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THE EFFECT OF SITE CONDITIONS ON BARK YIELD IN *PRUNUS AFRICANA* (HOOK. F.), KALKMAN (ROSACEAE) TREES

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ABSTRACT

The objective of the study was to assess the effect of site conditions on bark yield by assessing variation in bark thickness and relative bark thickness among populations of *Prunus africana* in two closed canopy natural forest (Kakamega and Elgeyo) and adjacent farmland. Other factors being equal bark thickness is an indicator of bark yield per tree. The study showed how Bark thickness (BKT) and relative bark thickness (BKR) vary among populations from closed canopy forests and open habitats, and the influence some factors have on them. Bark thickness (BKT) and relative bark thickness (BKR) in Prunus africana is strongly influenced by diameter at breast height (DBH). The influence of habitat on BKT and BKR is significant with constant DBH they are higher in open habitats than in closed canopy forests. The information obtained will guide in designing appropriate silvicultural and management methods to increase bark production by planting *Prunus africana* at wider spacing than would ordinarily be found in a closed canopy forest.

KEYWORDS: Diameter at Breast Height (DBH), Bark Thickness (BKT), Prunus, Canopy

INTRODUCTION

Prunus africana (Hook. f.) Kalkman (Rosaceae); (Syn. *Pygeum africanum)* is a geographically widespread species, although restricted to Afromontane 'islands' (White, 1983) in mainland tropical Africa and mountainous outlying islands. Medicinal products using *Prunus africana* bark extract are used in the treatment of benign prostatic hyperplasia (Stewart, 2009; Karani *et al*., 2013).

High bark production in trees is necessary whenever the bark of a tree species is of commercial value *(* Vinceti, *et al*., 2013*)*. Because of the importance of *Prunus africana* as a commercial medicinal tree, and as cultivation of *Prunus africana* in Kenya and elsewhere gets under way, tree characteristics that affect the overall bark production and hence profitability of the species need to be addressed in order to adopt efficient production strategies. For these, the estimation of bark yield based on measurements of tree size and bark thickness becomes important.

There is virtually no information on variability in the bark thickness in *Prunus africana*, but reports of variation in bark thickness in other tree species e.g (*Eucalyptus grandis*-; *Pinus contorta*-,; *Pinus radiata*-; and *Eucalyptus urophylla*,; *E Eucalyptus globules* - Iwu, 2014) suggest there might be potential to maximise bark yield either by selecting high yielding genotypes, or planting trees under ecological conditions that maximize bark production.

Several authors have recognised that bark development is environmentally influenced (Berens *et al*., 2014). Dezeew (1941) reported that saplings of several species of trees exposed to direct solar radiation formed deep seated periderms sooner than saplings of the same species that were grown under a forest canopy. Beyond these observations, data are lacking on the complex physiological processes involved in the development of bark. It is probable that these factors also influence formation of subsequent periderms, and thus influence development of the bark. Although the time of formation of the first periderm and subsequent phellogen activity vary directly with light intensity, there appears to exist a minimum light intensity requirement for this development (Berger, 1973; Craver, 2014).). Phellogen initiation and activity increases with a rise in temperature until a maximum activity is attained, then decreases with any further temperature increase (Berger, 1973). In some species, however, bark thickness has been reported to be under strong genetic control (Budde, 2014). In *Eucalyptus urophylla* for example, heritabilities range between 0.41 and 0.7 (Wei, 1997).

The bark of trees serves a protective function, insulating against extremes of temperature, fire, and desiccating winds and against herbivory and microbial infections (Vermeulen, *et al*., 2012; Courtois *et al*., 2012). Numerous factors influence the forms that barks take; among them are the tree's growth pattern, its need for defence against predators, its lack of photosynthetic tissue in the leafless condition, and its need for insulation against either heat or cold (Hedge, 1998). Many of these factors are linked to the ecology of the tree, which is to the habitat in which it grows. The link is especially clear in an arid area where conservation of water is essential to maintain life (Prance & Prance, 1993). In these areas trees remain leafless for up to 10 months, and so green bark assumes the life-sustaining photosynthetic function usually performed by the leaves.

It has been noted that barks of tropical rainforest trees are thinner and smoother than those of species in drier habitats (Rosell, *et al*., 2014). Thick bark like that of the European oak or pine is uncommon in the tropics. Even in large tropical forest trees it is often only a few millimetres thick. The measurements of the thickness of the bark for a number of tropical timber trees showed the average of 10 mm, maximum over 25 mm and minimum 4 mm (Fasola, *et al*., 2014).

The smoothness, which is a common feature of the bark of rain-forest trees, is no doubt a consequence of its thinness (Prance & Prance, 1997). The thinness and smoothness of rain-forest trees is well illustrated by comparing *Liphora procera*, a tall tree typical of Guinea-Congolean rainforest (White, 1983), with its close ally *Liphora elata*, which occurs in scrubland and savannas. The former has thin bark, while in the latter the bark is thick. Some families are fairly homogeneous in bark thickness, but others show great variability (Hedge *et al*., 1998).

METHODOLOGY

The aim was to sample at least 30 trees of 10 cm Diameter at breast height (DBH) or more in each habitat. The irregularity of the bark of trees makes it necessary that uniform methods of measurement be applied in order to obtain comparable and unbiased results. A bark borer, 3 cm in diameter was used to remove the portion of the bark to be measured. Callipers were used to measure bark thickness (BKT). To reduce sampling errors, bark thickness of a tree was measured at two diametrically opposite points of the stem at the same height (1.3m) above the ground avoiding warts, thorns or other protuberances (Hedge *et al*. 1998). The average of the two measurements was then recorded. Diameter at breast height (DBH) over bark of the tree was also measured. Relative bark thickness (BKR) was expressed as a ratio between BK and DBH.

RESULTS & DISCUSSIONS

Population averages for bark thickness (BKT) per diameter class are shown in Table 5.1. Relative bark thickness (BKR) (the ratio between BKT and DBH) is shown in Table 2.

The trees exhibit a wide range of variation in DBH in these habitats. The higher DBH classes were more frequent in Elgeyo natural forest that is a less disturbed habitat. The average bark thickness increased from 6.6 mm at 10-19 cm DBH class to 23.6 mm at ≥70class. There is a tendency for bark thickness to increase and relative bark thickness to decrease in the trees from open farmland as compared to closed canopy forests and was statistically significant at middle DBH classes (30-39, 40-49 and 50-59). BKT and was greater and BKR lower in Kakamega farms than in Elgeyo farms or in the two closed canopy forest habitats. As expected in all cases, BKT showed a positive relationship with DBH, with bigger trees tending to have thicker bark. However when expressed as the ratio of BKT to DBH (BKR), it generally showed negative correlations with DBH.

Table 1: Population Mean Bark Thickness for Different Diameter Classes

	Mean Bark Thickness (Mm) Per Study Site											
	Kakamega						Elgeyo					
DBH Class	Natural Forest			Farms			Natural Forest			Farms		
	Mean	StDev	n	Mean	StDev	n	Mean	StDev	n	Mean	StDev	n
10-19	6.6	1.5	5	-	-	-	6.3	1.4	6	7.0	1.4	6
20-29	9.0	1.2	11	9.7	0.9	12	8.6	0.7	9	10.1	0.8	9
30-39	10.8	0.9	11	13.1	0.7	10	11.0	0.8	10	12.0	0.8	7
40-49	14	1.6	9	15	0.8	7	12.2	0.8	5	14.3	0.6	3
50-59	15	0.9	6	17.0	0.8	4	15.5	1.0	4	16.5	0.6	4
60-69	17.4	1.1	5	18	0	1	17.7	0.6	3	18	0	1
≥70	-	-	-	-	-	-	23.6	4.0	9	-	-	-

Table 2: Population Mean Relative Bark Thickness for Different Diameter Classes

	Mean Relative Bark Thickness Per Study Site											
	Kakamega						Elgeyo					
DBH Class	Natural Forest			Farms			Natural Forest			Farms		
	Mean	StDev	n	Mean	StDev	n	Mean	StDev	n	Mean	StDev	n
10-19	0.89	0.11	5	-	-	-	0.87	0.14	6	0.93	0.14	6
20-29	0.74	0.12	11	0.87	0.07	12	0.69	0.05	9	0.81	0.08	9
30-39	0.63	0.04	11	0.75	0.06	10	0.63	0.04	10	0.72	0.06	7
40-49	0.62	0.06	9	0.74	0.05	7	0.56	0.02	5	0.63	0.02	3
50-59	0.56	0.04	6	0.64	0.01	4	0.58	0.02	4	0.61	0.02	4
60-69	0.56	0.04	5	0.31	0	1	0.58	0.03	3	0.31	0	1
≥70	-	-	-	-	-	-	0.48	0.08	9	-	-	-

Tables 1 and 2 summarises the data on bark thickness (BKT) and relative bark thickness (BKR) for the four habitats. Evidently, there is a clear tendency for greater prevalence of thicker bark in the farms which are basically open habitats consisting of planted trees or remnant trees from deforestation. It is common practice in Kenya to save some of the trees after forest clearance for agriculture or livestock production. This meets both practical needs (shade, edible fruits, timber, firewood, etc.), and cultural traditions.

Genetic, environmental or an interaction of both may exhert an influence on BKT and BKR. The influence of stand characteristics on BKT and BKR varies between studies. Pederick (1970) and Monserud (1979) claimed in studies of *Pinus teada* and *Pseudotsuga mensiesii* that environmental influences were low or did not follow any trends. On the other hand, Wei and Birralho (1997) found that faster growing provenances of *Eucalyptus urophylla* in South East China did not necessarily have thicker bark or higher proportion of bark. Bark of *Pinus elliottii* is relatively thicker on well-drained soils than on damp soils. Matziris (1995) found a positive correlation between bark thickness and growth rate in *Pinus radiata* grown in Greece, while Quilho and Pereira (2001) found that bark thickness in *Eucalyptus globulus* in Portugal was higher in sites with better growth. It is possible therefore that the variation in bark thickness observed in this study could be related to higher growth rates in the open farmlands due to favourable growing conditions.

The influence of tree age on BKT and BKR is uncertain. Investigations of age variation in BKT and BKR are rare. Studies on Norway spruce have shown that age has a low influence on BKT at a given diameter (Holmsgaard & Jacobsen, 1970). In *Pinus radiata*, BKR is not changed by tree age in the lower and central parts of the stem (Gordon, 1983).

The value of this study was to elucidate how BKT and BKR vary among populations from closed canopy forests and open habitats, and the influence some factors have on them. In general BKT and BKR in *Prunus africana* is strongly influenced by DBH. The influence of habitat on BKT and BKR is significant; with constant DBH they are higher in open habitats than in closed canopy forests. The causes of the variation between open habitats and closed canopy forests could be differences in light intensity, temperature, soil fertility, growth rates or competition, but it is not possible to unequivocally separate these effects. It could be argued that soil fertility would have a major impact on BKT and BKR. Lundqvist, *et al*., 2014 has shown that bole form varies with different forest vegetation types. However, the four localities in this study are all fertile, and variation due to this factor is probably limited. Variation due to competition is likely to be important since densities in open farmland habitats are low. There is a great difference in the level of illumination and temperature in closed canopy forests and open farmlands. Variation in light intensity and temperature in open farmland and closed canopy forests could be the variables of major importance for BKT and BKR in this study.

CONCLUSIONS

Although a testing programme covering a wide range of environments is needed, the implications of the study on bark thickness are that it should be possible to improve bark production by planting *Prunus africana* at wider spacing than would ordinarily be found in a closed canopy forest, thus exposing the trees to maximum illumination. This is in view of the fact that sale of the bark is based on quantity.

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