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The influence of stump diameter and height on coppicing ability of selected key Miombo woodland tree species of Zambia: A guide for harvesting for charcoal production

Ferdinand Handavu¹, Stephen Syampungani²* and Eric Chisanga²

¹Zambia Forestry College, Private Bag 1, Mwekera, Kitwe, Zambia.  
²Department of Forest Resource Management, School of Natural Resources, Copperbelt University, P. O. Box 21692, Kitwe, Zambia.

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A study was undertaken to investigate the influence of stump diameter and stump height on the coppice effectiveness in relation to interspecific variation. The overall objective was to provide an understanding of the coppicing ability of the selected key miombo species in order to provide a basis for sustainable management of the species. A total of 102 stumps were observed. Coppice effectiveness results varied among the key tree species with Brachystegia longifolia and Isoberlinia angolensis having the highest number of coppice shoots (9.8 ± 2.6) and 7.5 ± 1.6) and the least being Julbernadia paniculata (4.2 ± 1.3). High coppice effectiveness indicates a greater recruitment potential for miombo species. The study has revealed that the coppicing ability of miombo trees is species dependent. The results therefore suggest that management of miombo species should be species specific rather than holistic. The research has also provided a model for planning when cutting of the aforementioned miombo species for charcoal production in terms of the diameter classes that provide high coppice effectiveness.

Key words: Coppice effectiveness, sustainable management, regeneration.

INTRODUCTION

Miombo woodland species are known to re-sprout from roots and stumps once the above ground biomass is removed or killed by harvesting or fires (Luoga et al., 2004; Syampungani, 2008). This is the key attribute of the resilience and productivity of miombo species once their stems are damaged. Survival of the cut stem and growth rate of the resultant coppice shoots is influenced by several factors, including size of the tree, height of cutting, and root/shoot ration after felling (Tschaplinski and Blake, 1989). Some of these can be manipulated by forest managers or harvesters to maximize or suppress subsequent regrowth rates (Shackleton, 2000). The sprouts have been reported to grow faster than the newly established seedlings because they have a well-established root system with stored reserves (Grundy, 1995). However, little is known concerning the influence of stem sizes and stump heights on the coppicing ability for the Miombo woodland species following the removal of aboveground biomass (Grundy, 1990; Shackleton, 2000; Luoga et al., 2004).

Inadequate information on the influence of stem sizes on coppicing ability of Miombo woodland species made it difficult for forest managers to effectively devise conservation plans for Miombo woodland species used for charcoal production in the past (Grundy, 1995;
Mwabumba et al., 1999). Given the wide use of miombo species for fuelwood production, influence of stump diameter and height on coppicing needs to be understood in order to incorporate such when formulating forest management guidelines for forest programmes. In this study, the research objectives were to: i) determine the number of shoots in relation to stump size and height; ii) and determine the stump diameter class with the highest coppicing ability. The key questions were: i) what are the ranges of diameters and heights for each of the selected species in the study area? ii) what is the number of shoots or coppices on each stump diameter of each selected species?

MATERIALS AND METHODS

Study area

Three different sites namely Kaloko, Mwaitwa and Katanino in Masaiti District of the Copperbelt Province of Zambia were selected for the study (Figure 1). These sites are important for charcoal production. Tree stumps with shoots were thus readily available in the area. The sites were of known management history and age, and therefore provided for the selection of sites of the same age to prevent the influence of age if sites selected were to be of different ages. Three distinct seasons namely hot dry season (August to October), rainy season (November to April) and the cool dry season (May to July) occur in the area. The average annual rainfall in the area is 1250 mm (MTENR, 2003).

The characteristic vegetation in the area is Miombo woodland. Miombo woodland is the most extensive woodland formation in Africa, covering Angola, Zimbabwe, Zambia, Mozambique, Malawi, Tanzania and most of the Southern part of the Democratic Republic of Congo (Campbell et al. 2008). The woodland is dominated by Julbernadia, Isoberlinia and Brachystegia genera. It occurs on the Katanga rock system at an altitude of 1200 m (Chidumayo, 1997). The soils of the study site are of eluvial origin, occurring on basement quartzites, schists and granitic rocks. Such soils are Oxisols and Ultisols which are acidic (pH 4 to 5), sand rich and highly leached with sandy-silty-clayey textural composition (Chidumayo, 1997).

Sampling design

Charcoal regrowth stand sites that were 5 to 6 years old since charcoal production ceased were selected for study. On each site, corner coordinates were determined using the Global Positioning System (GPS) to show the extent of each regrowth stand. Plots were fixed along a transect line that ran along the middle of the site. Five circular sample plots, each with a radius of 20 m, were established in each of the three sites at 50 m intervals. Therefore, a total of 15 sample plots were established in which data were collected. Five sample plots per site were selected due to limited funds and time. The number was considered reasonable enough for generating data that would be inferred upon. Such approach has been used elsewhere within the miombo ecoregion, e.g. in Zimbabwe (Chigwerewe, 1996).

Data collection

The data was collected from charcoal plots which were 5 to 6 years old since charcoal production ceased. In each plot, tree stumps of selected key species (Brachystegia longifolia, Isoberlinia angolensis, Brachystegia floribunda and Brachystegia spiciformis) were identified and measured for diameter and height. The number of shoots on each stump was recorded. The data was analyzed to determine the relationship between stump size and coppicing ability.
The number of stumps among species result in significant variation among species affecting coppicing (B. spiciformis) between species. The influence of stump size on the coppicing ability varied between species. Multiple regression analysis for stump diameter and height revealed that only two (I. angolensis (P<0.04) and B. spiciformis (P<0.01) out of five species studied showed that both stump diameter and height have significant effect on coppicing ability. In other species, B. longifolia, J. paniculata and B. floribunda, the results indicate that the combination of both stump size and height did not have significant influence on their coppicing ability.

Effect of stump diameter and height on coppicing

Results for analysis of variance for stump diameter indicated that the diameter has influence on the coppicing ability in I. angolensis (P<0.05) and B. spiciformis (P<0.05). The linear relationship between stump diameter and the number of shoots was observed in I. angolensis and B. spiciformis. However, in other species (B. longifolia, J. paniculata and B. floribunda), no linear relationship between stump diameter and the number of shoots was observed.

The relationship between number of shoots, stump diameter and height

Coppicing ability of selected species varied between species and diameter size classes. I. angolensis and B. spiciformis had the highest number of coppice shoots in the 25.6 to 30.5 cm DBH while B. longifolia showed the highest number of coppice shoots in 30.6 to 35.5 cm DBH. J. paniculata and B. floribunda recorded the highest number of shoots in the lower diameter classes, 20.6 to 25.5 and 15.6 to 20.5 cm DBH, respectively (Figure 2). Development of shoots also occurred at different heights for each species with the highest number of shoots observed at < 1 cm height above ground for I. angolensis (89 stems/ha) and J. paniculata (12 stems/ha), while for B. longifolia (24 stems/ha), B. floribunda (11 stems/ha) and B. spiciformis (16 stems/ha) the development of

Table 1. Descriptive statistics for observer parameters.

<table>
<thead>
<tr>
<th>Species</th>
<th>Observation</th>
<th>Mean no. of shoots</th>
<th>Range of Diameter (cm)</th>
<th>Range (no. of shoots/stump)</th>
<th>Range (Stump height, cm)</th>
<th>Mean stump height (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isoberlinia angolensis</td>
<td>43</td>
<td>7.5 ± 1.6</td>
<td>13.9-37.0</td>
<td>1-26</td>
<td>27-160</td>
<td>73.0 ± 8.0</td>
</tr>
<tr>
<td>Brachystegia longifolia</td>
<td>24</td>
<td>9.8 ± 2.6</td>
<td>13.3-42.4</td>
<td>1-24</td>
<td>24-156</td>
<td>83.5 ± 15.6</td>
</tr>
<tr>
<td>Julbernadia paniculata</td>
<td>15</td>
<td>4.2 ± 1.3</td>
<td>10.0-36.2</td>
<td>1-8</td>
<td>24-110</td>
<td>70.1 ± 17.3</td>
</tr>
<tr>
<td>Brachystegia floribunda</td>
<td>10</td>
<td>6.0 ± 1.8</td>
<td>12.9-24.0</td>
<td>3-10</td>
<td>74-110</td>
<td>89.0 ± 7.7</td>
</tr>
<tr>
<td>Brachystegia spiciformis</td>
<td>10</td>
<td>5.0 ± 0.2</td>
<td>16.4-34.0</td>
<td>4-7</td>
<td>40-92</td>
<td>58.0 ± 9.6</td>
</tr>
</tbody>
</table>

Data analysis

The total number of stumps subjected to analysis varied from species to species depending on the availability of the stumps for each species. The number of stumps studied ranged from 10 (B. floribunda, B. spiciformis) to 43 (I. angolensis) (Table 1). The analysis determining the relationship between stump diameter, stump height and the number of shoots for each species. Additionally, analysis of individual parameters (number of shoots, stump height and stump heights) was conducted to show how each parameter influences the coppicing ability of the selected species.

RESULTS

Coppice effectiveness

Table 1 shows various observed parameters from the study. It shows the influence of stump diameter and height on the coppicing ability of each of the studied species. The table shows that the number of shoots per stump varied from species to species (I. angolensis (7.5 ± 1.6), B. longifolia (9.8 ± 2.6), Julbernadia paniculata (4.2 ± 1.3), B. floribunda (6.0 ± 1.8) and B. spiciformis (5.0 ± 0.2). B. longifolia with the average number of shoots per stump (9.8 ± 2.6) had the highest coppicing ability. The influence of stump size on the coppicing ability varied between species. I. angolensis, J. paniculata and B. spiciformis had the highest number of shoots per stump in the 25.6 to 30.5 cm DBH class while B. longifolia and B. floribunda had the highest number of shoots in 30.6 to 35.5 and 15.6 to 20.5 cm DBH classes, respectively (Figure 2).

Variation among species affecting coppicing

Analysis of variance revealed that differences in tree species result in significant variations in their coppicing ability. Multiple regression analysis for stump diameter and height revealed that only two (I. angolensis (P<0.04) and B. spiciformis (P<0.01) out of five species studied showed that both stump diameter and height have significant effect on coppicing ability. In other species, B. longifolia, J. paniculata and B. floribunda, the results indicate that the combination of both stump size and height did not have significant influence on their coppicing ability.
Figure 2. Stump diameter and their influence on number of coppice shoots per species.

The study has revealed that the coppicing ability of Miombo trees is mainly dependent on species. The influence of species on coppicing ability of trees has been reported in other parts of the African savannas (Shackleton, 2000; Luoga et al., 2002). The variation in coppicing ability between species may be attributed to their genetic differences which tend to influence their ability to produce growth hormones, buds and food reserves for bud development (Little et al., 2002).

**DISCUSSION**

**Coppicing ability and bud development**

The study has revealed that the coppicing ability of Miombo trees is mainly dependent on species. The influence of species on coppicing ability of trees has been...
Stump height (m)

**I.berlinia angolensis**

![Graph showing mean number of shoots per stump height class for *I.berlinia angolensis*.]

**J.ubernalia paniculata**

![Graph showing mean number of shoots per stump height class for *J.ubernalia paniculata*.]

**B.rackystegia longifolia**

![Graph showing mean number of shoots per stump height class for *B.rackystegia longifolia*.]
utilized for charcoal production, their coppicing ability allows them to persist, although this varies between species. Coppice effectiveness is a key attribute of resilience and productivity of the woodland savanna (Shackleton, 2000). The Miombo woodland species generally have both vertical and horizontal root systems which facilitate vigorous resprouting after cutting (Mistry, 2000). Lateral root lengths of 27 m have been recorded in *J. globiflora* (Strang, 1966), while the root depth of about 5 m have been recorded for most dominant species of Miombo woodland (Mistry, 2000). The horizontal root systems may additionally produce root suckers once the above-ground parts are removed (Strang, 1974). However, the precise contribution of root suckers to total regeneration in Miombo woodland needs an in depth study (Luoga et al., 2004). The variation in coppice effectiveness between species; *B. longifolia* (9.8 ± 2.6), *I. angolensis* (7.5 ± 1.6) and *J. paniculata* (4.2 ± 1.3) may be attributed to variation in bark thickness between species that tends to influence bud development (Khan and Tripathi, 1986).

Reports of coppicing ability varying with species, plant age at the time of cutting, stump height and the percentage of the stand removed have been made elsewhere (Shackleton, 2000; Luoga et al., 2002). Other factors shown to affect coppicing ability of site characteristics, angle of cutting and sharpness of cutting tools (Grundy, 1995). Grundy (1995) observed that *J. globiflora* coppiced better in shallow than in deep soils. Coppicing was also observed to be influenced by stump height in *J. globiflora* (Grundy, 1990). Development of shoots was observed to be influenced by stump heights in this study. A number of studies of different species and vegetation types support this observation (Bowersox et al., 1990; Huang, 1990). According to Canadell et al. (1991) this may be attributed to increased stump surface area with increasing cutting height. Grundy (1990) observed that cutting *J. globiflora* at ground level resulted in...
in fewer sprouts per stump compared with cutting it at a height of 120 cm. Mushove and Makoni (1993) also observed an increase in sprouting with increase in stump height in *Colophospermum mopane* in Zimbabwe. According to Mushove and Makoni (1993), the general tendency was for tall stumps to produce more coppice shoots than short ones. This is attributed to increased surface area which results in more buds on the stump (Shackleton, 1997) and also reduced impacts of browsers and fires. Cutting too low on the stem of the tree may encourage fungal infection because of moisture from the ground or the stump decay (Pawllick, 1989). Shackleton (2001) cautions that the positive effects of increased cutting height must be balanced against the loss of useful woody biomass that is left behind as stump.

Stump diameter has also been observed to influence the coppicing ability of the studied species. Most of these species produce the highest number of sprouts in the diameter range 15 to 35.5 cm. Shackleton (2000) also reported a positive relationship between stump size and number of coppice shoots in the eight South African savanna species. However, reports of decreasing survival of stumps and number of shoots per stump with increasing stump size have been made in many ecosystems (Chidumayo, 1997; Khan and Tripathi, 1986). Chidumayo (1997) observed decreasing coppicing ability with increasing stem size in the Zambian Miombo woodland while Khan and Tripathi (1986) observed the same pattern in four sub-tropical forest tree species. Khan and Tripathi (1986) attributed this to the increase in bark thickness of larger stems that prevents the emergence of buds. This implies that once the forest manager or the harvester has selected the size of tree to cut, options are available regarding the height at which to cut the tree, in order to encourage the optimum regrowth shoot development.

**Conclusion**

The study revealed that *J. paniculata*, *I. angolensis* and *B. longifolia* have higher coppicing ability than *B. floribunda* and *B. spiciformis*. Additionally, the study has also revealed variation in coppicing between species which may be attributed to differences in biological and morphological make-up of these species. The results therefore suggest that management of miombo species should be species specific rather than holistic. The study has also given the optimum diameter class time (15 to 35.5 cm) that may be utilized for charcoal production for enhancing coppicing ability in the studied species.

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**REFERENCES**


Shackleton CM (1997). The prediction of woody productivity in the
savanna biome, South Africa. PhD thesis, University of the
Witwatersrand, Johannesburg, p. 204.
Shackleton CM (2000). Stump size and the number of coppice shoots
tree species (Terminalia sericea) for fuel wood: the influence of
stump dimensions and post-harvest coppice pruning. Biomass
Bioenergy, 20: 261-270.
Strang RM (1966). The spread and establishment of Brachystegia
spiciformis Benth. and Julbernadia globiflora (Benth.) Troupin in the

Strang RM (1974). Some man-made changes in successional trends on
Syampungani S (2008). Vegetation change analysis and ecological
recovery of the Copperbelt Miombo woodlands of Zambia. PhD
Thesis, University of Stellenbosch, South Africa.