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Morphological and Growth Characteristics in *Brachylaena huillensis* (muhugu); Some Management Considerations

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SUMMARY

Investigations on relations of crown and stem forms revealed that *Brachylaena huillensis* (muhugu) has a crown that is much deeper than is wide. Comparisons with other local trees of approximately known light exposure requirements during their growth suggest that the tree is shade tolerant, at least in the early part of its life. After a seedling is well established, crown development starts as slender conical crown in light-restricted juvenility which expands into a wider but not expanding crown in emergent old age. Growth in height and crown declines significantly when bole diameter at breast height reaches about 45 cm and crown start deteriorating. For stems above 45 cm dbh, 28% were either dead or seriously rotting.

INTRODUCTION

In order to fully understand the occurence of the plants in relation to environment, it is necessary to know all the adaptations in the individual species and the value of the various adaptations. Among the essential features of a tree's life cycle are some basic aspects of morphological structure and growth in relation to environment. In the evaluation of possible role of tree morphology and form on growth and productivity, inheritance must be taken into consideration and it must be borne in mind that all trees are predisposed to assume a certain form. Environmental influences and cultural practices can only modify the basic form which is predestined by heredity.

Information on a tree shoot morphology may help to suggest requirements or adaptations of the tree for establishment, growth and its development within a community or stand. Crown form characteristics of a species may also indicate the degree of tolerance to shade or light (Larson 1963, Zimmerman and Brown 1971, Spurr and Barnes 1980). These authors agree that shade tolerant trees have deeper and denser crowns, will prune naturally at a slower rate, grow slowly and persist under canopies for long periods of time in natural stands; and tend to be more successful in mixture with other species of equal size and consequently form denser stands with more stems per ha. than do intolerant trees. The approximate tolerance rating of the more important and characteristic forest tree species must therefore be known and understood by the practicing silviculturist as a general frame of reference.

B. huillensis O. Hoffm is an important commercial and social tree species growing in the two forests. The ecosystem in which it occurs, is however, heavily disturbed and is diminishing. There is need to understand its regeneration dynamics and growth characteristics in order to manage it and also the remaining stands effectively.

MATERIALS AND METHODS

Study Area

Tree samples for the assessment were selected in Karura and Ngong forests both semi-deciduous tropical forests occuring on the central plateau highlands of Kenya. Karura is at 1790 m and Ngong at 1860 m in elevation and are both located about 1.5°S, 37°E and about 10 km apart. The two study forests occur within the vicinity of the Nairobi City.

Briefly, mean annual precipitation is about 1,000mm of which 80% falls mainly in April and May and less in October and November. Mean annual temperature is 24°C with a maximum of 33°C in March and minimum of 11°C in July. The soils are moderately deep sandy-loams to sandy-clay loams.

The degree of tolerance to light in *B. huillensis* was assessed through measurements of various tree parameters. These included evaluating the relations between developments in tree height and bole diameter, and crown depth and width. Three local tree species of known shade tolerance, which included *Bischoffia javonica* (bishop wood), *Juniperus procera* (East African pencil cedar) and *Vitex keniensis* (meru oak), were also similarly assessed to act as a yard-stick. The information on the shoot characteristics developed from the assessments is interpreted in terms of possible influence that management interventions may have on the regeneration and growth of *B. huillensis*.

METHODS OF DATA COLLECTION

Shot Development

Tree crown and stem parameters of 122 selected sample trees were measured in Karura and Ngong forests. A wide range of diameters and heights were aimed at. Almost all sample trees except a few young ones were in the open and had possibly been exposed to light for some time.

Height was measured by Suunto altimeters as an appropriate distance measured by a tape. For each tree, total height and height to crown base were measured. Crown depth was derived from the difference between the two.

Diameters of the tree boles were measured at 1.3 m above the ground using a diameter tape. Crown diameters were estimated by measuring three radii in pre-determined directions. A 2 m rod was used to help the assessor in aligning himself vertically at the edge of the crown. This was facilitated by a second person standing away from the crown and directing the assessor to move in or out with his raised rod to help closer alignment with the crown edge. The radius of the crown was taken from the assessor's position to the centre of the tree bole at height of 1.3 m. The mean of the three radii multiplied by 2 gave an estimate of crown diameter.

Fifty-seven tree of *Juniperus procera* at two sites, forty-two of *Bischoffia javonica* at Kakamega, Western Kenya and seventy-two of *Vitex keniensis* at Ragati, Central Kenya, had their crown and bole diameters measured also using the methods outlined above.

Incidence of Deterioration of Stems

On realizing that poor crowns were associated with dead unhealthy stems, two sample compartments (hereafter called sample plots) were selected in each forest (Karura and Ngong) in order to assess the distribution of dead and rotting trees. Transects, 10 m wide and 40 m apart, were used in the sampling. A 5 m long rafter was used to help in measuring the width of the transect and a compast guided the direction of the transect. All trees along a transect were recorded in terms of sound, unsound (rotting or dead). For each tree of 5 cm dbh and above, diameter of crown was also measured. Dead trees were easily identified while rotting trees were identified through partial death of stems and highly reduced crown

Data Organization and Analysis

To determine relationships between crown and bole characteristics, least square regression analysis was employed using a Minitab regression program. To test the linearity of each relationship, the raw data was transformed into natural logarithmic form and both direct and transformed data were thus tested for each set of parameters. The strength of the relationships were tested by using the coefficient of determination (r^2).

To test the degree of similarities of the relationships, the derived linear regressions were compared using the method of Snedecor and Cochran (1986). This method tests if the equations residual variances, slopes (regression coefficients) and Constants would be considered to have come from the same population.

The proportion of sound, rotting and dead trees was displayed by size-ckasses of 10 cm, starting from 5 cm to 45 cm dbh, and a class of those above 45 cm dbh. Proportions of rotting and dead trees were expressed as percentage of the total population in each size class and in each sample plot.

Table 1
Relationships between some growth (morphological) characteristics of *Brachylaena huillensis*

Regression Parameter	Base of inference	Regression Equation	Coefficient of determination (r^2)	F-Value	No. of observa-tion	Range of predictor (x)
Total height Vs Bole diameter	Linear	$Y = 4.81 + 0.451x$	72.7%	304.46***	116	5.5 - 60cm
	Logarithmic	$Log_e Y = 0.478 + 0.720 \log_e x$	76.7%	378.49***		
Crown depth Vs Total height	Linear	$Y = 0.853 + 0.482x$	81.5%	374.59***	87	3 - 25 cm
	Logarithmic	$Log_e Y = 0.393 + 0.916 \log_e x$	83.8%	436.06***		
Crown depth Vs Bole diameter	Linear	$Y = 2.77 + 0.227x$	54.6%	132.69***	112	5.5 - 50 cm
	Log	$Log_e Y = 0.184 + 0.599 \log_e x$	53.4%	126.43***		
Crown depth Vs Bole diameter	Linear	$Y = 1.40 + 0.130x$	75.1%	231.26***	78	5 - 76 cm
	Logarithmic	$Log_e Y = 0.935 + 0.733 \log_e x$	80.8%	321.50***		
	Quadratic	$Y = 0.33 + 0.215x - 0.00134x^2$	80.4%	150.60***		
Crown depth Vs Bole diameter	Linear	$Y = 2.88 + 1.07x$	54.6%	121.35***	103	1- 9 m
	Logarithmic	$Log_e Y = 1.12 + 0.608 \log_e x$	54.0%	117.74***		

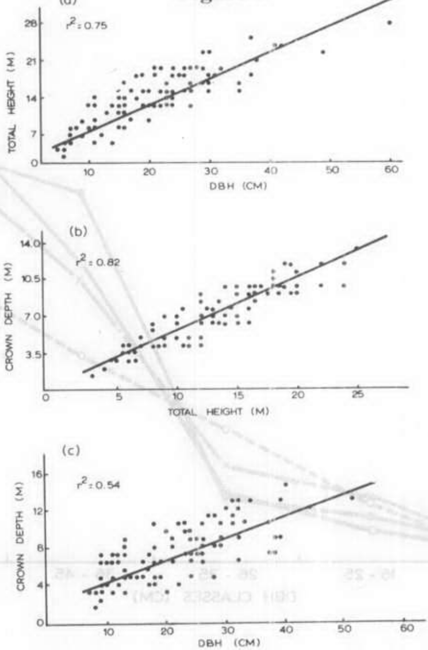
Where:
Y = Total height, crown diameter or crown depth (m)
*** = Significant at 0.1% probability level
X = dbh (cm) or crown depth (m)
Log_e = Natural logarithm base 10

RESULTS AND DISCUSSION

Table 1 presents a summary of the relationships between the various morphological characteristics. There was a positive relationship between growth in bole diameter and height, but a high variation was observed with 73% of the variation in height indicated by the linear regression.

A scatter diagram (Fig. 1a) indicated increasing height with increasing diameter up to about 40 cm dbh after which increase in diameter is accompanied by much lower increase in height. This observation is confirmed by use of logarithmically transformed data which improves the explained variation of height to 77% (Table 1). More variability in height is observed with trees between 15 cm to 40 cm dbh than those below or above these sizes (Fig. 1a). This may be explained as being due to variable environmental conditions especially overhead canopy openings as each individual tree attempt to reach the canopy and penetrate it.

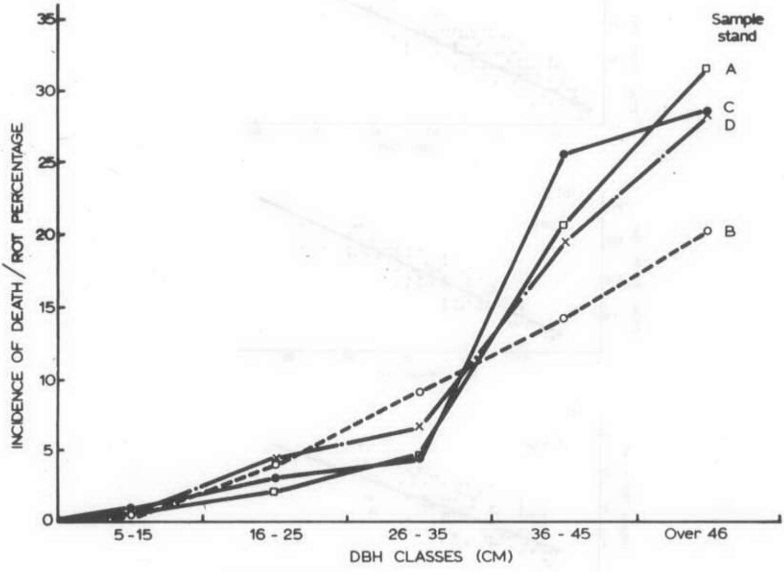
Figure 1



Relationship between total height and bole diameter (a), crown depth and total height (b), and crown depth and bole diameter (c), in *B. huillensis*.

A positive linear relationship was also indicated between crown depth and total height (Table 1). 82% of variation of crown depth was explained by the relationship. The relationship was fairly uniform over a range of tree heights showing a ratio of 0.47 at 3m height, 0.58 at 5 m, 0.55 at 15 m and 0.54 at 20 m (Fig. 1b); an average crown depth: total height ratio of 0.52 and a low coefficient of variation of 10.6%. This average crown depth cover indicates that half of the tree carries live crown which is little influenced by height (or age). Figure 1b however indicates that trees above 20 m height had slightly lower rates of increase in crown depth. This slight decline is confirmed by improved coefficient of determination when the data was analysed under logarithmic transformed form ($r^2 = 84\%$). Most large diameter trees in the field have deteriorating crowns which suggests that there is little input into tree growth and there would be no benefit in keeping trees above certain diameters in managed crops. Poor crowns were also associated with a tendency to stem rot and partial death (Fig. 2).

Figure 2



Incidence of dead and rotting stems of *Brachylaena* by diameter class in Karura and Ngong forests. A, B, C and D represent different stands.

Figure 2 shows the incidence of unsound trees in size-class. The proportion of defective stems rises with increasing dbh. Ager 35 cm dbh, a steep rise is evident which slows down at about 40 cm dbh. For stems above 46 cm dbh, 28% were considered as either dead or rotting. While one-third of this lot were dead, about two-thirds indicated serious rotting.

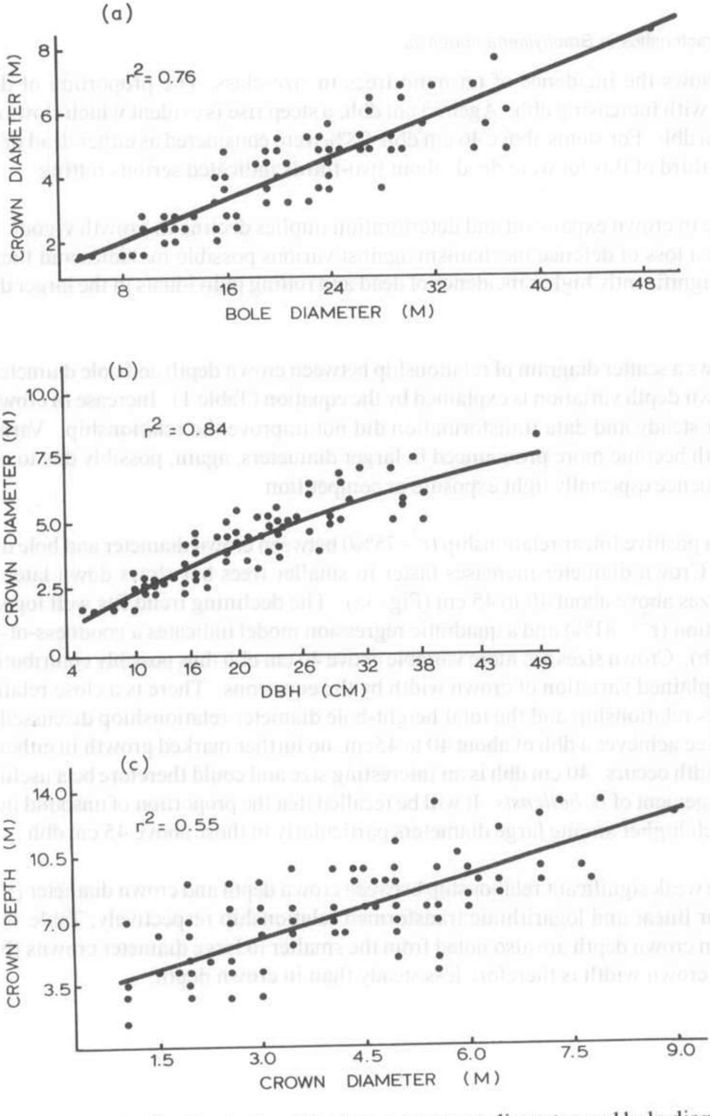
The decline in crown expansion and deterioration implies decline in growth vigour. This in turn means a loss of defence mechanism against various possible maladies and therefore a reason for significantly higher incidence of dead and rotting individuals in the larger diameter classes.

Fig. 1c shows a scatter diagram of relationship between crown depth and bole diameter. Only 54% of crown depth variation is explained by the equation (Table 1). Increase in crown depth is however steady and data transformation did not improve the relationship. Variation in crown depth become more pronounced in larger diameters, again, possibly due to environmental influence especially light exposure or competition.

There was a positive linear relationship (r^2=75%0 between crown diameter and bole diameter (Table 1). Crown diameter increases faster in smaller trees but slows down later in bole diameter sizes above about 40 to 45 cm (Fig. 3a). The declining trend fits well logarithmic transformation (r^2 = 81%) and a quadratic regression model indicates a goodness-of-fit (r^2 = 80%, Fig. 3b). Crown sizes are more variable above 40 cm dbh thus possibly contribution also to the unexplained variation of crown width by the equations. There is a close relationship between this relationship and the total height-bole diameter relationshiop discussed above. When the tree achieves a dbh of about 40 to 45cm, no further marked growth in either height or crown width occurs. 40 cm dbh is an interesting size and could therefore be a useful figure in the management of *B. hullensis*. It will be recalled that the proportion of unsound individuals was much higher among large diameters particularly in those above 45 cm dbh.

There was a weak significant relationship between crown depth and crown diameter (r^2 = 55% and 54% for linear and logarithmic transformed relationship respectively; Table 1). Wide variations in crown depth are also noted from the smaller to large diameter crowns (Fig. 3c). Increase in crown width is therefore less steady than in crown depth.

Figure 3



Linear (a) and quadratic (b) relationships between crown diameter and bole diameter, and crown depth upon crown diameter (c) in *B. huillensis*.

The findings from the above relationships lead to the main observations that *Brachylaena* has a crown that is much deeper than it is wide. For a shade bearer, this morphological feature would increase surface area of photosynthesis especially when trees are small and under other canopies where light supply may be limited. The narrow spear-headed shape would also enable the tree to penetrate through narrow canopy openings unimpeded as it grows up in search of light.

The observed steady increase in crown diameter is common with slow growing and shade tolerant species (Larson, 1963). The coefficient of determination value obtained by the relationship between crown diameter and bole diameter in *B. huillensis* could therefore have been a reflection of tolerance to shade. To qualify this further, Table 2 presents a comparison of this relationship with other less shade tolerant species.

Table 2
Relationships between Crown Diameter and Bole Diameter for four local tree species

Species	Regression Equation	Coefficient of determination (r^2)	F-value	No. of observa-tions	Range of predictor (x)
Juniperus procera (EA pencil cedar)	Y = 2.34 + 0.221x	95%	1110.86***	57	6 - 64 cm
Bischoffia javonica (nishopwood)	Y = 1.74 + 0.166x	91%	389.17***	43	5 - 43 cm
Vitex keniensis (meru oak)	Y = 2.80 + 0.136x	85%	305.71***	72	11- 81 cm
Brachylaena huillensis (muhugu)	Y = 1.40 + 0.130x	75%	231.27***	78	5 - 76 cm

Where:

Y = Crown Diameter (m)

x = dbh (cm)

*** = Significant at 0.1% probability level

The four relationships indicate a decline in strength especially when viewed from the coefficient of determinations points of view. The constants and slopes of the *Brachylaena* equation differed significantly (1% probability level) with the other tree species' equations.

Assuming that the hypothesis that stronger light demanders will express more strongly their crown diameter - bole diameter relationship than less light demanding species, it will be justified to suggest that *B. huillensis* is a stronger shade tolerant tree than the other three species. This implies a successful and continuous regeneration of seedlings and saplings of the tree under canopy. This factor also suggests possibility of management of the species through a selection system without serious negative effects on its regeneration under natural conditions.

ACKNOWLEDGEMENTS

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