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Full Length Research Paper

Assessing the post-harvest constraints in smallholders' groundnut production: A Survey in central Malawi

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Abstract

An in-depth scoping survey was conducted on 248 smallholder farmers producing groundnut in Malawi to delineate the constraints in production, especially on-farm post-harvest operations, while revealing various aspects in the status of production and consumption practices. The insightful outcomes included the farmers' perception of the post-harvest operations as highly labor demanding, being the major obstacle to production expansion for the lucrative and nutritious crop. In particular, shelling, lifting, and stripping were the top three processes of remarkable labor intensity. The respondents expressed the intention for scale-up as long as the labor constraints were mitigated, with expected welfare gain through increased income, improved nutrition, and reduced aflatoxin contamination, as well as mitigated drudgery for women.

Key Words: mechanization, equipment, labor, groundnut, gender, food safety, aflatoxin
JEL Codes: D13, I31, O13, Q12

Introduction

Groundnut is a growing and/or major income source for smallholder farmers in many countries of sub-Saharan Africa such as Malawi, Zambia, Mozambique, Tanzania, Uganda, Sudan, Nigeria, and Senegal. It is also an important food crop being an inexpensive source of balanced protein and essential fatty acids. In impoverished Malawi, the world's ninth largest exporter of groundnut, the crop has become the second income earner for smallholder groundnut growers after tobacco (Msere et al. 2015). Longwe-Ngwira et al. (2012) found that groundnut production in Malawi was efficient with competitive producer prices.

However, small-scale groundnut production is allegedly labor intensive, especially at the stage of post-harvest operations (ICRISAT, 2011). Orr et al. (2012) pointed out that despite the additional land available in Eastern Zambia, the area which shares the groundnut belt with Central Malawi, scope for expansion of area planted to the crop was limited because lifting (i.e., digging or harvesting), stripping, and shelling were laborious, tedious, and difficult components of production. Even those farmers who owned, or could hire, ox-drawn ploughs to prepare land (by clearing and creating ridges) had difficulty extending the area to any great extent because their animal-drawn implements were not suitable for application to harvesting and post-harvest operations (Orr et al., 2011). The issue of labor intensity is fuelled by the extent to which women are involved in the farming processes, particularly in stripping and shelling. According to Orr et al (2016), the crop is often referred to as a "women's crop" in the region, since the aforementioned post-harvest operations are typically handled by women as both family labor and low-paid casual labor. Further, Orr et al (2014) suggest that women deem such operations rather as drudgery than as income opportunities. Shelling can even damage their fingers. Yet, literature showing evidence of labor intensity in groundnut post-harvest is relatively scarce to date, and could be reinforced by further evidence from the ground particularly with respect to the prospect of introducing small-scale human-powered machinery.

Another key aspect is nutrition and food safety. The increase in groundnut production has led not only to increased income but also to higher consumption (Msere et al. 2015). One of the important roles of

groundnut consumption would be its benefit for child nutrition. Kalimbira et al. (2009) emphasizes the chronic deficiency of proteins and essential nutrients among children in Malawi, causing stunting at 49 % and underweight at 12 %, among other things. The national survey (NSO & ICF Macro, 2011) saw an inverse relationship between mothers' education attainment levels and incidence of underweight babies, suggesting the importance of knowledge for better child nutrition status. Consumption of inexpensive protein sources such as groundnut and other legume crops is expected to mitigate the child malnutrition problem. However, 49 % of groundnuts sold at local markets were found to have aflatoxin levels exceeding those considered safe for human consumption (Emmott & Stephens, 2014). Hence, farm level post-harvest aflatoxin control would be extremely important in addressing the food safety challenge.

Since 2010, International Crops Research Institute for the Semi-arid Tropics (ICRISAT) Malawi, Compatible Technology International (CTI), and Department of Agricultural Research Services (DARS) have collaborated to work toward developing post-harvest machinery designed to alleviate drudgery associated with the groundnut on-farm post-harvest handling, as well as to mitigate aflatoxin contamination. For a scoping purpose, an in-depth household survey was conducted of small-scale groundnut farmers in selected districts of Malawi to delineate the constraints on post-harvest procedures and to understand the child feeding practices in groundnut growers' communities. The result of this survey would inform the subsequent development of proto-type machinery, as well as the design of on-farm experiments on the suite of machines.

The major objective of this paper is to present the result of the scoping survey and discuss the potential of micro-scale post-harvest machinery for mitigating the constraints on smallholder groundnut farming. The minor objective is to examine the current status of smallholder groundnut production and consumption in general. Following this introduction, the next section describes the basic approach and survey design. Then, the whole range of results are presented. The last section provides concluding remarks.

Methodology

Sampling

The household-level scoping survey was conducted of smallholder groundnut growers during the 2009-2010 crop season. In Malawi, agriculture is predominantly rainfed and there is only one crop season that typically begins with the first rainfall in December and lasts until April. The survey focused on Kasungu and Lilongwe districts, which constitute the center of the 'groundnut belt' that lies from central Malawi to eastern Zambia, where groundnut production concentrates and similar ago-ecologies and cropping patterns appear. In each of the two districts, two-stage stratified sampling was employed. At the first stage, 16 villages (8 from each district) were selected, namely, Chinkhuti 1, Chinkhuti 2, Mzungu, Kandama, Sankhani 1, Kakungu, Suntche, and Mlomo in Lilongwe, and Mphandukira, Kamdidi 1, Kamdidi 2, Makhaza, Mlambali 1, Mlambali 2, Kanyunya, and Zinkambani in Ksungu. These villages were selected in favor of population of commercial producers as well as connection with Plan Malawi and ICRISAT. At the second stage, 10-20 respondents were randomly selected from each village by ensuring that at least 10 from each village had one or more children under five years of age (i.e., less than 60 months old). Among all the qualified households in the villages, the sample households were selected using a random number generator. In total, 248 households were included in the sample: 110 from Lilongwe and 138 from Kasungu. The survey program was implemented in April and May 2010.

Data

Semi-structured questionnaires were administered to collect quantitative and qualitative data. All the respondents were interviewed on the post-harvest questionnaire, while the ones with children under five responded also to the child nutrition questionnaire. In other words, the survey combined and integrated the technology and nutrition components. As for groundnut production practices, collected information included crop production, harvesting, post-harvest processes, and marketing. The questionnaire also covered information such as cropping patterns, farming system, asset holding, land holding, livestock holding, access to infrastructure, access to credit facilities, and sources of income and expenditure. As for child nutrition practices, the questionnaire covered information such as frequency of meals, ways of serving meals, use of vegetables in child meals, ways of preparing vegetables, use of complementary food, use of groundnut in child meals, and food given to weaned kids.

Analysis

Descriptive tables are presented to outline the status of and issues around the sampled smallholder groundnut producers. As needed, statistical tests such as t-test and chi square test were conducted on differences between the two districts and the corresponding p-values are presented in the tables.

Result

Demographic Characteristics

Table 1 presents the demographic status of the respondents. 89 % of the interviewed households were male-headed. The proportion of male-headed households was slightly higher in Kasungu (91 %). 92 % of the household heads were married, and 5 % were divorced. Although not presented, out of the female heads of households, 46 % were widows, 31 % had their husband staying away from home, and 19 % were divorced. The average age of the respondents is 41. It appears that the household heads in Lilongwe were slightly younger (39.6 years) than their counterparts in Kasungu (42 years). However, the age difference was statistically insignificant according to the independent two-sample t-test. The age difference between male

heads and female heads was also found to be statistically insignificant. The average number of years of schooling was 6.

The lower half of Table 1 looks into more details of the education status. 9 % of the respondents did not attend any formal education, while 52 % have gone up to senior primary school. The proportion of farmers who went to secondary school was higher in Kasungu (19 %) than in Lilongwe (9 %). This gap may be attributed to the cultural differences between the two districts. According to our discussion with local partners, parents in Kasungu had a greater tendency to perceive education as the key to arriving at stable income sources. While 91 % of the respondents went to school, the literacy rate and numeracy rate were 75 % and 79 % respectively, indicating a certain degree of common oblivion since the time of school attendance.

Table 1: Respondents' Demographic Characteristics

Variable	Lilongwe (N=110)	Kasungu (N=138)	Aggregate (N=248)	P-Value[2]
Gender of Household Head (1=Male, 0=Female)[1]	0.86	0.91	0.89	0.317
Married (1=Yes, 0=Not)[1]	0.92	0.92	0.92	0.156
Age (years)[1]	39.6	42.0	40.9	0.187
Years of Formal Education[1]	5.1	6.3	5.8	0.007
Literate (1=Yes, 0=Not)[1]	73	76	75	0.282
Numerate (1=Yes, 0=Not)[1]	76	82	79	0.251
Education Level Achieved (% of Respondents)				
No Formal Education	9	9	9	0.025
Junior Primary School	32	19	25	0.045
Senior Primary School	50	53	52	0.545
Junior Secondary School	5	10	8	0.135
Senior Secondary School	4	9	7	0.102

[1] Mean
[2] P-Value for t-test for continuous variables or χ^2-test for categorical variables
Source: Survey Data

Wealth

Table 2 indicates the household income sources. Overall, the largest income source was casual labor, followed by petty trading and remittances. The engagement in casual labor appeared to be more frequent in Lilongwe, while remittances were notably common in Kasungu, suggesting that there was more demand for labor in Lilongwe and part of the money earned in Lilongwe was sent to family members living in smaller towns. Petty trading, business earnings, beer sales were more prominent in Kasungu.

Table 2: Income Sources by District

	Proportion of respondents with different income sources (%)			P-Value[1]
	Lilongwe	**Kasungu**	**Aggregate**	
Remittances	17	34	26	0.002
Casual Labor	67	44	54	0.000
Sales of Beer	4	15	10	0.004
Petty Trading	18	44	33	0.000
Formal Employment	9	2	5	0.014
Business Earnings	16	19	17	0.504
Renting Out Houses	1	1	1	0.867

[1] P-Value for χ^2-test
NB: Households can have multiple income sources that are applicable. Thus, the sum does not tie with 100.
Source: Survey Data

Asset holding is critical for smallholder farmers since it facilitates investment required for adopting certain types of agricultural technologies (Asfaw et al., 2011). These days, telecommunication devices serve as a medium for acquiring information on new technologies, prices, diseases, gender, and so forth (Aker, 2011; Allahyari & Chizari, 2010). Productive assets can broaden households' ability to cultivate a bigger parcel for instance, whilst they can be encashed during periods of food shortage (Tsusaka et al., 2015). Table 3 shows that most of the respondents owned hand-held implements such as hoes, axes, sickles, and watering canes. Treadle pumps are important for attaining food security as they are used to pump water for winter irrigation. The major transport assets included bicycles and ox-carts. The proportion of households owning an ox-cart as well as an ox-plough was higher in Kasungu, which may be associated with the greater popularity of cattle there. As

for communication devices, half of the respondents owned a radio and 39 % owned a cell phone. It is important to note that almost all the respondents had no large-scale productive assets, implying that technologies designed for these farmers should not involve hefty investment as in large-scale mechanization.

Table 3: Asset Holding and Livestock Ownership

		Proportion of respondents who own different asset items (%)			
	Item	**Lilongwe**	**Kasungu**	**Aggregate**	**P-Value**[1]
Asset	Ox-ploughs	0	20	11	0.000
	Ox-cart	10	21	16	0.020
	Sickle	65	80	73	0.007
	Panga Knife/Machete	75	66	70	0.153
	Axe	57	89	75	0.000
	Spade/Shovel	18	25	22	0.233
	Hoes	96	99	97	0.141
	Sprayer	4	3	3	0.744
	Wheel Barrow	5	2	3	0.289
	Bicycle	59	61	60	0.741
	Radio/Radio Cassette	46	55	51	0.148
	Mobile Phone	39	39	39	0.969
	Television (TV)	8	1	4	0.010
	Watering Cane	68	76	73	0.155
	Tobacco Compressing Machine	0	3	2	0.073
	Treadle Pump	6	13	10	0.086
Livestock	Oxen	5	19	13	0.001
	Bulls	2	1	1	0.442
	Cattle	3	23	14	0.000
	Other cows	0	7	4	0.004
	Donkeys	1	1	1	0.880
	Goats	41	32	36	0.165
	Pigs	16	20	18	0.371
	Rabbits	2	2	2	0.830
	Chicken	65	87	77	0.000
	Guinea fowl	1	3	2	0.248
	Doves/pigeons	1	24	14	0.000

[1] P-Value for χ^2-test

NB: Households can have multiple items that are applicable. Thus, the sum does not tie with 100.

Source: Survey Data

Table 3 also presents the status of ownership of livestock. Chickens were by far the most common livestock in both Lilongwe and Kasungu, followed by goats, pigs, cattle, and oxen. Except for goats, all these livestock animals were more popular in Kasungu.

Access to Infrastructure

Water

Table 4 shows the sources of water used for different purposes among the respondents. For the purposes of drinking and cooking, 90 % of the respondents drew water from the borehole. A significant proportion (38 %) of respondents also cited village well as a major source. The striking contrast was found in access to rivers and streams, which was much higher in Kasungu as compared with only a minimal in Lilongwe. For the purpose of washing (house cleaning and laundry), the share of rivers and streams increased in place of the other two sources. By contrast, for the purpose of irrigation, rivers and streams were the dominant source even in Lilongwe. In Malawi, most of irrigated farming is found along riverbanks. Some respondents engage in home gardening by drawing water from village wells.

Table 4: Sources of Water for Drinking and Cooking

Purpose	Water Source	Proportion of respondents who have access to water (%)		
		Lilongwe	**Kasungu**	**Aggregate**
Drinking and Cooking	Village Well	36	40	38
	Borehole	90	90	90
	River/Stream	2	36	21
Washing	Village well	38	31	34
	Borehole	85	86	85
	River/stream	4	47	28
Irrigation	Village well	13	21	18
	Borehole	1	3	2
	River/stream	84	95	91

NB: Households can have multiple income sources that are applicable. Thus, the sum does not tie with 100.
Source: Survey Data

The average farmers traveled a distance of less than a half kilometer to draw water for different purposes (Table 5). Water for irrigation tended to be farther than water used for other purposes. The difference was smaller in Kasungu, though it was statistically significant (p=0.001).

Table 5: Distance to Water Sources

Purpose	Average Distance from Households (km)			P-Value[1]
	Lilongwe	Kasungu	Aggregate	
Drinking and Cooking	0.22	0.31	0.27	0.046
Washing	0.21	0.33	0.27	0.010
Irrigation	0.47	0.38	0.41	0.561

[1] P-Value for t-test
Source: Survey Data

Energy

Table 6 presents different sources of energy for lighting and cooking heat. Kerosene-based lanterns were the dominant source of lighting in both districts. Other important sources of lighting were candles, battery-based light bulbs, and torches. In Kasungu, farmers had access to diversified sources of lighting as compared with those in Lilongwe. On the other hand, firewood and charcoal were identified as major sources of cooking heat in both districts. Only three households used electricity for cooking. The excessive reliance on firewood and charcoal would pose a risk of deforestation, for which one way of mitigation would be to advocate use of haulms and shells in the form of briquette.

Table 6: Sources of Lighting

Purpose	Sources of Energy	% of Respondents with Access to Energy Sources		
		Lilongwe	Kasungu	Aggregate
Lighting	Electricity	0	2	1
	Kerosine/Lanterns	91	87	89
	Candles	3	27	16
	Natural Gas	0	4	2
	Bulbs (Battery)	5	22	14
	Torch	7	14	11
	Solar	1	4	3
Cooking Heat	Firewood	99	98	98
	Charcoal	14	18	16
	Electricity	0	3	2

NB: Households can have multiple income sources that are applicable. Thus, the sum does not tie with 100.
Source: Survey Data

Access to Markets and Credit

Markets

The respondents in Lilongwe traveled 2.3 km on average to reach the nearest village market whilst those in Kasungu traveled 1.8 km. However, the main market in Kasungu was rather far from the villages (Table 7). Also shown in the table is the average distance to the nearest clinic for infants, which was 4.2 km and 4.6 km in Lilongwe and Kasungu, respectively.

Table 7: Distance to Markets and Infant Clinic

	Average distance from households (km)		
	Lilongwe	Kasungu	Aggregate
Village Market	2.3	1.8	2.0
Main Market	4.5	8.4	6.7
Clinic for Infants	4.2	4.6	4.4

Source: Survey Data

Credit

Smallholder farmers' access to credit is vitally important to expedite investment in improved technologies and practices (Hazarika & Alwang, 2003; Kochar, 1997). Table 8 shows that 40 % of the respondents had access to credit over a period of 12 months. The access was better in Kasungu where they could better source within the communities. The major source of credit was informal money lenders who generally charged high interest rates. The main purposes of use of credit were buying food, capital for business, health care expenditure, and buying fertilizer.

Table 8: Access, Sources, and Purposes of Credit

		Lilongwe	Kasungu	Aggregate	P-Value[1]
Proportion of Respondents with Access to Credit (%)		20	55	40	
Source of Credit (%)[2]	Commercial Bank	4	1	2	0.337
	MFI	9	12	10	0.740
	NGO	4	1	2	0.337
	MARDEF	4	0	1	0.059
	Informal Money Lender	65	82	78	0.097
	Total	100	100	100	
Purposes of Credit (%)[2]	Capital for Business	22	16	18	0.524
	Buying Food	30	26	27	0.757
	Buying Farm inputs	22	14	15	0.339
	Paying for School Fees	0	5	4	0.277
	Health Care	9	12	11	0.629
	Buying Groceries	9	9	9	0.994
	Total	100	100	100	

[1] P-Value for χ^2-test
[2] Percentage out of those with access to credit
Source: Survey Data

Crop Production

Inputs

Land is one of the critical inputs for crop farming, affecting the scale and scope of production (Shipton & Goheen, 1992). The average size of land holding was 2.7 acres in Lilongwe against 4.9 acres in Kasungu, reflecting a denser population in Lilongwe. Likewise, the average size of land cultivated was 2.8 acres in Lilongwe and 4.8 acres in Kasungu. The difference between land owned and land cultivated implies that smallholders in Lilongwe tended to rent in a small piece of land. In Kasungu, some respondents reported to have put land on fallow, which explains why they cultivated less land than they owned.

Table 9 shows the proportion of respondents growing different crops in the two districts in the 2009/2010 season. Groundnut is omitted since, by design, all the respondents grew groundnut (i.e., 100%). It is not a surprise that all farmers reported to cultivate maize as it is the dominant staple food. In Kasungu, soy bean was much more popular than in Lilongwe. Cassava, sunflower, and common bean were also notable, indicating diverse cropping patterns in Kasungu.

Use of fertilizer is a standard practice as a result of the government's Farm Input Subsidy Programme that distributed fertilizers to smallholder farmers (Arndt et al., 2014; Dorwarda & Chirwab, 2011). All the respondents applied fertilizer in the 2009/2010 crop season. Nonetheless, fertilizers were mostly applied to maize and tobacco, and not to groundnut. Compared with fertilizer, use of pesticide was much less common (16 % in Lilongwe and 13 % in Kasungu), and it was applied mostly to tobacco and vegetables.

Table 9: Crops Cultivated during the 2009/2010 Season

Crops grown	Proportion of respondents growing different crops (%)			P-Value[1]
	Lilongwe (n=110)	**Kasungu (n=136)**	**Aggregate (n=246)**	
Maize	100	100	100	NA
Tobacco	38	31	34	0.452
Soybean	20	63	44	0.000
Sunflower	0	29	16	0.000
Common Bean	2	14	9	0.008
Sweet Potato	15	18	16	0.706
Cassava	2	27	15	0.000
Others	4	5	5	NA

[1] P-Value for χ^2-test
NB: Households can have multiple crops grown. Thus, the sum does not tie with 100.
Source: Survey Data

Output

Table 10 shows the average quantity harvested for different crops. For all the crops, production was remarkably higher in Kasungu than in Lilongwe, mainly because of the larger land holding. The precipitation pattern was also favorable in Kasungu, receiving prolonged rainfall.

Table 10: Quantity Harvested for Different Crops (kg), Farm Average

Crops	Lilongwe	Kasungu	P-Value
Maize	1443	3286	0.003
Tobacco	476	633	0.199
Groundnut	725	888	0.488
Soybean	100	435	0.021
Sunflower	NA	731	NA
Common Bean	13	111	0.070
Sweet Potato	283	715	0.007
Cassava	1000	1864	0.587

[1] P-Value for t-test
Source: Survey Data

Challenges in Groundnut Farming

This subsection focuses on groundnut and discusses major challenges associated with groundnut farming processes by smallholders in Malawi.

Production

Groundnut production faces a range of challenges from socio-economic limitations to agronomic and climatic constraints (Simtowe et al., 2009). Table 11 shows that diseases and pests were on top of the list. Other challenges were lack of reasonable input credits, shortage of arable land, lack of quality seed, and poor extension services. The magnitude of these constraints varied by district. Promotion of disease and pest tolerant varieties and good soil management would be necessary to overcome these production constraints.

Table 11: Major Constraints in Groundnut Production in Malawi

Constraints	Proportion of respondents who cited different constraints (%)			P-Value[1]
	Lilongwe	Kasungu	Average	
Diseases	81	92	87	0.013
Pests	77	88	83	0.018
Soil Fertility Degradation	35	47	42	0.055
Lack of Quality Seed	40	42	41	0.775
Poor Extension Services	22	48	36	0.000
Inadequate Land	53	47	50	0.315
Lack of Input Credit	44	60	53	0.014
Lack of Seed Buyers	32	51	42	0.002

[1] P-Value for χ^2-test
Source: Survey Data

Marketing

Crop sales are one of the main sources of income for villagers in Malawi (Bezu et al., 2014). It is estimated that over a half of the annual income for smallholder farmers comes from crop sales. In particular, groundnut sales have been an increasingly important source of revenue (Tsusaka et al., 2016a). For the 2008/2009 crop season, 85 % of the growers sold their harvest of groundnut. The proportion of farmers selling groundnut was higher in Lilongwe (90 %) than in Kasungu (83 %). The main varieties sold were CG 7, Chalimbana 2005, and traditional Chalimbana. Other varieties sold included Nsinjiro and Kakoma.

Shelling is one important way of value addition for groundnut. Shelled nuts attract a 100 % price premium compared with unshelled ones (Wanyama et al, 2013). In fact, in Kasungu, 82 % of the groundnut sales were of shelled nuts. In Lilongwe, however, 88 % of the groundnut sales were of unshelled nuts. This is because the output market is competitive in Lilongwe with a lot of buyers, thereby allowing farmers to sell unshelled nuts at a better price. This is an example of access to markets leading to more profitable farm enterprises (Yamano et al., 2011).

Who are the buyers then? Table 12 indicates that middlemen and fellow farmers constituted dominant buyers of groundnut. These middlemen in turn sell their consignment to processors, exporters, and other large-scale traders. NGOs are also identified as important players in Lilongwe.

Table 12: Main Buyers of Groundnut

Buyer	Proportion of respondents who sold groundnuts to different buyers (%)			P-Value[1]
	Lilongwe	Kasungu	Aggregate	
Consumer/Farmer	16	6	11	0.002
Broker/Middlemen	63	86	75	0.001
Farmer Group	3	3	3	0.853
Rural Retailer	12	1	6	0.000
Rural Wholesaler	0	2	1	0.101
Urban Wholesaler	0	1	0	0.344
NGOs/CBOs	6	2	4	0.028

[1] P-Value for χ^2-test
Source: Survey Data

The survey revealed that in the 2009/2010, 90 % of the respondents sold groundnuts between June and October. The nuts sold in October went to their fellow farmers who were in search for seeds in preparation for the subsequent rainfall season. Another finding is that 21 % of the respondents sold nuts more than once during the year. Table 13 provides the reasons behind selling nuts more than once. In Kasungu, the majority waited for the seasonal price to rise, while in Lilongwe they kept nuts as a tradable commodity to address emergent expenditure. This is likely because most farmers in Kasungu have diverse income sources and their income has less seasonality, which enables them to keep their produce until the price rises. This may be a good example of positive interaction between on-farm income and off-farm income in rural households as argued by Hoang et al. (2014), Estudillo et al. (2012), etc.

Collective marketing is one of the ways to improve marketing efficiency by gaining economies of scale, lowering transaction costs, acquiring bargaining power, and facilitating access to credit (Fischer & Qaim, 2012; Vittersø & Jervell, 2010). The survey revealed, however, that the majority (95 %) of respondents sold groundnut individually, which must be an obstacle for Malawian smallholders to obtaining favorable deals from buyers.

There was no groundnut moulting technology available in the studied areas. Farmers moulted maize, sorghum, and finger millet in preparation for sweet beer (thobwa).

Table 13: Reasons for Selling Groundnuts More than Once a Year

Reason	Proportion of respondents who cite reasons for selling groundnuts at different times of the year (%)			P-Value[1]
	Lilongwe	Kasungu	Aggregate	
Wanted price to increase	33	62	47	0.343
Shortage limitation by buyers/markets	15	15	15	0.770
To address pressing household problems as they arise	52	8	30	0.000
Unable to sell all at once due to difficulties in shelling	0	4	2	0.365
Constraint in transport to the market	0	12	6	0.115

[1] P-Value for χ^2-test
Source: Survey Data

Harvesting and Post-harvest Processes

In this study, we define the 'harvesting' process to consist of lifting, assembling, curing, and gleaning, whilst the processes of stripping, shelling, winnowing, sorting, roasting, processing (into flour and butter) are regarded as 'post-harvest' processes. The harvesting and post-harvest processes in groundnut production are known to be labor demanding and smallholder producers often face difficulties expanding the crop area due to labor shortage (ICRISAT, 2011).

Three quarters of the respondents indicated lifting as a labor-intensive process, followed closely by stripping (Table 14). They described these processes as tiresome and time consuming. Besides, it was observed that stripping was predominantly handled by women and children. Regarding the post-harvest processes, most (85 %) of the respondents cited shelling as

cumbersome, tedious, labor demanding, and painful with the thumbs. Sorting was also mentioned as difficult by many farmers (56 %). The main hardship with respect to sorting was the small grain size and lack of sorting equipment.

Another issue pertinent to harvesting and post-harvest processes is crop losses. The profitability of crop farming depends not only on crop yield per se but also on how the quantity and quality of the crop are maintained during the harvesting and post-harvest processes (Affognon et al., 2015). In formal markets, the quality of the produce has a direct impact on the commodity price (Abass et al., 2014). Obviously, loss in quantity translates into missing income opportunities. It is therefore important to find which processes incur losses in quantity and quality.

Table 14: Proportion of farmers perceiving difficulty in groundnut harvesting and post-harvest processes

		% of Respondents			P-Value[1]
	Process	**Lilongwe**	**Kasungu**	**Aggregate**	
Harvesting	Lifting	63	84	75	0.000
	Assembling	29	42	36	0.039
	Curing	10	22	16	0.013
	Gleaning	39	46	43	0.257
Post-harvest	Stripping	63	81	73	0.002
	Shelling	74	93	85	0.000
	Winnowing	28	35	32	0.248
	Sorting	34	74	56	0.000
	Roasting	3	18	11	0.000
	Processing to flour	10	23	17	0.007
	Processing to peanut butter	10	22	17	0.011

[1] P-Value for χ^2-test

NB: Households can cite multiple processes that are applicable. Thus, the sum does not tie with 100.

Source: Survey Data

The majority of farmers (75 %) perceived lifting as causing crop losses (Table 15). Many kernels were damaged while being lifted, which led to loss in quality. Besides, the quantity loss occurred as some pods were left in the soil as a result of late harvesting causing pod development at depth. Stripping was also cited by quite some farmers (33 %) as a source of loss. Farmers ate nuts while stripping, as well as threw away haulms when pods were not completely removed. As for post-harvest losses, shelling (53 %), winnowing (44 %), and sorting (39 %) were cited as major causes of losses in quantity. Breakage during shelling and winnowing as well as incidences of grade-out in sorting reduced the quantities that could have been sold.

Table 15: Groundnut harvest and post-harvest processes perceived as causing losses in quality and quantity

		% of Respondents			P-Value[1]
	Process	**Lilongwe**	**Kasungu**	**Aggregate**	
Harvesting	Lifting	69	79	75	0.050
	Assembling	22	43	33	0.000
	Curing	14	27	21	0.009
	Gleaning	18	25	22	0.228
Post-harvest	Stripping	32	34	33	0.673
	Shelling	74	93	85	0.005
	Winnowing	28	35	32	0.000
	Sorting	34	74	56	0.000
	Roasting	3	18	11	0.000
	Processing to flour	10	23	17	0.049
	Processing to peanut butter	10	22	17	0.278

[1] P-Value for χ^2-test

NB: Households can cite multiple processes that are applicable. Thus, the sum does not tie with 100.

Source: Survey Data

Use of Grade-outs and Crop Residues

With the growth of foreign demand for groundnut, today many farmers have learned to grade their nuts to target export markets (Matumba et al., 2015; Nzima & Kamwana, 2014). In return, there remain low quality nuts (grade-outs) in their hands, such as shrivelled, broken, discolored, and mouldy nuts. Table 16 presents different uses of grade-outs by type. Most of the shrivelled and broken kernels were processed into flour, since such nuts still maintained the nutrition quality and food safety. On the other hand, a lot (76 %) of the mouldy nuts were reported to be thrown away, since such nuts were considered no longer edible. Discolored nuts occupied the middle ground.

Table 16: Use of Groundnuts Grade-Outs

Type of Grade-outs	Use of groundnut grade-outs (% of respondents who chose different uses)				
	Processed into Flour	**Roasted/ Eaten Raw**	**Sold to Domestic Markets**	**Livestock Feed**	**Thrown Away**
Shrivelled	94	43	2	0	2
Broken	89	43	0	0	1
Discolored	59	22	1	2	25
Mouldy	16	9	3	0	76

Source: Survey Data

The respondents were also inquired as to how they handled groundnut crop residues, namely, haulms and shells. Many farmers used the residues as manure (Table 17). Haulms were also utilized as animal feed, whilst much of the shells were disposed particularly in Kasungu.

Table 17: Usage of Groundnut Crop Residues

Usage	Usage of groundnut residues (% of respondents)					
	----------Haulms----------			----------Shells----------		
	Lilongwe	**Kasungu**	**Aggregate**	**Lilongwe**	**Kasungu**	**Aggregate**
Manure	56	42	48	55	18	34
Burnt	6	6	6	8	26	18
Animal Feed	10	29	21	4	2	3
Thrown Away	10	11	11	28	44	37
Left in the Field	14	9	11	0	0	0
Embedded into Soil	4	0	2	0	0	0
Cooking fuel	0	0	0	5	3	4
Others	17	11	14	6	11	8

Source: Survey Data

Willingness to Scale up Groundnut Production

All the respondents indicated willingness to expand area sown to groundnut once the harvesting and post-harvest constraints were mitigated. 45 % of the respondents reported that they would increase groundnut area by 50 %, while 42 % indicated willingness to double the area. The farmers in Kasungu were more inclined to expand area than those in Lilongwe, presumably because of the relative abundance of land in Kasungu.

Nutrition Status

Staple Food

Almost all (99 %) of the respondents consumed maize as staple food in the form of hard porridge. 61 % of the respondents took three meals on the day before the interview, while 37 % took two meals. The survey found that there were three ways families consumed meals: 33 % of the households ate food from one same pot, 49 % reported that children ate from the common pot but separately from adults, and 12 % reported that each family member ate from a separate plate.

Complementary Food for Children

Green leafy vegetables are rich sources of vitamin C, beta carotene, folic acid, iron, calcium, potassium, and magnesium (Bunning & Kendall, 2012). Our survey found that almost all (99 %) of the households included green leafy vegetables in the meals of their children under five. The most common green vegetables were pumpkin leaves (97 %), cassava leaves (55 %), sweet potato leaves (51 %), amaranthus leaves (41 %), rape (25 %), and turnips (18 %). This also indicates the importance of cassava and sweet potatoes as dual (cash and food) crops.

These vegetables were cooked differently depending on mothers' preference and nutritional needs. The common ways of cooking these vegetables were: cooked and mixed with groundnut flour (87 %), cooked as plain leaves (78 %), and liquid vegetable extract (22 %). The vegetable extract is generally added to maize porridge, while at times kids drink it. It was also found that farmers preserved the vegetables during the period of plenty by drying and keeping them as powdered leaves (19 %).

The age at which children had been given complementary foods for the first time averaged 6 months old and ranged m 1 to 24 months. The majority (64 %) of the mothers started giving children complementary foods when they were between 4 and 6 months old. 30 % of them began giving it after 6 months. The main reason why mothers had started giving complementary foods was reported to be inability to produce enough milk, causing the children to be hungry.

Maize, groundnut, soybean, and common beans were used by 97 %, 91 %, 76 %, and 40 % of the respondents, respectively. It was found that all the respondents in Kasungu prepared meals for their own households while in Lilongwe only 88 % did so. The remaining 12 % purchased complementary foods at shops. The majority (75 %) of the households perceived legumes as a good source of protein that enabled children to grow healthy. 18 % perceived legumes as an enhancer of taste and flavor of food.

Mixing and milling raw groundnut with cereal grain was the most popular way of preparing groundnut based

meals for children, which was adopted by 76 % of the respondents. Further, 60 % of the households prepared meals for children by mixing groundnut flour with cereal flour. Mixing roasted groundnut with cereal grain was adopted by 26 % of the respondents. Other methods included mixing germinated groundnut with germinated cereals.

Frequency of Feeding Children

Frequency of feeding children can be a proxy indicator for extent of nutrition intake for healthy growth. 79 % of the households fed their children three times or more in a day (Figure 1). The situation was better in Kasungu, where the per-capita cropland was larger. There was a significant difference in feeding frequency (p= 0.009) between Lilongwe and Kasungu, indicating the linkage between crop production and food security. Nonetheless, Lilongwe has a higher proportion with four times feeding, suggesting a higher inequality in food security compared to Kasungu.

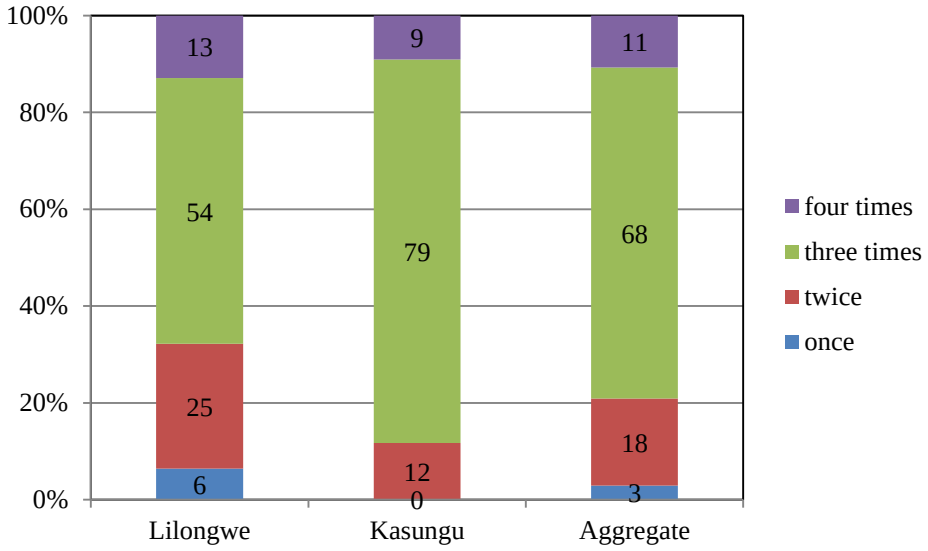

Figure 1: Frequency of Child Feeding, the Day before the Interview
Source: Survey Data

Weaning Age

Weaning is the process of withdrawing the supply of mother's milk and introducing the infants to adult diet. The average weaning age was found to be 27 months old. The most commonly observed weaning age range was 25-30 months (37 % of the households) and 19-24 months (35 %). The average weaning age was earlier in Lilongwe (24 months) than in Kasungu (30 months) by a statistically significant difference (p <0.001). The reginal difference may be attributed to the greater opportunity for casual work engagement in Lilongwe (Table 3). In fact in Lilongwe, 45 % of the households had weaned their children at 19-24 months while 27 % did so at 25-30 months. The same percentages were 27 % and 45 % in Kasungu.

Most of the households reported that they gave weaned children food that adults normally took, which included porridge, nsima (stiff porridge) fruits, sweet potatoes, tea, and bread, among which porridge (88 %) and nsima (84 %) were the most popular items in the studied areas.

Attendance to fewer than Five Clinics

All the respondents in Kasungu reported that they took their children to under five clinics to monitor the growth and development at the critical age. Most (94 %) of the respondents in Lilongwe did so as well. Body weight was the major index used to measure the health and nutrition status of children.

Expectation from Post-Harvest Mechanization

The respondents expected that use of post-harvest machinery would result in increased cash income through groundnut area expansion (50 % of the respondents), enough time for other socio-economic activities (39 %), improved nutrition and food safety (11 %). Those in Lilongwe expressed higher interest in cash income generation while those in Kasungu indicated as much expectation for enough time as for increased income. Improved nutrition and food safety was of interest to 3 % of the respondents in Lilongwe and 15 % of the respondents in Kasungu.

Discussion

The scoping study has led to several insights into the status of small-scale farmers producing groundnut in Malawi. First, the farmers perceive that the harvesting and post-harvest operations are so labor demanding, being the major obstacle to production expansion for the lucrative and nutritious crop. In particular, shelling, lifting, and stripping are the top 3 processes of remarkable labor intensity. Shelling and stripping are predominantly handled by women as well as children. Given the farmers' desire to expand groundnut area, development and dissemination of a suite of post-harvest machines

would help achieve improved welfare through increased production and saved opportunity costs. Mottaleb et al. (2016) and Wang et al. (2016) support our view by emphasizing the need for scale-appropriate machinery in poverty reduction among smallholders, based on the evidence from developing countries in Asia. Trade-off between reduction in women's drudgery and potential loss in women's control is quantitatively and qualitatively examined by Orr et al. (2016) and Tsusaka et al. (2016b), who find evidence that the introduction of machine sheller would actually ameliorate women's empowerment status. In addition, although many farmers in Lilongwe currently sell groundnut in-shell, machine shellers would enable them to gain price premium by selling shelled nuts, as shelled nuts generally attract a 100 % price premium compared with unshelled ones (Wanyama et al, 2013).

Second, farmers perceive the occurrence of significant post-harvest losses in groundnut. In particular, two thirds of the farmers describe lifting as a cause for losses in both quality and quantity. Nevertheless, some farmers process grade out nuts into flour and consume them as long as the nuts are still safe and edible.

Third, as poverty is rife among smallholders in Malawi (Pauw et al., 2014), we found that 95 % of the respondents were not formally employed and had to rely on sources such as casual labor sales, remittances, and petty trading, apart from farming. Kasungu farmers were better off with asset holding as many of them owned productive asset items such as ox-plough, cattle, and ox-carts, whereas the majority of those in Lilongwe resorted to hand-held implements such as hoes and axes. Furthermore, land ownership was competitive in Lilongwe with an average holding of 2.7 acres per household versus 4.9 acres in Kasungu. There were also interesting observations from the rural development perspective: As for groundnut sales, about a half of the farmers waited until the prices picked up toward the end of the post-harvest season. Yet, this practice was mostly observed in Kasungu where income sources were diverse in comparison with those in Lilongwe. This provides for a good example of positive interaction between on-farm income and off-farm income in rural households as argued for instance by Hoang et al. (2014) and Estudillo et al. (2012). In Kasungu, 82 % of the groundnut sales were of shelled nuts, whilst in Lilongwe 88 % was sold unshelled, since the competitive output market in Lilongwe allows farmers to sell unshelled nuts at a better price. This is a prime example of access to functional markets resulting in more profitable farm enterprises as discussed by Yamano et al. (2011). Notwithstanding the importance of collective marketing (Fischer & Qaim, 2012; Vittersø & Jervell, 2010) however, most of the respondents sold groundnut on an individual basis, which must be an impediment to obtaining favorable deals from buyers. Government extension officers as well as NGOs should enforce measures to incentivize smallholders to form market oriented farmer groups.

Fourth, maize is the common staple and 40 % of the households eat a meal twice a day or less. Most households feed children under five with green leafy vegetables. Notably, 86 % of households mix in groundnut flour when cooking leafy vegetables. Complementary food for children is usually made of maize, groundnut, soybean, and common beans. The average weaning age was 24 months in Lilongwe and 29 months in Kasungu. Hard porridge (nsima), soft porridge, sweet potatoes, pumpkins, and tea were the common weaning foods in all the studied villages. Most (93 %) of the households take their children to under five clinics.

Lastly, farmers expect that use of post-harvest machinery would result in increased cash income, enough time for other socio-economic activities, and improved nutrition and food safety. Those in Lilongwe expressed higher interest in cash income generation while those in Kasungu indicated as much expectation for enough time as for increased income. In all likelihood, it is important to note that 9 % of the respondents are illiterate, and therefore this group would require special attention when they are reached out to by technology recommendations.

Conclusion

The result implies the need for investment in developing small-scale machinery for post-harvest operations in groundnut-based farming systems in Malawi, in particular lifter, stripper, and sheller.

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