Gum Arabic Yield of *Acacia senegal* in Irrigated Plantations in Kenana Sugar Estate.

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1- Introduction:

*Acacia senegal* (Hashab) is a multi-purpose leguminous tree species, suitable for arid and semi-arid environments. *Acacia* is a genus of the subfamily *Mimosaceae* represented in Sudan by 31 species. Hashab produces the best quality of gum Arabic, good fodder, fuel wood, charcoal, and poles for building purposes, and fence posts. It is useful for environmental protection and conservation especially in sandy soils (*goz*). It fixes sand dunes, protects the soil from wind and water erosion and fixes nitrogen. As such, it is an integral part of the agroforestry practice widely known in Sudan as bush-fallow cultivation, where agricultural crops are grown in a time sequence with the trees.

The species has a wide geographical distribution in the Savannah belt of Africa. In the Sudan the tree is reported between latitudes 10-14° N. approximately, in an area that varies in climate and soil type. The climate
varies in rainfall in terms of quantity and distribution, temperature, wind, and humidity. This has resulted in variable growth rates or morphological characteristics, survival, gum productivity and seed yield.

Production and export of gum arabic decreased significantly from 80% in 1991 to 61% in 1998. The decline in export started very early and was attributed to the reduction of Kordofan gum production.

Tree growth characteristics are believed to affect gum yield. Many producers assume that good growth is indicative of high gum yield. This relation has not been critically examined or quantified. Pilot experiments in North Kordofan indicate presence of a relationship between yield and some of the morphological parameters.

Gum arabic is still largely collected from Acacia senegal natural stands rather than from plantations. But as a result of bad management, poor stocking and grazing, gum yield per tree and per unit area from natural stands is very low compare to plantation. This reflects the need for comparing gum yield between plantations and natural populations. Also,
there is a need for consolidation of the relationships between tree growth parameters and age with gum yield.

2- *Acacia senegal*

Most of the acacias in Sudan produce gum, either by natural exudation or after tapping. However, the commercial gum arabic is produced by *A. senegal* and *A. seyal*. *Acacia senegal* (L.) Willd var. *senegal* commonly known as Hashab is the widely distributed of the four varieties in Sudan and the best source of gum arabic.

Hashab is viewed as a major contributor in combating desertification problems in the gum belt. The rehabilitation of the gum belt gardens promised to provide cash for the farmers and to reduce ecological damage. Moreover, hashab trees are the main components of the agroforestry system practiced in Western Sudan, based on their positive contribution to soil fertility through nitrogen fixation.

*Acacia senegal* is described as a shrub or small tree, 2-12 m height with bark yellow to light brown or gray. It has rough- prickles at nodes in three, 2 lateral pointing upwards and one central pointing backwards. The
pods flattened elongate, pale brown colour, with one to five seeds. The
crown is variable, flat and spreading or rounded.

It is best found in sandy areas of annual rainfall of 300 - 450 mm but can
grow under 200 mm and up to 800 mm. It is also reported to occur in
southern Sudan, in Juba area in the stony soil of good drainage under 900-
mm annual rainfall. The mean annual temperature within the species range
is between 25°C and 27°C and a maximum of 45°C.

The species exists in a number of soil types. The two major and most
extensive types being the sandy soils and the dark cracking clay soils
where there is no risk of water logging. The suitable pH is about 7.8 to 8.

2.1 Regeneration

The species can be established by natural seed dispersal, coppice and
artificial means. The species occurs naturally on sandy soils in Kordofan
and Darfur in rotational bush-fallow cultivation systems and in the central
clay plains in association with other tree species such as Kitter (Acacia
mielifer), Heglig (Balanites aegyptiaca) and Talih (Acacia seyal).
Natural regeneration is by natural seed dispersion, probably by animals and wind and sprouting. The animal dissemination of seed helps in treating the seed for quick germination. Coppice is an important means in the bush-fallow system. The species sprouts vigorously from the cut stumps. The sprouts are usually cut to favour crops, until the fertility of the soil is reduced and then the cultivation is abandoned leaving the sprouts to grow. The trees are tapped until gum yield begins to drop and the area is put under cultivation again and so on for many years.

Direct seeding or transplanting of seedlings in small pits carries out artificial regeneration. Direct seeding in clay soils is done by mechanical means. Experienced farmers in Kordofan and Darfur practice manual direct seeding. As for seedlings, they are usually raised for 3 months in a nursery, reaching 30 cm in height, and then transplanted to the field in July and latest by early August. The suggested planting distance ranges from 3m X 3m to 5m X 5m.
2.2 Tapping

The trees are ready for tapping when they reach 1.2 m to 3.7 m in height with a main stem of about 5 cm or more in diameter. The trees ripe for tapping towards the end of the growing season when they start to shed their leaves naturally and bark colour changes from green to brown. In Kordofan tapping is usually carried out about the beginning or mid of October. Late tapping is done if the trees continue to grow instead of shedding their leaves due to extended rainy season or other factors. Tapping of trees in October yields significantly more gum as compared to late tapping in November or December.

Tapping is done using a sharp tool known as “Sonki” which is pushed through the bark of the branches having more than 2.5 cm diameter. The bark peels off to a length of 20 cm to 40 cm. Tree branches are tapped at alternate years. Tapping is carried out for coppice origin, seedling origin and natural stands at age 3 to 4, 5 and 6 to 7 years, respectively.
2.3 Gum yield

Gum exudes after tapping as tears of gum on the exposed-cut surfaces. The first collection of gum is after 2 to 5 weeks from tapping. Subsequent pickings are made from the same injured spot every 10 to 15 days for up to seven pickings. Usually the gum nodules are picked from the stem and branches by hand or by the "Sonki". The maximum gum yield is usually obtained between the second and fourth pickings.

Yield of gum arabic from individual trees is very variable ranging from a few grams to 10 kg. The average yield per tree and unit area varies from tree to another and also from season to the next. The overall average annual yield per tree is about 250 grams.

3. Gum Arabic

It is the oldest and best known of all natural gums. Commercial use of gum Arabic can be traced back to around the year 2000 BC, when the Egyptian used it in foods, adhesive, colour and paint industries. European traders, who imported the products from Arabian ports, coined the term gum Arabic. The uses of gum Arabic depend on its physical and chemical properties. Physically it is colorless, tasteless, odorless and readily soluble
in water. Chemically, it consists of a mixture of saccharides: L-arabinose, D-galactose, L-rhamnose and glucronic acid, with calcium, potassium and magnesium salts. The main function of gum arabic are: to prevent sugar crystallization, to emulsify the fat and keep it uniformly distributed throughout the product, also gum Arabic used as adhesive and binder. Because of these functions gum Arabic has been used in wide range of industries, particularly in food industry. It is used in confectionery, pharmaceutically industry (e.g. drugs, tablets, pills, cough drops and syrups), cosmetics (e.g. creams and lotions), lithography, ink, textiles, printing, water colour, Paints, paper sizing, pottery glazing and adhesive (including the traditional office glue and postage stamps).

It is known that gum is produced as a an injury response but the mechanism is not yet clear. It is not known when, where and how it formed. However, some correlations and observations were made on the factors affecting tree yield.

4. Factors Affecting Gum Yield

The peak of gum production is found in the sandy soil within the gum belt of Sudan in Kordofan and Darfur. Kordofan share was 60% and 50% of the country’s and world’s production, respectively.
However, gum Arabic production is subject to a number of constraints those have contributed to its declined production. The main problems are climatic factors, man, animals, type of stands, tree size and age, insects and fire.

4.1 Climatic factors

The climatic factors rainfall (intensity, frequency and duration), temperature and relative humidity affect gum yield significantly. Good rain years usually result in good gum production, but if the rains continue very late in the season, gum production will be impaired. This is primarily due to two reasons: 1) the tree will continue to grow and will not be ready for tapping, and 2) even if the trees are to be tapped the rain would reduce the quality of the gum as the wet nodules collect dust and other adherents. Furthermore, high annual total rainfall, if not well distributed throughout the season, will affect the survival and growth of the species and may result in low production.

4.2 Man

The increasing population and consequent pressure on land caused severe damage to the tree growth and gum production. The common practices done by man such as felling of mature trees for agricultural expansion,
firewood and charcoal, digging out the roots of the trees to be used for lining hand dug wells and making fibres besides the intensive use of fire to clear the grass for cultivation.

4.3 Animals

Grazing and browsing have important effects on the tree. Different types of animals vary in their damage to the trees. Goats are the worst in that they can graze practically every part of the tree. Camels also graze, mainly, the leaves and branches, and may cause considerable losses by eating the gum. Furthermore, repeated grazing kills the seedlings and can cause very serious damage to the soil.

4.4 Types of stands

Pure natural stands have low yield due to several factors. Natural regeneration is lacking in areas where shifting cultivation is practiced. In these areas over mature trees of hashab are found scattered and in many cases they die and are gradually replaced by other species. The natural stands density is very low as it varies from 1-500 trees per hectare, and the average density per hectare being about 95 trees. Plantations on the other hand are fully stocked and have high productivity in North Kordofan as compared with the natural stands.
5.1 Examples from Sudan:

a) Plantations vs. Natural Stands: Plantations were established in North Kordofan by the gum research since the sixties from nursery raised seedlings. The reported results showed most of the trees produced gum from age 4 and the yield increased with age. They produced significantly more gum than trees from natural stands of approximately similar age. Recent study compared plantations and natural stands at El Hineira site and El Demekeya sites. The plantation grew bigger in crown, diameter and height and produced more gum, almost double. Gum yield was low at age 5 to 10 years and increased to reach its peak at 15 and then decreased at age 20 years.

b) Plantations at Tendalti sites: Seedling Plantations established in the eighties by the Fimuida project around Tendalti area didn’t produce gum. The local farmers coined the term sterile trees and the believe that is due to the seedling origin.

c) Maternity Effect: Maternity effect was profound on the gum yield of trees in plantations. Tree plantation from High yielding mother-trees produced significantly more gum than plantations from bulk seeds at El Demekeya. High yielding started producing earlier (at age 4). The yield of trees from bulk seeds origin started at late age and their gum yield on the average was very low. This indicates the importance of the seed origin. The matter is further complicated as low yielding trees produce more seeds.

d) Effect of geographic source: Seeds from the sandy soil origin were indicated as the original source for the plantations established in the rainfed mechanized farms (El Daly way Elazmoun). These plantations were known to produce gum however in lesser quantity than the sandy stands.

5.2 Example from West Africa:

Major efforts were undertaken to establish Hashab plantations in Senegal, Burkina Faso and other countries that have climatic conditions similar to that prevailing in Sudan’s gum-belt. French groups aided them in the establishment. They complained about the low and almost no yield of gum and requested help from The Forest National Corporation in 1998.

6. Hashab In Kenya: (Case analysis)
4.5. Tree size and age

Producers believe that good growth may lead to high gum yield due to more branches, more leaves and hence more carbohydrates. Crown diameter, height and stem diameter were positively correlated with gum yield. The tree production span is between 4 years and up to 20-25 years of age. It was reported that yield from cultivated trees increases up to age 15 years and then decreased.

4.6 Insects

Various insect types leading to reduction of gum yield and infestation by termites that may kill some trees weaken the trees. Tree Locust was reported as an important pest that defoliates the trees and reduce gum yield.

4.7 Fire

Fire is a serious problem as hashab trees are not resistant to fire. Repeated fires for three years or more will kill the trees and will often reduce the gum yield.

5. Experiences of Plantations

Establishments of plantations were tried in Sudan and West Africa with mixed and confusing results.
6.1 Why Hashab was suggested: As a participant in the original formulation of the Forestry Project in Kenana, the suggestion was made according to: Following:
- Kenana site is on the northern natural gum-belt,
- Plantations were successfully established in North Kordofan,
- Movement of seeds from sand to clay was successful,
- Gum demand was very high in the early nineties,
- An attempt to concentrate a large number of trees in one site that is properly managed for high gum yield with less cost.

6.2 The problem:

Unlike the expectation:
- The gum yield per tree was low or close to none.
- The number of trees that yielded gum was very insignificant.

6.3 The Practice:

to me, the main practices that might have effect on gum yield as related to the Kenana plantation are the following:

6.3.1 Seed source:
Seed source is indicated to be from (Geiroha?) North Upper Nile. Seedlings were raised in the Forestry nursery in Kosti and then moved to the site where they were transplanted.

6.3.2 Irrigation:
After transplanting the seedlings were irrigated all-year-round for the first 1-2 years.

6.3.3 Silvicultural operations:
Land preparation, transplanting, weeding and protection from man and animals were properly done. The trees were severely sprayed last year (2000) to combat and control the Locust infestation.

6.3.4 Tapping age and time:
In 1998, the trees were tapped at age 4 and in 2000 at age 6. The tapping of the trees in 2000 was in early October and Gum was expected according in late to early December 2000.

6.4 Possible causes of the problem.
Gum yield is a very complex process that is affected by the genetic background, physiological conditions of the tree and the surrounding environment. In my opinion, it very difficult to pin point the causes. However, since some trees produced gum though very little indicates that there is inherent problem in the other trees. Possible reasons are:

a) Seed source and origin:
First, the seed source, though not surely known, is clay southern source. As indicated earlier there is no observed problems of moving seeds from sand to clay however there is no knowledge of the effect of moving seed from between clay geographical sources.

Second, the seeds were probably collected as bulk from trees of unknown gum yield. Negative correlation is believed to exist between gum yield and seed yield. Some of the trees that bear large amount of seeds are even tapped by the local farmers.

Seed source and origin should have been critically examined as the plantation is of high input nature.

b) Irrigation:
The natural habitat of the tree has cycle of dry and wet season where the trees shed their leave and the stem is considered dormant. The irrigation may have resulted in epi-genetic variation, a settled physiological effect that caused some trees to be sterile as far as gum is concerned.

c) The severe spraying may have affect the environment around and within the trees leading to reduction in yield.
7. Next (Forward):

Gum yield is a complex process that is not fully understood and is affected by many factors. Kenana plantations are pioneer in terms of irrigation and intensive cultural practices. The experience can be considered as large experiment and a learning process. The following is suggested:

- The high expectation from the plantations should be lowered modestly in term of gum quantity and revenue.

- Halt on new plantations

- More research to induce gum production for the existing plantations. The variables that can be tackled are:

  1) Timing and depth of tapping

  2) Spray to combat Locust with varying concentration.
References


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