OCCURRENCE AND INTENSITY OF SURFACE AND END CHECKS IN AIR SEASONED *Eucalyptus grandis* AND HYBRID CLONES

BY

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OCTOBER, 2019

DECLARATION

I, **Nankya Doreen Mirembe** declare that this research work is my original work and has never been submitted to any institution or University for any academic award

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Signature: ………………………… Date…18th. OCTOBER. 2019..

APPROVAL

This work has been compiled and submitted with the approval of my supervisor

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Signature: Paul Mugabi……… Date…21/10/19……

DEDICATION

I dedicate this work to the Almighty God for the diligence and wisdom during the course of this study. I also dedicate it to my parents and classmates who financially and morally supported me in this academic career

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LIST OF ACRONYMS

NFC	-	New Forests Company
m	-	meter
mm	-	millimeter

ABSTRACT

Splits and checks are the most limiting factor affecting pole treatment plants in Uganda. These are attributed to the seasoning methods and conditions poles are attributed to. Since losses caused by surface checks and end splits in air seasoned eucalyptus can be prevented if correct measures are taken in the rightful time to cub their formation, the study was carried out to assess occurrence and intensity of surface splits and end checks in *Eucalyptus grandis* and hybrid cones' poles New Forests Company pole treatment plant. The objectives were to determine the average surface check lengths and counts in *E. grandis* and in hybrid clones; to determine the average end check length in *E. grandis* and in hybrid clones as well as to assess the average end check depth in *E. grandis* and in hybrid clones . A total 40 *Eucalyptus* poles were obtained from 2 stacks of rejected poles. One stack contained *E. grandis* poles and the other GU7 rejects. 20 poles were randomly selected from each stack of rejects. The length of the surface and end checks was measured using a measuring tape while surface check count was taken by counting. End check depth was measured with the help of a metallic wire inserted into the check, the wire was drawn out and depth measured with a tape measure. Results showed that GU 7 splits more than *Eucalyptus grandis* with greater values of surface check length, end check length and depth. However GU 7 had fewer surface checks than *Eucalyptus grandis.* It was recommended that use of anti-split plates, girdling with wires and filling of splits with wax emulsion could be possible ways of reducing occurrence of splits in pole treatment facilities.

CHAPTER ONE: INTRODUCTION

1.1 Background

Splits and cracks in wood can be defined as ruptures or separations in the grain of the wood reducing the quality as measured by appearance, strength, or utility (Lamb, 1992). Splits and cracks caused by drying extend across one or more growth rings whereas many other ruptures extend parallel to the growth ring. Splits are directly attributed to these factors; differential shrinkage, growth rate of tree, site and silvicultural practices on tree taper, tree species therefore making them heritable and lastly growth stresses (Forrester *et al.*, 2013).

For the case of seasoned poles, splitting and end checking is attributed to; differential shrinkage where shrinkage occurs two times as much across the rings tangentially as compared to along the growth rings radially. This results into unbalances stresses that bring about check development. According to Shore, 1960 Surface fibers reach fiber saturation and begin shrinkage while the deeper layers are still wet. This results into tension of stresses that exceed the strength of the wood fibers resulting into a surface check (Shore, 1960). Similarly, since wood dries many times faster along the end grain than across, end checking occurs a few inches of the poles, high circumferential stresses are generated and hence the tendency for logs to develop radial split (Schaffner, 1981).

Eucalyptus are the most widely planted exotic hardwoods in the tropics and sub- tropics, because of their adaptability and utility (Hardie & Wood, 2019). High levels of growth stress in South African eucalypts are undoubtedly the most serious growth phenomenon affecting wood quality, product yield and product dimensions (Malan, 1995).

Splitting and end checking in *Eucalyptus* poles are mainly caused by drying stresses that develop during seasoning before the poles are subjected to chemical treatment. These stresses develop as a result of differential shrinkage in the radial and tangential dimensions, drying of the outer surface when the inner part of the pole is still wet, as well as from the pole ends when the middle is still wet (Anthony & Destefano, 2018).

Surface checks and end splits are drying related defects that occur during the drying of the poles and according to (Chudnoff, 1980), during the drying of heavy Eucalyptus poles, the stresses developed in the surface layers are far higher than thinner members and collapsing is accompanied by severe surface checking and end splitting. These defects can also be caused by the poor handling of the poles mostly during loading and offloading of these poles during which they are dropped, banged and in other ways damaged. These damages look like splits and surface checks in the grain of the wood.

Most pole treating companies in Uganda treat *Eucalyptus* Poles for utility purposes. New Forests Company (NFC) deals in procurement of mostly *eucalyptus* poles of different species and sizes, treats them with CCA preservative and dispatches to different governmental and non-governmental agencies. Since currently most pole treatment enterprises are facing a problem of continued pole splitting and end checking during seasoning, this study assessed the susceptibility of splitting and end checking in *Eucalyptus grandis* and GU7 in order to determine the less susceptible species that should be recommended in order to reduce losses incurred as a result of rejection of poles.

1.2 Problem statement

Frequent premature failures of treated poles in service have been reported in different parts of the Uganda leading to financial losses and risking lives in the case of electric transmission lines. This has raised questions regarding the wood material used, suitability of the preservative chemicals, and the methods of treatment (Mugabi & Thembo, 2018).

Poles are seen to develop end splits and surface checks at the seasoning stage of pole treatment as well as during in-service time line making it the predominant challenge to all pole treatment companies (Butler, 2018; Malan, 1995).

Pole splitting lowers wood quality especially for electricity transmission poles, through reducing pole strength and capacity of the wood fibers to retain the chemical after pole treatment (Gezer, Temiz, & Yüksek, 2015). Occurrence of many split and cracked poles leads to their rejection for treatment, which in return brings about losses to the pole treatment plant due to the loss of the initial and maintenance costs previously incurred. This study therefore aimed at assessing the occurrence of splits and surface checks in *Eucalyptus grandis* and GU7 in order to suggest possible ways of how defects can be minimized during utilization

1.3 Objectives

1.3.1 General Objective

- The main objective of the study was to determine the extent of splitting and end checking in *Eucalyptus grandis* and the hybrid, GU7.

1.3.2 Specific objectives

- To determine the average surface check lengths and counts in *E. grandis* and in GU7.
- To determine the average end check length in *E. grandis* and in GU7.
- To assess the average end check depth in *E. grandis* and in GU7.

1.4 Significance of the study

The study will generate information on the intensity of splitting in the different eucalyptus species. The study will also avail the treatment plant with information regarding the different measures that can be taken to overcome the problem of pole splitting and checking. This would therefore enable pole treatment plants minimize the losses they incur on rejected poles.

1.5 Scope of the study

This focused on splitting extents in *E. grandis* and GU7 poles at New Forest Company located in Mityana District.

CHAPTER TWO: LITERATURE REVIEW:

2.1 Wood seasoning

Seasoning is the removal of moisture from wood (Eckeiman, 1997). The principal objective of seasoning wood is to improve its suitability for the purpose for which it is intended. Drying wood enhances; dimensional stability, improves tensile strength and weight reduction, reduces the likelihood of staining, insect attack and decaying, successful preservative treatment, glue application, stronger joints with fasteners, better machining properties and better thermal and electrical insulation (Bergman, 2010).

When a tree is cut down it contains 50% of its weight in water as both free water and bound water. Free water in cell cavities is lost first as wood dries till fiber saturation point is reached about 25-30%. Bound water requires more energy because it is difficult to be removed as it is found within cell walls; therefore it majorly affects the physical and mechanical properties of wood such as quality (Kettula, 2015).

Better seasoning practice will reduce seasoning losses, decrease the drain on our forests, and give to the consumer material that is better suited to his needs (Mathewson, 1930). Proper methods of wood seasoning modify inherent properties of wood. These methods include air seasoning, and kiln drying.

2.1.1 Air seasoning.

In air drying poles are stacked with stickers in between to allow even distribution of air and drying is done by sunshine. The advantage of air seasoning over kiln is that it is relatively cheaper and covers a larger stock.

2.1.2 Kiln drying.

In kiln drying the process is controlled so that grade can be maintained, and moisture content of the dried product held to the needs of the product being fabricated. Heat supplies are used, and wood is placed inside the kiln. Here stacks can either be end-piled, cross-piled, or vertical-piled (Bergman, 2010). The advantage of kiln drying over air is that it is less time consuming and gives uniform results. The different types of kilns include ceramic kilns, metal clay kilns and glass kilns. These use different heat supplies the most prominent being electric kilns due to their ease of use, consistent results, low cost, and low emissions. Wood and gas fired kilns are also used by advanced artists and industry.

There are factors based on which a seasoning method is preferred and these include; minimum depreciation of stock, rapid rate of drying, low and uniform moisture content, economy in operating cost, and low investment cost (Mathewson, 1930). Other considerations to be considered individually include; wood specie, grade, size of stock and variations in the weather.

In terms of variations in weather, a site with continuous rainfall affects wood seasoning progress considering wood's hygroscopic nature.

2.2 Overview of splitting and end checking in wood

There are four categories of splits and cracks in wood: Resource Based, Processing Based, Changing Moisture Content Based, Use based (Lamb, 1992). Therefore, it is important to properly identify the cause of the splits and cracks as it is a critical issue to consider when coming to an appropriate corrective action that will actually solve the problem. The wrong diagnosis insures a wrong course of action and thus, a continuation of the problem.

Changing moisture content-based category being the case during pole seasoning is attributed to differential shrinkage that is expressed in different scenarios explained below;

During pole drying the surface dries much faster than the core leading to restrained surface shrinkage by the not yet dried core and this results into stress formation in wood that are relieved through check formation (Anthony & Destefano, 2018).

Cracks and splits that occur at the end of the pole are known as end checks (Armstrong & Hall, 1982). End checking is also due to differential shrinkage where the ends dry first, and tend to shrink but are restrained by the swollen core that has not reached fiber saturation point. The stresses are relieved through check formation and may eventually run the full length of the pole.

Wood shrinks roughly twice as much along the growth rings (radially) as it does across the rings (tangentially) resulting into unbalances stresses that bring about check development (Grohman, Knaggs, & Baso, 2009). Different factors can explain this observation: the cell arrangement of tissues, the difference between early wood and latewood, and the presence of ray cells. High circumferential stresses are generated and hence the tendency for logs to develop radial splits.

2.3 Eucalyptus species

Most hardwoods like *Eucalyptus* require more controlled drying schedules than softwoods that can tolerate harsh seasoning conditions (Kettula, 2015). The eucalypts are the most widely planted exotic hardwoods in the tropics and sub- tropics, because of their adaptability and utility (Hardie & Wood, 2019). *Eucalyptus* species have high shrinkage and low mass diffusivity making their material extremely difficult to season without degrade (Vermaas, 1995). Typical features are collapse, surface checking, high shrinkage, steep moisture gradients and pronounced drying stresses. Most *eucalyptus* species have mean basic densities of 500 - 800 kg.m-3 and are relatively impermeable and difficult to season. At moisture contents above fiber saturation point, they show an increasing tendency to check and collapse with rise in temperatures.

2.4 Factors affecting intensity of splits and cracks formation

In addition to the factors causing splitting and checking, there are other factors influencing amount or intensity of shrinkage and checking that will occur in a pole. The intensity of checking and splitting is attributed to; species, density, sapwood heartwood proportion, size and shape of wood, round or sawn timber, time of cutting, method of piling, yard site, and climatic conditions.

2.4.1 Effect of species on splitting intensity

Species have an important bearing upon the amount of moisture contained in a tree. Differences among species are large, therefore those with higher the moisture content will bring about increased difficulty to season wood without degrade. This also is backed up by the fact that different species have different shrinkage values.

2.4.2 Effect of size on splitting intensity

As trees grow, there is a reduction in sapwood proportion due to more depositions accumulating to form heartwood. Sapwood being the one with live cells and where growth takes place makes it more prone to growth stress development and eventually shrinkage during drying. The water in the sapwood proportion is lost and this shrinkage of cells is the reason for splitting and end checking especially when it occurs unevenly in the pole.

Mature trees have less sapwood and high density implying that there is less moisture to give up during drying which is the case for 12m poles as compared to 10m poles.

2.4.3 Effect of diameter on splitting

Butt logs ordinarily have higher moisture content than top logs (Mathewson, 1930). This explains why pole splitting and end checking mostly occur at the butt end and not the top end. However, variation in bottom diameter therefore has an effect on intensity of end checking because more mature poles have lesser sapwood compare to less mature poles.

2.4.4 Other factors that can influence the intensity of splitting in wood

Site and silvicultural practices also have a great impact on growth stress development in a tree. Live pruning increases growth stress levels as well as good quality sites. Stress accumulation in these trees is a resultant cause of pole splitting later during drying.

According to Malan (1995), a good quality site has twice as much effect on splitting of wood as compared to a poor quality site. This is because trees will grow much faster without good compaction of cells hence having fuzzy grain or weak grains that split easily when exposed to any external forces. A good site also results into trees of higher moisture content that has to be driven off during seasoning.

Shrinkage is also greatly affected by temperature. High temperatures result into rapid drying hence increasing shrinkage rate in a pole. Rapid shrinkage results into stress formations that are released through check formations (Kettula, 2015).Low humidity and exposure to direct sunlight favor the development of surface and end checks, which is the case for air seasoning conditions (Shore, 1960).

2.5 Ways of overcoming splits and cracks

End checking is one of the easiest drying losses to control because it is inexpensive and yet usually overlooked even when the costs of preventing it are returned, increasing profitability by thousands of dollars (Murray, 1993). Currently, the most effective way to prevent end checking is by sealing the ends of the poles with the heavy water-based wax emulsion sealers, applying anti split plates, using Aluminum pigment in latex, hardened gloss oils and using wires for girdling the poles.

2.5.1 Water-based wax emulsion sealers

According to Murray (1993), wax emulsion treatment, have the lowest cost and the second highest effectiveness and appear to be the most practical treatment tested. They are nonhazardous and relatively easy to use.

2.5.2 Anti split plates

These are circular plates that efficiently cover the pole ends and also serve the identification purpose if written on. They have round edges and therefore cannot cause damage. They have teeth that are hammered into the pole thus cannot easily be easily ripped off accidentally.

2.5.3 Wires for pole girdling

Wires are fastened around the end of the poles, slightly away from the faces depending on the intensity of the splits present. The binding is done using nails so as to grip the wire firmly onto the pole hence preventing further elongation of the splits.

2.5.4 Controlled Air seasoning

Shade should be provided especially during air seasoning to cub the effects of weather changes for example during a rainy season, hygroscopic nature of wood keeps fluctuating the moisture content leading to differential shrinkage.

2.6 Why cracks need to be sealed

Cracks can be end checks or surface checks depending on where they are formed. End checks occur on the end grain surfaces and run inwards from the butt face. These are very dangerous and can run deep as far as the length of a whole pole. Surface checks on the other hand are formed on the pole surface usually along the grain direction.

Checks have many shortcomings to the poles and owner. Poles with checks have reduced tensile strength, reduced physical quality and low capacity to hold chemical after treatment. The owner incurs extra costs of maintenance and losses in case the poles are severely damaged.

Checks facing upward collect water and this eventually increase the moisture content of the pole. Continued collection of water can result into decay, and insect infestations. This is mostly the case for surface checks.

CHAPTER THREE: METHODOLOGY

3.1 STUDY AREA.

This study was carried out from New Forests Company pole treatment plant in Mityana. It specializes in treatment and supplying of transmission pole across East and Southern Africa.

3.2 Research design

Experimental design that involved complete randomization and the parameters were exposed to the same condition. The parameters of this study were end check length and depth and surface check count and length. The variable of the study was the tree species i.e. *Eucalyptus grandis* and hybrid clone (GU7).

3.3 Sample size

A total of 40 debarked, dried rejects of *Eucalyptus* poles were used in this study. 20 poles of *grandis* and GU7 each were used for measurements.

3.4 Data collection

Twenty dried poles for both *Eucalyptus grandis* and GU7 were randomly selected from a stack of rejects and assessed for; surface check length and count and end check length and depth as explained below. Randomization was achieved by giving numbers to the poles which were written on small papers, 20 papers were randomly selected after raffling and selected numbers were the constituents of the sample.

3.4.1 Surface checks length and count

The length of all visible, individual surface checks $\geq$ 2mm in width were measured using a measuring tape and the average surface check length was then computed for both species. The most prominent cracks were considered, counted and their number recorded.

3.4.2 End checks length and depth.

The lengths of all visible individual end checks were measured using a measuring tape and the average value computed. The end check depth was measured using a ruler and an improvised depth gauge which would be inserted into the check at its extreme end and mark the part that touches the pole surface. The gauge would then be placed against the ruler to measure the marked part for depth and the average value for the end check depth was computed.

3.5 Data analysis

Data about surface check length and count, end check length and depth was analyzed and presented in form of tables. Analysis of Variance (ANOVA) to compare means of surface check length and count, end check length and depth between Eucalyptus grandis and GU 7.

Data collected was analyzed using SPSS, the quantitative data was represented using tables and a t-test was run to compare the occurrence of splits and checks in *Eucalyptus grandis* and GU7 poles.

CHAPTER FOUR: RESULTS

4.1 Surface check length and count of *Eucalyptus grandis* and GU7 poles.

From the data collected *Eucalyptus grandis* poles had a higher average surface check count (67) compared to GU7 which instead had higher average surface length (0.4m).

Table 1: Surface check length and count of Eucalyptus grandis and GU7.

	Average values for measurements taken.		
Species	**Surface check length (m)**	**Surface check count (checks above 12.5mm width)**	**p-value (surface check length)**
Eucalyptus grandis	0.20	6.5	0.000*
GU7	0.36	4.5	0.000*

*. The mean difference is significant at the 0.05 level.

Table 1 also shows that there was a significant difference (p=0.000) in surface check length between *Eucalyptus grandis* and GU 7 whereas there was no significant difference (p=2.170) in surface check count between the two species.

4.2 End check length of Eucalyptus grandis and GU7 poles.

The average length of surface checks in *Eucalyptus grandis* poles was less than that of GU7 poles with 0.20 m and 0.36 m respectively (Table 2). There was a significant difference (p=0.000) in end check length between Eucalyptus grandis and GU 7.

Table 2. End check length of Eucalyptus grandis and GU7 poles

	Average values for measurements taken.	
Species	**End check length (m)**	**p-value**
Eucalyptus grandis	0.2598	0.000*
GU7	0.4496	0.000*

*. The mean difference is significant at the 0.05 level.

4.3 End check depth of Eucalyptus grandis and GU7 poles.

The average end check depth of GU7 poles was also considerably higher than that of *Eucalyptus grandis* poles with 0.160 m and 0.2142 m respectively (Table 3). There was no significant difference (p=0.081) in end check depth between *Eucalyptus grandis* and GU7 poles.

CHAPTER FIVE: DISCUSSION OF RESULTS

5.1 Surface check length and count of *Eucalyptus grandis* and GU7 poles.

From the data collected, *Eucalyptus grandis* poles had a higher average surface check count compared to GU7 which instead had higher average surface length. The longer surface checks exhibited by GU 7 poles could be due to the weaker wood fibers that easily split wider apart in clones than in *Eucalyptus grandis.* According to Turinawe, Mugabi and Tweheyo (2014), clones have superior volume increment per unit time and moderate cleavage resistance values. These clonal attributes facilitate greater splitting in clones than in *Eucalyptus grandis.*

5.2 End check length of *Eucalyptus grandis* and GU7 poles.

The average length of surface checks in *Eucalyptus grandis* poles was less than that of GU7 poles with 0.2018 m and 0.3592 m respectively. This could be due to the differences in age at which the two species were harvest for utilization, that is to say, younger trees (GU 7) versus older trees of *Eucalyptus grandis. Eucalyptus grandis* poles are generally more mature as compared to GU7 poles due to the fact that they take long to reach maturity compared to GU7 poles. A more mature tree has less sapwood and more heartwood proportions due to the continued depositions of chemicals as compared to the younger tree. The higher the sapwood ratio the more prone a pole is to splitting and checking during seasoning since sapwood has the most moisture that is driven off as the pole dries. In the sapwood proportion is where growth cells exist hence there is accumulation of growth stresses that contribute to splitting. According to Travan, Allegretti and Negri (2010), it is these growth stresses which can induce later gradient stresses that mainly cause extensive splitting in younger poles.

5.3 End check depth of Eucalyptus grandis and GU7 poles.

The average end check depth of GU7 poles was also considerably higher than that of *Eucalyptus grandis* poles with 0.160 m and 0.2142 m respectively (Table 3). This could be due to the greater strength attributes in *Eucalyptus grandis* poles than in GU7 poles. Clones having for example having weaker cleavage resistance (Turinawe et al., 2014) may lead to initiation of deeper checks those in *Eucalyptus grandis*. Variation in strength attribute could be attributed to genetic differences and other localized site factors (Pima, Iddi, Chamshama, & Maguzu, 2018). Clones have superior volume increment per unit time due to faster growth (Turinawe et al., 2014), hence lower densities than the slow growing *Eucalyptus grandis* poles. Poles with a higher heart wood proportion have a higher density and they therefore have less moisture to drive off when drying whereas those with a higher sapwood proportion have a lower density and therefore have more moisture making them more prone to deeper surface and end checks. Therefore, GU7 poles are more prone to splitting and end checking as compared to *Eucalyptus grandis* poles.

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Generally, GU 7 splits more than *Eucalyptus grandis* with greater average values of surface check length. However GU 7 has fewer surface checks than *Eucalyptus grandis.*

GU 7 had longer and deeper end checks compared to *Eucalyptus grandis.*

6.2 Recommendations

For better management of checks and splits at New Forests Company and other pole treating plants, the following should be considered:

Selection of poles basing of species and age of trees should be adopted by pole treatment plants to reduce occurrence of splits.

Application of anti-split plates at the right time, that is prior to treatment process after cutting dried poles to size. This will prevent further penetration of the end checks deeper into the pole during pole handling and treatment process.

More research should be carried out to find out the effect of species on seasoning defects in order to provide a basis of creating new mitigation measures that are specie specific.

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