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ASSESSING THE IMPACT OF TOPPING TIMING ON COTTON DEVELOPMENT, YIELD COMPONENTS AND FIBRE QUALITY

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DECLARATION

I, Caleb Madzivanzira, do hereby declare that this research project is a result of my original Research work undertaken by me, except where clearly and specifically acknowledged. It is being submitted in partial fulfillment of the Bachelor of Agricultural Science Honors Degree (Crop Science). It has not been submitted before for any degree or examination at any other university.

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I have supervised the research project for the above-mentioned, and I am convinced that the Research Project:

a) Can be submitted

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I certify that I have checked the Research project and I am satisfied that it conforms to the Department of Crop Science guidelines for project preparation and presentation. I therefore authorize the student to submit this dissertation for marking.

Chairperson____________________________Signature_______________Date:

Official stamp/Date received in the Department of Crop Science office.

DEDICATION

I dedicate this dissertation to my cherished family and friends for their unwavering moral and spiritual support for the entire project duration

ACKNOWLEDGMENT

Firstly, I would like to thank the Almighty for the strength He gave me during this project. I am grateful to my family for moral, financial and physical support they gave me. My greatest appreciation goes to my supervisor Mr J.C. Chitamba for his tireless support from the initial stages up to the end of the research. I would want to express my sincere gratitude to Cottco's head grader Mr. Chitsinde and his team for their technical support. I owe Bindura University of Science Education a debt of gratitude for giving me the chance to apply the theoretical knowledge I have been taught into practise.

Abstract

Despite the widespread adoption of cotton production in Zimbabwe limited research has been carried out on how the timing of topping influences both yield and fibre quality under local field conditions. Most previous studies have emphasised general agronomic practices leaving a gap in understanding the optical topping period for maximum productivity. Addressing the gap is critical for providing farmers with evidence based recommendations suited to Zimbabwean growing environments. The field study was done at Conrise Farm, Rafingora, Zimbabwe during the 2024-2025 growing season to assess the impact of topping timing on cotton growth, yield components and fibre quality. The study was laid out in a randomized complete block design (RCBD) with four treatments namely no topping as the control, early topping (eight weeks after emergence), medium topping (12 weeks), and late topping (16 weeks). The study revealed significant treatment effects on plant height from 8 weeks after planting ($p=0.021$) to 24 weeks after planting ($p<0.001$), bolls per plant ($p<0.001$) and days to boll splitting ($p<0.001$). No topping had the highest number of bolls (12), while early topping resulted in significantly fewer number of bolls (7.62). Early topping accelerated the time to boll splitting (128.67 days) compared to late topping which had 138.67 days. Seeds per boll showed no significant differences among the different treatments ($p=0.58$) having an average of 15.7 across treatments. Fibre quality parameters such as micronaire ($p=0.501$) and upper half mean length ($p=0.264$) were not statistically significant. The study concluded that while topping timing significantly affects cotton development and some yield components, fibre quality remains relatively stable across different topping regimes. It was recommended that mid to late topping be done so as not to compromise yield.

Contents

DEDICATION i

ACKNOWLEDGMENT iii

Abstract iv

Contents v

Table of figures viii

List of tables ix

Appendicies x

CHAPTER 1: INTRODUCTION 1

1.1 Background of the study 1

1.2 Problem statement 2

1.3 Justification 2

1.4 Objectives 3

1.4.1 Main objective 3

1.4.2 Specific objectives 3

1.5 Hypothesis 3

CHAPTER 2: LITERATURE REVIEW 4

2.1 Cotton cultivation in Zimbabwe 4

2.2 Physiology of *G. hirsutum L.* 4

2.3 Topping as a crop management practice 5

2.4 Impact of topping on timing on cotton yield and quality 5

2.5 Effect of topping intensity on cotton development 6

2.6 Crop competition and light interception 6

2.7 Pest and disease management post topping 7

2.8 Socioeconomic effects of topping practices 7

2.9 Gaps in cotton topping studies 8

CHAPTER 3: MATERIALS AND METHODS 9
3.1 Study area 9
3.2 Experiment design 9
3.3 Treatments 9
3.4 Crop management 9
3.4.1 Land preparation and planting 9
3.4.2 Fertilisation 10
3.4.3 Weed management 10
3.4.4 Pest control 10
3.4.5 Cotton topping 10
3.5 Data collection 10
3.6 Data analysis 11
CHAPTER 4 RESULT 12
4.1 Effect of topping timing on cotton growth (plant height) 12
4.2 Effect of topping timing on cotton boll characteristics 12
4.2.1 Seeds per boll 12
4.2.2 Bolls per plant 13
4.2.3 Days to boll splitting 14
4.3 Effect of topping timing on cotton fibre quality (micronaire and upper half mean length) 15
CHAPTER 5 DISCUSSION 17
5.1 Effect of topping timing on cotton growth (plant height) 17
5.2 Effect of topping timing on cotton boll characteristics 17
5.2.1 Seeds per boll 17
5.2.2 Bolls per plant 18
5.2.3 Days to boll splitting 18
5.3 Effect of topping timing on cotton fibre quality (micronaire and upper half mean length) 18

CHAPTER 6 CONCLUSIONS AND RECOMMENDATIONS 20
6.1 Conclusions 20
6.2 Recommendations 20
References 21
Appendix 24

Table of figures

Figure 4.1: Effect of topping timing on seeds per boll 13

Figure 4.2: Effect of topping timing on bolls per plant.......... 14

Figure 4.3: Effect of topping timing on days to splitting.......... 15

List of tables

Table 4.1 Effect of topping timing on plant height 12

Table 4.2: Effect of topping timing on days to splitting 16

Appendicies

Appendix 1: Average number of seeds per boll 24

Appendix 2: Number of bolls per plant 24

Appendix 3: Number of days to boll splitting 24

Appendix 4: Upper Half Mean Length 25

Appendix 5: Micronaire 25

Appendix 6: Plant height 24wks 25

Appendix 7: Plant height 20wks 26

Appendix 8: Plant height 16wks 26

Appendix 9: Plant height 12wks 27

Appendix 10: Plant height 8wks 27

Appendix 11: Plant height 4wks 27

CHAPTER 1: INTRODUCTION

1.1 Background of the study

Cotton (*Gossypium hirsutum L.*) has been grown in Zimbabwe for a long time providing sustenance for farmers, raw materials for industry and earning the country foreign currency. It is an important cash crop in Zimbabwe's agricultural sector greatly impacting the economy and sustaining nearly 250 000 smallholder farmers (Mariga *et al*., 2022). The manipulation of the cotton plant structure by cultural techniques particularly topping plays an important role in maximising production potential and fibre quality characteristics.

Topping refers to the removal of the plant's apical meristem. It is an important management technique that has an effect on the physiological and morphological growth of cotton plants (Zhang *et al*., 2020). This practice redirects photosynthates from vegetative growth to reproductive development, possibly improving boll retention and fibre quality characteristics (Wilson *et al*., 2021). The effectiveness of topping is determined by its timing and intensity as well as the influence of the environmental conditions.

According to Nyakudya and Stroosnijder (2023), cotton producing areas of Zimbabwe, known for semi-arid climates and unpredictable rainfall, can benefit from the practice of topping. Recent research reveals that climate variability in sub-Saharan Africa has had the effect of altering the growing season and modified plant development patterns necessitating a reassessment of cotton management techniques (Moyo *et al*., 2021).

While previous research has analysed many aspects of cotton topping, most of the studies have taken place in temperate regions or under different agro ecological conditions compared to those prevalent in Zimbabwe (Thompson and Anderson, 2022). Studies pertaining to Zimbabwe specifically have been centred on general crop management techniques resulting in there being no guidelines for topping supported by scientific evidence (Chitagu *et al*., 2021).

Determining the ideal time for topping requires knowledge of the plant's physiological growth stages and their interaction with environmental factors. Studies have shown that the time of topping affects node development, blooming patterns and overall yield characteristics (Roberts *et al*., 2023). Similarly, topping intensity i.e. the number of nodes removed, can affect the balance between vegetative and reproductive developments affecting both yield components and fibre quality characteristics (Johnson *et al*., 2021).

The relationship between topping timing and intensity makes it necessary for studies to be conducted within specific agro ecological zones to come up with zone specific management guidelines. This is important considering Zimbabwe's unique combination of environmental factors, agricultural practices and socioeconomic challenges (Mapfumo *et al*., 2022). The increasing emphasis placed on sustainable cotton production and climate smart agriculture necessitates the formulation of specific management techniques to maximise resource usage efficiency.

This research aims to assess the impact of different combinations of topping timing and intensity on cotton crop growth, yield characteristics, and fibre quality within Zimbabwe's agro ecological context. The research will assess the impact of these elements on yield characteristics, reproductive growth, and plant structure.

1.2 Problem statement

There is little research-based information about appropriate topping management techniques suitable for Zimbabwe's local growing conditions. Cotton farmers are not clear regarding the ideal time of topping operations resulting in reduced crop performance and lower yields. The practise of topping is often applied differently within the different agro ecological zones of Zimbabwe making it difficult to formulate standardised guidelines. The lack of region specific research on the relationship between topping timing and intensity has left farmers with no option but to rely on generalised recommendations that may not maximise output in local contexts. The knowledge gap is concerning considering the rising climate variability and its impact on cotton phenology in Zimbabwe.

1.3 Justification

Cotton is a very important crop in Zimbabwe accounting for approximately 19% of agricultural GDP sustaining the livelihood of many smallholder farmers (Mariga *et al*., 2022). Optimising topping management procedures can significantly improve cotton yield and increase farmers' incomes. While research has proven that topping is advantageous in cotton growing, the majority of investigations have been done in regions with different climatic conditions and agricultural systems compared to Zimbabwe. In order to formulate suitable management strategies, localised research is necessary to account for environmental factors such as rainfall patterns, temperature variations, and soil characteristics. Climate change is gradually affecting crop phenology and development patterns in sub-Saharan Africa (Nyakudya and Stroosnijder, 2023). Understanding topping timing in this changing environment is important for developing resilient cotton production systems. The study addresses a notable knowledge gap in Zimbabwe's cotton industry. Farmers often rely on generalised recommendations as opposed to scientific evidence. This study will provide sound scientific evidence on which to base topping practices.

1.4 Objectives

1.4.1 Main objective

To assess the effect of cotton topping timing on cotton development, yield, and fibre quality.

1.4.2 Specific objectives

1. To evaluate the effect of topping timing on cotton plant growth in terms of plant height.
2. To assess the effect of topping timing on cotton boll characteristics (balls per plant and seeds per ball).
3. To evaluate the effect of topping timing on fibre quality parameters.

1.5 Hypothesis

1. Topping timing has no significant effect on cotton plant growth in terms of height.
2. Topping timing has no significant effect on cotton boll characteristics (balls per plant and seeds per ball).
3. Topping timing has no significant effect on cotton fibre quality parameters.

CHAPTER 2: LITERATURE REVIEW

2.1 Cotton cultivation in Zimbabwe

Cotton has been grown in Zimbabwe for a long time and has provided farmers with income and industry with raw material. First grown commercially in 1924 (Mariga *et al*., 2019), the crop has been fundamental to Zimbabwe's agricultural industry. The crop is mainly grown in three agro ecological zones; Gokwe north, Sanyati and the Zambezi valley with smallholder farmers responsible for approximately 75% of all production (Mapuranga *et al*., 2021).

The peak of cotton production was achieved in the 2000/2001 season with production estimates of 353 000 metric tons which contributed significantly to the country's foreign currency earnings (Zimbabwe Cotton Board, 2020). Even in the face of challenges such as climate variability and price fluctuations, cotton remains important to Zimbabwe's economy, employing approximately 400 000 households and accounting for around 19% of agricultural GDP (Chitamba *et al*., 2022).

The government has taken the lead in research into cotton production methods and crop improvement. The Cotton Research Institute at Kadoma has been at the fore of variety development and cotton related agronomic research, producing drought tolerant varieties suitable for local conditions (Mukanga *et al*., 2020). In recent years, production levels have fallen but the government has tried to reach old milestones through initiatives such as the presidential input scheme (Mandizvidza and Thompson, 2023).

2.2 Physiology of *G. hirsutum L.*

Cotton is a dicotyledonous plant from the family *Malyaceae* grown primarily for its lint although other useful products can be derived from it. Cotton displays distinct stages of growth which are affected by numerous management strategies and environmental factors (Robertson *et al*., 2020).

Under Zimbabwean conditions, it may take between 5 to 7 days after planting for the new plant to emerge with a vegetative stage that may last between 35 and 40 days (Nyakudya *et al*., 2021). The reproductive stage has 3 main features beginning with square formation followed by flowering then finally boll formation and development.

Studies undertaken by Masuka and Chiduza (2019) have shown that it takes cotton between 150 and 180 days to mature under Zimbabwean conditions with the flowering and boll filling stages being the most sensitive to water and nutrient levels. During these stages, source sink relationships are particularly important with Mapfumo *et al*. (2022) showing that modification of vegetative development by practices such as topping can assimilate distribution significantly. It is important to understand these physiological responses in order to optimise management strategies

2.3 Topping as a crop management practice

Topping refers to the removal of the apical meristem of a crop. The practice of topping has been done in cotton production for many years to shape plant structure and influence reproductive characteristics (Wilson *et al*., 2020). In Zimbabwe, topping practices were developed from the observation of improved boll retention and reduced plant height (Magorokosho *et al.,* 2019).

Studies undertaken by Dandajena *et al.* (2021) defined ideal topping as the removal of terminal bud to redirect photosynthates towards developing bolls. The practice is done for numerous reasons, i.e. to curtail excessive vegetative growth, facilitate better light penetrance, and improve boll retention (Ncube and Maphosa, 2020).

Research done at the Cotton Research Institute in Kadoma showed that topping could boost yield by between 15% and 30% with proper management (Mangwende *et al*., 2019). There is however no consensus on the correct timing or ideal intensity with different recommendations based on varying environmental conditions and variety characteristics (Chigumira and Muchena, 2023).

2.4 Impact of topping on timing on cotton yield and quality

Studies carried out in different cotton growing areas shown that cotton topping has a pronounced effect on the yield of the crop. Research undertaken by Makuvaro *et al*. (2021) revealed that topping at peak flowering i.e. at between 65 and 70 days after emergence resulted in an increase in seed cotton yield by roughly 23% when compared to untopped controls. Similarly, Mutasa et al. (2022) noted that fibre quality improved significantly in cotton that had been subjected to topping in the early to mid-flowering stages.

The effect of topping is particularly significant in water stressed situations as noted by Chapepa *et al*. (2020) who noted improved water use efficiency when topping was done at the onset of flowering. Moyo and Rusike (2023) warned that late topping, ie. topping after 80 days may result in depressed yield totals by restricting compensatory growth.

Fibre quality assessment done by Cotton Research Institute (2021) revealed that micronaire values and fibre length were optimised when topping was done during the early flowering period of cotton plant development showing that there is an important relationship between cotton topping timing and fibre development processes.

2.5 Effect of topping intensity on cotton development

The degree to which plant terminal meristems are removed has a profound effect on the growth and subsequent development of the plant. Mashingaidze and Nyakanda (2022) conducted research which showed that removing 2-4 nodes resulted in ideal balance between vegetative and reproductive growth while more extreme topping of 6 or more nodes resulted in vigorous lateral branching.

Gatawa *et al*. (2021) conducted plant hormone analysis which revealed that topping intensity impacts auxin-cytokinin ratios, which directly affected boll retention patterns. Makuvaro (2021) conducted research at different altitudes in Zimbabwe which showed that environmental factors interact with cotton topping intensity to determine compensation responses.

Moderate cotton topping of 4 nodes resulted in better performing cotton in terms of plant height, boll distribution patterns, and node numbers. Studies by Mapfumo and Chokowo (2023) revealed that ideal cotton topping intensity is dependent on variety, environmental factors and production management.

2.6 Crop competition and light interception

Light interception after cotton topping have been studied extensively in Zimbabwe's cotton systems. Studies conducted by Mabasa *et al*. (2021) using photosynthetic active radiation sensors showed that topped cotton demonstrated better light penetration through the canopy with up to 35% greater light interception in lower canopy layers compared to untopped controls.

Sibanda and Tongoona (2022) documented canopy architecture modifications which showed that topped plants maintained more efficient leaf angle distribution throughout a growing season when compared to untopped controls. Competition studies by Nyamapfene *et al* (2020) showed that when properly timed, topping had the effect of reducing inter-plant competition for light resources especially in high density planting.

However, research by Musara and Svotwa (2023) revealed that the benefits of topping depended largely on row spacing and plant population density interactions.

2.7 Pest and disease management post topping

The alteration of plant structure that results from topping has a significant effect on pets and disease dynamics. Studies conducted by Mandaza *et al.* (2021) showed reduced bollworm (*Helicovepa.amigera*) presence in topped cotton compared to untopped control plants. They attributed this to better spray penetration and natural enemy accessibility.

Research by Gusha *et a*l. (2020) conducted at the Cotton Research Institute in Kadoma revealed that topped plants exhibited less jassid inflicted damage by as much as 40% when compared to untopped plants. However, research by Chikowore and Tagwira (2023) revealed that excessive delay in topping resulted in an increase in susceptibility to bacterial blight (*Xanthomonas citri pv. malvacearum*), especially during prolonged wet spells in a season or generally wet seasons.

Mutasa and Chikwenhere (2022) conducted integrated pest management research which revealed that well timed topping could reduce application of pesticides by as much as 25% resulting in both economic benefits and enhance environmental health. According to Zinyemba *et al*. (2021), the interaction between topping and disease pressure seems to be closely linked to air circulation patterns in the canopy.

2.8 Socioeconomic effects of topping practices

The ramifications of topping go beyond cotton plant growth and development dynamics and yield effects. An analysis of labour requirements by Matondi and Chikwamba (2020) showed that hand topping necessitated the hiring of an additional 15 to 20 persons per hectare per day. This would be a significant addition to labour costs for most smallholder farmers. However, cost benefit assessment conducted by Rukuni *et al*. (2022) showed that topping at the right time can result in an increase in net revenue by between US$300 and US$450 per hectare as a result of higher yield and better quality parameters.

Research by Mutambara and Chitiyo (2021) showed that women farmers more often than not bear the burden of topping tasks making it necessary to evaluate labour availability in timing recommendations. According to Moyo *et al*. (2023), farmers who adopted the recommended topping measures experienced a 30% increase in income from cotton production when compared to those using traditional methods.

2.9 Gaps in cotton topping studies

While a lot of research has been done on cotton topping, numerous knowledge gaps are present in the Zimbabwean context. Mapfumo et al. (2023) identified the need for more thorough variety specific research under different agro ecological conditions across the various cotton growing regions of the country. With climate change necessitating alterations in management practices, Nyamangara and Siziba (2022) highlighted inadequate understanding of how topping recommendations should be modified under ever changing and increasingly variable weather patterns.

Masuka *et al*. (2021) noted limited research on the relationship between cotton topping and other management practices such as population density, fertility management, pest and disease management among others. Furthermore, Chigumira *et al*. (2023) highlighted the lack of long-term research analysing the long-term effects of different cotton topping practices on soil health and sustainable production.

The integration of scientific research and indigenous knowledge remains unexplored as noted by Zvobgo and Maphosa (2022), particularly with regards to local weather indicators and timing decisions.

CHAPTER 3: MATERIALS AND METHODS

3.1 Study area

The study was conducted at Conrise Farm, Raffingora (16°59'58S, 30°27'6.87E, elevation 1150m) during the 2024/25 summer cropping season. The farm is found in Mashonaland West Province falling in Natural Region III. The area receives between 650mm and 800mmof rainfall with mean temperatures ranging from 15℃ to 19℃. The area is dominated by sandy loam soils of good depth for cropping.

3.2 Experiment design

The experiment was set up using the Randomised Complete Block Design (RCBD) with each treatment being replicated 3 times. The chosen experimental site was divided into three blocks with each containing 4 plots. Each plot measured 4m×5m (20m²). A 2m path was left between plots to facilitate operations and reduce edge effects. On each plot, 4 rows were marked out spaced 1m apart with planting station in the rows marked at 0.3m apart giving a theoretical plant population of 33,333plants/ha.

3.3 Treatments

The topping treatments below were randomly assigned within each block:

- T1 Control (no topping)
- T2 Early topping (8 weeks after emergence)
- T3 Medium topping (12 weeks after emergence)
- T4 Late topping (16 weeks after emergence)

3.4 Crop management

3.4.1 Land preparation and planting

A tractor-drawn plough was used to plough the land before a tractor drawn disc harrow was used to break clods in order to achieve a fine tilth. Row marking was done by hand. The cotton variety Mahyco 567 was planted by hand with 3-4 seeds being planted at each station and later thinned out to one plant per station 10 days after emergence.

3.4.2 Fertilisation

Compound L fertilizer (5:18:10) was applied by hand at planting at a rate of 300kg/ha. Top dressing was done twice using Calcium Ammonium Nitrate (27%N) at a combined rate of 100kg/ha. The first application was done at flowering and the second three weeks after that.

3.4.3 Weed management

Weeds were controlled by hand hoeing operations and hand pulling to remove isolated weeds.

3.4.4 Pest control

Scouting was done on a weekly basis and relevant control methods were applied when pests reached economically significant levels. For sucking pests, Dimethoate (20ml/16l knapsack spray) and Abermectin (15ml/16l knapsack spray) where used alternatively. For boll worms and mealy bug, Emmemectin benzoate (25ml/16l knapsack), Carbaryl (30g/16l knapsack), and Lambda cyhalothrin (30ml/16l knapsack) were used.

3.4.5 Cotton topping

Topping treatments were done to on the relevant plots at the appropriate times. Early topping was done at 8 weeks, mid topping at 12 weeks, late topping at 24 weeks. Topping was done using hand method where the apical bud was removed to stop apical dominance, no chemical was applied on the topped plants.

3.5 Data collection

The following parameters were monitored and measured from the 2 central rows of each plot:

3.5.1 Growth parameters

- Plant height (cm) – this was measured at 4 week intervals from 10 randomly chosen tagged plants per plot.

3.5.2 Yield components

- Number of bolls per plant – bolls were counted from 10 randomly chosen plants per plot
- Number of seeds per boll- 10 randomly chosen plants had all their bolls counted and harvested. After processing, the seed from these bolls was counted and recorded.

- Fibre quality parameters (length, micronaire, Upper half mean length (UHML))- samples obtained from each plot were assessed in the lab to come up with the different parameters.

3.6 Data analysis

The collected data on plant height, yield parameters and fibre quality were analysed using GenStat statistical package 17th edition. Treatment means were separated by using Fisher's Protected Least Significant Difference (LSD) test at $P \leq 0.05$.

CHAPTER 4 RESULT

4.1 Effect of topping timing on cotton growth (plant height)

There were no significant differences in plant height among the different treatments at 4 weeks after planting (p=0.964). Significant differences were seen from 8 weeks (p=0.021) after planting to 24 weeks after planting (p<0.001). The no topping treatment recorded the tallest plants (132.67 cm) followed by late topping (102.67 cm) at 24 weeks after planting. Mid topping (64.67 cm) had intermediate height. Early topping (40.67 cm) had the shortest plants (Table 4.1).

Table 4.1 Effect of topping timing on plant height.

Treatment	4 WAP	8 WAP	12 WAP	16 WAP	20 WAP	24 WAP
T1	20.00^{a}	31.33^{a}	55.00^{b}	91.33^{b}	124.00^{b}	132.67^{b}
T2	19.33^{a}	25.00^{b}	31.00^{d}	33.33^{d}	36.00^{d}	40.67^{d}
T3	19.33^{a}	29.33^{a}	49.33^{c}	54.67^{c}	57.67^{c}	64.67^{c}
T4	20.00^{a}	31.67^{a}	57.00^{a}	77.67^{a}	91.67^{a}	102.67^{a}
P-value	0.964	0.021	<0.001	<0.001	<0.001	<0.001
SED	1.831	1.627	2.759	2.553	2.240	1.225
LSD (5%)	4.480	3.982	6.751	6.247	5.482	2.997
CV%	11.4	6.8	7.0	4.9	3.5	1.8

4.2 Effect of topping timing on cotton boll characteristics

4.2.1 Seeds per boll

There were no significant differences in number of seeds per ball amongst the different treatments (p = 0.583). Early topping and no topping treatments produced similar numbers of seed per boll (15.67) whereas mid and late topping treatments both produced 14.67 seeds per boll (Figure 4.1).

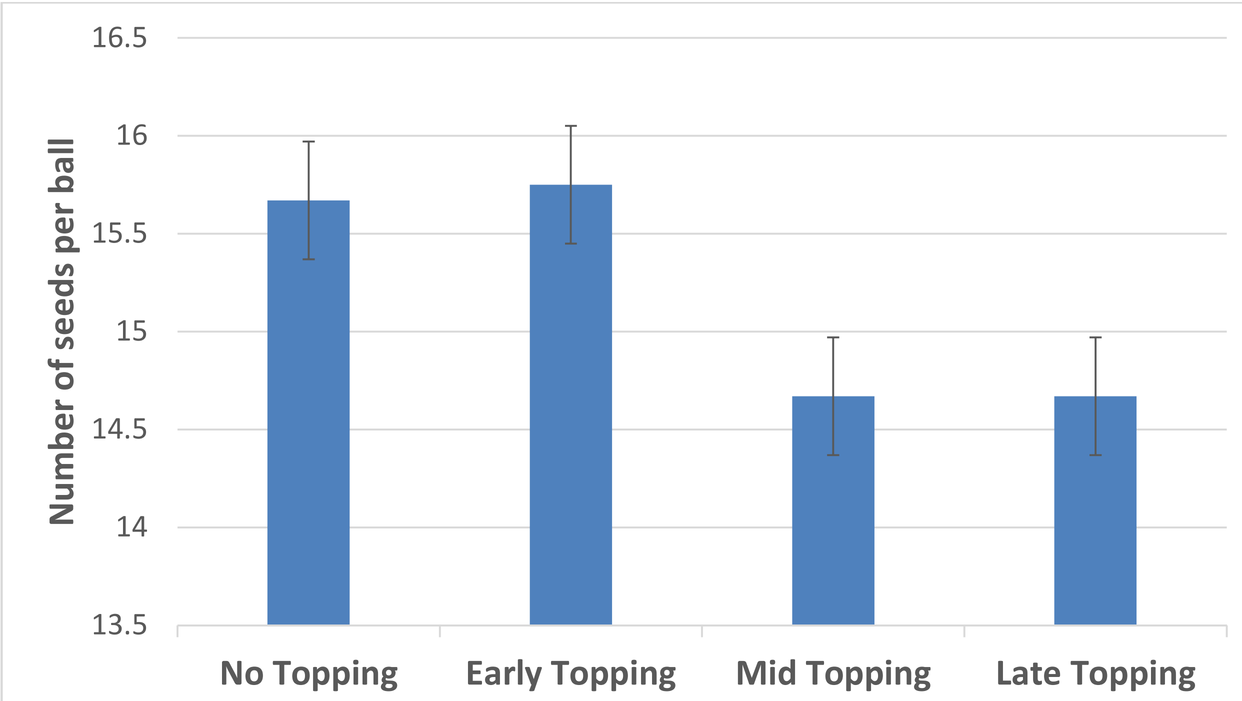

Figure 4.1: Effect of topping timing on seeds per boll

4.2.2 Bolls per plant

Highly significant differences (p<0.0.01) in bolls per plant were observed among the different treatments. The no topping treatment produced the highest number of bolls (12) followed by late topping (11.7) and mid topping (10.00). The early topping treatment produced significantly fewer bolls (7.67). Figure 4.2 illustrates this.

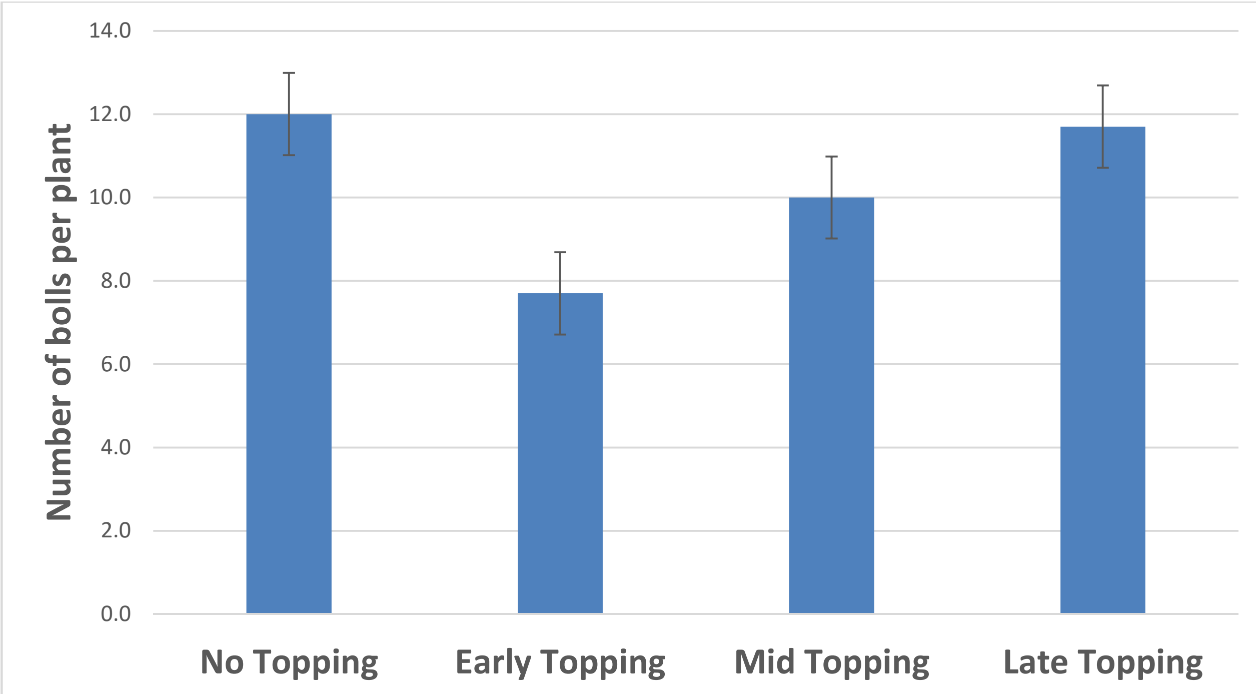

Figure 4.2: Effect of topping timing on bolls per plant

4.2.3 Days to boll splitting

The different treatment effects were highly significant ($p<0.001$). Early topping had the fastest ball splitting (128.67 days) followed by late and mid topping (133.67 and 134 days respectively). No topping had the longest time period to boll splitting (138.67 days). Figure 4.3 illustrates this.

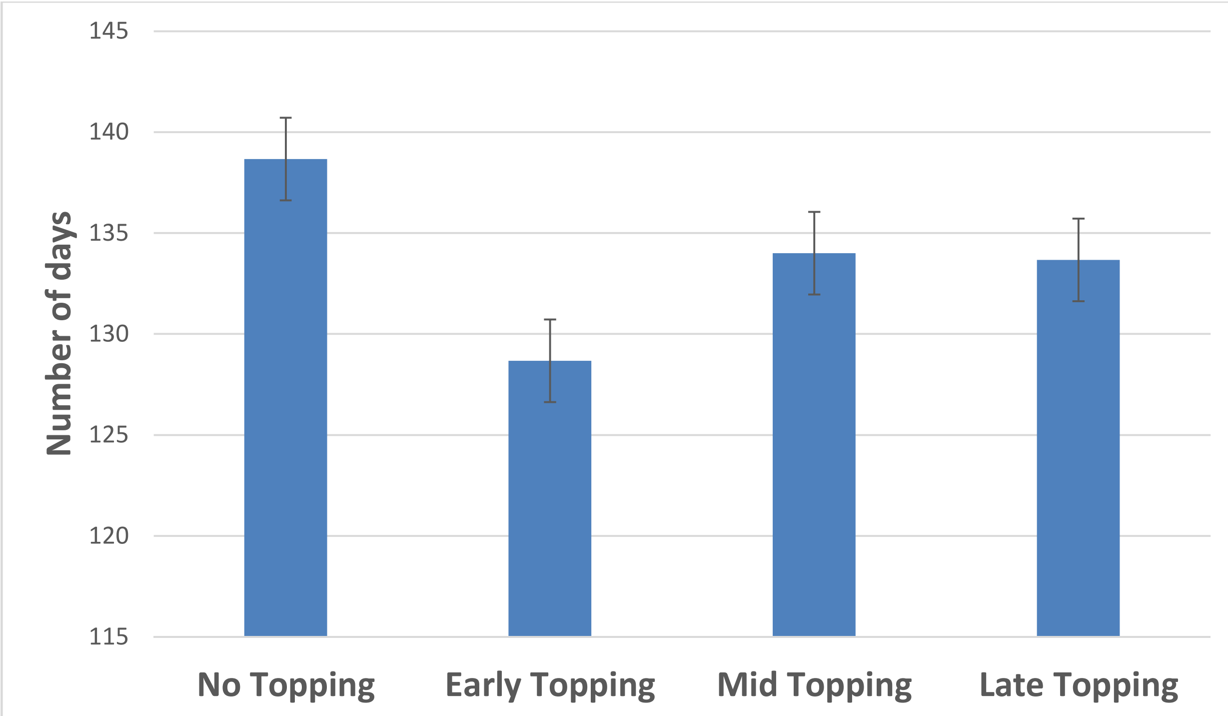

Figure 4.3: Effect of topping timing on days to splitting

4.3 Effect of topping timing on cotton fibre quality (micronaire and upper half mean length)

The effects of the different treatments were not significant (p=0.626). Mid topping and no topping showed identical values (4.26) whereas early topping resulted in a slightly lower micronaire of 4.17 (Table 4.1). There were also no significant differences noticed amongst the different treatments (p=0.264) on upper half mean length, with early topping having the highest value of 1.162 inches and no topping having the least value of 1.152 (Table 4.2).

Table 4.2: Effect of topping timing on days to splitting

Topping Stage	Micronaire (Mic)	UHML (in)
Early Topping	4.17[a]	1.162[a]
Late Topping	4.23 [a]	1.156 [a]
Mid Topping	4.26 [a]	1.160 [a]
No Topping	4.26 [a]	1.152 [a]
P value	0.626	0.264
Sed	0.076	0.0047
LSD (5%)	0.186	0.0116
C.V%	2.2	0.5

CHAPTER 5 DISCUSSION

5.1 Effect of topping timing on cotton growth (plant height)

The notable differences seen among the different treatments ($p<0.001$) from 8 to 24 weeks after planting show that topping intensity had a pronounced effect on cotton vegetative growth. No topping had the tallest plants with progressively shorter plants observed with increasing topping intensity, the shortest being early topping. This outcome is in line with previous studies. Magorokosho *et al*., (2019) and Dandajena *et al*., (2021) both noted that topping restricts apical dominance and limits excessive vegetative growth. Likewise, Mashingaidze and Nyakanda (2022) noted that higher topping intensities significantly reduced plant height due to redistribution of photosynthates towards reproductive structures as opposed to continued stem elongation. The study outcomes are also consistent with physiological expectations described by Robertson et al., (2020) were auxin suppression following apical meristem removal limits internodal elongation. However, the extent of height suppression in early topping suggests that topping intensity must be carefully managed to prevent overly stunted growth as extreme topping can limit canopy development essential for photosynthesis (Makuvaro *et al*., 2020). This is also a confirmation of the fact that topping effectively reduces plant height, an outcome beneficial for light interception, reduced lodging and improved spray penetration. There is a need however for careful timing and intensity balance for height reduction with optimal reproductive development.

5.2 Effect of topping timing on cotton boll characteristics

5.2.1 Seeds per boll

The absence of notable differences in seeds per boll across topping treatments indicates that this yield component is probably predetermined during early boll development stages. Makuvaro et al. (2021) noted similar outcomes reporting that seed number per boll is mainly influenced by pre-flowering conditions and genetic factors as opposed to post flowering management practices. The slightly higher seed numbers noted in early topped and no topping treatments (15.67) compared to mid and late topping (14.67) may reflect better resource allocation during the critical boll filling period though differences were not statistically significant. This stability in seed numbers across the different treatments shows that topping timing may have more influence on other components of yield then on individual boll seed content.

5.2.2 Bolls per plant

The significant reduction in boll numbers per plant with early topping (7.67) when compared to no topping (12.00) shows the critical importance of timing when it comes to topping operations. These findings are consistent with Moyo and Rusike's (2023) observations that premature termination of apical growth limit the plant's compensatory ability and its potential fruiting sites. The intermediate boll numbers per plant observed with mid and late topping (10.00 and 11.67 respectively) indicate a gradual improvement in the plant's capacity to maintain fruit load as topping is delayed. This pattern shows that early topping may overly restrict the plants reproductive potential while later topping permits for better establishment of fruit bearing positions before growth comes to an end.

5.2.3 Days to boll splitting

The notable acceleration of boll splitting with early topping (128.67 days) when compared to no topping (138.67 days) shows important changes in source sink relationships and the resource allocation patterns. This is consistent with Nyakudya *et al*. (2021)'s research Showing that manipulation of vegetative growth significantly affects cotton phenology. The intermediate performance of mid and late topping (134.00 and 133.67 days) indicates a graduated response to growth termination timing. The earlier boll splitting noticed in topped treatments might result from increased photoassimilate allocation to existing bolls following the removal of competing vegetative sinks potentially offering advantages for harvest timing and reducing exposure to late season risks.

5.3 Effect of topping timing on cotton fibre quality (micronaire and upper half mean length)

There were no significant differences in micronaire values. The small variations in micronaire values across the different treatment (range 4.16 - 4.263) show that fibre maturity and fineness are relatively stable under different topping regimes. The slightly lower micronaire in early topped crops (4.16) compared to other treatments (4.233 - 4.263) Might be a reflection of subtle changes in fibre development conditions. These findings are in sync with research by Dandajena et al. (2021) suggesting that fibre micronaire is more strongly influenced by environmental conditions and genetic factors than by topping timing. All the treatments produced micronaire values that were within the premium range for commercial cotton showing that topping timing does not compromise this quality parameter.

The consistency seen in fibre length across the different treatments (range 1.152 - 1.162 inches) shows that topping timing has minimal impact on this fundamental quality parameter. This stability is in sync with research undertaken by Cotton Research Institute Institute (2021) whose findings are that fibre length is primarily determined during early fibre development stages and is less affected by later management practices. The maintenance of fibre-length across the different treatments suggest that the timing of topping does not significantly disrupt fibre elongation processes once they have begun.

CHAPTER 6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Topping timing has significant effects on cotton plant growth in terms of height. Early topping particularly changed plant architecture resulting in reduced ball numbers compared to untreated control.

Topping timing has significant effect on bolls per plant and boll maturation patterns with early topping accelerating boll splitting by approximately 10 days when compared to no topping. However, topping has no significant effect on number of seeds per boll.

Topping timing has no significant effect on cotton fibre quality, as both micronaire and UHML remained stable across all treatments showing that fibre quality is largely independent of topping timing management.

6.2 Recommendations

Based on the research findings, farmers should avoid early topping (eight weeks after emergence) because of the significant reduction in boll numbers. Where topping is necessary, consider mid to late topping (12 to 16 weeks) as these timings showed less negative impact on yield components.

It is recommended that future research can look into multi-seasonal studies to validate findings across different weather conditions as well as investigating the interaction between topping timing and plant population densities. It is also advised to examine the economic implications of different topping timings including labour costs and yield benefits.

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Appendix

Appendix 1: Average number of seeds per boll

Variate: Avg_Seeds_Boll

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	0.167	0.083	0.06	
Block.*Units* stratum					
Topping_Stage	3	3	1	0.71	0.583
Residual	6	8.5	1.417		
Total	11	11.667			

Appendix 2: Number of bolls per plant

Variate: Bolls_Plant

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	0.1667	0.0833	0.43	
Block.*Units* stratum					
Topping_Stage	3	35.3333	11.7778	60.57	<.001
Residual	6	1.1667	0.1944		
Total	11	36.6667			

Appendix 3: Number of days to boll splitting

Variate: Days_to_Splitting

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	0.5	0.25	0.43	
Block.*Units* stratum					
Topping_Stage	3	150.25	50.0833	85.86	<.001
Residual	6	3.5	0.5833		

Total	11	154.25

Appendix 4: UHML

Variate: UHML_in

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	0.0002165	0.0001083	3.22	
Block.*Units* stratum					
Topping_Stage	3	0.0001723	5.742E-05	1.71	0.264
Residual	6	0.0002015	3.358E-05		
Total	11	0.0005903			

Appendix 5: Micronaire

Variate: Mic

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	0.037617	0.018808	2.17	
Block.*Units* stratum					
Topping_Stage	3	0.0162	0.0054	0.62	0.626
Residual	6	0.05205	0.008675		
Total	11	0.105867			

Appendix 6: Plant height 24wks

Variate: Height

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	7.167	3.583	1.59	

Block.*Units* stratum					
Treatment	3	14889	4963	2205.78	<.001
Residual	6	13.5	2.25		
Total	11	14909.67			

Appendix 7: Plant height 20wks

Variate: %20_wks

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	50.167	25.083	3.33	
Block.*Units* stratum					
Treatment	3	13435.33	4478.444	594.92	<.001
Residual	6	45.167	7.528		
Total	11	13530.67			

Appendix 8: Plant height 16wks

Variate: %16_wks

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	128	64	6.55	
Block.*Units* stratum					
Treatment	3	5883.583	1961.194	200.58	<.001
Residual	6	58.667	9.778		
Total	11	6070.25			

Appendix 9: Plant height 12wks

Variate: %12wks

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	102.17	51.08	4.47	
Block.*Units* stratum					
Treatment	3	1262.25	420.75	36.85	<.001
Residual	6	68.5	11.42		
Total	11	1432.92			

Appendix 10: Plant height 8wks

Variate: %8wks

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	78.167	39.083	9.84	
Block.*Units* stratum					
Treatment	3	84.667	28.222	7.1	0.021
Residual	6	23.833	3.972		
Total	11	186.667			

Appendix 11: Plant height 4wks

Variate: %4_wks

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	13.167	6.583	1.31	

Block.*Units* stratum					
Treatment	3	1.333	0.444	0.09	0.964
Residual	6	30.167	5.028		
Total	11	44.667			