

The Potential of *Acacia senegal* for Dryland Agroforestry and Gum Arabic Production in Uganda

Joseph Obua^{1*}, Jacob Godfrey Agea¹, Sara Namirembe¹, Simon Peter Egadu² and Patrick Mucunguzi²

Obua J, Agea JG, Namirembe S, Egadu SP and Mucunguzi P (2006): The potential of *Acacia senegal* for dryland agroforestry and gum Arabic production in Uganda. *Journal of the Drylands* 1(2): 186-193.

Studies were undertaken to determine the agroforestry and gum arabic production potential of *Acacia senegal* in the drylands of Luwero, Nakasongola and Karamoja districts of Uganda. In the Luwero-Nakasongola drylands, farm-transect walks and questionnaires were used to assess the proportion of farmland under *A. senegal* and to collect data on the socio-economic profile of the farmers, their willingness to plant and manage *A. senegal* on their farms respectively. The gum arabic production potential of *A. senegal* in the Karamoja region was assessed by establishing 135 sample plots each measuring 20 x 20 m in undisturbed land, grazed land and cultivated land. Farmers are willing to plant and manage *A. senegal* as an agroforestry tree species in Luwero and Nakasongola districts. The density of *A. senegal* varied in Karamoja and was highest in Jie county. Although there were few trees in the gum producing age of 12-12 years, there is a potential for gum arabic production. Local people use the gum for repairing household items, and use the wood for hand tools, fencing, firewood and building poles.

Key words: Tree management, rangeland, farmland, local knowledge

¹Faculty of Forestry and Nature Conservation, Makerere University, P.O. Box 7062 Kampala, Uganda

²Department of Botany, Makerere University, P.O. Box 7062 Kampala, Uganda

*Author for correspondence: Joseph Obua, Tel. +256-41-543647, Fax +256-41-533574, E-mail: obua@forest.mak.ac.ug

Received December 2004, Accepted July 2005

Introduction

Acacia senegal (L.) Willd is an important multi-purpose tree species (Cossalter 1991). It produces gum arabic, stabilizes sand dunes, fixes atmospheric nitrogen and is a source of fence posts, firewood and fodder (Katende et al 2000). The species extends over a wide ecological range that differs in rainfall, soil and altitude (Cossalter 1991). Traditionally, *A. senegal* has been growing wild in the wooded grassland and deciduous bushland of Uganda especially in Kotido, Moroto and Northern parts of Luwero District (Katende et al 2000). However, the local people are now integrating it in their farming system. It is retained in the gardens of cotton, millet, simsim, sorghum and groundnuts. Two studies have been integrated in this paper: the potential of *A. senegal* as an agroforestry tree species in Luwero and Nakasongola districts and a survey of *Acacia* trees for gum arabic production in Karamoja region focusing on *A. senegal*.

The resource of *Acacia* species in Luwero and Nakasongola districts is believed to have reduced

over the past years because of the increasing demands for fuelwood, fencing posts and overgrazing (Otike 1998). There is therefore a need to conserve the species if they are to meet the increased demand for fuelwood, fodder, soil improvement through nitrogen fixation, protection of the environment and to cater for gum production, which is an important source of cash. Furthermore, there is a need to understand farmers' attitudes towards planting of the species and the constraints and opportunities to management of the species by the local people. The aim of the study was to assess the local uses of *A. senegal* and farmers' willingness to plant and manage the species on their farms.

Karamoja region has limited sources of gainful employment for its people yet it has numerous resources that could contribute to its socio-economic development. Such resources include gum arabic, livestock and their products, minerals and other forest resources. At present, people depend heavily on livestock for their livelihood. Gum arabic production and marketing was a viable economic activity in Karamoja during the 1960s and 1970s until

the 1990s when it collapsed due to lack of adequate quantities of gum arabic to guarantee profitable trade and insecurity that made gum collection difficult and discouraged traders from going to Karamoja (Forest Department Moroto 1990). The security situation worsened when the Karimojong acquired small firearms to defend themselves against cattle rustlers from Kenya and to raid cattle from neighbouring districts.

The name gum arabic was derived in 4,000 B.C. when it was shipped to Europe from Arabian ports. Gum arabic or Acacia gum is a sap-like substance that exudes from fissures and wounds of Acacia trees and hardens after a few weeks into shiny amber-coloured globules (Friedman and Rangan 1993). Its colour varies from dark brown to white depending on the quantity of tannins (Coppen 1984). It consists mainly of high molecular weight polysaccharides and calcium, magnesium and potassium salts that on hydrolysis yield arabainose,

galactose, rhamnose and glucuronic acid. When purified, it is used in the textile and food processing industry and for the production of glue, medicines, paint and printing ink.

Acacia tree resources have contributed to the improvement and sustenance of the quality of life of rural communities in Karamoja. One of the important resources from *Acacia* trees is gum arabic, the best quality of, which comes from *A. senegal* and *Acacia seyal* (Coppen 1984). *Acacia nilotica*, *A. polyacantha*, *A. siberiana* and *A. nubica* produce lower quality gum (Adamson and Bell 1974). There are prospects for gum arabic production in Karamoja to alleviate poverty. However the current stocking density and sizes of the *Acacia* trees have not been comprehensively surveyed. Little is known about the current population status of the gum producing Acacias. The aim was to determine the population structure of *A. senegal* in different ecotones in Karamoja and the gum production potential.

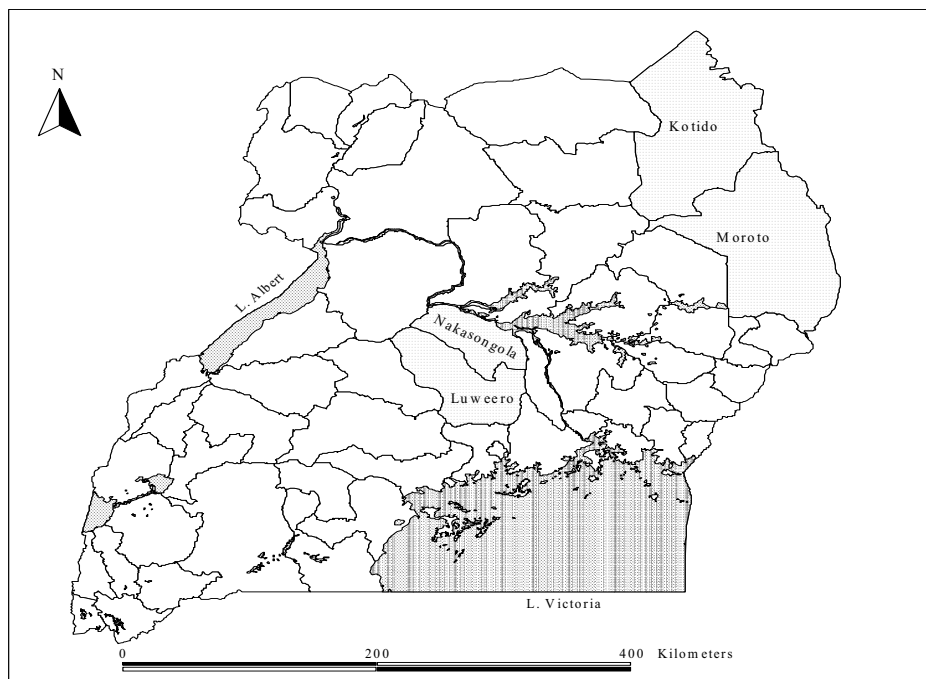


Fig. 1. Map of Uganda showing the location of the study areas (dotted)

Study areas

Figure 1 shows the location of Luwero-Nakasongola and Karamoja region. Luwero and Nakasongola districts ($0^{\circ} 43' - 1^{\circ} 18' \text{ N}$ and $32^{\circ} 27' - 32^{\circ} 30' \text{ E}$) cover an area of $9,204 \text{ km}^2$ representing 3.81 % of the country's total surface area. The districts are underlain by metamorphic rocks of pre-cambrian origin (Omoding 1994) and covered by the Buruli catena to the north and Lwampanga catena in the low-lying areas and valleys (Omoding 1994, Parker et al 1967). The mean diurnal maximum temperature range is $18 - 35^{\circ} \text{C}$ (Omoding 1994, Parker et al 1967). The annual rainfall is $1,000 - 1,250 \text{ mm}$. The vegetation is mainly forest/savanna mosaic, moist *Combretum* woodland, dry *Combretum* woodland, grass savanna, seasonally flooded grass swamps, permanently flooded swamps and post-cultivation vegetation (National Environment Management Authority, 1997).

Karamoja region ($1^{\circ} 31' - 4^{\circ} \text{ N}$ and $33^{\circ} 30' - 35^{\circ} \text{ E}$) is composed of Kotido, Moroto and Nakapiripirit districts located in Northeastern Uganda. It covers an area of $27,319 \text{ km}^2$, approximately 10% of Uganda's land area. It is bordered by Sudan in the north; Pader, Lira and Katakwi districts in the west; Kumi district in the southwest; Kapchorwa and Sironko districts in the south and the eastern borderline is shared with Kenya.

The annual rainfall ranges from $500-700 \text{ mm}$ in the east and central parts and $900-1500 \text{ mm}$ in the south and north (National Environment Management Authority 1997). The mean annual minimum temperature is about 15°C and the annual maximum is 30°C . The soils, sandy Ferrasols in the highlands and Vertisols in the north and south, vary in productivity. The vegetation consists of scattered tree and shrub formations over an open cover of grasses and herbaceous plants with much bare ground (Wilson and Rowland 2001). Other forms of vegetation are *Acacia-Commiphora* thickets, *Chrysopogon* grass steppe, *Lanea-Acacia-Balanites-Albizia-Dichrostachys* bushlands. *Themeda triandra* and *Hyparrhenia filipendula* grass dominate the lowlands (National Environment Management Authority 1997). The vegetation has faced gradual vegetation degradation since the 1960s due to deforestation, overgrazing, fires and monocropping that has resulted into occasional floods and drought (Wilson and Rowland 2001).

Methods

Assessment of agroforestry potential of *A. senegal* in Luwero and Nakasongola districts

On-farm transect walks were conducted in Butuntumula, Kakooge, Nabiswera, Ngoma and Wabinyonyi sub-counties in Luwero and Nakasongola districts. Fifty farms, ten in each sub-county, were randomly sampled and surveyed to gauge the extent to which *A. senegal* is already part of the farming system. One hundred and eighty four structured questionnaires were administered to collect information on the socio-economic profile of the farmers, uses and willingness to plant and manage *A. senegal* on the farms.

Assessment of *A. senegal* for gum arabic production in Karamoja region procedure

One hundred and thirty five sample plots each measuring $20 \times 20 \text{ m}^2$ (0.04 ha), were randomly selected and established in seven counties. Forty-five of the sample plots were set up in undisturbed land, 45 in grazed land and 45 in cultivated land. All individual trees in the sample plots were identified, counted and diameter breast height (DBH) measured. Gum exudates were extracted from five *A. senegal* trees and weighed to estimate the gum production potential. Two hundred and ten farmers were interviewed to solicit information on the usage of the trees and gum arabic, time of harvesting gum and local knowledge of habitats with *A. senegal*.

Data analysis

The scores for each species were summed across all respondents to derive a species priority list for Luwero and Nakasongola. SPSS was used to analyze the questionnaire responses for all the study sites. MS Excel was used to summarize tree density data for Karamoja region.

Results

Demographic and socio-economic characteristics of the farmers in Luwero and Nakasongola districts

Seventy eight percent of the respondents were above 26 years old (Table 1). The average family size was seven people per household. More than half of respondents were male and 55% were subsistence farmers. About 50% reared goats; 34% reared cattle (34%). More than 72% have lived in the study area for over ten years and about 50% of the families own less than 3 ha of land.

Table 1. Socio-economic characteristics of the households (N = 184)

Factor	(%)
Age	
<25	21.60
26-50	51.30
>50	26.46
Sex	
Male	60.58
Female	39.42
Current occupation	
Agriculture (farmer, herdsman)	55.08
Service worker (councilors, teachers)	10.26
Student	7.56
Others (Housewife, Blocker, Charcoal burner, market vendors)	24.30
Educational background	
No formal education	13.58
Primary	52.72
Secondary	26.63
Tertiary (Institutions)	7.06
Household yearly income (Ug.Shs.)	
<200,000	14.76
201,000-400,000	49.46
>400,000	34.78
Family size	
1-5	52.38
6-10	33.48
>10	13.50
Plot/land size (hectare)	
≤3	50.22
4-6	36.72
>6	12.42
Period of stay (years)	
≤10	27.00
11-20	35.10
>20	37.80
Have domestic animals	
Yes	84.24
No	15.12
Types of animals owned	
Cattle	34.02
Goats	51.30
Pigs	22.14
Rabbits	17.28
Bees	31.86
Others (sheep, horse)	24.30

Uses of *A. senegal* by the households

About 83.3% of the respondents are aware of the agroforestry potential of *A. senegal* and 44.8% protected the species on their land. *A. senegal* is a source of fuelwood, fodder, food, fencing posts, medicine and helps to conserve soil (Table 2).

Table 2. Uses of *A. senegal* reported by farmers (N=184)

Factor	(%)
Knowledge of <i>Acacia senegal</i> trees	
. Yes	83.2
. No	16.7
<i>Acacia senegal</i> grown or retained on household land	
. Yes	44.8
. No	55.2
Uses of <i>Acacia senegal</i>	
. Fodder for domestic animals	48.6
. Food	6.5
. Fuelwood	61.0
. Fence materials (Kraal)	19.9
. Soil conservation	32.4
. Others (medicinal, gum)	24.3

Problems of managing *A. senegal* on private lands

The problems faced in managing *A. senegal* are given in Table 3. Thirty five percent of the farmers said that grazing destroys seedlings through trampling and soil compaction. Other problems are insecurity of land and tree tenure, pests and diseases, wildfires and drought.

Table 3. Problems of managing *Acacia senegal* on the farms (N=184)

Challenges	(%)
Grazing animals	35.1
Pest and diseases	32.9
Land and tree tenure	30.9
Bush fires	26.5
Drought	9.7

Farmers' willingness to plant and manage *A. senegal*

About 53% of the respondents were willing to plant and manage the species on their land (Table 4). Those who were not willing (42.7%) said they did not have enough land to plant the trees and feared that government could take their land away if the trees begin to produce gum.

Table 4. Local communities' willingness to participate in planting and management of *A. senegal* (N= 184)

Factor	%
Future of <i>A. senegal</i> on private land	
Promising	27.5
Uncertain of its future	17.8
Don't know	55.0
Willingness to plant and manage <i>Acacia senegal</i>	
Yes	52.9
No	42.7
Don't know	4.3

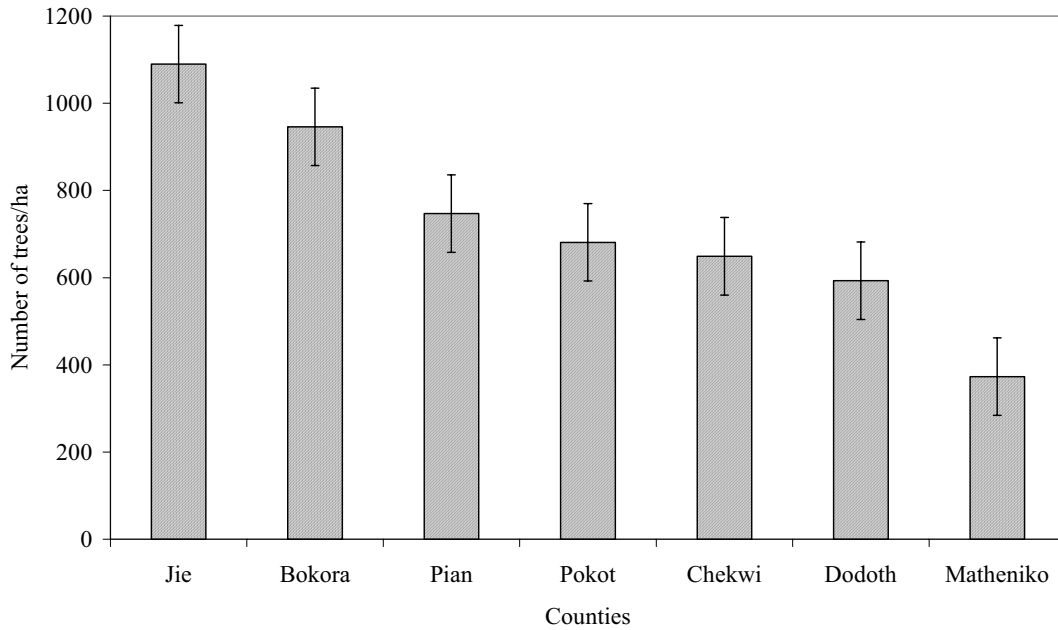


Fig. 2. Density of *A. senegal* per county in Karamoja region. Vertical lines on top of bars indicate S.E (± 5). Average number of trees/ha (741)

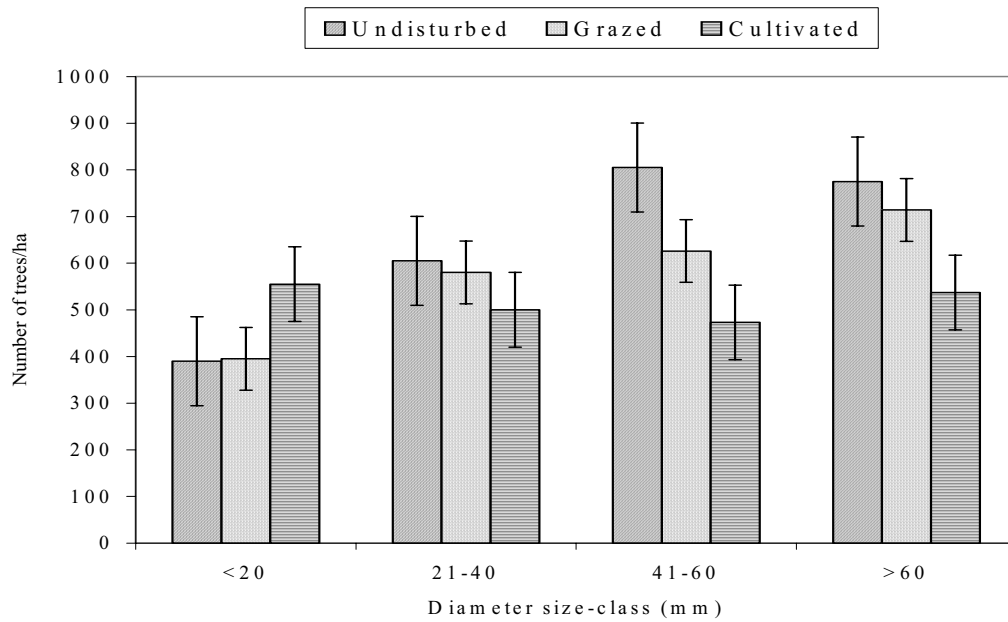


Fig. 3. Population structure of *A. senegal* in Karamoja region. Vertical lines on top of bars indicate S.E (± 5).

Density of *A. senegal* in Karamoja region

The density of *A. senegal* varied between the study counties (Figure 2). The highest was in Jie county (1,449 trees per ha).

The distribution of *A. senegal* in the different diameter size classes are shown in Figure 3. Generally, the density increased with increase in diameter size classes. In the <20 mm DBH, the density was highest on cultivated land. There was a high density of trees with DBH of >20 mm on the relatively undisturbed land.

Gum production potential of *A. senegal* and the uses of gum

The amount of gum produced in the dry season (November to March) amounts to 208 ± 85 g per tree. More gum was produced in December, January and February. The highest amount was produced in January (average of 360 g) and the lowest in March (120 g).

The gum is used for glueing household items such as broken earth pots, stools and calabashes and fixing arrows. The uses of *A. senegal* trees are given in Table 5.

Table 5. Uses of *A. senegal* trees stated by farmers (N=210)

Use	% Response
Fencing	100
Fuelwood	71
Poles	66
Gum	60
Crafts	57
Medicine	43
Fibre	14
Tannin	14

Local people's knowledge of the habitats where *A. senegal* trees grow is presented in Table 6.

Table 6. Local knowledge of the habitats of *A. senegal* trees (N=210)

Habitat	% Response
Lowlands	40.2
River valleys	13.3
Hills	13.2
Sandy loam soils	4.7
Gently sloping areas	3.6
Brown sandy soils	2.8

Discussion, Conclusions and Recommendations

Agroforestry potential and uses of *A. senegal* in Luwero and Nakasongola

The majority of the farmers are aware of the agroforestry potential of *A. senegal* and are willing to plant and manage the trees on their land. *A. senegal*

is used for fuelwood, fodder, food, fencing and kraal construction, soil conservation and medicine, thus confirming reports about the uses of the species by NAS (1980) and Booth and Wickens (1988). Although it is a good source of fuelwood, the biomass yield of *A. senegal* per unit area of land is generally low and may not warrant planting it purely for fuelwood.

The food values of *A. senegal* trees is well documented, for instance, by Booth and Wickens (1988), Dicko and Sikena (1992). They reported that leaves of *A. senegal* contain 10-13% of digestible protein and 0.12-0.15% of phosphorus, while the pods contain 15% of digestible protein and 0.12-0.14% of phosphorus. *A. senegal* and its close relatives are also known to be the major source of commercial gum arabic for food purposes. Anderson (1989) indicated that *A. senegal* is the only species in the *Acacia* family that produces *Acacia* gum evaluated toxicologically as a safe food additive.

Problems of managing *A. senegal* on private lands

The majority of people in Luwero and Nakasongola districts are pastoralists. As such, grazing is likely to remain a formidable problem in the management of *A. senegal* in the farmlands and fires will hinder the regeneration in the wild. According to Edwards (1984), fire is often used by pastoralists to control plant succession, encourage fresh grass growth early in the growing season, destroy undesirable plants and pests and reduce the fuel and potential risk of accident from wildfires. Because of inadequate information generated from research on the species in Uganda, problems such as pests and diseases will require comprehensive studies to establish their occurrence, intensity of infestation and how to manage them in an integrated manner, especially on-farm.

Luwero and Nakasongola districts are among the most overgrazed areas in Uganda. Overgrazing causes defoliation of trees, destruction of seedlings and roots of plants as well as compacting the soil through the trampling action by livestock. According to Bourliere (1992), soil compaction by grazing animals can significantly interfere with the regeneration of tree species. Many tree species tolerate the removal of a limited proportion (20-75%) of their foliage. Heavy grazing may completely remove *A. senegal* from the rangelands or may reduce them to low density. Overgrazing would also create a discontinuous relationship between the stocking rate and vegetation growth.

Insecurity of land and tree tenure is one of the most serious problems in management of *A. senegal*. Many farmers said that the rangeland is

public land and they do not have control over it. Some feared that the government may in future gazette the rangeland as a protected area, thus further reducing their access to tree resources from such areas. Some people preferred to cut *A. senegal* and replaced them with *Mangifera indica* for fear of losing land as a result of recent governments' interest in gum arabic production. Clearly, the perceived land and tree tenure systems in the rangelands may be a disincentive to the management and conservation of *A. senegal* and would discourage the farmers from planting *A. senegal* as an agroforestry tree species. This problem will need to be addressed through well articulated agricultural extension messages. The farmers' fear is consistent with Juma and Ojwang's (1996) observation that the absence of security of land ownership discourages farmers from long-term investment in land. Secure tenure and tree usage are usually incentives to households to plant and care for trees.

The problems associated with planting and management of *A. senegal* does not mean that the communities are unwilling to plant and manage the trees. It was noted that most of the farmers would be willing to participate in any long-term program aimed at conserving the species. There is therefore a need to build the capacity of the local communities to effectively manage and conserve the species in the rangelands and on the private lands. Although local people are willing to plant and manage the species, the problems given above may hinder their efforts. Such problems need to be addressed from the onset if the agroforestry potential of *A. senegal* is to be realised in the near future. Moreover, there is a need for farmers to have easy access to planting material that should be developed and provided through research. The proposed expansion of agroforestry programme by ICRAF/AFRENA to dryland areas should focus on planting material development.

Density of *A. senegal* in Karamoja region and potential for gum production

This study has shown that there is potential for gum arabic production from *A. senegal* in Karamoja region. The population structure revealed that most of the trees were old and this presents a problem in gum production because younger trees produce more gum. The growth of *A. senegal* seems to be linked to the soil type. The tree density was higher in Jie, Bokora and Pian counties, which are covered with Ferralsols and Vertisols considered to be relatively more fertile. The density was low in Matheniko County although it has the same soil types, perhaps due to high grazing pressure and cutting for charcoal production and fencing.

There were more trees in the larger diameter size classes indicating poor regeneration. Undisturbed land had higher densities of *A. senegal* because it is rarely accessed by local people to gather tree products and it is found mainly in the insecure areas of Karamoja. Grazed and cultivated areas had low densities of the species due to constant damage by fires, livestock and weeding by farmers.

The gum from *A. senegal*, and other gum producing Acacias, usually exudes from cracks in the bark of stems and branches. The amount of gum collected was highest in December, January and February because these are dry months and gum production is often highest in dry season. Gum arabic is only produced by trees that are in an unhealthy condition. Gum yields are improved by natural factors that lessen the vitality of the trees - hot weather, poor soil and lack of moisture (Coppen 1984). It is important to remember that a damaged tree will give a larger yield of gum. Thus, the natives often cut and strip the bark from a tree and return later to remove the tears of gum that are formed in wounds or scars.

Since the overall density of *A. senegal* trees in the study area was 741 trees per hectare thus producing about 154.128 kg of gum per hectare annually, it can be said that the potential of gum arabic production in Karamoja is high. *A. senegal* occurs in about 13,046 km² of land in Karamoja implying that there are about 1,306,400 ha with the potential to produce 201,353 tonnes of gum arabic per annually. According to Duke (1983), annual yields from young *A. senegal* trees may range from 188 to 2856 g/tree (avg. 900 g), from older trees, 379 to 6754 g/tree (average 2,000 g). The finding of this study implies that Karamoja gum would be able to meet the local demand for gum arabic and export the excess amount. However, there is a need for a deliberate effort by the government to improve the stock condition and the general management of the drylands and the resources therein.

References

- Adamson AD and Bell JMK (1974): The market for gum arabic. Tropical Products Institute, London.
- Anderson DMW (1989): NFT gums: Ancient and modern commercial products. NFTA Highlights 89-01.
- Booth FEM and Wickens GE (1988): Non-timber use of selected arid zone trees and shrubs in Africa. FAO Conservation Guide 19, Rome.
- Bourliere F (1992): Ecosystems of the world: Tropical Savannas. Elsevier, Amsterdam.
- Coppen JJW (1984): Gum arabic – its preparation and industrial uses. Overseas Development

Administration and Tropical Development Research Institute, London.

- Cossalter C (1991): *Acacia senegal*, gum tree with promise for agroforestry. NFT Highlights, NFTA 91-02. Nitrogen Fixing Tree Association, Hawaii.
- Dicko MS and Sikena LK (1992): Fodder trees and shrubs in range and farming systems in dry tropical Africa. pp. 27-45. In: Speedy, A. and Pugliese, P. L. (Eds), Legume trees and other fodder trees as protein sources for livestock. FAO, Animal Production and Health Paper, Rome.
- Forest Department Moroto (1990): Gum Arabic production and development. A document prepared by the District Forest Officer Moroto in preparation for a study tour in Sudan.
- Juma C and Ojwang JB (1996): Land tenure systems and natural resource management: In Land We Trust: Environment, Private Property and Constitutional Change. Nairobi and London: Initiatives Publishers and Zed Books, pp 85-90.
- Katende AB, Birnie A and Tengäs B (2000): Useful trees and shrubs for Uganda. Identification, Propagation and Management for Agricultural and Pastoral Communities. RELMA, Nairobi, Kenya.
- Ministry of Finance, Planning & Economic Development (1992): The 1991 Housing and Population Census. District Summary Series, Moroto District. Government of Uganda, Kampala.
- NAS (1980): Firewood crops. Shrub and tree species for energy production. National Academy of Sciences, Washington, DC.
- National Environment Management Authority (1997): The State of Environment Report for Luwero District. Ministry of Natural Resources.
- Omoding J (1994): Grasses of Luwero. M.Sc. thesis, Institute of Environment and Natural Resources, Makerere University, Kampala.
- Otiike P (1998): Population structure and natural regeneration of *Acacia tortilis* in the lake shore savannah woodlands in Nambieso sub-county Apac District. Faculty of Forestry and Nature Conservation, Makerere University.
- Parker D, Downer ER and Cole GED (1967): Atlas of Uganda. Dept. of Lands and Survey. Govt. Printer Entebbe.
- Wilson J and Rowland J (2001): Land and agriculture in Karamoja. A report of the European Union funded study. The EU, Brussels.