

## DENSITY AND GROWTH RATE OF FIRE-AFFECTED AND NON-FIRE-AFFECTED *TECTONA GRANDIS* FROM FOREST SAVANNA TRANSITIONAL ZONE, GHANA

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### Abstract:

*Teak (Tectona grandis), globally valued for its strength, durability, and aesthetic qualities, is a major plantation species in Ghana, supporting rural livelihoods, artisanal industries, and the national economy. However, recurrent fire incidence, often linked to land management and farming practices, threatens teak growth and wood quality. This study assessed the effects of annual fire incidence on the growth and properties of teak within Ghana's Forest-Savanna Transition Zone. Six sample trees (three fire-affected and three non-fire-affected) were felled from the Akomadan plantation for comparative analysis. Discs from butt, middle, and top sections were prepared for density determination, diameter at breast height (DBH) measurement, and growth ring analysis following BS 373:1957 standards. Results revealed that fire significantly reduced wood density, particularly at the butt (-27–38%) and middle (-25%) sections, while the top was less affected (-2–10%). Fire-affected trees recorded lower DBH (23.7cm) compared to non-fire-affected trees (25.2cm), reflecting suppressed radial growth. Although age and number of growth rings were unchanged, fire-affected trees exhibited narrower ring widths, confirming reduced growth rates. These findings highlight fire's detrimental impact on teak growth, structural integrity, and timber value. Effective fire prevention and management strategies are therefore crucial to sustain teak productivity and protect Ghana's forestry sector.*

**Key words:** Diameter at breast height (DBH), Fire-affected teak wood, Growth rings, Non-fire-affected and Radial growth ring width.

### INTRODUCTION

Teak (*Tectona grandis*), is globally recognised for its durability, strength, and aesthetic qualities, making it a preferred timber for high-end applications including shipbuilding, railway construction, high-class furniture, veneers, flooring, decorative components, and utility poles (Kollet 2012; Idrees *et al.* 2021). Teak (*Tectona grandis*) is ranked among the top priority species for plantation establishment in over 20 countries due to its strength, durability, and aesthetic appeal (Brown *et al.* 2016; Dadzie *et al.* 2023). Teak industry employs thousands of Ghanaians in planting, harvesting, processing, and trade. Smallholder farmers and private investors grow teak for long-term income, integrating it into agroforestry systems. Teak-based industries support woodworkers, carpenters, and artisans, strengthening rural and urban economies (Anaman *et al.* 2024).

However, Fire, both as a land management tool and as a destructive force, is a frequent feature in Ghana's forestry landscape. Farming-related fire management practices and man-induced wildfires are widely acknowledged as significant threats to farming and plantation health, healthy forest ecosystems, biodiversity, soil quality and the destruction of canopy trees, among others (Amissah *et al.* 2010). Among the timber species most affected by annual fire incidence is teak (*Tectona grandis*), an exotic but highly valuable plantation species cultivated extensively across the country.

The practice of intentionally setting fires, often employed in land management, continues to elevate the risk of uncontrolled wildfires, posing a significant threat to teak (*Tectona grandis*) forests. Recent studies highlight that such fires, particularly in Ghana's savanna and forest transition zones, have intensified in frequency and severity due to shifting fire seasonality and land-use pressures (Leverhulme Centre for Wildfires & A Rocha Ghana 2025). Intentional burning of teak plantations, commonly undertaken by farmers for land clearing or hunting is often rooted in traditional beliefs about soil fertility and game movement. However, contemporary research shows that these fires inflict substantial physiological stress on teak trees, reducing growth rates and timber quality (Dahan & Kasei 2022). Moreover, the spread of uncontrolled fires contributes to biodiversity loss and environmental degradation, with satellite data revealing increased tree cover loss in fire-prone regions of Ghana (Global Forest Watch 2024). Sustainable fire management strategies now emphasize integrating indigenous fire knowledge with scientific approaches to mitigate these impacts and promote ecological resilience (Leverhulme Centre for Wildfires & A Rocha Ghana 2025; Dahan & Kasei 2022).

One of the most significant tree variables measured in forestry is diameter at breast height (DBH) (Corral-Rivas et al. 2007; Bueno-López & Bevilacqua 2013; Di Cosmo 2020). Alongside tree height, diameter at breast height (DBH) serves as a fundamental determinant of tree volume, making its accurate and consistent measurement essential for reliable forest monitoring and the advancement of sustainable management practices (Daehak-ro 2019). Growth rings of trees are essential to comprehend events like fire, insect attack, climate change and so forth that happened in the past. The study of this science is known as dendrochronology (Deepak et al. 2010). Ring width, which reflects radial growth driven by vascular cambial activity, remains a widely accepted proxy for assessing tree growth rate. Recent studies confirm that tree-ring boundaries and width variations are closely linked to seasonal cambial dormancy and environmental conditions, offering reliable insights into species-specific growth dynamics (Williams-Linera et al. 2025). The widespread planting of teak is driven by the rising global demand for its durable, high-quality timber. To ensure the sustained production of superior teak wood and the implementation of effective forest management practices, it is crucial to understand the ecological, silvicultural, and market variables influencing teak growth. Recent assessments emphasize the importance of site selection, genetic improvement, and adaptive silviculture in optimizing yield and maintaining long-term sustainability in teak plantations (IUFRO 2022).

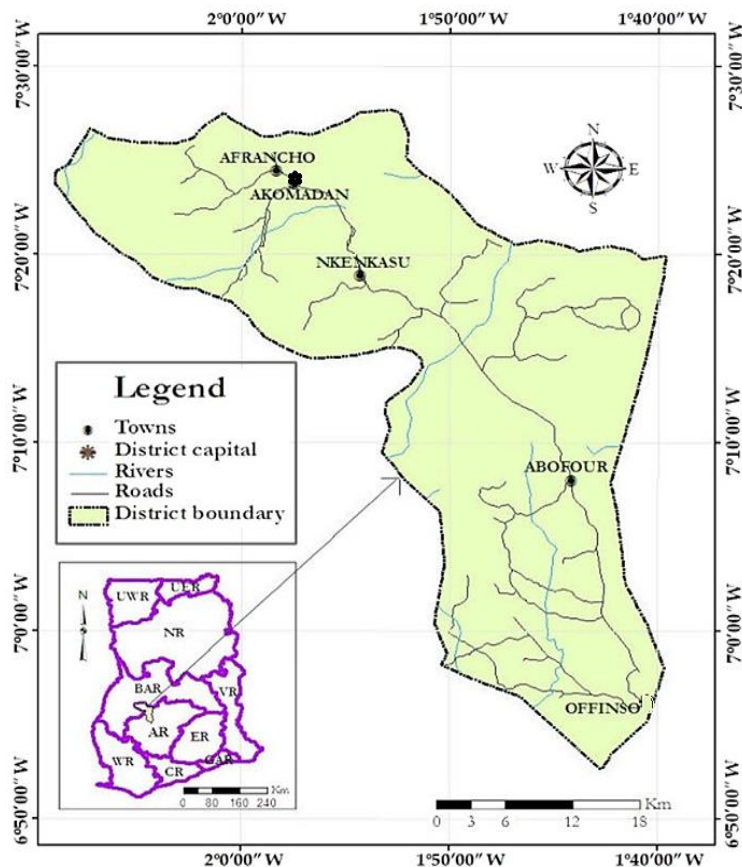
However, previous research has shown that when wood is exposed to a source of heat, its reaction to fire is revealed (Sanned et al. 2023). Several researchers have investigated the impact of fire on the growth rate of trees. Scherer *et al.* (2016) conducted a study on Long-term impacts of prescribed fire on stand structure, growth, mortality, and individual tree vigor in *Pinus resinosa* forests. Seifert et al. (2017) examined the effect of surface fire on the tree ring growth of *Pinus radiata* trees. Long-term effects of prescribed fire and thinning on residual tree growth in mixed-oak forests of southern Ohio (Anning *et al.* 2013). A 350-year tree-ring fire record from Białowieża Primeval Forest, Poland: Implications for Central European lowland fire history (Niklasson *et al.* 2010).

Despite the extensive body of research on the impact of fire on various tree species, a comparative analysis of the impact of annual fire incidence on teak growth rates has not been reported yet. Hence, the primary objective of this study is to conduct a comparative analysis of the impact of annual fire incidence on the teak growth rate of fire-affected and non-fire-affected teak timber from Ghana. This is aimed at understanding how fire influences the growth rate, such as diameter at breast height (DBH) and annual growth rings of teak wood, for sustainable forest management and timber production.

## **MATERIALS AND METHODS**

Six (6) teak sample trees were purposefully selected from the Akomodan teak plantation and they were made up of three (3) fire-affected and three (3) non-fire-affected trees located at (GPS: 7.32589, -2.0551) <http://maps.google.com/maps?q=7.32591%2C-2.05528> and (GPS: 7.32216, -2.04439) <http://maps.google.com/maps?q=7.32216%2C-2.04439>, respectively. The **Akomodan teak plantation** is located in the **Forest-Savanna Transition Zone (FSTZ)** of Ghana (Fig. 1). The study area falls within a transitional landscape comprising both forest and savanna ecosystems, characterised by scattered trees, patches of closed forest, and extensive grassland cover. The climatic conditions of this zone, marked by distinct wet and dry seasons, are highly suitable for teak cultivation, as the species thrives under such seasonal variations (Hapsari 2010). Furthermore, the ecological transition provides relatively fertile soils and favourable environmental conditions that enhance sustainable teak growth and development (Owusu 2019).

Fire-affected samples were attained from teak tree stands visible to fire events within the last 1-4 years. Non-fire-affected samples were obtained from similar-aged trees in nearby unaffected stands to guarantee consistency.



**Fig. 1.**  
**Map indicating the sample collection plot.**

**Temperature of fire and duration of teak plantation.**

Almost every year, there are forest or plantation fires, especially in the Akomadan plantation forest, which occurs from January to March. Fire always devoured not less than 20 hectares of the Akomadan teak plantation forest area. Data was collected on the temperature of the fire and the duration of the teak plantation. The highest maximum temperature recorded was between 145°C (15 minutes, 17 seconds) and 198°C (39 minutes, 21 seconds), consistent with plantation forest fire temperatures measured by others of 33°C (91°F) in a natural plot.



**Fig. 2.**  
**Evaluation of the temperature of fire and duration with Analog thermometer.**

### Sample Preparation

The harvested trees were divided into three unequal parts: butt, middle and top, from which a disc was obtained from each section (butt, middle and top) with an average diameter at breast height (DBH) range of 22.10cm - 25.16cm for the six sample teak trees. Eighteen (18) billets of 91.44cm in length were selected and for each billet, three (3) mini boards (sawn planks) were extracted, giving a total of two hundred and sixteen (216) sawn planks. One of every three boards (50mm) was kept in polythene bags to prevent changes in moisture content for basic density assessment.



**Fig. 3.**  
**Teak Tree Disc.**

### Density Assessment

Assessment of the density of fire-affected and non-fire-affected *T. grandis* specimens was done in accordance with the British Standards of testing materials, BS 373:1957. Specimens for basic density were prepared accordingly, using 20 specimens from each tree with geometrical properties of 20 × 20 × 20mm cubes, resulting in a total of 160 cubes.

To determine the basic density, specimens were oven-dried and conditioned to 20°C and 65% relative humidity for 120 days to reach a moisture content of approximately 12%. Masses and dimensions of the specimens at 12% MC were used to calculate their oven-dried density values. The volumes of the samples were calculated based on their dimensions after the samples were oven-dried. Thus, the basic density of the specimens was based on oven-dried mass divided by saturated volume, using Equation 1.

$$\text{Density } (\rho) = \frac{\text{Mass } (m)}{\text{Volume } (v)} \text{ (kg/m}^3\text{)}$$



**Fig. 4.**  
**Density determination.**

### Sample preparation for DBH and growth rings.

A tape measure was used to measure the circumference at breast height (CBH) of the selected sample trees (25 each of FA and NFA), at 130cm height (Fig. 3-6). The values recorded were calculated to

determine the average diameter at breast height (DBH) of the FA and NFA trees. The diameter was calculated using this formula:

$$D = \frac{C}{\pi}$$

were: D = diameter of the tree disc, C = circumference (same units as desired for D),  $\pi = 3.1416$ .



Fig. 5.  
Sample tree diameter determination of DBH.

### Evaluation of growth rings

Each sample disk was planned using Stanley jack plan and sanded to smoothness using sanding grits of sizes P60, P80 and P180, making the heartwood layer easily distinct from that of the sapwood to observe the growth rings better. The growth rings were visually identified with the aid of an image J. Rings were marked along a linear section that goes across the pith, avoiding reaction wood areas. False rings were excluded. Ring width was measured using a travelling microscope to an accuracy of 0.01 cm image J. The percentage of each wood type was evaluated using a measuring steel rule, and then computered (Fig. 5).



Fig. 6.  
Evaluation of heartwood and sapwood of teak.

## RESULT AND DISCUSSION

Wood is a combustible and hygroscopic material, making it highly susceptible to fire exposure. One of the critical factors determining the extent of fire damage in wood is fire permeability, which refers to the rate at which fire penetrates the wood structure. Fire permeability significantly influences the growth rate, including diameter at breast height (DBH) and annual growth rings. Understanding these effects is essential for evaluating fire resistance, structural integrity, and post-fire utilization of wood materials.

### Density

Studies on **teak (*Tectona grandis*) wood density** has shown that **basic density varies along the height of the tree**. Typically, the density increases from the bottom to the middle and decreases slightly toward the top (Cordero *et al.* 2003; Berrocal *et al.* 2020; Miranda *et al.* 2011). These results were manifested in the current study as indicated in Table 1.

Table 1

**Comparison of teak wood basic density at different stem heights (non-fire-affected vs fire-affected)**

Teak specimens		Density (kg/m <sup>3</sup> )			
		Non-fire-affected	Stdev	Fire-affected	Stdev
<b>Teak Group 1</b>	Butt	621.37	19.39	387.41	22.56
	Middle	594.08	23.77	375.92	37.08
	Top	545.49	14.21	496.77	15.74
<b>Teak Group 2</b>	Butt	569.17	18.18	414.23	52.82
	Middle	547.64	16.01	528.97	44.91
	Top	520.29	19.73	511.11	15.44
<b>Teak Group 3</b>	Butt	669.53	18.69	487.37	67.83
	Middle	647.74	15.53	502.28	54.71
	Top	598.95	10.11	541.46	23.36
<b>Average</b>		590.47	17.29	471.72	37.16

Legend: 6 teak trees were selected and felled for the study.  
Each TG = 1 non-fire-affected and 1 fire-affected for easy comparison.

Teak wood exhibits the typical density distribution pattern, with the highest density observed at the butt, moderate values at the middle, and the lowest density at the top. For all specimens examined (Teak G1, Teak G2, and Teak G3), density at the butt was consistently higher compared to the middle and top sections. Among the non-fire-affected samples, the highest density was recorded in Teak G3 at the butt (669.53 g/cm<sup>3</sup>), while the lowest was observed in Teak G2 at the top (520.29g/cm<sup>3</sup>). Fire incidence was found to exert greater intensity at the base of teak trees, where higher density and greater lignin and extractive content make the wood more combustible. The middle sections also experienced significant reductions in density, although to a lesser extent than the butt, reflecting their comparatively lower density. Conversely, the top sections showed the least reduction, which can be attributed to the predominance of juvenile wood that exhibits different combustion characteristics, as well as the lower fire intensity usually experienced in the canopy compared to the base (Table 2). These findings are consistent with earlier studies that report decreasing density with increasing tree height, primarily due to variations in the proportions of heartwood and juvenile wood (Curvo *et al.* 2024; Kokutse *et al.* 2004; Santos *et al.* 2021).

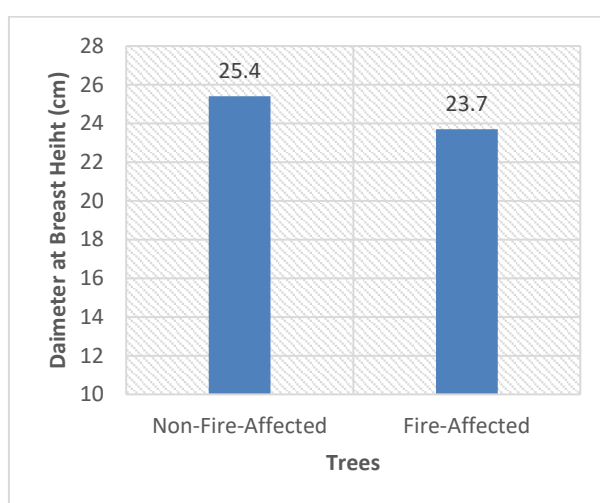
Table 2

**Teak density sectional behaviour with fire**

Teak section	Effect of fire on Density	Key observation
Butt (bottom)	Largest reduction (-27% to -37%)	Most affected by fire due to high extractive and some phytochemical contents
Middle	Moderate reduction (-25%)	Slightly more resistance than the butt
Top	Least reduction (-1.8% to -9.6%)	More fire-resistant, likely due to higher juvenile wood content and lower fire intensity at the top

The results indicate that fire significantly reduced wood density at the butt and middle sections, but less so at the top, with the greatest reductions consistently observed at the butt section across all specimens. Specifically, G1 butt decreased from 621.37 to 387.41kg/m<sup>3</sup>, representing a reduction (-37.6%). Similarly, G2 butt reduced from 569.17 to 414.23kg/m<sup>3</sup> a reduction of -27.2% whereas teak G3 butt declined from 669.53 to 487.37kg/m<sup>3</sup> also reflecting a -27.2% loss. However, the middle section also shows a drop, though slightly lower in magnitude. Surprisingly, the top sections of all trees retain higher densities compared to other parts. In some cases, fire-affected top densities were close to or even exceeded middle and butt densities. As teak G1 top reduced from 545.49 to 496.77kg/m<sup>3</sup> (-8.9%) (smallest reduction), teak G2 top reduced from 520.29 to 511.11kg/m<sup>3</sup> (-1.8%) (minimal reduction) and teak G3 top declined from 598.95 to 541.46kg/m<sup>3</sup> (-9.6%). Indicating that fire could not impact the density at the top as did at the butt and the middle. Fire significantly reduces teak wood density, especially in the lower sections. Fire-affected wood showed greater variability in density measurements, meaning that the impact of fire was not uniform across all specimens.

Diameter at breast height (DBH) is the cumulative outward expression of a teak tree's radial growth; the **growth rate** (usually expressed as annual diameter increment or ring-width) is the speed at which that diameter expands. Because DBH integrates every year's cambial increment, the two variables are mathematically and biologically linked but not in a simple linear fashion (Manso *et al.* 2022). In this study, 25 each of fire-affected and non-fire-affected teak were selected from a 22-year-old teak and their diameters were measured at breast height and recorded. The non-fire-affected trees recorded a mean diameter of 25.2cm, whereas fire-affected trees recorded 23.7cm, which indicates that there is a significant reduction in DBH as illustrated in Fig. 4. Studies by Qi, *et al.* (2022) have demonstrated that high-severity fires significantly reduced the DBH, height and biomass of individual trees. Murphy *et al.* (2010) agree that frequent fire occurrences have been shown to significantly reduce tree growth rates, with the extent of reduction intensifying proportionally to the severity of the fire event. According to literature, the age (22 years) of the selected Teak (**Tectona grandis**) is typically middle-age peak (20-25 years) and follows a sigmoid growth pattern (Cerrato *et al.* 2017; Dey *et al.* 2012). The authors indicate that at this age typical radial increment is 3-6mm yr<sup>-1</sup>, referred to as absolute increment often peaks. Their studies outcome emphasised that DBH typically reaches 23-35cm by age 15 years on good site (Cerrato *et al.* 2017; Dey *et al.* 2012).



**Fig. 7.**

**Diameter at Breast Height (DBH) of Fire-affected and Non-fire-affected Teak trees.**

**Growth Rings of Fire-affected and Non-fire-affected Teak trees**

Silva *et al.* (2019) emphasized that **growth rings** (also known as annual rings) are the concentric layers of wood added by a tree each year. Each ring represents one year of cambial activity, influenced by seasonal climate and physiological conditions.

The results in Table 3 show that the growth rings of the 6 selected teak trees were the same (44), and their ages were also the same (22 years); hence, there is no significant difference in the growth rings and ages, respectively (Table 3).

Table 3

**Growth Rings of Fire-affected and Non-fire-affected Teak trees**

Tree	Growth Rings	Age
Fire Affected		
Tree 1	44	22
Tree 2	44	22
Tree 3	44	22
Non-Fire-Affected		
Tree 1	44	22
Tree 2	44	22
Tree 3	44	22

Callister (2021) and Hegde *et al.* (2025) agreed that by quantifying how annual diameter increments translate into cumulative DBH under varying conditions, foresters can optimise rotations, thinning regimes, and genetic deployment to maximize both volume yield and timber quality in teak. **DBH = 2 × Sum of Radial Growth (Ring Widths).** Further studies indicate that each year, teak trees add a certain thickness of

wood to their radius. Anish *et al.* (2015), Callister (2021) confirmed that when measured over time, the sum of these annual increments (ring widths) defines the total radius, and thus the diameter (DBH).

Several studies reported that, (i) **early diameter increment sets the trajectory**, plantations that average >5mm ring width ( $\approx 15\text{mm yr}^{-1}$  diameter) in the first decade almost invariably reach merchantable DBH five to seven years sooner than slower sites, (ii) **the DBH-growth curve is elastic** – management (spacing, thinning, fertilizer) and genetics can shift it upward or prolong its middle-age peak, but it always flattens eventually, and (iii) **large DBH brings added value** – faster radial growth not only increases harvest volume but also boosts heartwood proportion and, therefore, log price. (Anish *et al.* 2015; Callister 2021; Koirala *et al.* 2017; Pandey & Brown 2000).

The relationship between **DBH and growth rings in teak** is both **direct and diagnostic**. The relationship is fundamental to understanding tree development, productivity, and timber quality. Here's a comprehensive discussion DBH is the physical expression of a tree's accumulated radial growth, and that growth is recorded in the width of each annual ring. The results of this study indicate that growth rings give insight into how teak trees respond to environment, silviculture and age (Table 3), which in turn shapes their DBH development and timber value. However, Callister (2021) emphasized that fast and slow grown teak tree showed similarity with respect to other properties such as heartwood content (%), heartwood colour and bark thickness.

Literature explains how and why growth rate changes with diameter at breast height; (i) **physiological limits**: as the tree gets larger, a bigger proportion of photosynthate is needed just to maintain existing sapwood and crown, so the **relative diameter growth** ( $\% \text{ yr}^{-1}$ ) declines, (ii) **stand competition**: increasing canopy closure reduces light and soil moisture per tree; thinning or wider spacing mitigates this, sustaining higher radial increments, (iii) **site resources and climate**: deep, well-drained alluvials and >1500mm rainfall support faster early increments, yielding larger DBH at any given age. Conversely, infertile or dry sites push the DBH curve downward, (iv) **genetic quality**: clone trials in humid Malaysia showed 7-yr DBH ranged 16-23cm among genotypes, a  $\pm 30\%$  swing in radial increment potential, and (v) **silvicultural interventions**: Fertilisation, irrigation and timely thinning can lift annual increment by 20-40% during the first decade, compounding to much larger DBH later (Anish *et al.* 2015; Callister 2021; Hegde *et al.* 2025; Koirala *et al.* 2017; Pandey & Brown 2000).

It is therefore expedient that the importance of the Diameter at Breast Height-Growth Rings (DBH-GR) relationship is established. Firstly, Zhang *et al.* (2023) explained that the DBH-GR relationship helps in Timber Yield Forecasting. The authors emphasised that accurate modeling of growth rings allows foresters to project DBH and estimate future timber volume. Secondly, Plantation Rotation Planning has been identified as another essential benefit of the DBH-GR relationship. Hence Messerer *et al.* (2020) and Soman *et al.* (2020) emphasized that understanding how ring width contributes to DBH helps determine optimal harvest age for economic returns.

Additionally, Timber Quality and Heartwood Formation has been identified as one of the important results from DBH-GR relationship. Wider growth rings are often associated with greater heartwood percentage and improved timber properties (Cardoso & Pereira 2017). Moreover, Chavardès *et al.* (2022) and Rodríguez *et al.* (2021) emphasized that Site Evaluation should be factored as one of the importance of the DBH-GR relationship. The author reiterated that ring width and resulting diameter at breast height are strong indicators of site productivity. Thus, it could therefore be concluded that DBH in teak is the time-integrated mirror of annual ring formation (Auykim *et al.* 2017). Empirical studies across Asia and Africa consistently show that wider early growth rings in timber, moderated competition and favourable site factors translate into larger diameters and higher-value logs (McIntire 2017), while poor sites, dense stands and advanced age narrow ring width, slowing DBH growth and delaying economic returns (Thomas 2011).

Annual or growth ring (GR) width is the primary radial increment laid down by the vascular cambium, whereas diameter at breast height (DBH) is the cumulative outcome of those increments measured 1.3m above ground. Because physiological, climatic and silvicultural factors modify GR through time, the DBH-ring-width relation is inherently non-linear and site-specific. Hence, the outlined established empirical patterns in literature need to be appreciated.

Kokutse *et al.* (2010) identified ontogenetic decline as a pattern in their studies. The authors outlined that in a 24-year chronosequence from Togo, mean ring width in dominant teak dropped from  $13\text{mm yr}^{-1}$  in year 2 to  $1.6\text{mm yr}^{-1}$  by cambial age 23, with the steepest contraction before age 10 Kokutse *et al.* (2010). A comparable unmanaged stand in Timor-Leste showed juvenile ring widths of 4.3–7.3 mm (0–20 yr), narrowing to 3.3–5.1mm by age 45 (Sousa *et al.* 2012). These data confirm the typical sigmoid DBH trajectory: a rapid 'surge' phase, a middle-age plateau and a mature deceleration. Sousa *et al.* (2012) emphasized that site quality and climate must be named in this direction. Wide juvenile rings are favored on deep, moist Alfisols; large inter-annual variation in ring width tracks monsoon rainfall, underscoring the sensitivity of radial growth to water supply (Sousa *et al.* 2012). On the best Myanmar and Indian sites, trees reach ca 60 cm DBH by 50 yr, versus <40 cm on poorer soils (Krishnapillay, fao.org).

Wood quality linkages was named by Callister (2021) as one of the advantages of DBH-GR relationship in teak plantations. The authors emphasized that faster radial growth benefits value: in Kerala, India, heartwood proportion correlated strongly with ring width ( $r = 0.73$ ) and, to a lesser extent, with DBH ( $r = 0.46$ ) in 8- to 52-yr-old material (Krishnapillay, fao.org). Wider rings, therefore, not only hasten diameter accrual but also accelerate economic heartwood formation.

Also, studies identified stand density as a benefit of this relationship. In their study, Samamba *et al.* (2024) identified a 24-yr spacing trial in Longuza, Tanzania, found the largest individual DBH at 4 × 4m spacing, whereas 3 × 3m maximized mean annual increment (MAI); closer spacing suppressed ring width through competition for light and moisture (Samamba *et al.* 2024). Moreover, Thom and Keeton (2020) argued that silvicultural intervention is another benefit derived from the DBH-GR relationship. The author reiterated that moderate to heavy thinnings in a humid-tropical Costa Rican plantation raised heartwood percentage and sustained higher radial increments compared with an unthinned control, demonstrating that periodic removal of competitors can prolong the middle-age growth plateau (Pérez & Kanninen 2005).

### Radial growth rings width of Fire-affected and Non-fire-affected Teak trees

According to Prothero J. (1997), A ring refers to the annual growth increment of a tree, while ring width denotes the mean distance between the inner and outer radii of a given growth ring. Ring width, which reflects the radial growth of a tree resulting from vascular cambial activity, is widely used as an indicator of growth rate (Sinha *et al.* 2014). In this study, discs were cut from a teak tree at 130cm height, and the ring widths were measured and recorded. The maximum diameter 11.4mm (2.1) was recorded by the fire-affected tree 1, whereas the minimum was recorded by non-fire-affected tree 3, 6.2mm (1.1), indicating a significant reduction in growth ring width of the fire-affected specimen, as illustrated in Fig. 8. According to existing literature, the mean ring width of teak ranges between 4.3-7.3mm during the first 20 years of growth and narrows to between 3.3-5.1mm between 30 and 45 years (Sousa *et al.* 2012). Wei *et al.* (2023) reported that the radial growth of *P. sylvestris* and *L. gmelinii* tree rings decreased following fire events. Also in the burned area, the average tree-ring width of the two species examined measured over 10mm before the fire event, but declined to approximately 7mm following the fire. This reduction highlights the adverse influence of fire on radial growth. Supporting this observation, Ballikaya *et al.* (2022) and Wei *et al.* (2023) reported that forest fires exert a significant effect on the accumulation of elements within tree rings. Such variations are primarily attributed to the altered metabolism of substances resulting from interactions among the atmosphere, soil, and trees, which ultimately affect nutrient uptake and growth processes. The suppression of growth in these species was attributed to increased temperatures and drought stress (McLaughlin & Percy 1999; Voelker 2011), both of which were closely associated with fire occurrence. Typically, fire-affected trees exhibit not only localized damage to tissues but also systemic responses, which are reflected in the annual ring widths of the stem (Schweingruber 1993; Grissino-Mayer 2010; Fulé 2010; Seifert *et al.* 2017).

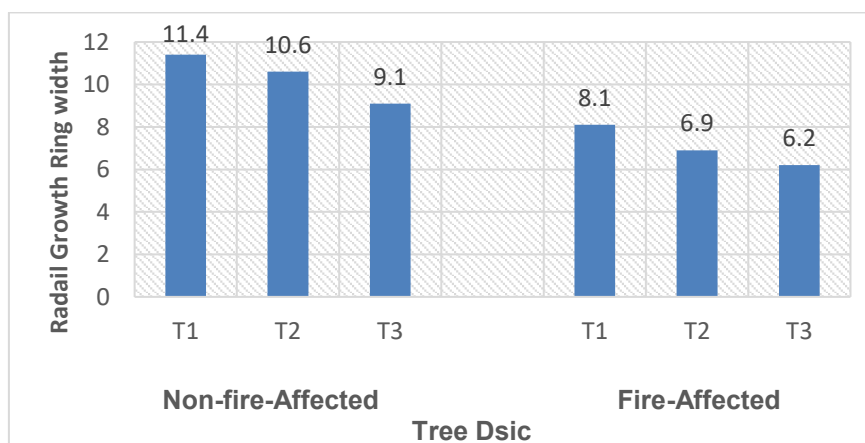


Fig. 8.

Radial growth rings width of Fire-affected and Non-fire-affected Teak Trees.

### CONCLUSION

This study demonstrates that annual fire incidence significantly reduces the growth and wood properties of teak (*Tectona grandis*) in Ghana's Forest-Savanna Transition Zone. Fire-affected trees showed marked declines in basic density, with reductions of 27–38% at the butt, about 25% at the middle, and minimal losses at the top. DBH was also lower in fire-affected trees (23.7cm) compared to non-fire-affected ones (25.2cm). Although both groups were the same age (22 years, 44 rings), ring widths were narrower in fire-affected specimens (6.2-11.4mm), indicating reduced radial growth. These results confirm that fire

suppresses growth rate and timber quality without altering chronological age. Effective fire management strategies, such as firebreaks, community education, and monitoring, are therefore essential to sustain teak productivity. Future research should broaden sampling, quantify fire severity and track long-term recovery to strengthen evidence-based management of teak plantations in fire-prone landscapes.

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