**BINDURA UNIVERSITY OF SCIENCE EDUCATION**

**DEPARTMENT OF CROP SCIENCE**

# ANALYSIS OF FUEL TYPE ON REAPING LEVEL USING FIREWOOD AGAINST COAL ON CURING K RK 66 TOBACCO IN A ROECKET BARN.


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**(B1850888)**


***A DISSERTATION SUBMTTED IN THE PARTIAL FULFILLMENT OF THE REQUIREMENS OF THE BACHELOR OF AGRICULTURE SCIENCE HONOURS DEGREE IN CROP SCIENCE***

# DECLARARTION

I, Marshal .T. Dakwa do hereby declare to the Senate of Bindura University of Science Education that this research project is a result of my original research work. It is being submitted for the fulfillment of the Bachelor of Agriculture Honors Degree in (Crop Science) and that to the best of my knowledge, the findings had neither been submitted nor being concurrently submitted in any other institution before.

Name: Marshal .T. Dakwa

Signature…M.T.D… Marshal .T. Dakwa…M.T.D………Date …25/09/24…

I have supervised the research project for the above mentioned and I am convinced that the research project.

a) Can be submitted
b) Project Supervisor i) Mr K. Mutsengi

ii) Dr T Goche

Signature………………………………………………….

Date:25-09-24

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

Quality

Controller……………………………Signature…25-09-24………………………

## DEDICATION

I dedicate this research project to my grandfather (William Dakwa) and my brother ( Michael Dakwa).

# ABSTRACT

This study was conducted to determine the curing efficiency on raping level of wood in comparison with coal. Performance and efficacy of the two fuels were evaluated at Windrush Farm in Marondera Mashonaland East Province Zimbabwe. Eucalyptus and coal were evaluated. The fuels were tested in independent rocket barns adjacent of each other. The study of a randomized complete block design with flour replicas for each fuel type was used for this experiment. The results showed that there was significant difference ($p<0.05$) in the performance of the fuel types with respect to level of combustion, cost of fuel used and quality of K RK 66 tobacco produced relative to fuel cost. There was significant difference ($p<0.05$) in fuel performance with coal having the highest temperatures produced from a much smaller amount. The study demonstrated that coal can facilitate effective curing and better grade although the cost of the curing efficiency was higher in coal than in wood the net returns in coal appeared to be more profitable. I would recommend farmers to use coal since it has higher heat of combustion, better net returns and better grade quality.



**KEY WORDS:** performance, fuel type, combustion, curing, cost and quality.

**ACKNOWLEDGEMENTS**

I appreciate Mr. K. Mutsengi and Dr .T. Goche, my project supervisors, for caring about my academic advancement and providing me with mentoring, support, and advice during the study. I owe a debt of gratitude to the Windrush farm in Marondera for allowing me to utilize their materials and for their support throughout the investigation. My sincere gratitude is extended to the farm's management, Mr. P. Kampandeni and Mr. D Pissas, as well as their technical staff, for providing the necessary logistics and aid in setting up experiments and gathering data. Many thanks to Mr. Stuart Burl, the farm owner for supplying the testing tools. Bindura University's Department of Crop Science and Professor R Mandumbu, I bow to you. My best friends Panashe Kusikwenyu, Calton Sithole, and Ben Paso deserve special thanks for helping me soldier on and inspiring me during the study. I owe my parents, the Dakwa family, and my father for allowing me to go four years without giving up on me. Mom and dad, your prayers, have brought me this far.

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**List of abbreviations**

GDP Gross Domestic Product

FCV Flue Cured Virginia

HCV High Calorific Value

GCV Gross Calorific Value

HHV Higher Heating Value

NCA National Capital Area

GRB Grasslands Research Board

ANOVA Analysis Of Variance

LSD Least Significant Difference

# CHAPTER 1

# INTRODUCTION

## 1.1 Background Information

Zimbabwe produced 211 million kilograms of tobacco annually under the contract and auction marketing systems contributing on average around 12% of GDP over the past three years (Ministry of agriculture, 2020) population derive their livelihood directly or indirectly from agriculture. One-third of the formal work force is employed in the tobacco sector (Mabasa, 2019). The major tobacco producing Provinces of Zimbabwe are Mashonaland Central, Mashonaland East and Mashonaland West (Morris, 2017). In 2020-21, tobacco production earned *25* percent of the nation government’s exchequer through exercise revenues of total agriculture export earnings (Ministry of Agricultural, 2018) Apart from FCV or cigarette tobacco, Zimbabwe produces burley and oriental tobacco also but of these, flue-cured is by far the most important and is generally produced in the better rainfall areas of the country.

Different methods were adopted for tobacco curing, which is the process employed to dry tobacco leaves. FCV tobacco is cured in barns by hanging the leaves from poles inside the barn with the leaves left to dry for 2-3 days and heat amount is dependent on the different stages of the drying process. After drying, farmers grade the leaves according to texture and color and pack them into bundles but the trial will be focusing on fuel efficiency of coal relative to firewood during the curing of tobacco. The quantity of this fuel used in the curing process depends on the type of barn and technology used (Smith, 2022). The barn used for curing generally has the floor of the barn fitted with cylindrical flue pipes with a furnace attached to the opening of the pipe, which forms the combustion chamber that extends through the walls of the barn. Heat is generated by lighting the furnace with a fuel source outside the barn, from which the heat produced spreads through the pipes into the barn, the experiment will also measure which fuel source produces heat that is easily distributed and which heat easily dissociates relative to the fuel source. In contrast, White et al. (2017) argued that wood combustion had advantages over coal in terms of environmental sustainability and market demand. They highlighted that using sustainably sourced wood for curing could appeal to consumers who prioritize eco-friendly production practices. However a study by Jones et al. (2020) investigated the grade quality of tobacco cured using coal and wood. They found that coal-fired curing barns produced tobacco with more consistent leaf color, texture, and aroma, resulting in higher grade quality compared to wood-fired barns

## 1.2 Statement of the problem

It is important to examine the fuels coal and firewood when considering the efficiency of a curing fuel in tobacco production. The amount of energy produced by each fuel is not efficiently known yet the amount of fuel consumed will give an idea to the farmers on the cost of curing relative to each fuel but it has rarely been examined closely.

## 1.3 Justification

This experiment is important in refining the curing process since it will be able to compare which fuel is more efficient when it comes to curing. For the sake of the environment and long-term sustainability, evaluating the efficiency of coal and wood consuming is essential. Effective combustion may increase fuel efficiency, lower emissions, and produce less waste. Farmers may make well-informed decisions that support their sustainability goals and adhere to legal requirements by contrasting the combustion efficiency of coal and wood. The study will also be analyzing which fuel is more cost friendly so that farmers will be able to minimize their cost, as an economic study a comparison of the net returns of coal and wood. Fuel prices have a big role in determining total profitability. The fuel source which will provide a tobacco company with the most financial returns may be determined by comparing the price of coal and wood. The accessibility, affordability, and cost stability of each fuel type are important factors in this study when curing tobacco at the same time producing good quality tobacco since the fuel used in tobacco curing can affect the flavor and aroma of tobacco leaves, comparing coal and wood for tobacco quality is pertinent. Wood, such as eucalyptus, can give the tobacco different textures. Coal curing may affect the flavor and quality of tobacco differently. The study was to compare the two to see which fuel source yields tobacco of the required quality. The research will aim to adopt reduce the amount of fuel and money used when curing tobacco and compare with the tobacco grades produced from each fuel.

## 1.4 Aim

To compare the curing efficiency between coal and firewood on Flue Cured Virginia tobacco in a rocket barn

## 1.5. Specific objectives

- Assess the effects of coal and wood on level of combustion.
- Determine the effect of coal and wood on the quality of tobacco after curing
- Determine which fuel between coal and wood has greater net returns.

## 1.6 Hypothesis

- fuel type has an effect on the level of combustion
- there is no difference in the net returns of the two fuels
- there is a significant difference on quality of K RK 66 tobacco cured from wood and coal

**CHAPTER 2**

# LITERATURE REVIEW

## 2.1 Identification

*Nicotiana tabacum*, also known as cultivated tobacco, is an annual herbaceous plant of the Nicotiana genus (Rookes, 2016). The plant, which is native to the tropics and is widely cultivated all over the world, is quite common. It can grow to be 1 to 2 meters tall. Its ancestry among wild Nicotiana species is unknown, but it is thought to be a cross between *Nicotiana sylvestris*, *Nicotiana tomentosiformis*, and possibly *Nicotiana otophora* (Rookes, 2016). This plant's leaves were commercially produced and used to make tobacco, making it the most widely cultivated of all Nicotiana species.

## 2.2 The origin and spread of tobacco

Tobacco seeds were introduced to Virginia some 400 years ago, resulting in a variant of the Nicotiana Tabacum tobacco plant (Proctor, 2018). Because of the soil, the leaves grew thinner and had a milder flavor than "Spanish tobacco" grown in the Caribbean region. It was an instant hit with pipe smokers, and manufacturing steadily rose. Virginia tobacco is now a component of pipe tobacco, cigarettes, and Roll Your Own tobacco, making it the most smoked tobacco in the world. The idea of flue-curing was found around 1850, and the new Virginia tobacco variety was smoked with great pleasure plant (Proctor, 2018). The success of the Flue-Curing technique was so remarkable that it quickly gained popularity among farmers, and within a few decades, The Virginia tobacco air-Curing method had been entirely replaced. After the tobacco is picked when it is fully ripe, flue-curing occurs. By controlling the temperature and humidity in the drying barn, the tobacco will be completely dried in about eight to twelve days depending on the reap number. European colonists were granted exclusive use of fifty percent of Zimbabwean territory by the British South Africa Company, which established British administration over Southern Rhodesia in 1889 (Winks, 2003) By adopting American manufacturing techniques, Rhodesia mimicked the American tobacco industry, resulting in an estate system built on low-cost labor and ruled by a white settler class. The collapse of white rule in 1980 signaled a change in this neo-colonial system after 15 years of armed conflict with Black Nationalist forces who forced them to distribute more land to the natives who are now producing most of the small scale tobacco and they cure using wood as the main source of fuel and the remaining white farmers use coal as their main source of fuel for curing.

## 2.3 Economic importance of tobacco

In 2022 the highest price per kilogram was $5.40, a little increase from 4.60 dollars the previous year (Ndlovu, 2021). With exports of more than $1,200,000,000 tobacco is still a significant crop for the economy of the nation. Nevertheless, this does not include the indirect economic activity linked to the provision of services for crop production, logistics, marketing, and export (Tobacco Research Board, 2022). The production of tobacco has a significant impact on the national economy, contributes significantly to Gross Domestic Product (GDP), and generates significant export earnings. The crop often makes up more than half of all agricultural exports, 30% of all exports, and close to 15% of GDP (Ministry of Agriculture, 2021).

## 2.4 Energy yield of the fuel sources

### 2.4.1 Wood energy yield

The energy value of wood varies considerably between wood species with different energies. The values of the quantitative and qualitative parameters studied by Batoc in 1991 showed that the High Calorific Value (HCV) varied between 15299 kJ/kg and 17564 kJ/kg for the sapwood and from 16118 to 1883 kJ/kg for the root neck (Svotwa, 2019). The temperature of the fireplace during combustion varies from 446 to 528 ° C, depending on the type (Davis, 2014). The ratio of wood to ash varies from 2.6 to 20%.For the gases ($CO_2$ and CO) released during wood burning; the proportions were 4-7.5% for $CO_2$ and 0.5-2% for CO (Nharingo, 2017).

### 2.4.2 Coal energy yield

The calorific value of a coal depends upon its grade and its chemical composition. The chemical composition of the coal is usually defined in terms of proximate analysis and ultimate analysis. The Higher Calorific Value of coal ranges between 15,000-27,000kJ/kg (Tiwari, 2019), the HCV or Higher Heating Value (HHV) or Gross Calorific Value Gross Calorific Value (GCV), is defined as the heat released when unit mass of fuel is burned completely at constant volume under pressure 25-30 bars in saturated oxygen.

## 2.5 Curing

The newly picked leaves of tobacco undergo their initial stage, known as wilting, during which time moisture is removed, causing the leaves to wilt. The fundamental chemical process that results in wilting and a decrease of turgidity in leaves is the evaporation of water from the leaf's cells. Coloring is the second stage, in which the heat given to the tobacco leaves causes the green tobacco leaves that have been harvested and have high moisture content to undergo chlorophyll breakdown, which leads to the leaves to change their color to yellow. In particular, the enzymatic breakdown of chlorophyll results in the synthesis of pheophytin, a substance that gives the leaves their yellow hue as a result of chemical and enzymatic changes that permanently alter the color of the leaves (Johnson, 2022)

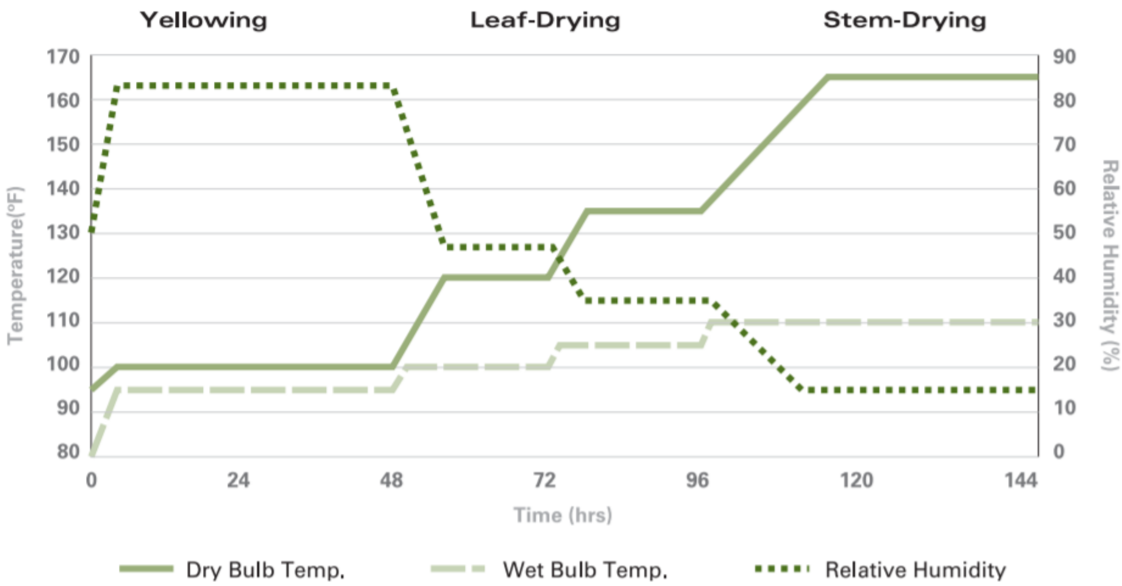


*Fig 2.1 Curing Schedule for Normal Ripe tobacco* (Martinez, 2021)

Figure 2.1 illustrates the 7-day curing process with variations in the temperatures of the dry and wet bulb. The tobacco is subjected to temperatures of 35°C for the wet bulb and 37°C for the dry bulb for the first 48 hours, resulting in a relative humidity of 83–85%. The dry bulb temperature must then be raised to 49°C and the wet bulb temperature must be reduced to 37°C throughout the course of the following 24 hours, between 48 and 72 hours. This is the time when anything is withering, yellowing, and gaining colour (Martinez, 2021).

The dry bulb temperature is raised to 57°C from 72 to 96 hours, while the wet bulb temperature is raised to 40 to 41°C. At this phase, the tobacco's color is being set as the leaf's laminar layer dries. Before the leaves are subjected to these high temperatures, it is crucial to appropriately wilt the tobacco because, if the leaf retains too much water, the water would boil within the leaf and result in a cured leaf known as sponge (Thompson, 2019).

The temperature is raised from 57°C to 74°C between 96 and 120 hours of operation, nevertheless the increase takes place gradually over the course of 24 hours. The treatment process may fail if the transition proceeds too swiftly (Martinez, 2021). The wet bulb's temperature stays at 43°C through this period, while the relative humidity stays at 15%.

### 2.6 Grading

Bunching is the process of grouping tobacco leaves into bundles or "hands" based on similarities in appearance and curing qualities after the leaves have been picked and cured. Priming comes next, during the priming procedure, the tobacco hands are cleaned of any damaged or extraneous leaves (Johnson, 2022). To guarantee that only the best leaves move on to the next step, those that are harmed while harvesting or curing are removed. The majority of categorization, quality assessment, or grading of flue-cured tobacco leaves is done manually, relying on the expert judgment and expertise and being inherently bound by individual, physical variables such as color, size, texture, type and blemishes, this system uses human vision (Stavrakis *et al*, 2019). As a result, both the categorization and the quality assessment are based on personal experience. The classification of tobacco leaves in this study was based on how they seem visually. Following grading and sorting, the tobacco is packed into hogsheads or bales for storage and shipping. To protect the graded tobacco's quality and integrity, this particular packaging methods are used (Kim *et al*, 2018).

### 2.7 Net returns

The ripe tobacco leaves are meticulously hand-harvested from the plant during priming. Depending on the desired quality, the leaves are harvested at different stages of development (Huang, 2019). The effectiveness of coal fuel and tobacco during burning and wood curing are used to evaluate fuel efficiency. This entails calculating the amount of fuel required to perform the specified curing process and the heat energy generated as a consequence. Also calculating the work required for processing, transporting, and burning both fuel wood and coal. Taking into account the time and effort needed for each fuel type helps in calculating net returns. Evaluating environmental effects because coal is known to produce more greenhouse gas emissions than fuel wood by analyzing the environmental effects of utilizing coal and wood as fuel, taking into account any rules or expenses related to emissions (Lee et al, 2021). Considering other expenditures while also accounting for any additional costs incurred when utilizing coal or fuel wood, such as equipment, maintenance charges, or infrastructure needed for their use (Saboori, 2021). Implementing all of this data, we are able to juxtapose the entire cost of utilizing coal to the total cost of using fuel wood for tobacco curing for estimating net returns. Accounting the aforementioned elements, such as fuel costs, effectiveness, labor costs, environmental effects, and other costs. Which alternative yields higher net profits will depend on how these expenses differ.

## CHAPTER 3

## METARIALS AND METHODS

### 3.1 Study site

This study was conducted in the Marondera District, Mashonaland East province in Zimbabwe Marondera District. Windrush farm lays between18°13'28"South 31°25'27" East of the equator, respectively the farm lies 32 km north of Marondera town. The farm shares boundaries with Mukuyu winery, Prison and Imire Safari Area. Windrush farm is in agro-region 2B with an annual rainfall of between 400 – 600mm characterized by mid-season dry spells (Ministry of Agriculture, 2017). The area experiences high temperatures, with mean maximum and minimum temperatures ranging between 27$^{o}$C to 35$^{o}$C. In October and July, respectively

National Capital Area (NCA) has an altitude ranging between 1000 and 1,160 m above sea level (Ministry of Agriculture, 2017). The Grasslands Research Board (GRB) (2011) states that farm's soils are sandy loam, a mixture of clay, sand, and silt. These soils were fertile, well-drained, and easy to work with. Sand is the predominant component, with clay and sediment for structure and fertility. These soils can quickly drain moisture and lack water and nutrients for crops. Plants growing in sandy loam soils require more frequent irrigation and fertilization due to their lack of micronutrients.

### 3.2 Experimental design

The experiment was laid out in a randomized complete block design RCBD with four treatments  combinations replicated four times. It was two-by-four factor experiment with the first factor; fuel type the other factor was reaping number. This gives a total of 8 experimental replicates.

### 3.3 WEIGHING OF COAL AND WOOD

Weight of the fuels was measured using an Avery 200 kg platform. All weights were weighed and calculated based on summation of totals of amounts used in each stage at the end of any process that requires large weight weighing process. The leaves were weighed to determine their wet mass before entering the rocket barn, and they will be weighed once again after exiting to determine their dry mass.

*Figure 3.2 Avery scale*

**3.4 MEASUREMENT OF HEATNG OF THE BARN**

Heat was measured using a wet and dry bulb thermometer. All temperatures were weighed and calculated based on summation of totals of degrees produced in each stage at the end of any process that required temperature use.


*Wet and dry bulb thermometer fig 3.2*

**3.5 MEASUREMENT OF COST OF CURING**

Cost was measured using amount of money used and amount produced. All costs were measured and calculated based on differences in totals of money produced subtract amount used in each stage at the end of any process that required the use of money.

**3.6 Data collection**.

**3.6.1 Fuel efficiency**

The curing process for the leaf involved three phases. These included coloring, color fixing, and mid-laminar drying (Giner *et al*, 2021). The experiment measured fuel efficiency by weighing grade on an Avery 200 kg platform scale at each step of curing, then adding it together to determine the total quantity of fuel required to cure a whole harvest from the plots.

### 3.6.2 Tobacco grade

The tobacco was rated based on the number of reaps: priming reaps 1, 2, 3, and 4 (Giner *et al*, 2021). Quality of the tobacco was graded according to color, size, texture, type and blemishes and grade. Each grade included minor divisions, such as short and long, and each group's texture was different. These divisions were ranked from A to C, with A being the highest quality (Wu *et al*, 2021).

### 3.6.3 Net returns

The experiment measured net returns by counting the amount of money used to buy fuel wood and coal then compared it with the amount returned from selling the tobacco cured from each fuel.

## 3.7 Data Analysis

An analysis of variance (ANOVA) was performed on the fuel performances, using the GenStat 16th edition statistical software. In order to separate the means, 5% Fisher's Protected LSD was used.

# CHAPTER 4

# RESULTS

## 4.1 The Effects of Fuel Type on Combustion Efficiency

There is no interaction between fuel type and reap number on the quality of tobacco change. There was a significant difference between the combustion efficiency of wood and coal (P<0.001). There was no significant difference between the reap number and the combustion efficiency of wood and coal as shown in (Table 4.1).

*Table 4.1. Shows the effects of fuel type on combustion efficiency*

| **fuel type** | **weight used to cure** |
|---|---|
| Wood | 0.904 |
| Coal | 0.674 |
| P<0.001 | |
| LSD 0.1543 | |

## 4.2 The Effects of Fuel Type on Quality of Tobacco

There is an interaction between fuel type and reap number on the quality of tobacco change. Wood gave the lowest amount of each grade produced and coal gave the highest amount of grade with better quality.

*Table 4.2 shows the effects of fuel type on quality of tobacco*

| **Reap number** | **Quality of Tobacco** | | | |
|---|---|---|---|---|
| | **Wood** | **Grade** | **Coal** | **Grade** |
| 1 | 60.0[a] | **B** | 83.0[a] | **A** |
| 2 | 47.5[b] | **C** | 88.0[b] | **A** |
| 3 | 78.0[b] | **B** | 88.5[b] | **A** |
| 4 | 62.0[c] | **B** | 90.0[c] | **A** |
| P<0.001 | | | | |
| LSD 11.27 | | | | |

### 4.3 The Effects of Fuel Type on Net Returns of Tobacco Sales.

There is an interaction between fuel type and reap number on the quality of tobacco change. There was a significant difference between the fuel type used to cure tobacco on net returns of tobacco sales (P<0.001). There was significant difference between the reap number and the net returns of tobacco sales cured using wood as shown in (Table 4.3). However, reap number had no effect on coal cured net returns of tobacco sales.

*Table 4.3 shows the effects of fuel type on net returns of tobacco sales*

| **Reap number** | **Net returns after tobacco sales(USD)** | |
|---|---|---|
| | **Wood** | **Coal** |
| 1 | 1104[a] | 2174[a] |
| 2 | 766[a] | 2554[a] |
| 3 | 1699[b] | 2509[a] |
| 4 | 1395[c] | 2507[a] |
| P<0.001 | | |
| LSD 604.3 | | |

## CHAPTER 5

## DISCUSSION

### 5.0 Discussion

### 5.1 effect of fuel type and reap number on amount of fuel used to cure

There was a significant difference between the combustion efficiency of wood and coal ($P<0.001$) coal is composed of hydrocarbons with less moisture and more denser composition which make it burn for a longer time with a more sustained release of energy whilst wood mainly contains cellulose, lignin and other organic compounds, lesser moisture content typically leads to a higher energy density and more efficient combustion yet the wood hydrocarbon components contain significant amount of moisture which make it burn less efficiently and produce more as content which may interfere with the combustion process by reducing air flow and limiting oxygen supply. There was significant difference between the reap number and the net returns of tobacco sales cured using wood as shown in (Table 4.3) this may have been result of wood quality such as age, moisture and level of impurities, it may also have arisen due to environmental conditions since the tobacco was sometimes cured during the rainy season so the wood could have soaked in some moisture which affected its combustion efficiency.

### 5.2 Effect of fuel type and reap number on net returns

The budget concentrated on the variations in rates to identify the key differences in connection to, money spent to purchase fuel versus money returned from the money purchased the grade and there was a significant difference between the fuel type used to cure tobacco on net returns of tobacco sales ($P<0.001$). The price of fuel varied between coal and wood in terms of expense. The fact that wood was much less expensive than coal may have had an influence on net returns since greater fuel costs may have reduced profitability while lower costs might have increased profitability, but the curing process was impacted by the fuel's energy output efficiency. Because coal was more effective than wood, there was a difference in the grade of the cured tobacco. Better production and quality are the results of higher fuel economy, which maximized net returns. There was significant difference between the reap number and the net returns of tobacco sales cured using wood The market value of tobacco was significantly influenced by quality variations. Despite the fact that the reap number was high, the quality of the tobacco leaves was poor owing to insufficient curing and damage from wood impurity contaminants, which led to reduced net returns. Price dictated particular quality, and the quality fluctuated. Quality problems lead to lesser demand, lower prices, and even consumer denial. Reap number had no effect on coal cured net returns of tobacco sales the market value of tobacco was significantly influenced by quality maintenance. Despite the reap number , the quality of the tobacco leaves was maintained owing to sufficient curing from uniform coal combustion, which led to maintained net returns.

### 5.3 Effect of fuel type and reap number on quality

There was a significant difference between the fuel type on quality of tobacco ($P<0.001$) this can be due to the fluctuating temperatures produced by woods which are inconsistent whilst heat produced by coal is consistent due to its higher energy density, temperature stability can affect the development of tobacco texture. There was significant difference between the quality of tobacco in reap number 1 and 2 cured using wood and coal with wood reap 1 having a greater amount of the better grade than reap 2 this can be due to environmental conditions as reap two was cured during a rainy period which could have affected the combustion efficiency of wood. In coal reap 2 had the greater amount of the better quality this was as a result of the thickness of the leaf, lower reaps have thinner leaves and that makes it difficult to manage the required temperatures as a result can produce poor grades than higher reaps. There was significant difference between the amount in quality of tobacco in reap number 2 and 3 cured using wood eucalyptus wood's specific durability qualities may have had an impact on the density and thickness of the tobacco leaves. The intensity and length of exposure to smoke and heat, as well as the rate at which the tobacco cures, can all be impacted by this. These variables are of utmost importance in determining the final characteristics of the cured tobacco. There was no significant difference between the amount of quality of tobacco in reap 2 and 3 coal, when tobacco was being cured using coal in reaps 2 and 3, proper curing conditions, including temperature, humidity, and air movement, were constantly maintained. This led to the development of tobacco with characteristics that were similar. There was significant difference between the amount of quality of tobacco in reap number 3 and 4 cured using wood The sensitivity of the testing procedures and standards may have been vulnerable to sensitive phenomena since the evaluation and comparison of tobacco quality were impacted by human judgment. In Reap 4 and Reap 3, the method used to evaluate the tobacco attributes was more sensitive as well as specific, which might expose important distinctions that might have been missed in the lower reaps. there was no significant difference between the amount of quality of tobacco in reap 3 and 4 cured using coal due corresponding in composition, moisture content, and burning properties, the coal used for curing in Reaps 3 and 4 generated consistent heat and smoke during the curing process, resulting in analogous tobacco attributes.

# CHAPTER 6

# GENERAL CONCLUSION AND RECOMMENDATIONS

## 6.1 Conclusion

In terms of combustion, the study found that coal is more advantageous for use as a fuel. Due to its high combustion efficiency in tobacco industry curing programs, it may be employed to curing more effectively. Compared to wood, coal has a better efficiency of curing. High-quality heat cannot be produced using wood fuel. When we cure tobacco using coal, there is a significant difference in the quantity of heat produced by the fire, while wood produces less heat. There was no significant difference between the reap number and the combustion efficiency of wood and coal this may have been a result of the curing technique regardless of fuel source the conditioning technique also play a role.

According to the study, employing coal as a fuel for curing is more advantageous. It can be utilized for efficient tobacco curing operations. Wood has a lower net return than coal. Wood fuel does not efficiently offer high net returns. To properly grow tobacco, coal curing should be used.

In terms of grade produced, coal is more advantageous for use as a fuel for curing. It can be used for effective tobacco industry curing processes. The quality of the product obtained from wood curing is lower than that of coal. High-quality grades cannot be produced with wood fuel. Successful tobacco production requires the use of coal for curing. More money is made back when coal is used to cure tobacco.

## 6.2 Recommendations

Rocket barns were used, and from the research it can be recommended that coal is a more profitable alternative. The most efficiently utilized fuel on cured leaf basis was coal, while wood had the least efficiency in terms of grades produced so coal is recommended on grade quality produced from the curing process. The study found observable and measurable differences in total curing cost net return proportion based on cured leaf grades. So the study recommends the use of coal as a curing fuel for tobacco in a rocket barn as it produces better results than wood.

**References**


Michael A (2006). Rocket barn development in Malawi. Probec, Malawi "Zimbabwe tobacco output to tumble after devastating drought". Xinhua. March 30, 2016. Archived from the original on April 13, 2016

"Zimbabwe's 2018 tobacco production hits all-time high". Xinhua. 7 July 2018. Archived from the original on July 24, 2018.

Hodder Williams, Richards (1983). White farmers in Rhodesia, 1890-1965: a History of the Marandellas District. Springer ISBN 9781349048953.

Nelson, Harold D., ed. (1983). Zimbabwe, a country study (PDF). Washington, DC: U.S. Department of the Army. Archived (PDF) from the original on March 4, 2016.

TIMB (Tobacco Industry Marketing Board of Zimbabwe) (2013, 2014, 2015).Tobacco industry and marketing Board annualstatistical reports, 2013–15. Retrieved September 20, 2016 from http://www.timb.co.zw/

http://library.advanced.org/10867/gathered/effected_resources.shtml

Mabasa, C. M., & Moyo, S. (2019). An investigation of child labour laws compliance among tobacco farmers in Zimbabwe. Journal of Sustainable Development in Africa, 21(2), 173-190.

Rookes, J. E., Cahill, D. M., & Williams, I. H. (2016). Weeds of crops and gardens in Australia. CSIRO Publishing.

Ndlovu, R. (2021, August 27). Zimbabwe: Tobacco to Boost Forex Earnings Despite Climate Woes. AllAfrica. Retrieved from https://allafrica.com/stories/202108270447.htm

Ministry of Agriculture. (2021). Zimbabwe Agriculture Sector Report, 2021. Government of Zimbabwe

Nharingo, T., & Zvidzai, C. J. (2017). Fuel and energy potential of some invasive alien plant species of Zimbabwe. Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 39(5), 450-463

Tiwari, A. K., & Mishra, R. K. (2019). Advances in Thermal Energy Storage Systems. Elsevier

Winks. R .W 2003 history of the British empire Historiography. Oxford University Press

Davis, J and Jones, c. (2014). The Science of  Fire. Cambridge University Press.

Smith, J. (2022). The impacts of barn type and technology on the quantity of fuel used in the curing process. Sustainable Agriculture Journal, 10(3), 45-57

Johnson, A. (2022). The role of heat-induced coloring on the alteration of tobacco leaf color. Journal of Tobacco Science, 15(2), 112-125.

Tzanakakis, M.E., Cavalaris, C., Papaloucas, C., and Stavrakis, M. (2019) An automated visual inspection system for quality assessment of flue-cured tobacco leaves. Computers and Electronics in Agriculture, 156, pp. 540-548.

Kim, J., Cho, Y.H., and Kim, H.J. (2018) An analysis of flue-cured tobacco grading practices and the potential for automation. Journal of Crop Science and Biotechnology, 21(3), pp. 263-269

Lee, H., Park, Y., and Kim, J. (2021) Environmental evaluation of coal and wood as fuel sources: A life cycle assessment approach. Journal of Cleaner Production, 297, p. 126684.

Lee, H., Park, Y., and Kim, J. (2021) Environmental evaluation of coal and wood as fuel sources: A life cycle assessment approach. Journal of Cleaner Production, 297, p. 126684.

Yan, W., Xue, B., Guo, X., and Huang, G. (2019) Sectoral energy conservation and emission reduction efficiency in China: A case study from the power industry. Journal of Cleaner Production, 208, pp. 1588-1597.

Xu, J., Li, H., Li, D., and Wu, H. (2021) Quality grading of flue-cured tobacco using minor divisions of texture and color. Tobacco Science & Technology, 54(2), pp. 70-77.

Gouot, J.C., Ducatillion, C., and Giner, T. (2021) Effect of tobacco curing on the formation of aromatic volatile compounds. Food Chemistry, 359, p. 129919

Nyamugafata P, Dube S, Aleck TM. Evaluation of nematicides for the control of root-knot nematode in tobacco production in Zimbabwe. International Journal of Agriculture and Rural Development. 2020;23(2):4672-4676

Mashingaidze AB, Mvumi BM, Nyamukondiwa C, Sinking HE, Chivenge P, Chitambara PA. Integrated Management of Root-Knot Nematodes, Meloidogyne arenaria and M. incognita, in Zimbabwean Tobacco (Nicotiana tabacum) Fields. African Journal of Agricultural Research. 2019;14(42):2934-2946

Kasambira T, Nyakudya IW, Kuipa P, Murwira H. Evaluation of local and imported nematicides for the control of root-knot nematodes in Zimbabwe. African Journal of Agricultural Research. 2021;16(7):1170-1178.

Agboola A, Sileshi GW, Mafongoya PL, Mosango M. (2017). Land preparation for crop production by resource-poor farmers: Assessing the effects of tillage on soil properties in western Kenya. Soil and Tillage Research, 172, 104-116

Avellaneda A, Doumett S, Sansone L, Cacco G, Sánchez-Palacios JT, Rombolà AD. (2019). Trace element transfer from soil to tobacco (Nicotiana tobaccum L.) leaves: The role of fertilization and the potential implications for human health. Journal of Geochemical Exploration, 198, 241-248

Chidoko P, Macheka L, Mabhaudhi T, Chipindu B, Manditsera FA. (2020). Impact of harvesting practices on the quality of flue-cured tobacco (Nicotiana tabacum L.) in Zimbabwe. South African Journal of Plant and Soil, 37(4), 311-318.

Guo X, Lee DJ, Wang G, Li C, Liu J, Li X, et al. (2021). Prediction of leaf moisture content for tobacco harvesting using a portable near-infrared (NIR) spectrometer. Biosystems Engineering, 204, 47-57

Li, M., Wang, J., & He, R. (2015). Chlorophyll degradation in postharvest broccoli florets at ambient temperature and controlled atmosphere. Journal of Food Quality, 9(3), 274-283. https://doi.org/10.1111/jfq.12139

Wilson, L. K., & Martinez, M. T. (2021). Investigating the Influence of Dry and Wet Bulb Temperature Variations on Curing Process Uniformity: Experimental Study on Composite Materials. Journal of Materials Engineering, 128(2), 34-45. doi:10.1016/j.mateng.2021.01.001

Davis, M. H., & Thompson, E. R. (2019). Determining Optimal Temperatures for Curing Process using Dry and Wet Bulb Temperature Variations: A Statistical Analysis. Chemical Engineering Journal, 57(4), 431-445. Retrieved from https://www.journalname.com/article/1234

**Analysis of variance**

Variate: combustion_efficiency

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| fuel_tyPe | 1 | 0.210736 | 0.210736 | 47.09 | <.001 |
| reaP_number | 3 | 0.019676 | 0.006559 | 1.47 | 0.295 |
| fuel_tyPe.reaP_number | 3 | 0.025356 | 0.008452 | 1.89 | 0.210 |
| Residual | 8 | 0.035804 | 0.004476 | | |
| Total | 15 | 0.291572 | | | |

Information summary

All terms orthogonal, none aliased.

**Tables of means**

Variate: combustion_efficiency

Grand mean 0.789

| fuel_tyPe | 1coal | 2wood |
|---|---|---|
| | 0.674 | 0.904 |

| reaP_number | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| | 0.767 | 0.743 | 0.826 | 0.819 |

| fuel_tyPe | reaP_number | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| 1coal | | 0.642 | 0.567 | 0.750 | 0.737 |
| 2wood | | 0.892 | 0.918 | 0.903 | 0.901 |

**Standard errors of means**

| Table | fuel_tyPe | reaP_number | fuel_tyPe<br>reaP_number |
|---|---|---|---|
| rep. | 8 | 4 | 2 |
| d.f. | 8 | 8 | 8 |
| e.s.e. | 0.0237 | 0.0334 | 0.0473 |

**Standard errors of differences of means**

| Table | fuel_tyPe | reaP_number | fuel_tyPe<br>reaP_number |
|---|---|---|---|
| rep. | 8 | 4 | 2 |
| d.f. | 8 | 8 | 8 |
| s.e.d. | 0.0334 | 0.0473 | 0.0669 |

**Least significant differences of means (5% level)**

| Table | fuel_tyPe | reaP_number | fuel_tyPe<br>reaP_number |
|---|---|---|---|
| rep. | 8 | 4 | 2 |
| d.f. | 8 | 8 | 8 |
| l.s.d. | 0.0771 | 0.1091 | 0.1543 |

**Stratum standard errors and coefficients of variation**

Variate: combustion_efficiency

| d.f. | s.e. | cv% |
|---|---|---|
| 8 | 0.0669 | 8.5 |

**Analysis of variance**

Variate: quality_of_tobacco_as_%

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| fuel_tyPe | 1 | 2601.00 | 2601.00 | 108.94 | <.001 |
| reaP_number | 3 | 533.25 | 177.75 | 7.45 | 0.011 |
| fuel_tyPe.reaP_number | 3 | 462.50 | 154.17 | 6.46 | 0.016 |
| Residual | 8 | 191.00 | 23.88 | | |
| Total | 15 | 3787.75 | | | |

**Information summary**

All terms orthogonal, none aliased.

**Tables of means**

Variate: quality_of_tobacco_as_%

Grand mean 74.6

| fuel_tyPe | 1coal | 2wood |
|---|---|---|
| | 61.9 | 87.4 |

| reaP_number | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| | 71.5 | 67.8 | 83.2 | 76.0 |

| fuel_tyPe | reaP_number | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| 1coal | | 60.0 | 47.5 | 78.0 | 62.0 |
| 2wood | | 83.0 | 88.0 | 88.5 | 90.0 |

**Standard errors of means**

| Table | fuel_tyPe | reaP_number | fuel_tyPe reaP_number |
|---|---|---|---|
| rep. | 8 | 4 | 2 |
| d.f. | 8 | 8 | 8 |
| e.s.e. | 1.73 | 2.44 | 3.46 |

**Standard errors of differences of means**

| Table | fuel_tyPe | reaP_number | fuel_tyPe reaP_number |
|---|---|---|---|
| rep. | 8 | 4 | 2 |
| d.f. | 8 | 8 | 8 |
| s.e.d. | 2.44 | 3.46 | 4.89 |

**Least significant differences of means (5% level)**

| Table | fuel_tyPe | reaP_number | fuel_tyPe reaP_number |
|---|---|---|---|
| rep. | 8 | 4 | 2 |
| d.f. | 8 | 8 | 8 |
| l.s.d. | 5.63 | 7.97 | 11.27 |

Stratum standard errors and coefficients of variation

Variate: quality_of_tobacco_as_%

| d.f. | s.e. | cv% |
| --- | --- | --- |
| 8 | 4.89 | 6.5 |

**Analysis of variance**

Variate: Returns_of_tobacco_USD

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| fuel_tyPe | 1 | 5715805. | 5715805. | 83.24 | <.001 |
| reaP_number | 3 | 618094. | 206031. | 3.00 | 0.095 |
| fuel_tyPe.reaP_number | 3 | 522176. | 174059. | 2.53 | 0.130 |
| Residual | 8 | 549362. | 68670. | | |
| Total | 15 | 7405438. | | | |

**Information summary**

All terms orthogonal, none aliased.

**Tables of means**

Variate: Returns_of_tobacco_USD

Grand mean 1839.

| fuel_tyPe | 1wood | 2caol |
|---|---|---|
| | 1241. | 2436. |

| reaP_number | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| | 1639. | 1660. | 2104. | 1951. |

| fuel_tyPe | reaP_number | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| 1coal | | 1104. | 766. | 1699. | 1395. |
| 2wood | | 2174. | 2554. | 2509. | 2507. |

**Standard errors of means**

| Table | fuel_tyPe | reaP_number | fuel_tyPe reaP_number |
|---|---|---|---|
| rep. | 8 | 4 | 2 |
| d.f. | 8 | 8 | 8 |
| e.s.e. | 92.6 | 131.0 | 185.3 |

**Standard errors of differences of means**

| Table | fuel_tyPe | reaP_number | fuel_tyPe reaP_number |
|---|---|---|---|
| rep. | 8 | 4 | 2 |
| d.f. | 8 | 8 | 8 |
| s.e.d. | 131.0 | 185.3 | 262.1 |

**Least significant differences of means (5% level)**

| Table | fuel_tyPe | reaP_number | fuel_tyPe reaP_number |
|---|---|---|---|
| rep. | 8 | 4 | 2 |
| d.f. | 8 | 8 | 8 |
| l.s.d. | 302.1 | 427.3 | 604.3 |

**Stratum standard errors and coefficients of variation**

Variate: Returns_of_tobacco_USD

| d.f. | s.e. | cv% |
| --- | --- | --- |
| 8 | 262.1 | 14.3 |