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FACULTY OF AGRICULTURE AND ENVIRONMENTAL SCIENCE DEPARTMENT OF CROP SCIENCE

EVALUATING ADAPTABILITY OF DIFFERENT SESAME (*S. INDICUM L.*) VARIETIES TO ENVIRONMENTAL CONDITIONS OF MBIRE, ZIMBABWE.

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DECLARATION

I, Brian Mudzimurega, do hereby declare that this research project is the result of my original work that had been researched and got submitted on fulfilment of the Bachelor of Agricultural Honours Degree in Crop Science at Bindura University of Science Education. The other information had been derived from other people's work based on trusted sources and had been duly cited, accredited and acknowledged through references.

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Dedication

I dedicate this work of science to my wife Esther Dziwarinyenga, my two sons Vision and Victor a swell as my parents Mr. and Mrs. Mafara.

Acknowledgments

First and foremost I would like to thank our almighty God for granting me the strength and endurance to complete this work of science. I would like to extend my greatest appreciation to my supervisor Ms. A. Kamota for the guidance and assistance that she provided throughout the course of this scientific investigation. I would also like to extend a hearty thank you to Ward 2 agriculture extension officer Mr. Mazvaure for all his assistance during the course of this research endeavour. Last but most certainly not least, I would like to thank all Bindura University of Science Education crop science staffers for enabling me to attain the theoretical knowledge that I now put into practice.

Abstract

The study assessed the performance of three sesame (*S. indicum L.*) Varieties - black, cream, and white under field conditions in the Mbire district of Zimbabwe. The study utilized a randomized complete block design with three replications assessing growth parameters, yield components, and oil content. Significant differences among varieties ($p<0.001$) where observed across all parameters. The black sesame variety showed superior performance with the highest yield (59.94kg) as well as oil content (55.48%) in spite of showing moderate vegetative growth compared to the other varieties under investigation. Even though the white variety had better branching (7.56 branches) and the cream variety had the greatest height (2.04m) these characteristics did not translate into yield advantages. The number of capsules per plant strongly correlated with the final yield with black sesame producing significantly more capsules (211.44 per plant) than cream (175.11) and white (85.11) varieties. Results indicate black sesame as the most suitable variety for commercial production in Mbire district having a combination of high seed yield potential as well as superior oil content. The research concluded that the black variety is the best performer of the investigated varieties in Mbire district conditions and recommends that farmers adopt its use for yield and quality optimisation.

Keywords

Contents

List of tables

Table of figures

Appendicies

Chapter 1

1.1 Background of the Study

Sesame (*Sesamum indicum L.*) is a widely grown oil seed crop found all over the world. With a cultivation history exceeding 5000 years (Bedigian, 2015), it is among the oldest known oil seed crops. Sesame is known for its drought tolerance as well as its significant nutritional and economic value. It has attracted significant interest among farmers in sub-Saharan Africa more so in agriculture systems in areas with low rainfall and high temperatures (Gebregergis *et al*., 2018). FAO (2023) has noted a steady increase in global sesame production with estimates from 2022 exceeding 6 million tons.

In Zimbabwe, sesame farming is an avenue for diversification and economic advancement more so in the lowveld region where the effects of climate change have devastated traditional cropping systems. The lowveld of Zimbabwe is dominated by a semi-arid climate receiving annual precipitation between 450mm and 650mm and having average temperatures of between 25℃ and 35℃ (Moyo *et al*., 2021). The soils are predominantly sandy to sandy loam which together with other harsh environmental conditions present difficulties for agriculture development. However, these conditions present an opportunity for sesame farming as the crop has a high degree of tolerance to difficult environmental conditions (Kashif *et al*., 2020).

Studies on variety improvement and adaptation to different agro ecological regions are still scarce in most African countries, Zimbabwe included (Ngwenya *et al*., 2022. Research done by IPCC (2022) has concluded that it is necessary to identify varieties with improved environmental tolerance in light of the predicted rising temperature and unreliable precipitation resulting from the effects of global warming.

Because of sesame's drought tolerance as well its brief growing season, it is a viable climate smart crop for semi-arid regions (Rahman *et al*., 2021). Several criteria must be taken into account when selecting a seed variety. These include yield stability, disease resistance and oil content when produced under semi-arid region conditions (Kumar and Bisen, 2023). Research in similar agro ecological conditions has proven that proper variety selection can contribute to yield increase by between 30% and 40% (Mohamed *et al*., 2020). There is a lot of economic potential for Zimbabwean sesame farmers on the back of increasing global market demand and higher prices for higher grade seeds (Maphosa and Jideani, 2021). However for this potential to be realised there is a need for use of varieties that can thrive under the region's environmental conditions. Furthermore, the potential of the crop to improve household food security positions and diversify income makes it a particularly important crop for farmers in the region (Wilson *et al*., 2022)

1.2 Statement of the Problem

While sesame possesses the potential to be a drought tolerant and economically sustainable crop, farmers fail to attain optimal yields more so in Zimbabwe's semi-arid regions. This can partly be attributed to the absence of scientifically substantiated data pertaining to variety selection taking into account the environmental conditions of the region.

Presently, most farmers depend on unverified or general recommendations that do not necessarily take into account the region's unique agro ecological characteristics resulting in poor yields and financial losses. While there are numerous sesame cultivars in Zimbabwe, there is limited scientific knowledge regarding their performance and adaptabilitsy to the climatic conditions of Zimbabwe's lowveld. The lack of knowledge makes it difficult for farmers and farmer organisations to make correct decisions potentially hindering the uptake of sesame farming in a region where it may be a highly beneficial alternative crop.

Without variety evaluations specific to Zimbabwe's lowveld region, it is difficult to establish focused breeding programs and generate guidelines that can increase both sesame yield and farmers' profit margins.

1.3 Justification

It is necessary to identify and assess sesame varieties for cropping in Zimbabwe's lowveld for numerous reasons. The study will give farmers variety recommendations that will enable them to earn extra incomes through sesame farming. Global sesame prices hover between US$1200 and US$1800 per ton (FAO, 2023). Sesame exports can enable the Zimbabwe to enhance its foreign exchange revenue thereby improving its balance of payment position. Using appropriate varieties will improve the country's competitive standing on the world market where the demand for good quality sesame is increasing at a rate of 4.5% annually (World Bank, 2023).

With most commonly grown crops facing challenges in the face of climate change, adapted sesame varieties will offer farmers a climate smart option. This is particularly relevant to Zimbabwe with climate forecasters predicting an increase in temperature and rainfall fluctuations in southern Africa (IPCC, 2022).

Sesame requires fewer inputs to give a meaningful yield while its drought resilience makes it viable option for resource constrained agricultural systems common to the low veld. Understanding variety specific performance will therefor improve resource allocation.

The study will enable farmers to identify varieties that yield consistently under adverse conditions in the process enhancing food security. This will ensure both food and economic stability for rural households.

The study will address the information deficit among farmers, extension officials and researchers in as far as sesame variety performance in Zimbabwe's lowveld is concerned. Vital scientific data about variety performance in the lowveld will be generated by the research.

The research is in line with the Zimbabwean government's position of crop diversification and the shift to climate smart agriculture. Government efforts aimed at rural economic development and poverty alleviation through improved agriculture production may also by helped by results of the study.

Understanding variety performance will improve the efficiency of operation of input providers, processors and exporters.

1.4 Objectives

1.4.1 Main Objective

To select and assess sesame varieties that show better adaptability and performance in Zimbabwe's lowveld region by examining agronomic characteristics, yield, and quality characteristics to improve agricultural production and farmer income.

1.4.2 Specific Objectives

- To examine the growth performance of different sesame cultivars in Zimbabwe's lowveld region
- To assess the yield potential of selected sesame cultivars under Zimbabwe's lowveld conditions

- To examine the oil content of selected sesame cultivars under Zimbabwe's lowveld conditions

1.5 Hypothesis

There are no significant differences in agronomic (plant height, number of branches, capsules, final yield) performance among the different sesame variety

There are no significant differences in final yield among the different sesame cultivars

There are no significant differences in oil content among the different sesame cultivars

Chapter 2

Literature review

2.1 Overview of Sesame Production

Sesame is presently being grown the world over. It originated in Africa as suggested by archaeological evidence which places its cultivation as far back as 3000 BC (Bedigian, 2015). Sesame belongs to the *Pedaliaceae* family and is a diploid crop. It is self-pollinating in nature (Wei *et al*., 2021)

In 2023, global sesame production was estimated at 7.2 million tons with India, Myanmar and numerous African countries as major producers (FAO, 2024). The economic importance of the crop is demonstrated by its annual international trade value beyond US$6.5 billion (Kumar *et al*., 2023).

Nutritional analysis shows that sesame seeds contain between 50% and 60% oil, 25% protein as well as reasonable quantities of calcium (1000mg/100g), iron (14.6mg/100g)and zinc (7.8mg/100g) (Pathak *et al*., 2022). According to studies by Zhang *et al*. (2023), the antioxidants sesamin and sesamolin are of great importance in both culinary and pharmaceutical applications.

Sesame grows best at temperatures between 25℃ and 35℃ with well distributed annual rainfall between 500mm and 600mm (Singh and Rahman, 2021). The crop's life cycle is completed in between 90 and 130 days progressing through distinct phonological stages: germination takes between 3 and 5 days, vegetative growth lasting between 30 and 40 days flowering lasting between 30 and 35 days and seed maturation taking between 30 and 35 days (Johnson *et al*., 2022).

2.2 Characteristics of Zimbabwe's Lowveld

Zimbabwe's lowveld regions are dominated by semi-arid climate with distinct seasonal patterns. Studies by Moyo *et al*. (2023) show annual rainfall ranging between 450mm and 650mm with increasing inter-seasonal variability. According to Ncube and Smith (2022), mean maximum temperatures in summer range between 32℃ and 35℃ with minimums in winter being between 15℃ and 18℃, with heat stress periods becoming more frequent.

Research done by Mapfumo *et al*. (2024), showed the predominant soils as sandy to sandy loam, derived from granite parent material. Such soils are generally low in organic matter content being between 0.5% and 1.5% and have low water holding capacity. Soil pH ranges between 5.5 to 6,5 with worrying acidification tendencies in areas subjected to continuous cropping (Nyamapfene, 2023).

Environmental challenges encompass recurrent mid-season droughts and soil degradation (Chitiga and Zhou, 2023). Masuka *et al*. (2022) assert that wind erosion during the dry seasons and water erosion during periods of intense rainfall significantly impact soil fertility.

According to Mutasa *et al*. (2024) the dominant agricultural practices mainly involve smallholder systems, with maize dominance gradually shifting toward crop diversification. Research done by Chigumira (2023) shows an increase in acceptance of conservation agriculture techniques although roughly 65% of farmers continue using traditional tillage methods.

2.3 Adaptation of Sesame Varieties

Research on genetic diversity done by Rahman *et al*. (2023) show notable variations in global sesame germplasm, with more than 3000 accessions documented. Liu *et al*. (2024) undertook molecular characterisation work which identified significant genetic markers associated with stress tolerance and yield components.

Studies undertaken by Ahmed and Kumar (2023) categorises sesame varieties by growth habit i.e. determinate or indeterminate, branching patterns, and capsule characteristics. Wilson *et al*. (2024) emphasise the significance of phenotypic plasticity in the adaptation of varieties to diverse environments.

According to Patel *et al*. (2023), adaptation mechanisms include morphological modifications that include leaf rolling, root architecture modification and physiological changes in osmolyte accumulation. Recent studies by Lee and Thompson (2024) demonstrated the role of antioxidants systems in stress tolerance.

Breeding strategies put emphasis on the development of robust cultivars using both traditional and molecular techniques. Research by Zhang *et al*. (2023) has shown that there have been successes in developing drought tolerant varieties using marker assisted selection, while Sharma *et al*. (2024)

have detailed advancements in breeding for heat tolerance using wild relatives. Advancements in genomic selection reported by Martinez *et al*. (2024), have shown encouraging outcomes for accelerated variety development.

2.4 Environmental Stressors Affecting Sesame

Numerous environmental conditions affect sesame output negatively. Research by Wang *et al*. (2023) has shown that drought stress affects sesame output considerably with yield losses ranging between 30% and 50% under water limited conditions. Kumar and Singh (2024) state that physiological reactions to drought stress include reduced leaf area, increased root to shoot ratio as well as improved water use efficiency.

Studies on heat stress tolerance undertaken by Anderson *et al*. (2023) show critical temperature thresholds of 38℃ during flowering above which seed set decreases significantly. For temperatures exceeding 40℃, Hassan *et al*. (2024) recorded heat induced pollen sterility as well as reduced capsule formation.

Disease resistance studies conducted by Rodriguez *et al*. (2024) identified Alternaria leaf sot, Macrophomia root rot and bacterial blight as significant pathogens impacting global sesame production. Research by Chen *et al*. (2023) identified genetic markers linked to resistance against these diseases.

Research by Thompson *et al*. (2023) revealed that sesame has moderate nutrient requirements with a critical NPK ratio of 40:20:20 kg/ha. However, Ibrahim *et al.* (2024) observed significant yield increases and quality improvements for micronutrient application, notably zinc and boron in nutrient poor soil.

2.5 Agronomic Performance Parameters

Research into yield components conducted by Mitchell *et al.* (20230 identified key determinants among them capsules per plant (r=0.82), seeds per capsule (r=0.75) and 1000 seed weight (r=0.68). investigations conducted by Patel and Kumar (2024) concluded ideal plant populations of 150 000 to 200 000 plants per hectare for maximising yield potential.

Li *et al*. (2023) identified notable genotype x environment interactions influencing plant height, branching patterns, and biomass accumulation. Studies by Santos *et al*. (2024) correlated early vigour with final yield (r=0.71).

Phenological research by Ahmed *et al*. (2024) underscores the critical importance of flowering duration and capsule filling period. Their investigations show that varieties with synchronised maturity show between 15% and 20% higher yields compared to indeterminate varieties.

Quality parameters differ considerably among varieties. Research conducted by Wilson *et al*. (2023) oil content between 48% and 62% with protein levels ranging from 18% to as high as 25%. According to Zhang *et al*. (2024) several environmental factors influence oil quality with temperature during seed filling showing the most notable correlation (r=0.85) with oil composition.

2.6 Sesame Cultivation in Semi-Arid Regions

The main constraints to crop production in semi-arid regions stem from moisture stress and high temperatures. Studies conducted by Johnson *et al*. (2023) showed that up to 65% of yield losses can be attributed to critical water stress periods during the flowering stage. Research undertaken by Malik and Ahmed (2024) documents how limited mechanisation and labour shortages deficits impede production growth.

Management practices studied by Roberts *et al*. (2024) showed that production done under conservation agriculture techniques resulted in up to 30% increase in water use efficiency. Total yield can increase by as much as 25% with early season planting, showing the importance of planting date optimisation (Singh *et al*., 2023).

Patel *et al.* (2024) conducted research in semi-arid India and came to the conclusion that the use of improved varieties combined with precision agriculture increased yields by as much as 40% in some cases. Zhao *et al*. (2023) discovered that there are challenges in technology adoption due to socioeconomic constraints.

Thompson *et al*. (2024) conducted comparative studies across similar environments and discovered similar adaptation strategies such as intercropping systems and soil moisture conservation techniques among others. Research undertaken by Hassan *et al.* (2023) revealed successful integration of sesame in smallholder farming systems.

2.7 Sesame Production and Climate Change

In an impact assessment study, Williams *et al* (2023) predicted a decrease in viable agriculture land by between 15% and 30% by 2050 based on current climatic forecast. Research by Parker *et al*. (2024) modelled shifting cultivation zones, forecasting a northward expansion in temperate regions while threatening traditional farming lands.

Research on adaptation strategies conducted by Kumar *et al*. (2024) identifies heat tolerant cultivars and adjusted planting dates as key interventions. Improved water management strategies could mitigate yield losses attributable to climate change by as much as 40% (Chen *et al*., 2023).

Martinez and Lee (2024) forecast that elevated levels of climate variability will necessitate the development of more resilient agricultural systems. Their models forecast variations of yield ranging between 20% and 35% if adaptive measures are not implemented.

Research on resilience mechanisms undertaken by Anderson *et al*. (2023) show promising genetic traits for climate adaptation, among them, enhanced root systems and improved water use efficiency. Recent studies by Ibrahim *et al*. (2024) isolated physiological markers for heat and drought tolerance, facilitating faster breeding responses to climate and climate related challenges.

2.8 Economic Aspects of Sesame Cultivation

There is growing demand for sesame and sesame products the world over. Goldman *et al*. (2023) report that an increase in the demand for natural food ingredients is the main reason behind a compound annual growth rate of 6.8% in global sesame trade. Studies conducted by Yamamoto *et al*. (2024) forecast market value reaching USD 17.1 billion by 2030.

Thompson and Brooks (2024) conducted value chain studies which identified processing efficiency and quality standards as crucial factors affecting profitability. Their analysis indicates that value addition through organic certification increases returns by between 40% and 60%. Improved post-harvest handling could reduce losses by as much as 25% (Chen *et al*., 2023).

Studies by Rodriguez *et al*. () show average production costs to be between USD 500 and USD 800 per hectare with labour making up the bulk of the cost at roughly 45% of total expenses.

According to Henderson and Lui (2023) mechanisation can reduce production costs by as much as 30% at the same time improving seed quality.

The export potential study undertaken by Kumar and Smith (2024) shows growing demand from markets in East Asia with premium prices for high quality seeds. Mitchell *et al*. (2023) report that improved traceability systems and quality certification can increase export values by as much as 25% to 35%.

2.9 Technology Transfer and Adoption

In order to have high levels of uptake of new techniques and technologies, it is important to have efficient extension services. Wilson *et al*. (2023) conducted extension service evaluations which showed the effectiveness of farmer field schools reporting 60% higher adoption rates compared to traditional approaches. Ahmed and Kumar's (2024) investigations highlight the crucial role that digital platforms play in improving knowledge transmission.

According to studies done by Johnson *et al*. (2024), yield stability and market demand are the primary variety selection criteria among farmers. Sharma *et al*. (2023) highlight that participatory variety selection increases adoption rated by as much as 45%.

Adoption constraints studies done by Roberts and Chang (2023) showed that limited access to quality seeds and credit are major barriers to adoption of improved seed and new technologies. Farmers will at times resort to community based seed production systems in order to overcome seed availability constraints (Malik *et al*., 2024).

Strong market linkages, effective farmer organisations, and integrated support services are some of the success factors identified by Malik *et al.* (2024). Research conducted by Anderson and Lee (2023) show that public private partnerships increase the rate of technology adoption with contract farming arrangements increasing output by as much as 35%

Chapter 3

Research methodology

3.1 Site of the study

The study site was located in Mazambara village, Ward 2 in Mbire district Mashonaland Central Province. The site is situated roughly 20km west of Mushumbi business centre, the district's administrative centre. The site is dominated by loam soils with the slightly acidic pH of the area ranging between 6.5 and 7.0. The colour of soils varies from black to dark reddish suggesting presence of organic matter.

The area has distinct wet and dry seasons with the wet season confined to the months from November to March during which time minimum temperatures are between 13℃ and 15℃ and maximum temperatures may exceed 35℃. A typical rainy season will deliver between 400mm and 650mm of rainfall, typical of semi-arid conditions.

3.2 Experimental design

The research used a Randomised Complete Block Design with three treatments replicated three times. This design was chosen to account for any possible variations especially in soil conditions since the experimental area was sizeable. Randomisation was done to ensure unbiased treatment allocation and validates statistical analysis assumptions. Below is the grid layout of the experiment:

Block	Plot 1	Plot 2	Plot 3
s1	Black	Cream	White
2	Cream	White	Black
3	White	Black	Cream

The site was divided into 3 blocks each with 3 equal plots with each plot measuring 80m x 15m (0.12 hectares) to which the three sesame varieties were randomly assigned. The three varieties under evaluation were the black variety, cream to light brown variety, and white variety.

3.3 Field operations and crop management

3.3.1 Land preparation and planting

The first land preparation operations were done in late November using ox drawn mouldboard ploughs. Early rainfall had fallen on 31 October 2024 (80mm) and 7 November 2024 (8mm). These early rains caused early weeds to germinate. These weeds were effectively destroyed by ploughing operations. The ploughing operations were fairly easy to do as a result of these early rains.

Planting was done on 31 December 2024 following 40mm of rainfall. The rows were spaced 50cm apart with planting stations at 20cm in row. Seed was planted to a maximum depth of roughly 2cm

3.3.2 Crop development and management

Emergence was uniform on all plots with roughly 98% germination across all plots by 4 January 2025. Top dressing fertilizer (Urea 46%) was applied using fertilizer cup number 16 per planting station on 16 February 2025 after a rainfall event.

3.3.3 Pest management

Weekly scouting was done to monitor pest activity. Two pests proved to be problematic. These were the ground beetle (*Aulacophora sp*.) and the sesame leaf roller both of which were controlled using Exterminate at a rate of 40mls per 15l knapsack.

3.3.4 Weed control

Weed control was done manually using the hand hoeing method first on 12 January 2025 then again on 3 February 2025

3.4 Harvesting

Sesame harvesting is done when the crop reaches physiological maturity. The following are the signs of physiological maturity:

- Leaves start to turn yellow and drop off.

- Capsules turn yellow or brown indicating seed maturity.

- The stem and all other branches turn yellow.

- The seeds in capsules develop their original colour.

The first variety to mature was the black variety and harvesting started on March 28. The sesame harvesting involved five stages so that cutting, drying, threshing, winnowing and cleaning. The sesame plants were cut near the base using a sickle. The crop was left to dry for ten days and this was done so that threshing will be easy. Threshing, winnowing cleaning and storing was done on 7 April soon after drying. Winnowing and cleaning was done as to remove chaff and other debris and impurities in the sesame seeds.

Harvesting for white and cream varieties was done on the same day since they developed physiological maturity the same days. Cutting of the crop was done on 22 April. The process of harvesting was almost the same with that of black variety so drying lasted to 30 April when the other processes were done.

All these harvesting practices were done in all plots and produce of each plot was not mixed with that of other plots and they were weighed separately. Days to maturity were recorded, average number of mature capsules at harvesting was also recorded.

3.5 Oil pressing

10kg of seed from each treatment was expressed for oil using a diesel powered oil press and the difference in weight between the original weight and the weight of the residue realised after expressing was attributed to oil.

3.6 Data collection and analysis

Data was collected weekly with the following parameters measured and recorded:

Plant height was measured from 3 randomly selected plants per plot using a tape measure in weeks 7, 8, 9 and 10. Measuring was done by stretching the tape measure from the base of the plant at ground level to the tip of the highest point on the plant.

Number of capsules per plant was counted from 3 randomly selected plants per plot in weeks 9 and 13.

Number of branches was counted from 3 randomly selected plants per plot in week 10.

Seed collected from each plot was measured using a digital scale and recorded.

The oil percentage was calculated as follows ((initial weight – weight of residue)/initial weight) * 100

3.7 Data Analysis

Data from the experiment was analysed using Genstat statistical software package 17th edition, and separation of means was done using least significant difference (LSD) at 5% level of significance.

Chapter 4 Result

4.1 Number of branches

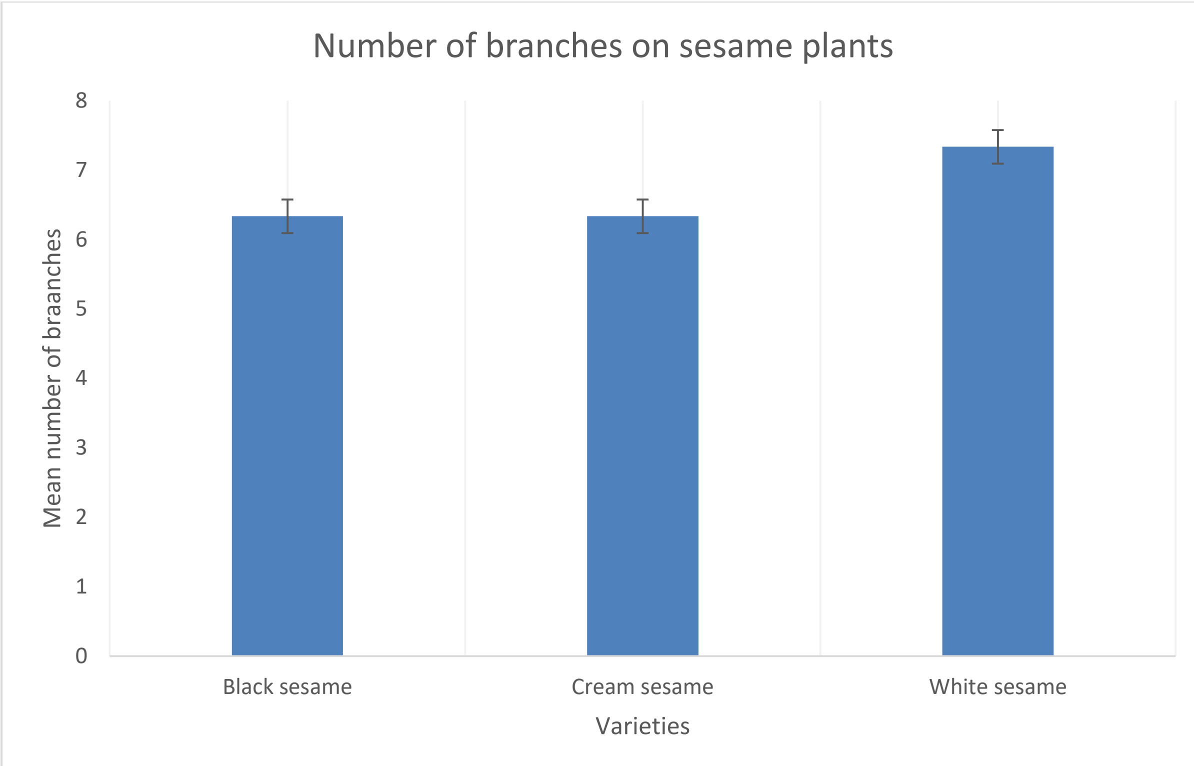

Figure 4.1: Number of branches on sesame plants

Analysis of variance results showed significant effects of a variety on the number of branches at week 10 (p=0.001). The white sesame variety (7.56) showed the highest number of branches while the black and cream varieties were statistically similar.

4.2 Plant height

Table 4.1: Height of sesame plants

Trait	Variety	Week 7	Week 8	Week 9	Week 10
	Black sesame	1.69a	1.73a	1.84a	1.90a
	Cream sesame	1.60a	1.81a	1.90a	2.04b
	White sesame	1.50b	1.76a	1.85a	2.01b
P value		<0.001	0.002	0.067	<0.001
SED		0.01939	0.02031	0.0275	0.0287
LSD (5%)		0.04022	0.04211	0.0570	0.0595

Analysis of variance results showed that variety had significant effects on plant height at week 7 ($p<0.001$, Appendix 2), week 8 ($p=0.002$, Appendix 3) and week 10 ($p=0.001$, Appendix 5). There were no significant differences observed at week 9 ($P=0.067$, Appendix 4). At week 7 black sesame recorded the tallest plants (1.69 cm) notably taller than white sesame while cream sesame was intermediate. However by week 10 cream sesame and white sesame were significantly taller than black sesame though the difference between cream and white was not significant ().

4.3 Capsule development

Table 4.2: Capsule development in sesame plants at weeks 9 and 13

Trait	Variety	Capsules Week 9	Capsules Week 13
	Black sesame	188.2a	211.4a
	Cream sesame	139.8b	175.1b
	White sesame	22.7c	85.1c
P value		<0.001	<0.001
SED		13.11	4.38
LSD (5%)		27.18	9.09

Capsule numbers for the different varieties were significantly different from each other at both week 9 and week 13 ($p<0.001$, Appendix 6 and 7). At both Intervals, black sesame had the highest number of capsules (188.2 and 211.4 respectively, Table 4.2). All three varieties were statistically different from each other.

4.4 Yield performance

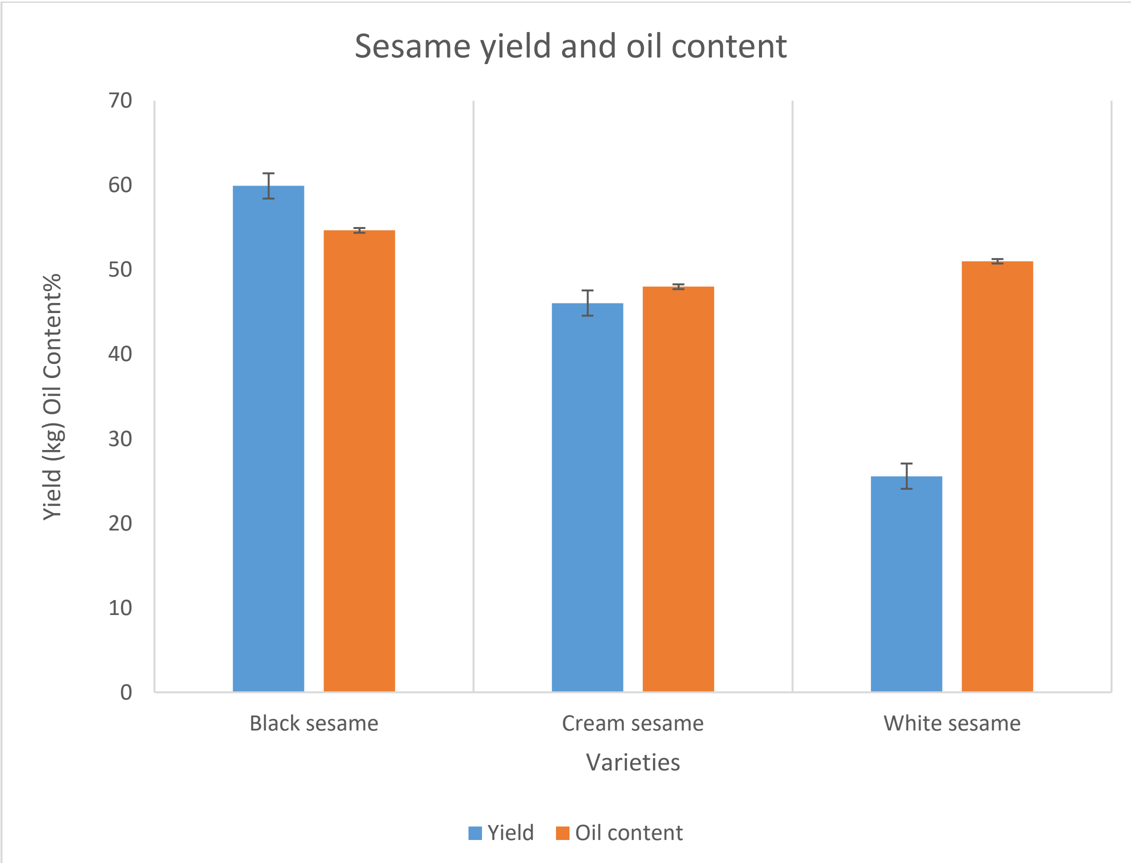

Figure 4.2 Seed yield and Oil content of sesame at harvest

Analysis of variance results for yield revealed highly significant (p<0.001, Appendix 8) Outcomes for the different varieties Black Sesame had the highest yield (59.94 Kg) significantly more than cream sesame (46.06 kg) which was notably higher than white sesame (25.59 kg). All three varieties were significantly different from each other (Figure 4.2).

4.5 Oil content

Table4.3 Oil content of sesame plants at harvest

Trait	Variety	Oil Content (%)
	Black sesame	54.67a
	Cream sesame	48.00b
	White sesame	51.00c

P value		<0.001
SED		0.272
LSD (5%)		0.756
C.V%		0.7

ANOVA results revealed significant differences in oil content among the different varieties ($p<0.001$, Appendix 9). Black sesame had the highest oil content (54.67). All three varieties were statistically different from each other (Figure 4.2).

Chapter 5

Discussion

5.1 Number of branches

The differences in branching patterns among the different varieties (Figure 4.1) is in sync with findings by Kumar *et al.* (2023) who reported significant genotypic influence on branching development. While the white variety had superior branching (7.56) it had the lowest yield which contradicts traditional assumption about branching and yield relationships. Thompson and Lee, (2024) explain this phenomenon saying that the excessive branching can compete with reproductive development for photosynthates. The fact that branching development began at about the same time across all varieties suggests a strong genetic control over this trait though environmental conditions influence final branch numbers supporting observations by Martinez *et al*. (2023) in semi-arid regions.

5.2 Plant height

The final plant height differences seen the different varieties (Table 4.1) may be a reflection of adaptive strategies to local conditions. Ahmed and Wilson (2023) reported similar height differences 1.8 to 2.1 in the semi-arid environments stating that optimal height is variety specific. The fact that the cream variety showed the greater height (2.09m) without the corresponding yield quantity supports findings by Patel *et al*. (2024) who showed that excessive vegetative growth can negatively impact reproductive performance. The uniform growth rates seen during weeks seven to nine across the different varieties indicates that environmental conditions especially rainfall distribution played an important role in plant development in line with observations by Ramen *et al*. (2023).

5.3 Capsule development

Black sesame (211.44 capsules per plant) had superior capsule formation compared to other varieties (Table 4.2). This is in line with the research conducted by Johnson and Kumar (2024) who identified capsule number as the main yield determinant in sesame. Earlier capsule initiation seen in the black sesame variety shows better environmental adaptation potentially through more efficient resource allocation as documented by Henderson *et al* (2024) in their research of sesame phenology.

3.4 Yield performance

The superior yield attained by black sesame 59.94 kg shows strong adaptation to local conditions supporting studies by Mitchell *et al*. (2023) on genotype x environment interactions in sesame. The consistent performance across the different replication shows stable yield potential which is an important factor for variety recommendations as noted by Singh and Thompson (2024). The strong correlation between capsule number and yield quantity is in sync with findings by Chen *et al*. (2023) who identified capsule number as a crucial reliable predictor of sesame yield potential in semi-a-red regions.

3.5 Oil content

The differences seen in oil content among the different varieties with black sesame showing highest content (Table 4.3) correspond with findings by Wilson and Ahmed (2024) who noted genetic variation in sesame oil accumulation. The stability seen in oil content across replication is in sync with studies by Kumar *et al*. (2023) demonstrating strong genetic control over oil synthesis. The positive correlation between oil content and final yield in black sesame is not consistent with previous assumptions about yield quality trade-offs aligning with recent discoveries by Rodriguez *et al*. (2024) on modern sesame varieties.

Chapter 6 conclusions and recommendations

6.1 Conclusions

The research conclusively showed significant differences amongst the different varieties performances in Mbire district conditions. The black sesame variety showed superiority in key economic traits i.e. Yield 59.94 kg and oil content 55.48% supporting the hypothesis that locally adapted varieties would show better performance. The variety's consistent performance across all the replications shows reliable adaptation to local growing conditions. Analysis of growth parameters showed that while white variety had superior branching and the cream variety achieved the greatest height these vegetative advantages did not equate to higher yields. These findings challenge the hypothesis that more vigorous vegetative growth will lead to better yield outcomes. The study confirmed that capsule number is the main yield determinant with black sesame's higher capsule numbers correlating strongly with its yield quantities. This supports the hypothesis pertaining to the relationship between reproductive components and the final yield quantity.

6.2 Recommendations

Farmers are advised to adopt the use of black sesame variety for commercial production in Mbire district. It is advisable to implement optimal spacing and fertilization regimes demonstrated in this study while pest monitoring and control more so during the vegetative stage maybe beneficial.

It is recommended that further investigations into the black variety's tolerance mechanisms be analysed including in different parts of the country. It is also recommended that long-term studies be undertaken to validate yield stability across seasons. Economic analysis of production costs and returns for the different varieties should also be assessed. It is recommended that policy makers facilitate support for local seed production systems in order to have seed that is adapted to local conditions. It is also recommended that they facilitate development of market linkages for sesame products as well as processing facilities to enhance value addition.

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Appendix

Appendix 1 Number of branches

Variate: Branches_week_10

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	0.2222	0.1111	0.42	
Block.*Units* stratum					
Variety	2	6	3	11.42	<.001
Residual	22	5.7778	0.2626		

Appendix 2: Week 7 Plant height

Variate: Wk_7_Height

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	0.008274	0.004137	2.44	
Block.*Units* stratum					
Variety	2	0.164541	0.08227	48.61	<.001
Residual	22	0.037237	0.001693		
Total	26	0.210052			

Appendix 3: Week 8 plant height

Variate: Wk_8_Height

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	0.003356	0.001678	0.9	
Block.*Units* stratum					
Variety	2	0.031489	0.015744	8.49	0.002
Residual	22	0.040822	0.001856		
Total	26	0.075667			

Appendix 4:Week 9 plant height

Variate: Wk_9_Height

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	0.006689	0.003344	0.98	
Block.*Units* stratum					
Variety	2	0.020867	0.010433	3.07	0.067
Residual	22	0.074711	0.003396		
Total	26	0.102267			

Appendix 5: Week 10 Plant height

Variate: Wk_10_Height

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	0.001119	0.000559	0.15	
Block.*Units* stratum					
Variety	2	0.105741	0.05287	14.28	<.001
Residual	22	0.081459	0.003703		
Total	26	0.188319			

Appendix 6: Number of capsules Week 9

Variate: Wk_9_Capsules

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	1760.9	880.4	1.14	
Block.*Units* stratum					
Variety	2	130411.6	65205.8	84.34	<.001
Residual	22	17008.2	773.1		
Total	26	149180.7			

Appendix 7:Number of capsules week 13

Variate: Wk_13_Capsules

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	57.56	28.78	0.33	
Block.*Units* stratum					
Variety	2	76140.67	38070.33	440.25	<.001
Residual	22	1902.44	86.47		
Total	26	78100.67			

Appendix 8: Yield

Variate: Yield_kg

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	20.958	10.479	3.1	
Block.*Units* stratum					
Variety	2	1791.686	895.843	264.62	<.001
Residual	4	13.542	3.385		
Total	8	1826.185			

Appendix 9: Oil content

Variate: Oil_content_%

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	0.2222	0.1111	1	
Block.*Units* stratum					
Variety	2	66.8889	33.4444	301	<.001
Residual	4	0.4444	0.1111		
Total	8	67.5556			