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Effectiveness of raw eucalypt pole pre-supply operations in reducing surface and end checking in electricity distribution poles in Uganda

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Abstract

Premature failure of utility poles is a significant problem in Uganda, leading to substantial financial losses, operational disruption and safety risks. Among several factors that cause premature failure, it is critical to note that, frequent development of drying defects such as surface checks and end splits compromise the mechanical strength and durability of the poles. This study sought to contribute to the durability of treated poles by evaluating the effectiveness of three different pre-seasoning interventions, pre-felling girdling, bark girdling post-felling, and foliage retention post-felling in reducing surface and end checks in *Eucalyptus grandis x camaldulensis*. A sample of 100 poles was divided into four groups – the control and three treatment groups "Treatment 1 – pre-felling girdling, Treatment 2 – bark girdling post-felling, and Treatment 3 – foliage retention post-felling". Over a period of five months, regular measurements of moisture content, check length, width, and depth were taken. The treatments were effective in reducing the number of checks compared to the control group. Specifically, Treatment 3 (foliage retention after felling) was the most effective in reducing check depth, with a mean of 60.60 mm compared to 74.83 mm for the control. Overall, the control group exhibited the highest values for check number, depth and width across all groups. Based on these findings, it is recommended that pole suppliers in Uganda adopt these practices to improve the durability of their products. Further research is necessary to explore the combined effects of these treatments and to determine the effective duration for girdling.

Key words: *Eucalyptus, Surface checks, End checks, Girdling*

1 Introduction

Until about fifteen years ago, *Eucalyptus grandis* from Ugandan government forests was the most commonly used for utility poles. Of late, poles are mainly sourced from private forests around the country, which predominantly grow the fast-growing hybrid clones (Mugabi & Thembo, 2018). These fast-growing trees of forest plantations possess growth stresses present in the living trees which are the main causes of end splitting and surface checking in logs (Moya & Tenorio, 2021. When a tree is felled, the growth stresses are released abruptly, causing the outer portions of the log to be under tension and the central portion to be in compression, with a neutral zone in between (Yasin and Raza,1992).

As wood loses moisture into the atmosphere, the rate of moisture loss influences the quality of wood in all species but is more pronounced in some than others (Muthike et al., 2022). Eucalyptus poles experience excessive surface and end checking at the time of treatment, with a possibility of widening and deepening after treatment (Otuko et al., 2024). These splits and checks are the most limiting factor affecting pole treatment plants in Uganda (Nakya,2019), leading to their frequent premature failures in service as reported from different parts of Uganda. This has led to financial losses and risking lives in the case of fallen electric transmission lines (Mugabi & Thembo, 2018).

Muthike et al. (2022) reported that keeping full foliage, i.e., top, branches and bark on felled trees for one-month, reduced surface checking in poles, while Yasin and Raza (1992) indicated that bark girdling of standing trees and girdling trees after felling, among other operations, released growth stresses slowly, thus reducing surface and end checking. However, none of these operations has been tried in Uganda despite the excessive checking the pole industry is faced with.

This study sought to contribute to the durability improvement of treated poles in service by assessing the effectiveness of three main pre-supply operations: pre-felling girdling, post-felling foliage retention and partial debarking with 1m retention in reducing surface and end checking that lowers the suitability of the poles, due to reduced strength.

2 Materials and methods

2.1 Pole Sampling

A total of 100 pole-size *Eucaluptus spps* trees were selected and divided into four sets of 25 each. Each set was subjected to one of the following treatments: Treatment 1, the bark was removed from the trunk of a standing tree, in the form of a ring at the butt end, and a slight cut was made into the cambium (Figure 1). Felling was delayed for 30 days. Treatment 2, the trees were felled, partially debarked up to 2m at the butt and branches removed, while the tops were left on for 30 days, after which the tops and the remaining bark were also removed (Figure 2). Treatment 3, these trees were felled and left with branches and tops (full foliage) as well as bark for 30 days, then the bark, branches and tops were removed (Figure 3). For the control, Treatment 4 trees were felled, debarked, and branches and tops removed, and cut to pole size immediately. After the treatments, all poles were cut to standard lengths and then stacked separately at a seasoning yard and dried to 25-28% moisture content (MC) at mid-length.

2.2 Pre-seasoning treatments



Figure 1: Girdling trees before felling (Treatment 1



Figure 2: Partial debarking after felling (Treatment 2)



Figure 3: Foliage retention after felling (Treatment 3)

2.3 Data collection

Using an electrical meter, the moisture content (MC) of each pole was measured and monitored at an interval of 15 days from the felling time until the poles attained an MC of (20-23) %. The lengths of all visible individual end checks were measured using a measuring tape and recorded. The end check depth was measured using a ruler and an improvised depth gauge, which was inserted into the check at its end to mark the part that touches the pole surface. The gauge was then placed against the ruler to measure the marked part for depth, and the end check depth was computed as deployed by Mugabi et al. (2010). Similarly, the lengths, widths and depths of all visible, individual surface checks greater than or equal to 2mm in width were measured at the widest point and recorded.

2.4 Data Analysis

Descriptive and inferential statistics were used to evaluate the effectiveness of pre-seasoning treatments in reducing end and surface checks. Means were used to summarise the data on check parameters (number, depth, length, width) and moisture content across treatments. Using the IBM SPSS statistical software, mixed ANOVA was used to test the effects of time and treatment on moisture content, revealing a significant time effect and treatment-time interaction. Tukey's HSD post-hoc tests compared the variation of check parameters between treatments at a 95% confidence level.

3 Results and Discussions

3.1 Check parameters and treatments

A one-way ANOVA demonstrated a statistically significant ($p \leq 0.001$) effect of treatment on check number, check depth and check length, with a non statistically significant ($p = 0.078$) effect on check width (Table 1).

Table 1: ANOVA between check parameters and treatment

Variable	Source of variation	Sum of Squares	d.f	Mean Square	F	Sig.
Check Number	Between Groups	102.512	3	34.171	27.221	.000
	Within Groups	937.722	747	1.255		
Check depth	Between Groups	29346.233	3	9782. 078	5.798	.001
	Within Groups	1267018.844	751	1687.109		
Check length	Between Groups	1053236.426	3	351078.809	8.022	.000
	Within Groups	32866897.359	751	43764.178		
Check						

Width	Between Groups	22.625	3	7.542	2.283	.078
	Within Groups	2447.308	741	3.303		

3.1.1 Check number and girdling.

The control group (Treatment 4) resulted in a significantly higher number of checks (2.69) compared to Treatment 1 (1.99), Treatment 2 (2.04), and Treatment 3 (1.74). This higher defect rate in the control is attributed to the abrupt release of growth stresses inherent in living hybrid eucalypt trees upon felling, a phenomenon widely documented by Mugabi (2007), Mugabi et al. (2011), and Moya and Tenorio (2021). A similar finding is observed with Treatment 2 (2.04) where only a limited amount of foliage (tops) was left on for 30 days before removing.

Pre-felling girdling (Treatment 1) disrupts physiological processes, causing the tree to slowly die and dry while still standing. This allows for a more uniform release and relaxation of internal growth stresses throughout the trunk rather than the rapid release seen in standing tension filled hybrid eucalyptus trees when felled. This aligns with the findings of Salah and Hakam (2014). Furthermore, Basri et al. (2015) emphasize that girdling reduces growth stresses and their gradients from the pith toward the bark, thereby lowering end checking.

Table 2: Variation of means of check parameters by Treatment

Parameter	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Check No	1.99	2.04	1.74	2.69
Check Depth (mm)	61.75	60.65	60.60	74.83
Check Length (mm)	280.00	194.50	298.25	375.97
Check Width (mm)	3.74	3.44	3.81	3.90

3.1.2 Check depth and foliage retention

The mean check depth for the control was extremely high at 74.83 mm, while Treatment 3 (foliage retention) recorded a significantly lower mean check depth of 60.60 mm ($p = 0.004$) and Treatment 1 recorded 61.75 mm ($p = 0.016$). As shown in Figure 5, Treatment 3 proved to be the most effective intervention for minimizing check depth.

These results support the findings of Muthike et al. (2022), who observed that retaining foliage (tops, branches, and bark) on felled trees results in lower check numbers and depths. Maintaining full foliage ensures that the wood loses initial moisture much more slowly, preventing rapid desiccation and reducing end splitting and surface checking.

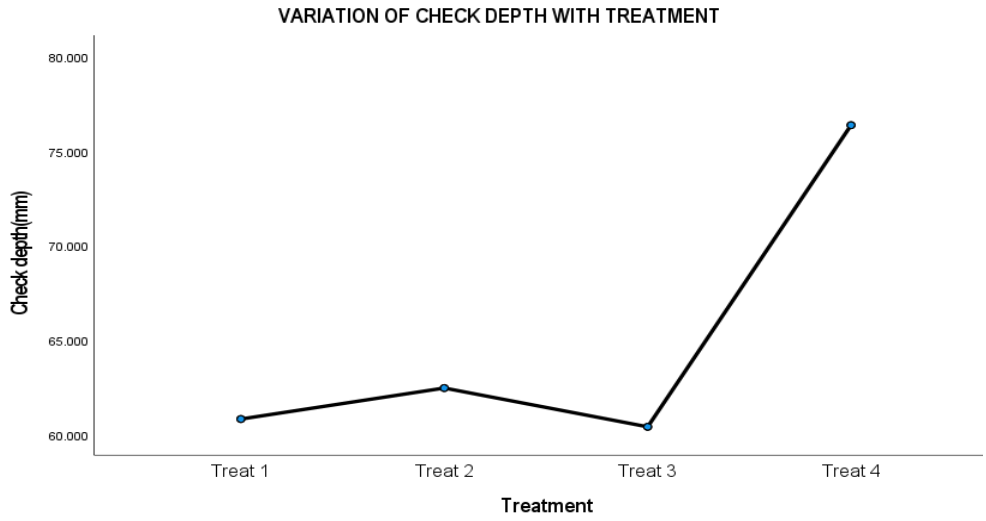


Figure 5: Variation of Check depth across different treatments

3.1.3 Check length and width

Tukey's HSD post-hoc tests indicated that the control group had a significantly greater check length (375.97 mm) compared to Treatment 1 (280.00 mm, $p < 0.001$), Treatment 2 (194.50 mm, $p < 0.001$), and Treatment 3 (298.25 mm, $p = 0.002$).

Although check widths remained almost the same across all treatments, ranging from 3.44 mm (Treatment 2) to 3.90 mm (Control), the absence of a statistically significant difference ($p = 0.078$) indicates that the width is less influenced by these specific pre supply interventions. Nonetheless, the substantial reductions in check depth and length across the treated groups reflect the relevance of the interventions in overall structural integrity, as wide checks cause the greatest threat to utility pole mechanical strength and durability.

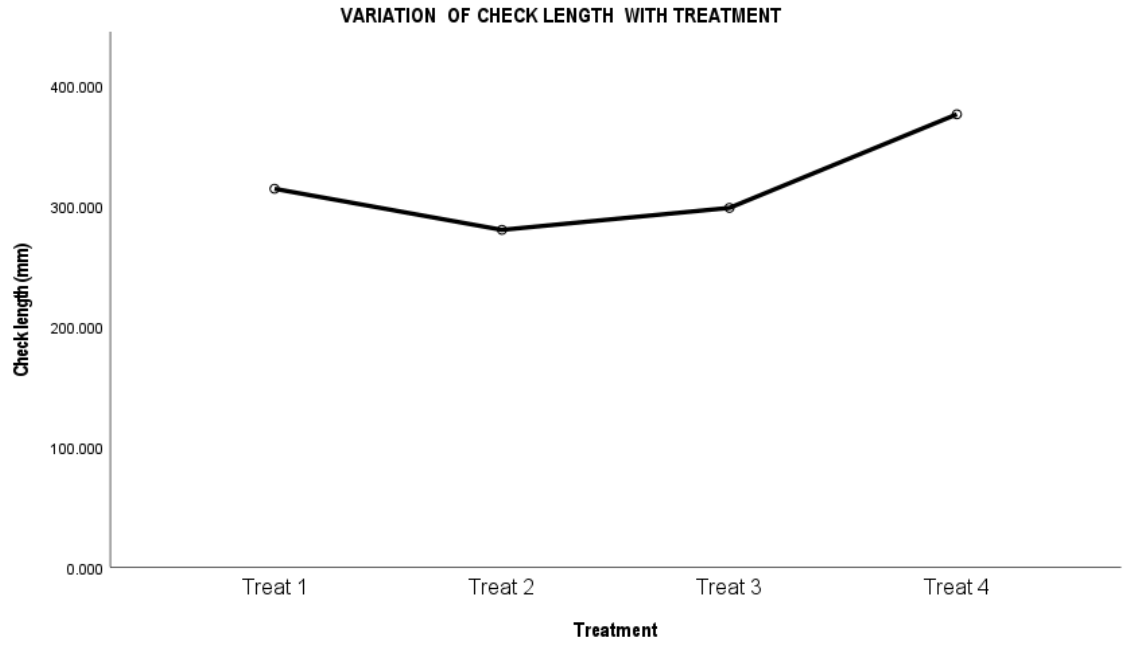


Figure 6: Variation of check length across treatments

3.2 Moisture Content

The mean moisture content across all four treatment groups decreased steadily over the seven measurement periods. The control group (Treatment 4) achieved the lowest mean moisture content by Period 7 at 28.96%, whereas trees girdled before felling (Treatment 1) recorded the highest at 31.00%.

A mixed ANOVA revealed a statistically significant ($p < 0.001$) effect of time on moisture content ($p < 0.001$) as well as a significant ($p < 0.001$) interaction between moisture content and treatment with a substantial effect size (Partial Eta Squared $\eta_p^2 = 0.147$). This indicates that the rate of moisture loss over time varied significantly across the treatments. The physical state of the tree whether standing girdled, partially debarked, or retaining foliage, fundamentally alters drying kinetics, allowing the wood structure to adjust to moisture changes with minimal rupture (Elustondo et al., 2023). By slowing down the drying rate, these interventions reduce the moisture difference between the heartwood core and sapwood outer layers, establishing a more uniform moisture distribution that reduces surface checking.

As shown in Figure 4, the mean moisture content for all four treatment groups decreased steadily over time. The drying rates differed between the treatments, with the control (Treatment 4) achieving the lowest mean moisture content by Period 7 (28.96%) compared to trees girdled before felling (Treatment 1), which had the highest (31.00%).

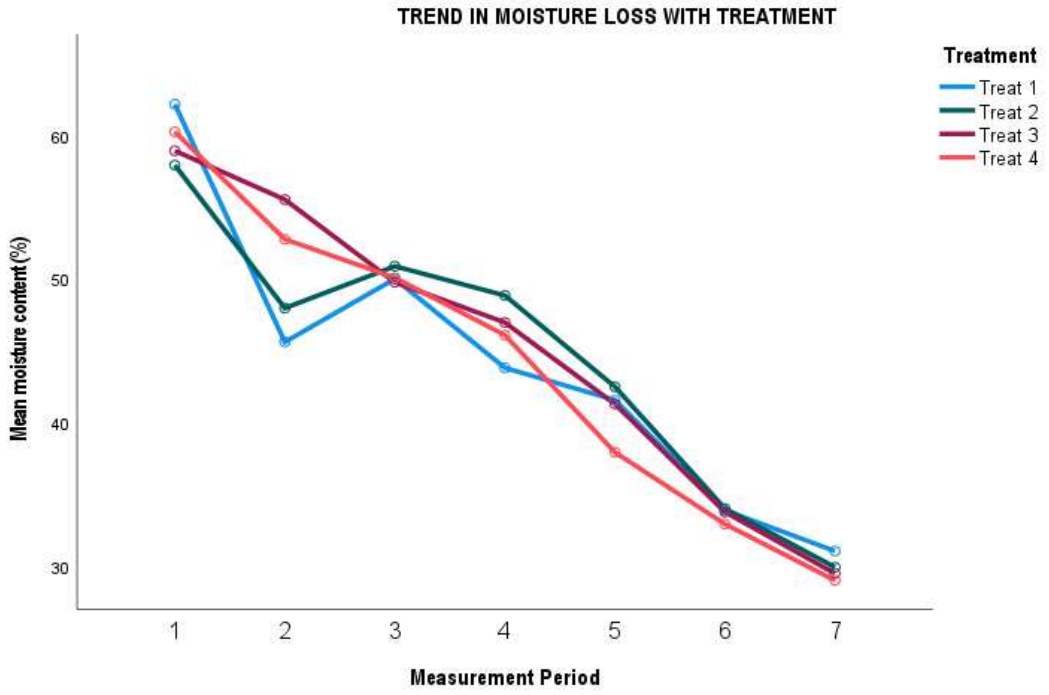


Figure 4: Changes in Moisture Content across treatments and periods of measurement.

4 Conclusion and Recommendations

This study has demonstrated that pre-supply operations significantly enhance the quality of utility poles by reducing surface and end checking. Specifically, retaining foliage post-felling proved to be the most effective intervention for minimizing check depth, while girdling and partial debarking also provided significant advantages over the immediate cutting of all foliage

post-felling. These methods collectively control the rate of moisture loss, which prevents the abrupt release of growth stresses and mitigates the development of severe drying defects.

Based on these results, it is recommended that electricity utility pole suppliers in Uganda adopt these low cost, pre-supply interventions to extend the service life of wooden infrastructure and reduce the financial losses associated with premature pole failure. Future research should focus on determining the optimal duration for these interventions, specifically testing different girdling and foliage retention timeframes, and assessing the long-term field performance of treated poles to quantify the total economic benefits of these practices.

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Declarations
Conflict of interest: There was no conflict of interest whatsoever.
Consent to publish: Consent is provided to publish this research
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Data availability statement
The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.
Plant guidelines: All plants were obtained according to national guidelines and were obtained from a licensed plantation farmer.

The research is not a clinical trial

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