3) / W1 × 100 Where: W1 = weight of sample, W2 = dried residue, W3 = residue after ignition
Crude Protein	1g sample digested with H_2SO_4 + catalysts (K_2SO_4 + $CuSO_4$), distilled with NaOH, absorbed in boric acid, and titrated with HCl.	%N = V1 × n1 × F1 × MWn / (Ws × 10) %Protein = %N × Protein Conversion Factor (e.g., 6.25)

Crude Fat	2g of sample extracted using Soxhlet with n-hexane for 4 hrs, solvent evaporated, and residue weighed.	%Fat = (W2 − W1) / 2 × 100 Where: W1 = empty beaker, W2 = beaker + fat
Carbohydrate	Calculated by the difference method from other proximate values.	%CHO = 100 − (%Moisture + %Ash + %Protein + %Fat + %Fibre)
Total Energy (kcal)	Calculated based on Atwater factors using protein, fat, and carbohydrate values.	Energy = (Protein × 2.44) + (Lipids × 8.37) + (CHO × 3.57)

3. Results and Discussion

3.1 Plant heights of sesame varieties at Ejigbo and Osogbo

The data on plant heights (PH) of three sesame varieties (White Benue, Cameroon White, and E8) measured at 3, 4, 5, and 6 weeks after sowing (WAS) across two locations (Ejigbo and Osogbo). The data is analyzed for varietal differences, location effects, and their interactions. At all stages of growth, the varieties did not differ significantly (LSD = Ns), though Cameroon White generally had the highest plant height across weeks, peaking at 98.47 cm by 6 WAS, followed by White Benue (97.52 cm) and E8 (87.11 cm).

Location effects were more pronounced and statistically significant at most measurement periods. At 3 WAS, plants in Ejigbo were significantly taller than those in Osogbo (9.57 cm vs. 6.82 cm). However, this trend reversed in later weeks. By 5 WAS and 6 WAS, plants in Osogbo were significantly taller than those in Ejigbo. The difference was particularly striking at 6 WAS, where plants in Osogbo reached an average height of 119.83 cm compared to 68.90 cm in Ejigbo.

Interestingly, at 4 WAS, there was no significant difference in plant height between the two locations, suggesting a period of similar growth rates despite the initial advantage in Ejigbo and the later advantage in Osogbo. The table also indicates significant interactions (V x L) between variety and location for all measurement periods. This suggests that the performance of each variety varied depending on the location, implying that certain varieties may be better suited to specific environmental conditions present in either Ejigbo or Osogbo.

The increase in height with an increased number of weeks observed in this study is similar to the report of Olawuyi *et al*. (2023) in which morphological characteristics of ten accessions of sesame were evaluated. The lack of variability in height at different weeks among the varieties used in this study contradicted the findings of Olawuyi *et al*. (2023) in which the height of sesame accessions used were greatly varied. Tadesse *et al*. (2020) observed that sesame genotypes exhibit significant variation in height due to genetic factors and environmental interactions. This aligns with the variability observed by Olawuyi *et al*. (2023). Eneji *et al*. (2011) highlighted the importance of soil fertility and moisture in determining sesame growth, which could explain the higher heights observed in more fertile areas. The rainforest's multilayered structure allows for optimized light capture, contributing to greater photosynthetic activity (Mokany *et al*., 2021). Conversely, the savanna's open environment, while providing full sunlight, often leads to harsher conditions such as drought and nutrient deficiency, which can stifle growth.

Table 5. *Plant heights of sesame varieties at Ejigbo and Osogbo*

Treatments	**3 WAS (cm)**	**4 WAS (cm)**	**5 WAS (cm)**	**6 WAS (cm)**
Variety (V)				
White Benue	7.74[a]	21.00[a]	45.50[a]	97.52[a]
Cameroon White	9.25[a]	22.89[a]	46.33[a]	98.47[a]
E8	7.59 [a]	20.32 [a]	44.40[a]	87.11[a]
SE±	0.73	1.35	3.56	10.38
LSD (0.05)	Ns	Ns	Ns	Ns
Location (L)				
Ejigbo	9.57[a]	21.09[a]	38.77[b]	68.90[b]
Osogbo	6.82[b]	21.71[a]	52.05[a]	119.83[a]
SE±	0.65	0.82	1.53	3.46
LSD (0.05)	1.85	Ns	5.29	10.61
Interaction				
V x L	*	*	*	*

WAS – Weeks after sowing
* – Significant at $p < 0.05$
SE± = Standard Error of the mean
a, b = Means with the same letter are not significantly different.
LSD (0.05) = Least Significant Difference at 5% probability level
Ns = Not significant

3.2 Stem girth of sesame varieties at Ejigbo and Osogbo

The data on stem girth (SG) of three sesame varieties (White Benue, Cameroon White, and E8) measured at 3, 4, 5, and 6 weeks after sowing (WAS) across two locations (Ejigbo and Osogbo). The data is analyzed for varietal differences, location effects, and their interactions. Regarding varietal differences, Cameroon White consistently showed the largest stem girth throughout the growth period. At 3 WAS, Cameroon White (2.56 cm) had significantly larger stem girth than E8 (1.80 cm), while White Benue (2.08 cm) was intermediate and not significantly different from either. This trend continued at 4 WAS, where Cameroon White (4.72 cm) significantly outperformed both White Benue (4.22 cm) and E8 (3.96 cm). At 5 WAS, Cameroon White (5.01 cm) maintained its lead, significantly different from E8 (4.29 cm) but not from White Benue (4.55 cm). By 6 WAS, Cameroon White

(5.50 cm) had significantly larger stem girth than both White Benue (4.83 cm) and E8 (4.55 cm).

Location effects were pronounced and statistically significant at all measurement periods. Interestingly, the trend reversed after the initial measurement. At 3 WAS, plants in Ejigbo had significantly larger stem girth than those in Osogbo (3.04 cm vs. 1.25 cm). However, from 4 WAS onwards, plants in Osogbo consistently showed larger stem girth. The difference was particularly notable at 6 WAS, where plants in Osogbo reached an average stem girth of 5.73 cm compared to 4.19 cm in Ejigbo.

The table also indicates significant interactions (V x L) between variety and location for all measurement periods. This suggests that the performance of each variety in terms of stem girth varied depending on the location, implying that certain varieties may respond differently to the specific environmental conditions present in either Ejigbo or Osogbo. Cameroon White consistently demonstrated superior stem girth development compared to the other varieties. Location played a crucial role in stem girth development, with Osogbo generally promoting larger stem girth after the initial growth stage. The finding highlights the influence of environmental factors on stem girth development, emphasizing that location significantly affected growth outcomes. Specifically, Osogbo provided more favorable conditions for stem thickening after the early growth phase, likely due to differences in soil fertility, moisture availability, or microclimate. This affirmed that beyond genetic potential, the growing environment plays a pivotal role in determining the vegetative performance of sesame varieties.

Studies have shown that stem girth tends to increase in various crops, including sesame, due to factors such as photosynthetic activity and nutrient uptake (Singh *et al*., 2019). Furthermore, the finding that stem girth in sesame plants from both derived guinea savanna and rainforest zones exhibited similar growth patterns suggests a resilience in growth traits across different ecological conditions. This is consistent with research by Ojo *et al*. (2020), which demonstrated that certain crop species can adapt their growth characteristics to varying environmental conditions without significant differences in physical traits like stem girth.

Moreover, the lack of influence from ecological zones on stem girth supports the notion that intrinsic genetic factors and plant management practices may play a more crucial role in determining growth parameters than the immediate environmental factors (Adeola and Olatunji, 2021). This finding is particularly important for agricultural practices, suggesting that sesame cultivation can be optimized similarly across different ecological zones.

Table 6. *Stem girth of sesame varieties at Ejigbo and Osogbo*

Treatments	3 WAS (cm)	4 WAS (cm)	5 WAS (cm)	6 WAS (cm)
Variety (V)				
White Benue	2.08^{ab}	4.22^{b}	4.55^{ab}	4.83^{b}
Cameroon White	2.56^{a}	4.72^{a}	5.01^{a}	5.50^{a}
E8	1.80^{b}	3.96^{b}	4.29^{b}	4.55^{b}
SE±	0.38	0.34	0.28	0.28
LSD (0.05)	0.49	2.10	0.51	0.44
Location (L)				
Ejigbo	3.04^{a}	3.36^{b}	3.90^{b}	4.19^{b}
Osogbo	1.25^{b}	5.24^{a}	5.34^{a}	5.73^{a}
SE±	0.15	0.14	0.15	0.12
LSD (0.05)	0.40	0.40	0.41	0.36
Interaction				
V x L	*	*	*	*

WAS – Weeks after sowing
* – Significant at $p < 0.05$
SE± = Standard Error of the mean
a, b = Means with the same letter are not significantly different.
LSD (0.05) = Least Significant Difference at 5% probability level
Ns = Not significant

3.3 Number of Leaf of sesame varieties at Ejigbo and Osogbo

The data on leaf number (LN) of three sesame varieties (White Benue, Cameroon White, and E8) measured at 3, 4, 5, and 6 weeks after sowing (WAS) across two locations (Ejigbo and Osogbo). The data is analyzed for varietal differences, location effects, and their interactions. Regarding varietal differences, there were no statistically significant differences in leaf number among the three sesame varieties at any of the measurement periods, as indicated by the non-significant (ns) LSD values. Although not statistically significant, Cameroon White showed a slight numerical advantage in leaf number throughout most of the growth period. At 6 WAS, Cameroon White had the highest average leaf number (28.37), followed closely by E8 (27.87) and White Benue (25.50). However, these differences were not large enough to be considered statistically significant.

Location effects, on the other hand, were pronounced and statistically significant at all measurement periods. Plants in Osogbo consistently produced more leaves than those in Ejigbo from 3 WAS to 5 WAS. At 3 WAS, plants in Osogbo had an average of 10.16 leaves compared to 4.91 in Ejigbo. This trend continued at 4 WAS (19.75 vs. 6.83) and 5 WAS (21.25 vs. 8.25). Interestingly, this trend reversed at 6 WAS, where plants in Ejigbo had significantly more leaves than those in Osogbo (31.25 vs. 23.25). This reversal suggests a possible change in growth patterns or environmental conditions that favoured leaf production in Ejigbo during the later growth stage. The reversal in leaf production at 6 WAS, where Ejigbo plants outperformed those in Osogbo, may indicate a shift in environmental factors such as soil nutrient availability, moisture retention, or microclimatic conditions that became more favourable in Ejigbo at later growth stages. It could also reflect delayed growth response or stress recovery in Ejigbo, allowing for a late surge in leaf development, while Osogbo plants may have reached a growth plateau or experienced limiting factors that suppressed further leaf expansion.

The table indicates significant interactions (V x L) between variety and location only at 5 WAS. This suggests that at this particular growth stage, the performance of each variety in terms of leaf number varied depending on the location. For all other measurement periods, the interaction was not significant (ns), implying that the varieties responded similarly to the different locations in terms of leaf production. While varietal differences in leaf number were not statistically significant, location played a crucial role in leaf development. Osogbo promoted greater leaf production in the early to mid-growth stages, but Ejigbo showed an advantage by 6 WAS. The significant variety-location interaction at 5 WAS highlights the potential for specific varieties to perform differently under varying environmental conditions at certain growth stages. The significant variety-location interaction at 5 WAS underscores the importance of matching sesame varieties to specific environmental conditions for optimal performance. It indicates that certain varieties may exhibit superior leaf development in particular locations during critical growth stages, which can influence overall plant vigor and yield potential.

There is no significant difference in the number of leaves in both agroecological zones at various weeks. Increased in number of leaves was experienced in both zones. The number of leaves obtained from Derived Guinea Savanna and rainforest agro-ecological zone in the present study ranged from (29.25-33.25) and (21.75-26) is lower than that (39.00-60.33) obtained from the study by (Olawuyi *et al.*, 2023). Nutrient availability and soil moisture are critical factors influencing leaf production. Adequate soil nutrients and consistent moisture levels can promote robust leaf development *(*Ademiluyi *et al., 2019).* According to *Khan et al., (2020),* temperature and light conditions can affect leaf number and growth. Sesame plants require optimal temperatures and photoperiods to maximize leaf production. *V*ariations in soil type and pH can affect nutrient availability and, consequently, leaf development (Singh *et al.*, 2016).

Table 7. *Number of Leaf of sesame varieties at Ejigbo and Osogbo*

Treatments	**3 WAS**	**4 WAS**	**5 WAS**	**6 WAS**
Variety (V)				
White Benue	7.00^{a}	13.25^{a}	14.50^{a}	25.50 ^{a}
Cameroon White	8.87^{a}	13.37^{a}	15.75^{a}	28.37^{a}
E8	6.75^{a}	13.25^{a}	14.00^{a}	27.87^{a}

SE±	0.90	2.37	2.19	2.95
LSD (0.05)	ns	Ns	Ns	Nss
Location (L)				
Ejigbo	4.91[b]	6.83[b]	8.25[b]	31.25[b]
Osogbo	10.16[a]	19.75[a]	21.25[a]	23.25[a]
SE±	0.86	0.75	0.76	1.52
LSD (0.05)	1.67	1.78	1.61	6.23
Interaction				
V x L	ns	Ns	*	Ns

WAS – Weeks after sowing
* – Significant at $p < 0.05$
SE± = Standard Error of the mean
a, b = Means with the same letter are not significantly different.
LSD (0.05) = Least Significant Difference at 5% probability level
Ns = Not significant

3.4 Leaf area of sesame varieties at Ejigbo and Osogbo

The data on the leaf area (LA) of three sesame varieties (White Benue, Cameroon White, and E8) measured at 3, 4, 5, and 6 weeks after sowing (WAS) across two locations (Ejigbo and Osogbo). The data is analyzed for varietal differences, location effects, and their interactions. Regarding varietal differences, there were no statistically significant differences in leaf area among the three sesame varieties at any of the measurement periods, as indicated by the non-significant (ns) LSD values. Although not statistically significant, White Benue showed a slight numerical advantage in leaf area during the early growth stages (3-5 WAS). By 6 WAS, Cameroon White had the largest average leaf area (225.87 cm^2), followed closely by White Benue (219.78 cm^2), while E8 had the smallest leaf area (184.65 cm^2). However, these differences were not large enough to be considered statistically significant.

Location effects, on the other hand, were pronounced and statistically significant at all measurement periods. Plants in Osogbo consistently produced larger leaf areas than those in Ejigbo throughout the entire growth period. At 3 WAS, plants in Osogbo had an average leaf area of 74.66 cm^2 compared to 34.33 cm^2 in Ejigbo. This trend continued and the difference became more pronounced as the plants grew. By 6 WAS, the average leaf area in Osogbo was 253.12 cm^2, significantly larger than the 167.08 cm^2 observed in Ejigbo. This consistent trend suggests that the environmental conditions in Osogbo were more favourable for leaf expansion throughout the growth period.

The table indicates a significant interaction (V x L) between variety and location only at 6 WAS, denoted by the asterisk (*). This suggests that at this final measurement stage, the performance of each variety in terms of leaf area varied depending on the location. For all other measurement periods, the interaction was not significant (ns), implying that the varieties responded similarly to the different locations in terms of leaf area development during the earlier growth stages.

Studies have shown that the rainforest zone generally has more favourable conditions for plant growth compared to the derived guinea savanna. The rainforest typically has higher rainfall, more fertile soils, and a more stable microclimate, which can promote larger leaf development in sesame plants (Alege *et al*., 2022; Muhamman *et al*., 2009). In contrast, the derived guinea savanna is characterized by lower rainfall, less fertile soils, and more variable environmental conditions, which may limit the leaf area expansion of sesame.

Previous studies in Nigeria have reported that environmental factors such as soil fertility, moisture availability, and canopy cover significantly influence leaf development (Afolabi *et al*., 2017; Ogunleye *et al*., 2016).

In rainforest zones, higher humidity and more consistent rainfall generally promote larger leaf area development, which is crucial for maximizing photosynthesis (Sullivan *et al*., 2020). Conversely, the derived guinea savanna, characterized by a more variable climate and poorer soil fertility, tends to produce smaller leaf areas as plants adapt to conserve water and energy (Adegbite and Fadimu, 2019).

Table 8. *Leaf area of sesame varieties at Ejigbo and Osogbo*

Treatments	**3 WAS (cm^2)**	**4 WAS (cm^2)**	**5 WAS (cm^2)**	**6 WAS (cm^2)**
Variety (V)				
White Benue	58.50[a]	111.37[a]	161.25[a]	219.78[a]
Cameroon White	55.12[a]	104.25[a]	138.00[a]	225.87[a]
E8	49.87[a]	100.62[a]	155.62[a]	184.65[a]
SE±	8.19	11.63	12.86	17.88
LSD (0.05)	Ns	Ns	Ns	Ns
Location (L)				
Ejigbo	34.33[b]	74.66[b]	136.16[b]	167.08[b]
Osogbo	74.66[a]	136.16[a]	167.08[a]	253.12[a]
SE±	3.26	6.52	8.62	13.93
LSD (0.05)	10.02	20.45	27.42	32.19
Interaction				
V x L	Ns	Ns	Ns	*

WAS – Weeks after sowing

* – Significant at $p < 0.05$

SE± = Standard Error of the mean

a, b = Means with the same letter are not significantly different.

LSD (0.05) = Least Significant Difference at 5% probability level

Ns = Not significant

3.5 Leaf proximate of sesame varieties at Ejigbo and Osogbo

The leaf proximate analysis of three sesame varieties (White Benue, Cameroon White, and E8) grown in two locations (Ejigbo and Osogbo). The analysis includes moisture content, ash, fibre, fat, protein, carbohydrate, and calorie content. Among the varieties, there were significant differences in moisture content and carbohydrate content, as indicated by the asterisk (*) in the LSD row. White Benue had the highest moisture content (14.74%), followed by Cameroon White (14.01%), and E8 (12.94%). Conversely, E8 had the highest carbohydrate content (54.44%), followed by Cameroon White (52.50%), and White Benue (51.36%). These differences in moisture and carbohydrate content led to a significant difference in calorie content, with E8 having the highest (251.38 Kcal), followed by Cameroon White (247.03 Kcal), and White Benue (244.37 Kcal).

For the other parameters (ash, fibre, fat, and protein), there were no significant differences among the varieties, as indicated by "ns" (not significant) in the LSD row. This suggests that these nutritional components are relatively consistent across the three sesame varieties studied. Regarding location effects, there were no significant differences between Ejigbo and Osogbo for any of the measured parameters. This implies that the growing location did not substantially influence the leaf-proximate composition of the sesame plants.

The interaction between variety and location (V x L) was also not significant for any parameter, indicating that the varieties performed consistently across both locations in terms of their leaf-proximate composition. While the sesame varieties differed in moisture content, carbohydrate content, and consequently calorie content, they were similar in other nutritional aspects. The growing location did not significantly affect the leaf proximate composition, suggesting that these varieties may be cultivated in either location without substantial changes in their nutritional profile.

Table 9: *Leaf proximate of sesame varieties at Ejigbo and Osogbo*

Treatments	Moisture content (%)	Ash (%)	Fibre (%)	Fat (%)	Protein (%)	Carbohydrate (%)	Calories (Kcal)
Variety (V)							
White Benue	14.74[a]	4.91[a]	9.04[a]	2.08[a]	17.86[a]	51.36[a]	244.37[a]
Cameroon White	14.01[ab]	4.97[a]	9.10[a]	2.06[a]	17.34[a]	52.50[ab]	247.03[ab]
E8	12.94[b]	5.15[a]	9.11[a]	2.07[a]	16.26[a]	54.44[b]	251.38[b]
SE±	0.38	0.02	0.01	0.01[a]	0.43	0.51	1.12
LSD (0.05)	*	ns	Ns	Ns	Ns	Ns	Ns
Location (L)							
Ejigbo	13.95[a]	5.01[a]	9.07[a]	2.08[a]	16.91[a]	52.95[a]	247.75[a]
Osogbo	13.84[a]	5.01[a]	9.09[a]	2.06[a]	17.40[a]	52.58[a]	247.44[a]
SE±	0.36	0.07	0.02	0.01	0.51	0.70	1.56
LSD (0.05)	Ns	ns	Ns	Ns	Ns	Ns	Ns
Interaction							
V x L	Ns	ns	Ns	Ns	Ns	Ns	Ns

WAS – Weeks after sowing
* – Significant at $p < 0.05$
SE± = Standard Error of the mean
a, b = Means with the same letter are not significantly different.
LSD (0.05) = Least Significant Difference at 5% probability level
Ns = Not significant

3.6 Proximate of three cultivars of sesame seeds at Ejigbo and Osogbo

The proximate analysis of three sesame seed cultivars (White Benue, Cameroon White, and E8) grown in two different locations (Ejigbo and Osogbo). The analysis includes moisture content, ash, fibre, fat, protein, carbohydrate, and caloric content. Among the varieties, E8 showed the highest moisture content (7.97%), followed closely by Cameroon White (7.93%) and White Benue (7.84%). White Benue had the highest ash content (5.52%), while E8 had the highest fibre content (4.12%). In terms of fat content, E8 ranked highest (31.12%), followed by Cameroon White (31.00%) and White Benue (29.69%). Cameroon White showed the highest protein content (17.51%), marginally higher than E8 (17.50%), while White Benue had the lowest (16.19%). Interestingly, White Benue had the highest carbohydrate content (36.94%), followed by Cameroon White (35.07%) and E8 (34.26%). Cameroon White provided the most calories (425.94 Kcal), closely followed by E8 (425.47 Kcal), with White Benue having the lowest caloric content (419.24 Kcal).

Regarding location effects, seeds grown in Ejigbo generally had higher moisture content (7.99%), fat content (31.70%), protein content (18.18%), and caloric value (427.60 Kcal) compared to those grown in Osogbo. Conversely, seeds from Osogbo showed higher ash content (5.33%), fibre content (4.12%), and carbohydrate content (37.83%).

The table also indicates significant interactions between variety and location (V x L) for ash, fibre, fat, protein, carbohydrate, and caloric content, suggesting that the nutritional composition of these sesame cultivars is influenced by both genetic factors and growing conditions. The least significant difference (LSD) at 0.05 level was significant for all parameters in the variety comparison, while in the location comparison, it was significant for all parameters except caloric content.

The agroecological zones did not influence the nutritional compositions of the sesame varieties. The ranged values of ash (4.93-5.15%) and 4.90-5.15%) obtained for rainforest and derived guinea savanna in the present study were within the same range (3.01-5.93%) as those recorded by (Nweke *et al*. 2011) for various varieties in their study including Cameroun white. The crude fibre which ranges from 9.06 to 9.13% in the rainforest and 9.02 to 9.11% in the derived guinea savanna was within the range (4.21-10.90%) reported by (Nweke *et al*., 2011). The results of crude fat obtained in this study were lower than those obtained by Nweke *et al*. (2011) while crude protein and nitrogen-free extract were less than those reported in the present study.

The CP 16.61-17.94% and 15.93-18.08% recorded in the rainforest and derived guinea savanna showed that the varieties are good sources of protein. Also, the crude protein values (5.85-7.92%) reported in the study by Katanga *et al*. (2017) were lower than those obtained in this study. The comparison of plant protein with the standard set by the World Health Organization provides a basis on which plant protein quality is assessed (Nweke *et al*., 2011). The values obtained showed that sesame varieties sown in the present study contained enough protein required for human consumption. Previous studies in Nigeria have also reported similar findings regarding the minimal influence of agroecological zones on the nutritional compositions of sesame varieties. A study in the northern Guinea savanna and Sudan savanna zones of Nigeria found no significant differences in the ash content of sesame varieties grown in these different agroecological zones (Agele *et al*., 2018).

Table 10. *Proximate of three cultivars of sesame seeds at Ejigbo and Osogbo*

Treatments	Moisture content (%)	Ash (%)	Fibre (%)	Fat (%)	Protein (%)	Carbohydrate (%)	Calories (Kcal)
Variety (V)							
White Benue	7.84^{c}	5.52^{a}	4.05^{c}	29.69^{c}	16.19^{c}	36.94^{a}	419.24^{c}
Cameroon White	7.93^{b}	4.99^{c}	4.08^{b}	31.00^{b}	17.51^{a}	35.07^{b}	425.94^{a}
E8	7.97^{a}	5.02^{b}	4.12^{a}	31.12^{a}	17.50^{b}	34.26^{c}	425.47^{b}
SE±	0.04	0.16	0.01	0.57	0.72	1.20	2.46
LSD (0.05)	*	*	*	*	*	*	*
Location (L)							
Ejigbo	7.99^{a}	5.02^{b}	4.08^{b}	31.70^{a}	18.18^{a}	33.01^{b}	427.60^{a}
Osogbo	7.83^{b}	5.33^{a}	4.12^{a}	29.50^{b}	15.36^{b}	37.83^{a}	419.50^{b}
SE±	0.05	0.16	0.01	0.57	0.72	1.20	2.46
LSD (0.05)	*	*	*	1.87	2.27	3.37	Ns
Interaction							
V x L	Ns	*	*	1.87	2.27	3.37	*

WAS – Weeks after sowing
* – Significant at $p < 0.05$
SE± = Standard Error of the mean
a, b = Means with the same letter are not significantly different.
LSD (0.05) = Least Significant Difference at 5% probability level
Ns = Not significant

4. Conclusion

Based on the results, Cameroon White emerged as the most suitable sesame cultivar due to its consistent superiority in plant height, stem girth, and leaf development across measurement periods, as well as its high nutritional value, particularly in protein and fat content. Among the two locations, Osogbo provided more favourable environmental conditions, promoting better vegetative growth (height, girth, leaf number, and area) and seed nutritional quality in most parameters. Therefore, Cameroon White is recommended for cultivation, particularly in Osogbo or similar rainforest agroecological zones, to maximize growth performance and nutritional output. Further studies should investigate long-term yield performance and adaptability across seasons.

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