CROWN AND BOLE PROJECTION AS A TOOL FOR SILVICULTURAL MANAGEMENT OF A TREE CROP

by

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A paper presented at the 'First KEFRI Annual Scientific Conference', 17th to 18th October, 1990; Muguga, Kenya.

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INTRODUCTION

Among the essential features of a tree's life cycle are some basic aspects of morphological structure and growth in relation to environment. It has been shown that the form of the stem is a function of the crown (Larson 1963). Understanding the relationship between the two morphological features therefore has a practical bearing on forest management in terms of growth and yield as well as genetic improvement of a tree.

Crown diameters bear definite relation with their bole diameters irrespective of site and age, and in some cases irrespective of treatment (Dawkins 1963). When any kind of definite relation can be discovered between crown diameter and bole diameter, then it is possible to predict the basal-area density of a crop for any given canopy density, and vice-versa. Such relations have been used in the evaluation of initial espacement of a species being used in plantation (Kwan 1966), and for stocking control in stands (Suri 1975, Mugasha 1980).

The crown-bole diameter relationship may also be used in defining the ecological and silvicultural behaviour of a species. Among these is the sensitivity to or tolerance of crown density and possibly to basal-area density. The present paper reports results of investigations undertaken with the objective of determining the relationship between crown diameter and bole diameter of five local species and its possible application to stand density control.

To demonstrate the influence of site on the crown-bole diameter relationship, the cedar data collected from over five sites was used.

The value of coefficient of determination obtained by relating crown diameter on bole diameter may be a reflection of tolerance to crowding and may be also to shade. To demonstrate this factor, the five species' regression equations were statistically compared.

To demonstrate the application of the crown-bole diameter relationship in the control of density of a crop, the data collected for cedar and muhugu were used. Crown diameters of various bole diameters were estimated from the developed regression equations and the corresponding crown:bole diameter ratios computed from the two parameters. Maximum attainable basal area was estimated from the crown closure or the relationship;

$$\frac{\text{Unit area (1 ha) x Canopy density (1)}}{(\text{Crown:bole diameter ratio})^2} = \text{Basal area } (m^2/ha)$$

Using the derived basal area and canopy density cover, a feasible stocking control for each species was developed and tabulated.

Results and Discussion

Influence of Site on Crown-Bole Diameter Relationship

Table 1 shows regression equations for cedar assessed at five sites. All are significant ($P = 0.01$). No significant difference among the five regression lines was found and a pooled regression line was therefore computed. This explained 87 percent of variation in crown diameters.

Similarity among the five regression equations indicate that the relationship is not affected by site. But constant 'a' varied with site. This variation is a reflection of 'plasticity' in crown diameter and therefore tolerance of crowding. A high positive value of 'a' is associated with a high density whereas a low or negative value of 'a' indicates sufficient growing space and crown development is unimpeded (Dawkins 1963). This observation is in close agreement with the present results in that, Elburgon and Muguga plantation crops which were more crowded gave higher 'a' values (Table 1). The most openly growing individual trees measured in Upland gave the lowest constant 'a' value.

TABLE 1

REGRESSION ANALYSIS OF CEDAR CROWN/BOLE DIAMETERS FROM FIVE SITES

Sites	Regression equations	Coefficient of determination (r^2)	F-values	No. of observations
Timboroa	Y = 1.17+21.29x	83%	140.27***	44
Elburgon	Y = 3.29+17.59x	62%	34.81***	34
North Kinangop	Y = 1.80+26.72x	83%	371.29***	41
Uplands	Y = 0.54+28.07x	77%	94.21***	29
Muguga North	Y = 2.76+18.99x	94%	251.10***	94
Pooled equation	Y = 2.44+19.91x	87%	982.69 ***	198

Y = Crown diameter

x = dbh (m)

*** = Significant at 0.1% probability level

TABLE 2

RELATIONSHIPS BETWEEN CROWN DIAMETER AND BOLE DIAMETER OF FIVE TREE SPECIES

Species	Regression equations	Coefficient of determination (r^2)	F-Value	No. of observations	Range of predictor (x)
Maesopsis eminii (mutere)	Y=2.34+0.221x	95%	1110.86***	98	8 - 92cm.
Bischoffia javonica (bishopwood)	Y=1.74+0.166x	90%	386.17***	43	5 - 43cm.
Juniperus procera (EA pencil cedar)	Y=2.44+19.91x	87%	982.70***	198	6 - 93cm.
Vitex keniensis (meru oak)	Y=2.80+0.136x	81%	305.71***	72	11 - 81cm.
Bracylaena huillensis (muhugu)	Y=1.40+0.130x	75%	231.27***	78	5 - 76cm.

Y = Crown diameter (m)

x = dbh (cm)

*** = significant at 0.1% probability level

Tolerance to Density

Table 2 shows a comparison of relationships of crown-bole diameter derived from five tree species. Maesopsis eminii (mutere) indicates the best goodness-of-fit for Linear regression (r^2 = 95%). The regression fit for the other four species follows each other in the order of magnitude with the fit for muhugu (r^2 = 75%) being the weakest.

Assuming that the hypothesis that the 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 muhugu is the most strongest crowding, and possibly also, shade tolerant tree species compared to the other four species. Conversely, mutere is the most crowding intolerant with the other three lying in-between and indicating varying degrees of crown plasticity during their growing life cycles.

Stand Density Control

To facilitate unrestricted continuous freedom of growth in a crop, stocking must be controlled as the crop puts on more volume and therefore a need for more space. Table 3 shows estimates of maximum carrying capacity in terms of basal area and stocking per ha. for cedar. Table 4 shows the same parameter estimates for muhugu.

A mean bole dbh of 60cm. indicated a crown:bole diameter ratio in cedar of 23.5 and 17 for muhugu. These ratios correspond to maximum attainable basal area of $18.5m^2$/ha and $28m^2$/ha respectively. Dawkins (1963), working with several tropical secondary hardwood species came up with crown:bole diameter ratios ranging from 19 - 25. He concluded from his studies that an average crown:bole diameter ratio of 20 permits tropical hardwood even-aged crops to attain 19 - $23m^2$/ha of basal area without serious crown interference. While estimated values for cedar fall within the Dawkin's range, estimates for muhugu are slightly outside the range; crown:bole diameter ratio being 17 and maximum basal area at $28m^2$/ha. The lower crown: bole diameter ratio is a reflection of the smaller crown diameter characteristic of muhugu. This allows the possibilities of packaging more crown individuals per unit area and hence a higher maximum limiting basal area. This also implies that while it is more critical to maintain the crown:bole diameter ratio in cedar to avoid crown overlap and possible deterioration, crown development in muhugu will be less affected by the adjustments of the ratio.

TABLE 3

RELATIONS BETWEEN CEDAR CROWN:BOLE DIAMETER RATIO AND LIMITING BASAL AREA AND STOCKING

dbh (cm)	CD:BD ratio	Basal area (m^2 ha^{-1})	Stocking (stems ha^{-1})
5	60	2.78	1,416
10	40	6.28	796
15	33	9.18	520
20	30	11.11	353
25	28	12.75	260
30	27	14.03	199
35	26	14.79	154
40	25	16.00	127
45	24	16.79	106
50	24	17.36	88
55	24	17.95	76
60	23	18.42	65
65	23	18.74	57
70	23	19.24	50

CD = Crown diameter

BD = Bole diameter

TABLE 4

RELATIONS BETWEEN CROWN:BOLE DIAMETER RATIO IN BRACHYLAENA AND LIMITING BASAL AREA AND STOCKING

dbh (cm)	CD (m)	CD:BD ratio	Basal area (m^2/ha)	Stocking (stems/ha)
5	1.7	34	6.67	3,460
10	2.5	25	12.66	1,613
15	3.2	21	16.78	950
20	4.0	20	19.63	625
25	4.8	19	21.68	442
30	5.5	18	23.31	330
35	6.3	18	24.50	225
40	7.0	18	25.60	203
45	7.8	17	26.23	165
50	8.5	17	26.89	137
55	9.3	17	27.54	116
60	10.0	17	28.26	100
65	10.8	17	28.52	86
70	11.6	17	28.85	75
75	12.3	17	29.14	66
80	13.1	16	29.64	59
85	13.8	16	29.89	52

CD = Crown diameter

BD = Bole diameter

In conclusion therefore, it is possible to develop suitable crown and bole diameter relationships capable of predicting a crop development in space, and in relation to age. The nature of the relationship assists in determining effects of treatment, particularly crown freedom and shading. A stocking control regime(s) can then be developed particularly where no growth information on a species is available or where experimental plots are still immature.

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