Can Africa rely on indigenous cereals for food security? Securing sorghum food through agricultural production.

Cecilia A. Scurrah-Ehrhart
Graduate Group in Ecology, University of California, Davis Campus, P.O. Box, 110220, Dar es Salaam, Tanzania, Email: Cecilia@auberon.org

Abstract

Agricultural production and cropping strategies have been recognized as integral to the debate on household food security since the 1970s. The genetic diversity characteristic of indigenous African cereals is vital to the present and future food security of sub-Saharan households and nations. However, the nature and usefulness of that diversity, and how it is managed, are not well valued or understood. This study looked at sorghum producing households in Eastern Uganda and found that food security and vulnerability were the result of a complex combination of crop-related and systemic issues. Thus, sorghum represented a reliable, labor saving source of daily carbohydrate and cash incomes which drew on a dynamic, highly diverse and vast regional pool of seed sources. At the same time, sorghum production suffered setbacks associated with insufficient land allocation, storage failures, seed supplies vulnerable to the effects of famine or harvest failure, and indiscriminate susceptibility to particular diseases. Finally, systemic issues pertaining to the environment, human health and economic marginality pointed to a lack of insurances against food security shocks amongst all households.

Introduction

Agricultural cereals indigenous to Africa, such as rice (*Oryza glaberrima*), pearl millet (*Pennisteum americanum*), sorghum (*Sorghum bicolor*) are important but little mentioned biodiversity resources of the sub-Saharan sub-continent. The genetic diversity within and between these plant species is vital to the present and future food security of sub-Saharan households and nations, yet the nature and usefulness of that diversity, and how it is managed, are not well valued or understood (Monde and Richards, 1992). At the same time, agricultural changes are sweeping through the region. Resource depletion and population growth are triggering agricultural intensification, while the HIV-AIDs epidemic weakens labor supplies and maize, a crop with good marketing options but relatively high resource demands and genetically uniform seed which has limited viability, is replacing diverse and resilient cereals and starches across vast territories in Southern and Eastern Africa. Amidst this and other significant changes, there is a conspicuous lack of debate about the role costs, and benefits of indigenous crops in providing food for both present and future African populations.

Agriculture has been an integral part of debates surrounding food security since its inception. Thus, it became an important component of supply side food security, a theme underscored in the wake of the African food crisis in the early 1970s (the argument is made explicit in the 1974 World Food Conference). Later, the concept of food security was elaborated to include cyclical and other time-related factors, accessibility to food, degrees of vulnerability and risk management strategies (Borton and Shoham, 1991; Walker and Jodha, 1986). Correspondingly, crop centered diversification and farmer cropping strategies were recognized as essential components of risk management strategies minimizing food insecurity (Longhurst, 1986).

This paper discusses current and future access to grain sorghum (*Sorghum bicolor* (L.) Moench) by small farmers through production, consumption and sale. Sorghum is an indigenous cereal first domesticated in north central Africa (Harlan, 1992; Wayne Smith and Frederiksen, 2000), but cultivated today throughout sub-Sahara by small-scale rural farmers

as a primary source of carbohydrate[1]. This paper draws on the FAO definition of food security, 'ensuring that all people at all times have both physical and economic access to the basic food they need' (FAO, 1983). The definition emphasizes the ability to access food, whether through production or purchasing power. As such it is relevant to the discussion presented here which has a supply side emphasis.

The data and observations presented below are based on a six-month research study by a student at the Graduate Group in Ecology, University of California, Davis Campus, conducted amongst rural Adhola and Iteso households in Tororo district, Eastern Uganda.

Materials and Methods

This paper draws on a six month study carried out in 2001 in Rubongi sub-county, Tororo, Uganda, by a graduate student of the University of California, Davis Campus. The guiding methodologies for this research were consultative participation (Biggs, 1989) and correlational analysis (Bryman and Cramer, 1990; Okigbo, 1996). It incorporated 108 survey questionnaires, a collection and description of 95 sorghum samples, and interviews, focus group sessions and information sharing workshops carried out with villagers and other relevant stakeholders. The questionnaires, focus group sessions and some workshops were conducted among Ugandans of Adhola and Iteso tribal background residing in four sub-Parishes of Nyankole Parish, Rubongi sub-county. The farmers surveyed represented 13.4% of all households in the Parish while the sorghum plant samples covered a slightly wider Adhola and Iteso tribal area. The questionnaires were analyzed with a combination of models and tests, namely Chi-square tests, Analysis of Variance and simple Regressions.

Results and discussion

A . Securing access to food through the consumption and sale of sorghum

In conjunction with cassava, sorghum in Tororo was in the unique position of being staple food carbohydrate *par excelence*. One of two ingredients required for preparing *kalo*, a time-honored household staple, sorghum is a tasty, resilient grain and high in micro-nutrients (94.4% of households surveyed relied on sorghum as a main ingredient in *kalo*). Moreover, due to its low market potential, sorghum cultivation had been relegated to women, whose culturally defined responsibilities of household food provision and child rearing had only served to increase the crop's food security value[2] (villagers, personal communication; see also Price Gittinger, 1990). Though sorghum's status as a non-tradable[3] conferred it with obvious disadvantages, this characteristic also protected it from being sold at a whim to satisfy the chronic cash needs sustained by rural African households. However, the grain had some disadvantages that curtailed accessibility. It only lasted six months in storage, compared to millet and cassava, which was reported to last a year or more. This means that two separate annual harvests were required to provide a household with sufficient food. While storage time could be improved through simple processing methods such as grain roasting and storing with natural repellents, improvements were not significant enough to alter the bi-annual pattern of sorghum cultivation. At current levels of soil fertility and current rainfall, a family with six children was said to require 1 acre of sorghum per season (2 acres, or 0.8 ha per annum) while a single woman with two children required ¼ acre per season (½ ac or 0.2 ha per annum). In

[1] Most household studies of food security have focused on staple carbohydrates. While it is recognized that carbohydrates only constitute part of the requirements for a balanced diet, they are understood to be appropriate indicators of regular food consumption among poor households.

[2] 100% of sorghum plots surveyed were sown, weeded and harvested by women.

[3] The term non-tradable is used here to define agricultural crops which are not generally marketable in global or large regional markets.

reality, many households fell short of these figures. During the season of fieldwork, the average size of a sorghum plot came to ½ acre (.2 ha), and sizes ranged between 1/8 and 1 acre. Many households had variable and inconsistent harvests. All of this meant that grains were consumed before the six months were over. This and the short-term storability of sorghum resulted in minimal post-harvest insurances against food shortages.

In addition to the direct consumption of sorghum, the production and sale of sorghum beer helped to secure food through cash purchases. The fact that it beer was almost exclusively sold by women increased the probability that expenditures were directed at household items directly associated with food preparation. This was made evident by an examination of women's and men's list of purchasing responsibilities, the latter which were completely lacking in kitchen items (tables 1 and 2).

Table 1. Number of women who brewed traditional beers

	Frequency	Percentage of total surveyed	Percentage of total women brewers
Women brewers who brewed for sale	52	49.5	80
Did not brew beer for sale	53	50.5	
Women that brewed with sorghum as an ingredient	42	39.6	36.9
Did not brew with sorghum	64	60.4	

Table 2. Men's and women's household purchasing responsibilities*

Men's items	Women's items
Seed	Cooking fuel
Agricultural labor	Cooking oil
Agricultural chemicals	Salt
Clothes	Knife
Notebooks and pens	Pots
Construction materials (nails, corrugated iron, or thatch reeds)	Cups and plates
Occasionally meat	Sugar
	Milk
	Soap
	Pens and notebooks
	Occasionally medicine, meat and clothes

*The items here are listed in order of importance, as reported by villagers during focus group sessions.

Incomes obtained from beer sales were crucial, but nominal and precarious, offering little in the way of long term insurances against food insecurity. Beer could only be sold to local consumers in the informal market. Law prohibits the sale of traditional beer in the district capital, and retail prices are low. Moreover, brewing was only possible for those women who were physically strong and who could afford to purchase brewing equipment. Nonetheless, this activity, carried out by 49% of women surveyed, represented by far the most important source of income for women. Indeed, it was said to explain why women's income contributed a greater amount to the household than the income generated by husbands or remittances obtained from relatives (table 3).

Table 3. Greatest household income provider

Greatest household income provider	Frequency	Percentage of total
Husband	26	24.53
Wife	70	66.04
Relatives	5	4.72
Husband and wife equally	5	4.72
Not reported	7	

B. Securing supplies of, and access to, food through sorghum production

Sorghum occupies a similar niche to maize in the farming system and therefore tends to be replaced by it. Yet sorghum is adapted to savanna climates, and shows greater drought and flood resistance and greater resilience under low soil fertility, than maize (Doggett, 1988). In Tororo, sorghum seed is scatter-sowed by hand, after which the crop only requires one weeding before harvest. The fact that it requires little in-field attention compared to other carbohydrates including millet, sweet potatoes and maize, may explain why it was favored over by households with limited labor available (table 4). Female-headed households, in particular, had limited labor-hiring capacity and dedicated significantly greater proportions of total land to sorghum when compared to male-headed households (tables 5 and 6).

Table 4. Proportion of land grown to sorghum by labor hiring capacity

	Hired labor last season	Did not hire labor	F value	P value
Mean proportion of land grown to sorghum, ha.	-0.9630	-0.8277 +	4.73	.032**
St dev	.2993	0.2997		
N	49	44		

Results are for a one way unbalanced ANOVA. Response (proportion of land grown to sorghum) is log transformed.
** indicates significant difference between means + indicates the higher mean
Tests were run for 95% confidence levels.

Table 5. Proportion of land grown to sorghum by marital status

	Male headed h	Female headed h	F value	P value
Mean proportion land grown to sorghum , ha.	-0.9259	-0.7534 +	5.55	.020**
St dev	0.3105	0.3193		
N	76	24		

Results are for a one way unbalanced ANOVA. Response (proportion of land to sorghum) is log transformed.
** indicates significant difference between means + indicates the higher mean
Tests were run for 95% confidence levels.

Table 6. Chi-square test for independence and cross tabulations of marital status by ability to hire labor

	Did not hire labor	Hired labor	
Male headed households	45.24	54.76	Row %
	71.70	88.46	Column %
	38	46	N
Female headed, widows	57.14	42.86	Row %
	15.09	11.54	Column %
	8	6	N
Female headed, all other	100.00	--	Row %
	13.21	--	Column %
	7	0	N
	Chi-sq = 4.610	P-val = 0.032**	

Agricultural labor in sub-Saharan Africa as a whole is a valuable resource suffering declines associated with HIV-AIDs related death and illness (Brown et. al., 2002; Traore, 1991). Uganda is no exception, where a 14% labor force reduction in labor is predicted for Uganda between 1985 and 2020 (FAO, 2001). This situation is made more acute by a decline in children's contributions to agriculture resulting from structural adjustment policies facilitating universal primary education. The loss of middle-aged members of the population among the Adhola and Iteso was evidenced by the increased burden of child rearing placed on older women. Table 7 shows that old and very old women reported having more children under their care than the young or middle aged. At the same time, increased levels of school attendance meant that more children did not necessarily translate into more help in the fields (villagers, personal communication). All of this suggests that sorghum's labor saving qualities assisted households suffering from a number of social and economic stumbling blocks.

Table 7. Number of children cared for at time of survey by women's age[4]

	Young (14-27)	Middle-aged women (28-41)	Old women (42-55)	Very old women (56+)	F value	P value
Young women	3.296	4.500+	5.048+++	4.956++	2.58	.057
St dev	1.463	1.863	3.025	3.612		
N	27	34	21	16		

[4] Age categories based on age of early marriage 14/15, and life expectancy 51 (male) 55 (female) (Macmillan Social Studies Atlas for Uganda, 1998).

Results are for a one way unbalanced ANOVA.
** indicates significant difference between means ++ indicate incrementally higher means
Tests were run for 95% confidence levels.

As well as saving on labor, sorghum responds well to high density sowing, which allows for higher yields on smaller plots of land. Tororo farmers, who reported land fragmentation, diminishing fallow periods and declines in soil fertility, increasingly value this option. Indeed, sorghum's ability to cope will low soil fertility is another characteristic in its favor. Caudatum sorghums, the race of sorghum cultivated in Tororo, are known to be particularly hardy in this respect.

Production related vulnerability was, however, also identified for sorghum. Thus, none of the landraces were resistant to rusts or smuts, two potentially devastating diseases. In addition, the decreased fallowing was associated with increased incidences of *Striga,* a sorghum parasitic weed that destroys newly emerging plants. Then, sorghums were so daylight sensitive that non-timely planting would lead to loss of the entire crop. The latter was especially problematic because temporary setbacks or delays were a common occurrence among women due to accident, illness and competing household demands.

Finally, women farmers did not culturally own land, and could not make independent land allocation decisions, even for those crops under their responsibility. For better and for worse, final decisions associated with land-use and land ownership were made by the husband. This compromised women's capacity to plan for food security, and impeded them from drawing on land as a resource in times of trouble.

C. Access to quantity and quality of sorghum seed supplies

The sorghum seed available to Tororo farmers surveyed in this study produced highly diverse varieties (table 8) and was obtained almost entirely for 'free', without a monetary transaction of any kind (table 9). 100% of the seed sown belonged to landraces or advanced generation cultivars obtained from neighbors, friends, family or tribal members through gifting and or bartering. These seed exchanges took place over an extensive region covering various districts, suggesting the existence of seed meta-population dynamics[5]. Moreover, the supplies of seed were independent from either Ugandan or Kenyan state or privately sponsored seed supplies[6]. The self-reliance in seed supplies confers obvious advantages, as does the extensive and ecologically diverse geographic expanse of sorghum cultivation. The latter suggests that growers draw on a large gene pool for sorghum diversity, protecting farmers from losses associated with more localized harvest failures. In addition, large gene pools create opportunities for obtaining new and better variety traits, which in turn would increase sorghum performance and resilience.

Table 8. Description of sorghum morphotypes sampled in Rubongi sub-county, Tororo[7]

Sorghum morphotype	Local name in Japadhola	Race (based on	Type	Use	Ave. height at maturity (m)	Grain color (Munsell color & chart

[5] Sorghum is cultivated in districts covering a continuous belt of territory which stretches from the border with the Sudan to the North, to Kenya to the East, and Tanzania to the South. Farmers traveled 1-3 km on average to collect new seed supplies. However, seed was reported as coming from as far as 240-300km. away.

[6] Samples were taken for identification to the two largest distributors of sorghum seed in Uganda and Kenya, Serere Research Station in Uganda and Kenya Seed Ltd. both institutions confirmed that all samples collected in the field were landraces. Morphotype 1 in table 8 was identified as a possible descendant of Serena, an improved sorghum cultivar released by Serere Research Station in the early 1970s.

[7] Distinctions between morphotypes were based on those identified by farmers.

		spikelet type)				number included)
1	Serena	Caudatum	Advanced generation cultivar	Food and *nguli* brew	1.8	Yellow-Brown (Mahoganny/Sienna 7/10 7.5YR)
2	Nyabara Lit. 'open headed' or 'Obote' after the general's hair-do	Caudatum	Landrace	Food and *nguli* brew	2.1	Brown (Mahoganny 4/8 2.5YR)
3	Nyawa Bel	Caudatum	Landrace	Food and *kongo* brew	2.6	Opaque white
4	Bel Mwenge, or Nyamwenge Lit. 'banana beer sorghum'	Caudatum	Landrace	*Mwenge* brew	2.5	Red (4/10 5R)
5	Nylon	Caudatum	Landrace	Food and *mwenge* brew	1.5	Red (4/10 10YR or 3/6 5R)
6	Atong-like	Caudatum	Landrace	Food	1.8	Yellow Red (4/62.5YR or 6/107.5YR)
7	Atong Red Lit. 'red spear'	Caudatum	Landrace	*Mwenge* brew	1.3	Red (5/10 5YR or 4/10 10R)
8	Serena-like, open	Caudatum	Landrace	Food	2.6	Yellow (Sienna 6/10 5YR)
9	No name	Caudatum	Landrace	Food and *kongo* brew	Unk	Opaque white
10	Serena-like	Caudatum	Landrace	Food	2.6	Pale beige (Sienna 8/6 7.5YR)
11	Serena-like	Caudatum	Landrace	Food	1.9	Pale beige w red (Sienna 7/10 7.5YR)
12	Atwal Red	Caudatum	Landrace	Food and *mwenge* brew	3.2	Deep red (Red 3/8 5R)
13	Atong White Lit. 'white spear'	Caudatum	Landrace	Food and *kongo* brew	1.8	White-yellow-beige (8/6 7.5YR)
14	Nyero Lit. 'laughter'	Caudatum	Landrace	Food and *mwenge* brew	2.6	Orange-red (4/10 10R)
15	Atwal white	Caudatum	Landrace	Food and *kongo* brew	Unk	Polished white (8/2 7.5YR)

N = 95 individual sorghum accessions

Table 9. Proportion of farmers who purchased sorghum seed

	Farmers who purchased sorghum seed this season	Farmers who did not purchase sorghum seed this season	Farmers who purchased any part of their sorghum seed lot	Farmers who did not purchase any part of their sorghum seed lot
Frequency	10	95	43	60
Percentage	9.5	90.5	41.7	58.3

Nevertheless, evidence suggests that the seed flow system is not invulnerable. Seed turnover in the study site was extremely high, and seed storage somewhat limited (tables 10 and 11). If this phenomenon is widespread, then seed reserves in any given region may be kept at constant low levels. This would leave farmers and their varieties susceptible to permanent losses during periods of widespread or prolonged harvest failure or famine. Rare varieties would be especially vulnerable to disappearance, as their current distribution is limited to just a few households. Table 12 shows the amount of seed cultivated to each variety, and their distribution across households by farmers surveyed the season of fieldwork.

Table 10. Proportion of women farmers storing sorghum seed

	Frequency	Percentage
Store food and seed grains separately	59	52.7
Do not store seed.	53	47.3

Table 11. Total seed turnover rates, second season 2001

Total sorghum seed lot, this season (kg)	Newly acquired seed (kg) (off-farm)	Proportion of seed acquired off-farm	Rate of seed turnover, this season
263.512	54.976	.209	20.9 %

Table 12. Variety seed lots (relative proportions of total seed lot by variety), and percentage of households cultivating each, for one season in 2001

Sorghum type in order from most to least common	Total seed lot this season (kg)	Percentage Of total seed lot cultivated, in order from most to least common	Percentage of total households surveyed which reported to cultivate it this season
1	73.107	27.7	62
5	64.290	24.4	53.7
2	32.037	12.2	30.5
4	22.334	8.5	29.6
9	22.334	8.5	13.0
10	19.786	7.5	27.7
3	11.008	4.2	22.2
6	3.287	1.3	8.3
12	3.253	1.2	6.5
14	2.876	1.1	7.4
8	2.05	.80	6.5
11	2.112	.80	6.5
Unk	1.8	.70	1.9
13	1.555	.59	3.7
7	1.075	.41	2.8
15	.608	.20	2.8
Total	263.512	100	100

Changes to the composition of farming system crops, such as the switch to maize cultivation, may also threaten the regional meta-dynamics of seed supply. If sorghum populations become confined to a few, geographically isolated pockets, their vulnerability will increase, and farmers would find it difficult to replace lost stocks. Then, the fact that none of the varieties are resistant to certain diseases suggests that there is room for greater genetic diversity. Some of this diversity could come from international seed exchange-programs and formal plant breeding. However, Ugandan government investment in sorghum research and development is currently threatened by the privatization of agricultural extension services outlined under the current Plan fro the Modernization of Agriculture (MAAIF and MFPED, 2000). This policy states that government will rely on private companies to guide investment in agriculture. Since private companies only invest where there are market incentives, such a policy excludes non-tradable food crops such as sorghum, which are largely disarticulated from the market.

In sum, while sorghum seed supplies are self-reliant and seed procurement networks cover a large region, a look beneath the surface reveals their vulnerability. Rapid seed turnover rates, uneven distributions of rare varieties, changing farming systems, and decreasing government

support for non-tradable crops all augur a precarious future. From the point of view of agricultural performance, an important guarantee for coping with an unpredictable future is genetic diversity. Among cereals and, for practical purposes, this equals seed diversity. Thus, if seed diversity is lost, farmers' options for dealing with unknown future production risks will be greatly limited.

Conclusion

The diversity typical of African agricultural systems is as important as ever for household food security, both in terms of food supplies and in terms of risk management strategies. Due to their African origins, indigenous crops can spread risks of harvest failure through their high diversity and continued adaptation to sub-Saharan conditions. This analysis of sorghum production has provided a good entry point for examining these issues.

The study revealed that sorghum producing Adhola-Iteso households were engaged in a process that conferred both food security and food vulnerability. Sorghum is an agriculturally reliable, non labor-intensive source of daily carbohydrate and income that can be particularly helpful for households suffering from socio-economic and resource-related obstacles. However, the study also found that sorghum producers, who are women, also suffered from sorghum food insecurity. Setbacks included cultivation in plots insufficiently large enough to guarantee harvests to last the season; storage time limitations; relatively low proportions of farmers who store seed; high seed turnover rates; limited marketability for the grain and its products; inability to own land, and little interest in sorghum research and development from government and private industry. Moreover, future seed supplies are potentially at risk as changes in farming systems associated with intensification, fragmentation and economic incentives threaten to break up the traditionally extensive network of sorghum seed flows.

At the same time, systemic factors pertaining to environmental risks, the HIV-AIDs epidemic and lack of opportunities for income diversification, render households vulnerable not only to failures in sorghum supplies, but to food insecurity in general, by undermining options for building insurances against risk. Indeed, rural families in Tororo are vulnerable to food security shocks of the mildest kind. There is clearly a need to address this vulnerability, much of which pertains to sub-Saharan Africa as a whole.

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