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Use of indigenous knowledge in predicting fruit production of shea butter tree in agroforestry parklands of north-eastern Uganda

J. B. L. Okullo, J.Obua and G. Okello
Department of Forest Biology and Ecosystems Management, Makerere University, P.O.Box 7062, Kampala.

Abstract

Seventy-two farmers (24 from each district) were interviewed in Lira, Pader and Katakwi districts in north-eastern Uganda between June and October 2001 to document their use of indigenous knowledge to predict fruit production by *Vitellaria paradoxa* (The shea butter tree) by use of participatory rural appraisal (PRA), group discussions and personal interviews with sampled respondents. The farmers' ability to predict fruit yield was influenced by how long they have managed the shea butter trees for high fruit production. Eighty percent of the respondents reported that gravel soils supported high yielding shea trees and early burning stimulated high fruit production in *Vitellaria paradoxa*. Fifty-five percent recognised that better yielding trees could be both tall and short and occurring in good soils. Eighty-three percent were aware that height of shea trees was dependent on location rather than on variety and that high fruit production depended entirely on the location of individual trees, farmers' management skills and type of soil. Ninety percent reported that late fire reduced fruit yields. The selection and elimination of *Vitellaria* stands by the local farmers was guided by their local knowledge of tree spacing on farms, size, growth habit, age and frequency of good fruiting. Traditional beliefs have been very useful in maintaining high fruit production in the area. G-test of association in predicting fruit production using defoliation effect was highly significant between the males and the females (G=212.33, df=1) in all the three districts. This implies that farmers' knowledge related to shea tree production and yields is at certain level, although, the information that they have was not recognised and linked to scientific information. The results of this study strongly recommend that use of IK should be emphasised and validated to improve conservation and sustained yields of shea butter and other Cinderella parkland fruit trees.**

Keywords: *Vitellaria paradoxa*, farmers' local knowledge, traditional beliefs, environmental factors

Introduction

The majority of the populations in most developing countries are small-scale farmers, each working less than two hectares of land. These farmers belong to various ethnic groups. In most instances, the knowledge systems of these farmers related to fruit production and other farming activities have never been recorded in written form. Although such knowledge systems remain invisible to the development community and are not easily accessible to agricultural researchers, extension workers, and development practitioners operating in rural communities, they are vital in the search for solutions to community problems (Warren and Rajasekaran, 1993).

Indigenous (local) knowledge is part of the overall culture of indigenous people (Warren, 1991) and is vital to their survival (Dewes, 1993). In sub-Saharan Africa, local people preserve some trees on farm fields because of benefits such as food, wood, fodder, medicine, climatic amelioration and boundary demarcation (Barrow, 1996; Boffa, 1999). Wooded-farmed lands or Agroforestry Parkland Practices or Agroforestry Parkland Systems have scattered trees that form open permanent over-storeys for associated annual crops (Pullan, 1974;White, 1983; Nair, 1993; Sinclair, 1999). Strategies for maintaining such parklands are a challenge and would benefit from documented indigenous knowledge and practices.

Although many countries across sub-Saharan Africa have in the recent past realised the importance of IK and the formidable task of documenting it before it is lost (Barrow, 1996), there is still little research on use of indigenous knowledge in tree growing and management. In view of the above, this study was undertaken (1) to document use of indigenous knowledge in predicting fruit production of *Vitellaria paradoxa* trees and (2) to assess variations in the use of indigenous knowledge between females and males, and between the districts under study.

Indigenous woody plants of agroforestry parklands such as *Vitellaria paradoxa* C.F.Gaertn. Subsp. *nilotica* Kotschy (Sapotaceae), the shea butter tree or 'Yao' (*Lango*), Yaa (Acholi), Ikunguru (Ateso) Lulu (Dinka of Southern Sudan) or karité (French), with edible fruits, play important roles in rural household consumption, *Vitellaria* provides food supplement, has cash importance in local economies and international trade besides having primary traditional role arising from the oil present in the kernels being a source of

vegetable fat. Other uses range from the household production of cheese through the industrial production of cosmetics and medicines, wood and soap production to illumination (Ezema & Ogujiofor, 1992; Ezema & Ozoiko, 1992).

Vitellaria paradoxa has two subspecies. The western (typical) subsp. *paradoxa* occurs from Senegal to the Central African Republic. The eastern subspecies (subsp. *niloticum*) occurs in Ethiopia, southern Sudan, Democratic Republic of Congo and northern/eastern Uganda from roughly 1º-10ºN (Katende *et al*., 1995 and Hall *et al.*, 1996). Subsp. *nilotica* is the subspecies of the eastern section of the species' range (Hall *et al*., 1996). It is a deciduous, compact tree usually 7 to 13 m tall but exceptionally up to 25 m tall (Amin, 1990). The species is traditionally associated with cattle in the silvopastoral systems and wooded grassland where it is a dominant tree forming almost pure stands in northern Uganda (Katende *et al*., 1995; Hall *et al.,* 1996).

Methods

Data were collected from June to November 2001 in the COVOL-Uganda Shea Project districts of Lira, Pader and Katakwi in north-eastern Uganda (Masters & Puga, 1994). These districts lie between latitudes 1°30'-2°47'N and longitudes 31°00'-33°38'E respectively and altitude of 1000-1300 m above sea level (Rwabwogo, 1996). The area has convectional bimodal rainfall with a mean annual total of 1000-1500 mm (FAO, 1984). The soils are mainly ferralsols (FAO-UNESCO, 1977) with woody savanna, savanna thicket and riparian vegetation (NEMA, 1997).

The Langi, Acholi and Itesot are the main ethnic tribal groups in Lira, Pader and Katakwi districts respectively. The majority of households carry out subsistence agriculture. The main cash crops include cotton, sunflower, simsim, groundnuts and rice. Household income is also obtained from formal employment and activities such as shea nut collection and processing. Rearing animals such as goats, sheep and cattle are also common activities in the shea parklands.

Respondents were purposely chosen from the study sites in the three districts of lira, Pader and Katakwi. Selection was based on the cultural differences, accessibility to and availability of the shea processors' groups and the prevailing security situation in the sampled villages, and presence of registered members of the Shea Project (The Northern Uganda Shea Processors Association-NUSPA. In each county and a sub-county were randomly sampled, that is, Adwari sub-county (Otuke County-Lira district), Amuria sub-county (Kapyelebyong County-Katakwi district) and Agago sub-county (Agago County-Pader district). From each of the sub-counties, two villages were sampled giving a total of six. A village list of NUSPA was used to randomly selected six female and six male respondents who were interviewed. In total 72 respondents were interviewed comprising of 36 females and 36 males.

Data were collected using participatory rural appraisal (PRA), group discussions and personal interviews. Pre-tested questionnaires were administered to the respondents Each respondent was interviewed separately to avoid bias. One day was spent in each village to administer the questionnaires. Research assistants administered the questionnaires and the following questions were asked in order to get data to fulfil the aim of the study: How do indigenous people use their traditional knowledge to ascertain good fruit production in terms of season, location of the crop, human activities, age of the tree, flowering and fruiting times and related environmental factors? How do the existing indigenous knowledge (related to fruit production of shea trees) vary among females and males in the study area? What are the major constraints in the use and sustenance of indigenous knowledge in the area?

Demographic and socio-economic profile of the farmers were tallied; frequencies/percentages assessed and summarised the Statistical Package for Social Scientist (SPSS for Windows 98). G-tests (Fowler *et al*., 1998) were performed to show association (s) of use of indigenous knowledge in predicting fruit production with gender and location (geographical districts).

Results

Demographic and socio-economic characteristics of the respondents

A summary of demographic and socio-economic characteristics of the respondents showed that majority of the respondents (74%) was above 30 years old (Table 1). Seventy eight (78%) of the respondents had spent more than 20 years in the shea parkland and had experience concerning the fruiting behaviour of the shea butter trees and possible factors affecting fruit production. Forty percent have lived in the area since birth. Fifty eight percent of the respondents had received primary education and only 5% had not undergone any formal education.

Subsistence agriculture is the main economic activity of the people in all the three counties, employing 82, 93 and 96% of the working population in Otuke, Kapyelebyong and Agago counties respectively. Very few people are engaged in commercial farming. The hoe and the cutlass (machete) are the main farm implements used and farm holdings are small (1-2.5 ha). Staples and vegetables are produced for household consumption although some are sold. The shea nuts are exclusively processed to obtain oil and butter for domestic consumption and sales.Using local knowledge to predict variation in fruit production

All the respondents were aware of variation in yield of the shea trees. The yield variations were within and between shea trees. Variation in yield was based on quantity of nuts collected per tree (or per season) and on quantity of oil extracted per basin full of nuts from each tree. Respondents reported that if a tree yielded more than 100 kg of nuts in a fruiting season then the yield would be lower (less than 50 kg) in the following fruiting season.

Tables 1a-e. Demographic and socio-economic profile of the respondents by numbers

(1a) Respondents' age classes by sex and county

Parameters		Age in years (N=72)					
County	Sex	<20	20-30	31-40	41-50	>50	Total
Otuke	Female	01	02	02	03	04	12
	Male	01	05	03	02	01	12
Kapyelebwong	Female	01	02	04	02	03	12
	Male	01	01	03	03	04	12
Agago	Female	00	01	03	05	03	12
	Male	00	02	05	03	02	12
	Female	02	05	09	10	10	36
	Male	02	08	11	08	07	36
	Both	04	13	20	18	17	72
Total							

(1b) Period of stay in the area by gender (N=72)

Gender	Since birth	< 20 years	<40 years	≥40 years	Total
Female	20	08	04	04	36
Male	09	8	11	08	36
Total	29	16	15	12	72

(1c) Educational status of the respondents by gender (N=72)

Gender	None	Primary	Secondary	Tertiary	Total
Female	11	24	01	00	36
Male	00	18	14	04	36
Total	11	42	15	04	72

(1d) Marital status of the respondents by gender (N=72)

Gender	Married	Single	Divorced	Widowed	Total
Female	31	01	00	04	36
Male	29	03	00	04	36
Total	60	04	00	08	72

(1e) Occupational status of the respondents by gender (N=72)

Progressive farmer	Peasant farmer		Self-employed	Teacher	Total
Female	30	01	04	01	36
Male	33	02	01	00	36
Total	63	03	05	01	72

Table 2. Factors affecting fruit production between and among *Vitellaria paradoxa* trees

Factor	Percentage respondents
Human Activities	100
Climatic/weather variation	72
Parasitic/pest attack	100
Soil type and location	83
Age of tree	47
Pollinator activity	60
Phenological events	65
Traditional belief	54

Trees to tree differences in fruit production were reported for trees growing under the similar environmental conditions. Fifty eight percent of the respondents were aware of differences in fruiting behaviours of different branches within the same tree, at a point in time and over years. Production of more fruits by certain branches within a given tree was reported to be dependent on position of the branch and the strengths of the prevalent winds in the previous rainy season.

Influence of fire on fruit production in Vitellaria

Bush fires, branch cutting, charcoal burning, and opening of land for farming were responsible for variations in fruit production of *Vitellaria paradoxa* (Table 2). Although wild fires that burnt shea trees reduced fruit production the following fruiting season, 89% of the respondents noted that some of these trees could still be protected from wild fires by weeding around the trees or growing agricultural crops within. Sixty eight percent revealed that trees protected through early burning yielded better than those trees left in the bush and prone to attack by wild fires.

The increased fruit production as result of early burning was due to less destructive impact on the trees which would not be in flowers and fruit at this time compared to negative effect of fires late in the dry season. Branch cutting was reported to reduce fruit yields because potential branches would be few or the tree would die. The respondents were also aware that charcoal burning was a major threat to *Vitellaria* trees and reduced fruit yield.

Influence of climate/weather on fruit production

Eighty percent of the respondents in Katakwi, 77% in Lira and 71% in Pader revealed that changes in weather patterns such as rainfall variation, length of drought and the strength of wind were responsible for the variation in shea fruit. Moderate rainfall during flowering and fruiting season was reported by more than 80% of the respondents to result in good fruit production. Most respondents reported that heavy rainfall during flowering and fruiting season resulted in flower and fruit fall/abortion. This would then lead to reduction in fruit yield. Rainfall was a necessary requirement during fruit maturation and ripening. Prolonged drought and strong easterly winds were undesirable because it reduced fruit production. Most respondents (77%) said that strong winds during rainy or dry season, during flowering and fruiting times reduced fruit production at ripening. In particular, strong winds resulted in increased flower and immature fruit fall.

Insect defoliation and fruit production

Above half, 58% and 50% of the respondents in Lira, Katakwi and Pader districts respectively reported that defoliation by caterpillars resulted into increased fruit production (Table 3). Sixty one percent of the females and 47% of the males noted that defoliation of shea trees by caterpillars increased fruit production in *V. paradoxa*. In terms of gender, 45% of the males and 33% of the females reported that defoliation had no effect on shea fruit yields but only 8% and 13% of males and females respectively believed that defoliation could reduce fruit production (Table 4).

G-tests of association revealed that there were highly significant differences in the use of insect defoliation to predict fruit production between the males and the females ($G=212.33^{**}$, df=1). However, there was strong association of use of insect defoliation ($G=0.33^{ns}$, df=2) and weather changes ($G=0.45^{ns}$, df=1) to predict fruit production by *V. paradoxa* in all the three districts.

On the other hand, the proponents of insect defoliation causing an increment in fruit production had a view that, defoliation had to occur just before the onset of flowering or in the middle or before end of the second rainy season. Generally, the respondents reported the presence of caterpillars to be highest in early July and August, although this may vary from year to year.

Mistletoe presence and fruit production

Sixty percent of the respondents were ignorant of how the prevalence of hemi-parasitic plants (mistletoes) on the sheanut tree could affect fruit production. Only 40% of the respondents knew of the presence of mistletoes on Vitellaria trees. Respondents who had observed the parasites reported that the mistletoes reduced the yield of Vitellaria trees. They said that as the mistletoe increased in size, the yield of sheanut tree also decreased, although it rarely killed the tree.

Soil physical characteristics and fruit production

The majority of respondents in Lira (73%), Katakwi (76%) and Pader (89%) reported that fruit production potential of particular shea trees varied with soil types and location. Vitellaria trees located on farmland were reported to be better yielding than those in the bush or in fallow land are. Trees near swamps were reported by 80% of the respondents to have very low fruiting potential.

Seventy six percent of the respondents noted that shea trees growing on gravel soils produced more fruits than those located on other types of soil. Shea trees on gravel soils grow shorter than in other locations. However, the respondents noted that the occurrence of short stout Vitellaria trees was not related to fruit production potential but rather to soil type.

Vitellaria leafing/flowering patterns and fruit production

Up to 57% of respondents reported that when *Vitellaria* tree came in full leaf before peak flowering, low fruit production resulted. Thirty three percent of the respondents could not tell the relationship between leafing and fruit production. Only 10% reported that leafing had no effect on the level of fruit production by shea trees.

Table 3 Influence of defoliation on fruit production of *Vitellaria* by district

Perceived effect of insect defoliation on fruit production	Respondents' area			Total
	Lira (Otuke)	Katakwi (Kapyelebyong)	Pader (Agago)	
	%	%	%	%
Increased yield	54	58	50	54
Decreased yield	13	04	04	07
No effect on yield	33	38	46	39
Total	100	100	100	100

Table 4 Use of defoliation to predict yield of *Vitellaria* by gender

Perceived effect of insect defoliation on fruit production	Sex of respondent		
	Male	Female	Total
	%	%	%
Increased yield	47	61	54
Decreased yield	08	06	07
No effect on yield	45	33	39
Total	100	100	100

Discussion

Most respondents (87%) reported that high flower production and initiation of fruits led to high and better fruit yields of *Vitellaria* trees in the season provided they are protected from fires and both the wind strength and rainfall amounts were moderate.

Ninety four percent reported that a better flowering shea tree would produce strong sweet smell (odours) as early as 5.00 a.m. every morning and also from 16:00 p.m. until late in the night every evenings during flowering periods. The odours produced by flowering Vitellaria trees was reported by 99% of the respondents to be correlated with attraction of bees during the day and bats during night. Locating beehives near shea trees was reported by 90% of the respondents to result in high fruit production. Bats were considered to be more destructive during fruit fall season than during the flowering period. The bats were reported to carry fruits to isolated places where fruit collection would not be possible. Sixty seven percent of the respondents correlated the bats' activities to facilitating seed dispersal of shea fruits to other areas where they could germinate and grow to new shea seedlings and eventually trees when protected from fires or during farming.

Influence of traditional beliefs/practices on fruit production

In Agago county (Pader district), respondents reported that sacrifices were offered yearly on Mt. Amyel to please the gods so that fruit production would be high. It was believed that if one cut a branch or the entire shea tree without good reason, that person would die. In order to prevent such death, the one responsible would sacrifice a black goat to please the gods and request them to allow high fruit production.

Recent studies of indigenous knowledge in agriculture has changed the attitudes of policy makers and agricultural development planners in recent years, and led to renewed interest in this type of knowledge (Warren and Rajasekaran, 1993). This study has shown that the farmers in north-eastern Uganda engaged in management of the shea trees had bountiful seasonal ways of using indigenous knowledge to predict fruit production in *Vitellaria* based on environmental factors such as length of rainy season, defoliation by caterpillars, occurrences of fires, length of dry season, direction and strength of wind and human activities during fruiting season.

The local people are aware of threats of bad human activities on better fruit production and sustained yield of *Vitellaria paradoxa*. The activities have led to selection of better populations of sheanut trees on farmlands, a situation reported for *Vitellaria paradoxa* subsp. *paradoxa* in Ghana (Lovett & Haq, 2000). The possible interpretation for this finding could be that cultivation under the tree would result in improved fruit production, due to reduced competition and protection from fires. As the local farmers eliminate unwanted woody species on farmland, they leave behind only those sheanut trees that meet their criteria based on local knowledge of spacing, age/size, growth and health status considered for high fruit production.

Insect defoliation of the leaves was also noted immediately and after fruit fall, a situation also reported by Nok-Rach (2001) in north-eastern Uganda. The occurrence of defoliation by caterpillars in July, August and/or September after fruit ripening would not lead to reduction in fruit

production in the following fruiting season. Indeed 43% of the respondents concurred that this kind of defoliation has no effect on fruit yield in *Vitellaria*, but were just feeding on the leaves since the defoliation usually occurred just immediately after the end of fruit fall with no significant impact on the expected yield. However, defoliation could as well increase fruit production by triggering off massive subsequent foliage development as over 70% of the respondents stated that defoliation that occurred just before flowering during dry season combined with early burning contributed to high fruit production.

Although the respondents could not establish easily the effect of mistletoes on fruit production, they noted that mistletoes affected only young branches and hindered their growth. In West Africa, burning or removing the affected branches of *Vitellaria paradoxa* subsp. *paradoxa* controls the parasitic plant (Boussim *et al*. 1993). In the study area, many farmers associated mistletoes with witchcraft and fear cutting them. Premature fruit fall and other fruit abnormalities noted by farmers could be due to pest attack, diseases or competition for resources.

Over 88% of the respondents said that too much rain during flowering was responsible for low fruit production in *Vitellaria*. Phenological monitoring of the trees also revealed that as rainfall increased, the number of trees coming into flower decreased (Okullo *et al*., 2004). After flowering there is usually subsequent fruit development and the plant has to re-allocate its available resources to fruit development with the increase in monthly rainfall total. However to confirm this local knowledge of the farmers, longer and location specific monitoring will be more informative. Ninety percent of the respondents reported that most fruits ripen from May through June and July, coinciding with the period of the year when the soil is well supplied with plant available water. Given the fact that *Vitellaria* seeds are highly recalcitrant (Hall *et al*., 1996), fruit ripening during the rainy season could be a dispersal adaptation for maintenance of the species in its environment. Indigenous management activities such as digging under or slashing around shea trees resulted into protection, less competition and reduced seedling mortality. The homecompound and protected trees also indirectly enjoyed more favourable conditions for reproduction - presumably from these indigenous management practices.

Personal observations revealed that as soon as the *Vitellaria* ripening season arrives, intensive collection from tree to tree by both children and women starts. On private land (fallow or under crops) and near homes *Vitellaria* trees are given more protection than trees in more remote stands. However, the Karimojong raids and the incursions by the Lord's Resistance Army (LRA) rebels in the area have made most indigenous people in the area move to towns resulting into extensive areas without management where wild fires threaten to reduce the *Vitellaria* populations and yield. Traditional beliefs have been very useful in maintaining high fruit production in the area. In Lira district, particularly in Otuke County, there is a belief that to keep the fruits up a tree and in order to avoid premature flower and fruit fall, the shea tree trunk at around breast height should be tied using spear grass (*Imperata cylindrica*).

Conclusions

Vitellaria trees play an integral role in local rural life and rural people in north-eastern Uganda have an extensive local knowledge for predicting its fruit production. This knowledge provides the basis for research and can be built upon to develop sound resource management policies and extension services. The farmers' local knowledge of *Vitellaria* leafing, flowering and fruiting is well developed. The farmers' can recognise a prospective high fruit yielding trees before the actual fruit collection season and are able to apply appropriate indigenous management strategies to make sure they get the maximum yields and avoid unnecessary losses before fruit fall period. This implies that qualities of trees affect their use and determine individual and group social strategies towards their management and conservation.

Recommendations

Usually, development attempts to define species choice based on scientific information, which ignores the local knowledge database. Hence, for proper agricultural development, the capacity of indigenous organisations such as Northern Uganda Shea Processors' Association (NUSPA) which can play a developmental function within the community needs to be strengthened. Project planners, implementers of research and development projects/programmes have to first identify and incorporate the use of indigenous knowledge and roles of trees in particular land use for the people they are working with. This is useful in gauging the perception of how people value and use trees, which trees they value and why, how people perceive problems concerning trees and how they can be solved through their social systems, cultures and norms. Information reported in this study can be used by extension workers, development partners, NGOs, both central and local government departments to facilitate incorporation of improved scientific management practices to ensure sustained high fruit production and other products *of Vitellaria paradoxa* and other parkland fruit trees.

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