



PEARL MILLET SOCIOECONOMIC AND PRODUCTION CHARACTERISTICS IN UGANDA

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Table of Contents

List of Tables v
List of Figures vii
Acronyms ix
Acknowledgment x
Foreward xi
Summary xii
Section 1 1
1.1 Introduction 1
1.2 Research statement 2
1.3 Objectives 2
1.4 Research methodology 3
1.4.1 Study area 3
1.4.2 Selection of farmers and enumerators 4
1.4.3 Data collection 5
1.4.4 Data analysis and quality control 5
Section 2 Demography 7
2.1 Age of heads of household members 7
2.2 Gender of household members 9
2.3 Marital status and relation to heads of households 10
2.4 Education level of the household members 11
2.5 Human population in households 13
2.6 Housing conditions and sanitation 13
2.7 Economic activities of the household members 16
2.8 Household food security situation 18
2.8.1 Food availability in households 18
2.8.2 Causes of food shortage and coping strategies 20
Section 3 Socioeconomic capital and technology adoption 22
3.1.1 Access to credit 22
3.1.2 Sources of financial credit 23
3.1.3 Reasons for accessing financial credit and related transactions 24
3.2 Access to agricultural training 25
3.2.1 Participation in selected agricultural training 25
3.2.2 Types of trainings received and training organisations 26

3.2.3 Technology adoption for selected enterprises 27
3.2.4 Access to extension services for selected agricultural activities 30
3.2.5 Sources of information for selected agricultural activities 34
3.3 Group dynamics 35
3.3.1 Membership in organisations or social groups and their main activities....35
Section 4 Importance and utilisation of pearl millet....37
4.1 Importance of pearl millet in terms of cultivation frequency and being food security crop.37
4.2 Importance of pearl millet relative to other crops....38
4.3 Changes in crop value and reasons for the changes 40
4.4 Uses and utilization of pearl millet....41
4.5 Unacceptable taste characteristics of pearl millet and coping strategies....43
Section 5 Agronomic characteristics 44
5.1 Types of pearl millet varieties planted by farmers in Uganda 44
5.2 Season or time of planting pearl millet 45
5.3 Pearl millet crop production systems 47
5.4 Pearl millet planting methods....48
5.5 Productivity and seed rates....49
Section 6 Desirable and undesirable pearl millet traits 50
6.1 Traits of pearl millet genotypes grown by farmers....50
6.2 Undesirable traits of the cultivated pearl millet....51
6.3 Attributes to be introduced or improved and related information for pearl millet improvement....53
Section 7 Factors of production in the pearl millet cropping system 55
7.1 Crop production inputs....55
7.1.1.1 Land access, ownership and perception about soil fertility 55
7.1.1.2 Size of land (acres) parcels owned or operated and distance to the land parcels...56
7.1.2 Area planted, cost of seed and sources of seed 58
7.1.2.1 Area planted and cost of seed....58
7.1.2.2 Pearl millet sources of seed 59
7.1.2.3 Pearl millet units of measurement for seed grain and produce grain 60
7.1.3.1 Labour hours, sources and total cost for labour....61
7.1.3.2 Sources of labour for pearl millet activities 62
7.1.4 Access to agricultural equipment 64
7.1.5 Expenses on selected inputs 66

7.2 Livestock production and sales....66
Section 8 Post harvest handling of pearl millet and fate of grain....69
8.1 Harvesting, drying and threshing....69
8.2 Storage of pearl millet....71
Section 9 Pearl millet production constraints and coping strategies....73
9.1 Field constraints and control strategies....73
9.2 Marketing constraints, control strategies and access to markets....77
9.3 Storage constraints and control strategies....78
Conclusion....79
References....80
Appendix: Common sources of information for selected agricultural activities....90

List of Tables

Table 1.1: Grain quality components of pearl millet and common cereals ($100g^{-1}$ of grain) 1
Table 1.2: Location characteristics of the study districts 3
Table 2.1: Age groups of household members and dependency ratios 9
Table 2.2: Broad age grouping of household members 9
Table 2.3: Gender of household members 10
Table 2.4: Marital status of heads of households 11
Table 2.5: Marital status of household members 11
Table 2.6: Relation of household members to heads households 11
Table 2.7: Education level of heads of households 12
Table 2.8: Education level of spouses 12
Table 2.9: Highest education level attained by household members 13
Table 2.10: Response about number of household members 13
Table 2.11: Housing conditions for pearl millet farmers 15
Table 2.12: Economic activities for heads of households 17
Table 2.13: Economic activities of household members 17
Table 2.14: Household responses about changes in food availability and quantity 19
Table 2.15: Causes of food shortage in households 21
Table 2.16: Coping strategies during food shortage 21
Table 3.1: Reasons for not accessing financial credit 23
Table 3.2: Sources of credit 24
Table 3.3: Reasons for accessing credit 24
Table 3.4: Percentage response and range of amount of money borrowed by region 24
Table 3.5: Interest rate per month and payback period 24
Table 3.6: Types of training received by household members 27
Table 3.7: Duration of trainings 27
Table 3.8: Major organisations that trained pearl millet farmers 27
Table 3.9: Enterprises affected by training 29
Table 3.10: Technologies adopted and response about success 29
Table 3.11: Factors considered for technology adoption 30
Table 3.12: Visits by extension agents for selected pre-harvest activities 32
Table 3.13: Visits by extension agents for selected post-harvest activities 33
Table 3.14: Group membership by categories of household members 36
Table 3.15: Role of household members in groups 36

Table 3.16: Group main activities 36
Table 3.17: Registration and annual fee paid for membership in groups 36
Table 4.1: Frequency of planting pearl millet 37
Table 4.2: Reasons for pearl millet being a food security crop 38
Table 4.3 Crops commonly grown and reasons why they were grown 39
Table 4.4: Ranking of most important crops 39
Table 4.5: Uses of pearl millet in Uganda 42
Table 4.6: Percent household response about utilisation of pearl millet as food in Uganda 43
Table 5.1: Percentage household response about pearl millet planting season and type of varieties planted 46
Table 6.1: Traits of pearl millet genotypes grown by farmers 52
Table 6.2: Desirable pearl millet traits 52
Table 6.3: Undesirable pearl millet characteristics 52
Table 6.4: Supplementary information important for pearl millet improvement 54
Table 7.1: Ease to hire land for agricultural production 55
Table 7.2: Forms of land ownership and soil fertility perception 56
Table 7.3: Land availability and distance from home to the land 58
Table 7.4: Sources of pearl millet seed 60
Table 7.5: Units of measurement for seed grain 61
Table 7.6: Units of measurement of harvested and sold pearl millet grain 61
Table 7.7: Gender contribution of labour hours and total labour cost for selected field activities 64
Table 7.8: Percentage of households owning farm equipment and forms of access 65
Table 7.9: Types of livestock owned, percentage owning, number owned by majority and value of livestock and products 67
Table 8.1: Storage facilities for various forms of pearl millet 71
Table 9.1: Percentage response of households about pearl millet field production constraints 73
Table 9.2: Common pearl millet marketing constraints 77
Table 9.3: Possible solutions to common pearl millet marketing constraints 77
Table 9.4: Storage constraints 78

List of Figures

Fig 1.1: Map of Uganda showing location of the study areas....4
Fig 1.2: Using charts to identify constraints with a group of key informants....6
Fig 1.3: Interviewing a household head....6
Fig 2.1: Age groups of heads of households and their spouses....8
Fig 2.2: Typical homestead of pearl millet farmers....16
Fig 2.3: Household response about experiencing food shortage....19
Fig 2.4: Household response about number of meals eaten per day....20
Fig 3.1: Household response about access to financial credit....23
Fig 3.2: Response about access to agricultural training....25
Fig 3.3: Response about heads of households and spouses who accessed agricultural training....26
Fig 3.4: Household response about technology adoption....28
Fig 3.5: Comparison of frequency of extension visits by Government and NGO agencies for selected activities....31
Fig 3.6: Common sources of agricultural information....34
Fig 3.7: Household involvement in social organisations or groups....35
Fig 4.1: Pearl millet as a food security crop....38
Fig 4.2: Perceived change in crop value....40
Fig 4.3: Causes of change in crop rank....41
Fig 4.4: Response of households about taste constraints....43
Fig 5.1: Response of households about types of pearl millet varieties grown....44
Fig 5.2: Reasons for planting unimproved local varieties....45
Fig 5.3: Reasons for planting in second season....46
Fig 5.4: Household response about cropping systems....47
Fig 5.5: Mixed cropping system of pearl millet, sorghum and finger millet....48
Fig 5.6: Pearl millet planting methods....49
Fig 6.1: Pearl millet attributes to be introduced or improved....53
Fig 7.1: Response about area planted with pearl millet....59
Fig 7.2: Storage of pearl millet grain for seed....60
Fig 7.3: Farming activity by gender....62
Fig 7.4: Farming activities done by women....62
Fig 7.5: Farming activities by source of labour....63
Fig 7.6: Forms of access to ox-plough....65
Fig 7.7: Types of livestock owned and products....67

Fig 7.8: Livestock types and products sold 68
Fig 7.9: Percentage of poultry sub units 68
Fig 8.1: Drying of pearl millet on the mat 69
Fig 8.2: Drying of pearl millet on bare ground 70
Fig 8.3: Woman winnowing pearl millet after threshing 70
Fig 8.4: Forms of pearl millet storage 71
Fig 8.5: Fate of harvested pearl millet grain 72
Fig 9.1: Farmers' pearl millet infected by ergot 74
Fig 9.2: Farmers' pearl millet infected by rust 74
Fig 9.3: Farmers' pearl millet infected by smut 75
Fig 9.4: Farmers' pearl millet infected by both ergot and smut 75
Fig 9.5: Knowledge about pearl millet rust symptoms 76
Fig 9.6: Sterile panicles affected by drought due to late planting 77

Acronyms

ACCI: African Centre for Crop Improvement

A2N: Africa 2000 Network

DANIDA: Danish International Development Agency

ECA: Economic Commission for Africa

FAO: Food and Agricultural Organisation of the United Nations

Gov't: Government

IRC: International Rescue Committee

LWF: Lutheran World Federation

NAADS: National Agricultural Advisory Services

NARO: National Agricultural Research Organisation

NaSARRI: National Semi Arid Resources Research Institute

NGOs: Non-Governmental Organisations

UNAFFE: Uganda National Farmers' Federation

UBOS: Uganda Bureau of Statistics

URCS: Uganda Red Cross Society

UNBS: Uganda National Bureau of Standards

TEDO: Teso Diocese Development Organization

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Foreword

The National Semi Arid Resources Research Institute (NaSARRI) of the National Agricultural Research Organisation (NARO) in Uganda is mandated to undertake strategic research on pearl millet (*Pennisetum glaucum*). The crop is multipurpose serving as food, source of income and animal feed for people living in extreme drought-prone environments in Uganda where conditions do not favour reliable production of other cereals such as maize or sorghum. In developing countries in Africa and Asia pearl millet still survives in arid conditions. This calls for a concerted effort from research institutions and other stakeholders to develop and promote technologies adapted to such conditions.

Key stakeholders need to know the socioeconomic and production environment of pearl millet in Uganda in order to make informed decisions on how to direct resources aimed at increasing production and productivity. Through participatory rural appraisal techniques, the authors of this report therefore contribute to the growing literature and knowledge about pearl millet in Uganda by assessing the socioeconomic and production characteristics of the cropping system for the period 2010 - 2012. Important indicators included; 1) demographic characteristics, 2) socioeconomic capital and technology adoption, 3) importance and utilisation, 4) agronomic features, 5) desirable and undesirable traits, 6) factors of production, 7) post-harvest handling, and 8) production constraints and coping strategies. The information will be of importance to researchers, scholars, policy makers, agri-business community, extension agents, farmers and all those who wish to enhance their knowledge about the crop. It is hoped that information in this report will enhance production and marketing of pearl millet and thus contribute to improved livelihood of resource poor farmers in the drought-prone regions.

I thank all the development partners for supporting the work that resulted in this publication. The management of NARO and NaSARRI greatly commends the team that wrote this document. We hope that more of such useful documents will be availed to our stakeholders in the near future.

Have a good reading

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Summary

Pearl millet is an important cereal grown by farmers in environmentally marginalised areas. In Uganda it is mainly grown in northern (Acholi), northeastern (Karamoja) and eastern (Teso) regions. The regions are characterised by semi-arid conditions with high temperatures, low mean annual rainfall and widespread chronic food insecurity. Technologies that increase pearl millet productivity under such conditions have been developed in international research institutes to highlight the importance of pearl millet as a resilient crop suitable for drought conditions. However, not much is known about the importance of the crop in Uganda. A baseline survey was thus conducted to document pearl millet farmers' socioeconomic and production characteristics in the country. Information was collected about demography and food security situation, livelihood, social capital and trainings, importance and utilisation of pearl millet, agronomic characteristics, desirable and undesirable traits, factors of crop and animal production, post-harvest handling, production and marketing constraints and coping strategies.

Results indicated that the average age of heads of households (mainly males) was 45.78 years while that of their spouses was 37.22 years; with a pearl millet growing experience of over six years. In addition, majority of the households had 6-10 members many of whom were below 15 years. The heads of households were married with education experience of more than five years while their spouses were generally illiterate. The household heads and their spouses farmed the land as their main economic activity. Furthermore, majority of the households lived under poor conditions where the main house had a single room built of mud and wattle with grass as the main roofing material and earth floor. The poor living standards were worsened by majority of the households facing perpetual food insecurity mainly due to drought, insect pests, plant diseases and lack of improved planting materials.

Social capital, access to trainings and group dynamics of the farmers were also assessed. Majority (over 83%) of the households interviewed did not access credit for agricultural activities due to a dearth of credit source in the village. Lack of collateral and high interest rates were among the other important reasons for not accessing credit. However, the few (about 16%) households that accessed credit did that majorly to pay for labour for farming activities. Other reasons for accessing credit included; paying school fees, financing retail businesses and purchasing livestock. The main sources of credit were the village banks or cash boxes where the majority accessed small loans of up to 200,000/= (less than USD 100) for three months with interest rate of 10%. In addition to few households having access to credit, less than 50% of the

households had at least a member receiving agricultural training. More households in the northern region received agricultural training than the eastern region and generally more heads of households attended the trainings than the spouses. Most households received training in modern agriculture while a few households in the north had members attending training in agricultural marketing. A few households in the eastern region had members trained in insect pest and disease control. Most training schedules lasted for about two days where the NAADS and NGOs were the main trainers. After receiving the trainings majority of the participants reported that they applied the skills received. The farmers were trained mainly in the modern techniques for the production of the most important crops especially ground nuts, cassava and vegetables. Unfortunately, after receiving the agricultural trainings there was no technical backstopping in form of extension to ensure farmers implemented the skills appropriately. This was reflected by the majority of the households receiving no extension visits and a few being visited only once in two years to be advised in proper planting and crop spacing.

Group dynamics was another form of social capital considered. It was observed that majority (over 58%) of the households had at least an individual being a member of a community group. The heads of households and to a lesser extent the spouses were involved in group activities. However, the majority were ordinary members with no leadership role while few were chairpersons and general secretaries. The farmers got involved mainly in mutual support groups commonly known as ‘merry go round’ in addition to a few being involved in group farming while others provided labour for agricultural activities. Most groups were also characterised by no membership or annual fee being charged for one to join a group.

Pearl millet uses were documented after establishing the farmers’ attachment to the crop. The farmers actually valued the crop since majority had grown the cereal 3-4 times in the last five years. It was grown as a food security crop in addition to being used as food and source of income while a few used it as yeast for brewing. As food, pearl millet was eaten as soft or hard porridge while some ate it in gain form after boiling. Relative to other crops pearl millet ranked the fourth after cassava, sesame and ground nuts respectively. It was more important than sorghum, maize, finger millet, green gram and sweet potatoes. The ranking was an average of the importance of the crop as food and source of income. However, the crop ranking was dynamic in the last five years and the dynamism was expected in the next five years as long as variation existed mainly in palatability, being source of income, marketability and change in household population.

After establishing that pearl millet was important, agronomic characteristics were then noted. It was observed that majority of the farmers planted local unimproved land races of pearl millet once a year in the second rains (September-January) to avoid birds and control ergot disease. The unimproved varieties were grown mainly because farmers did not have alternative planting materials. The sole cropping system was adopted where farmers practiced broadcasting as the planting method. Broadcasting led to use of high seed rate of about $20Kgha^{-1}$ instead of the recommended $2\text{-}5Kgha^{-1}$. The agronomic practices and the production constraints resulted in average low productivity of $658Kgha^{-1}$. In addition, the local materials also had desirable and undesirable traits. Some of the desirable traits reported were; being tall, high tillering, stay green and white/grey grain colour while the undesirable traits included being susceptible to ergot and rust diseases, low yielding, low tillering ability, late maturity and susceptibility to drought which resulted in sterile panicles. It was observed that genotypes from northern Uganda were generally late maturing (taking 4-5 months) while those from eastern, especially Kumi district matured within three months. Farmers highlighted introduction of ergot resistant varieties and training in modern agricultural practices as the most important aspects needed to increase productivity.

Factors of production considered were land, seed and labour. Majority of the farmers owned the land they cultivated while some rented and a few borrowed. The farmers reported that the soil fertility was good much as the productivity was low. Most farmers planted pearl millet on up to one acre of land which was mainly their home stead parcel and the seed was either bought or own-saved from the previous season's harvest. The bought seed was not certified or authentic but grain. The labour used in pearl millet production was mainly family labour where men, women and children were all involved; but women provided more labour hours than men or children. The women were mainly associated with harvesting, threshing and weeding and to some extent planting while men were involved in land preparation and planting. Hired labour was also used to some extent mainly to harvest and land preparation. The common equipment used on the farms were the hand hoes, pangas, ox-ploughs, bicycles and axes which were mainly purchased or hired. However, none of the households used inputs like fertiliser, manure, herbicides or pesticides to enhance productivity.

Results also show that more than 87% of the households interviewed reared at least one type of livestock with poultry and small ruminants being the common animals kept. Chicken ranked

highest among the poultry reared while goats formed the majority of the small ruminants. However, pigs were the most sold animals followed by poultry especially the turkeys and chicken. Much as more than 87% of the households reared some livestock, none of them used the technology of manure to improve soil fertility but cow dung was used in making house floors. Simple materials were used in post-harvest handling where the pearl millet was harvested using hands and knives. The harvested panicles were transported to the drying ground by carrying them on the heads. The drying was either done on bare ground or on mats and tarpaulin. Threshing was done by women where the millet was beaten and winnowing done to remove chuff before storage. However, from planting to storage pearl millet production faced numerous constraints. Production constraints included ergot, birds, weeds, rust and drought while low prices (33.95%) followed by high market taxes, lack of transport to markets, lack of markets and unscrupulous middlemen were some of the marketing constraints. In most cases farmers had no effective suggested solutions to the constraints.

Section 1

1.1 Introduction

Pearl millet is a primary food grain crop for millions of people in the tropical and sub-tropical areas of Africa (Ndjeunga and Nelson, 2005) and India (Roden et al., 2007). In most African countries where the cereal is grown and production is documented, pearl millet ranks high in terms of importance. For example, in Niger it ranks first in terms of total cereal cultivation and production (Ndjeunga and Nelson, 2005) and the most important staple cereal in Namibia (Ipinge, 1998). In Eritrea it is the second most important staple cereal after sorghum (Roden et al., 2007). Nutritionally, it contains high levels of quality protein (Roden et al., 2007) in addition to having good levels of micro-nutrients relative to common cereals like sorghum, rice, maize and wheat (Table 1.1) (Khairwal, 1999).

Table 1.1: Grain quality components of pearl millet and common cereals ($100g^{-1}$ of grain)

Nutrients	Pearl Millet	Sorghum	Maize	Rice	Wheat
Protein	11.60	10.40	11.10	6.90	11.80
Fat (%)	5.00	1.90	3.60	0.40	0.90
Iron (mg)	8.80	6.20	2.20	2.80	1.00
Fibre (%)	1.20	1.60	2.70	0.20	0.30
Energy (Kcal)	360.00	349.00	342.00	348.0	349.00
Carotene (mg)	132.00	47.00	90.00	9.00	29.00

Source: Singh et al. (1987)

Pearl millet is consumed as thick or thin porridge, cakes, or steamed granulated products in addition to the grain being used as source of yeast in the brewing industry (Murty and Kumar, 1995). All these forms of pearl millet utilisation meet particular standards set by the users who may be producers, processors or direct consumers. This leads to variety preference which forms a basis for pearl millet breeders to develop varieties that have the desired qualities needed by the end-users. However, until recently plant breeders had not involved pearl millet end-users in developing varieties with users' desirable characteristics. The result is many varieties not being adopted by the intended beneficiaries. For example, in Niger more than seventeen pearl millet varieties have been developed by ICRISAT-West Africa but few have been adopted by the beneficiaries (Ndjeunga et al., 2000). Ndjeunga et al. (2000) noted that the low adoption rate may partially be explained by the poor seed supply system and demand factors. The low supply of seed, poor estimation of seed demanded, poor seed distribution and low seed quality are among the seed-related constraints leading to low adoption rate of

improved pearl millet varieties in West Africa (Ndjeunga, 1997). In addition, the cooking traits in pearl millet are not well researched and documented as is the case for competing cereals; also contributing to the low adoption rate of improved varieties of pearl millet (Ndjeunga and Nelson, 2005). This implies that knowledge of traits preferred by the pearl millet users is important to design an effective breeding strategy and improve adoption rate (Ndjeunga et al., 2000).

However, much as pearl millet is an important food grain with research relatively advanced elsewhere, in Uganda research is just being revived. Therefore most of the comparison is based on work done elsewhere; calling for a need to initiate studies to provide information about the importance of the crop in Uganda. A participatory rural appraisal study was then conducted to establish pearl millet production characteristics like demography, productivity, uses/importance, important factors of production, constraints (production, storage, taste and market), desirable traits, establishing the socioeconomic features and showing relevance of pearl millet as a food security crop in Uganda. Thus, a baseline survey was done to document the socioeconomic and production characteristics of the pearl millet cropping system in Uganda. The information will be used to develop an effective participatory plant breeding programme which takes into account pearl millet users' views.

1.2 Research statement

Pearl millet is grown by farmers in semi-arid areas in Uganda but no documentation about its importance and production characteristics is available. In addition, farmers have preferred traits in their diversified locally adapted materials which partly determines the rate of adoption of modern technologies.

1.3 Objectives

To establish the socioeconomic and production characteristics of pearl millet in Uganda, a participatory rural appraisal was conducted to;

- Establish demographic and socioeconomic characteristics of pearl millet farmers
- Identify social capital and technology adoption characteristics
- Establish the importance and utilisation of pearl millet
- Assess the agronomic features of the pearl millet cropping system
- Establish pearl millet productivity and factors of production and their common units
- Identify farmers' preferred traits, production and marketing constraints

1.4 Research methodology

1.4.1 Study area

A baseline survey was conducted in January 2012 in two farming systems, the Teso and Northern systems (Ronner and Giller, 2013), where pearl millet is predominantly grown. The two systems do not differ much in terms of socioeconomic characteristics and agricultural livelihood. Both systems are characterised by rearing of cattle and production of annual crops such as cotton, sorghum, millets, cassava, sweet potatoes, ground nuts, sun flower and sesame (Ronner and Giller, 2013). Due to the production of annual crops and cattle rearing as economic activities, the systems are also called the 'annual cropping and cattle teso system' and the 'annual cropping and cattle northern system' respectively (Mwebaza, 2006). However, the Teso system has a bimodal rainfall pattern with shorter dry seasons and low fertility sandy-loam soils (Mwebaze, 2006). On the contrary, the Northern system has a less pronounced bimodal rainfall pattern which reduces to a unimodal pattern with longer dry intervals in the far north and northeastern Uganda. The locations of the study districts are as indicated in Table 1.2 and Fig 1.1. In the Teso system, the study was conducted in Kumi and Katakwi districts. In Kumi district forty households were covered in the three villages of Olupe, Asinge and Okouba while in Katakwi still forty households were covered in Olera and Usuku villages. In Kitgum district the study was conducted in Kitgum town council, Mucwini and Kitgum Matidi villages covering thirty-eight households while in Lamwo data were collected from Rudi and Pobar villages covering twenty-two households.

Table 1.2: Location characteristics of the study districts

Regions	District	Latitude	Longitude	Altitude (m.a.s.l)	Average rainfall (mm)	Soil types
Eastern	Kumi	01° 30′N	033° 57′E	1138	1270	Sandy loam
	Katakwi	01°54′N	034°00′E	1107		Sandy loam
Northern	Kitgum	03°13′N	032°47′E	969	1130	Sandy loam
	Lamwo	03°32′N	032°48′E	1100		Sandy loam

Source: http://en.wikipedia.org/wiki/Districts of Uganda, accessed on 19/03/2011.

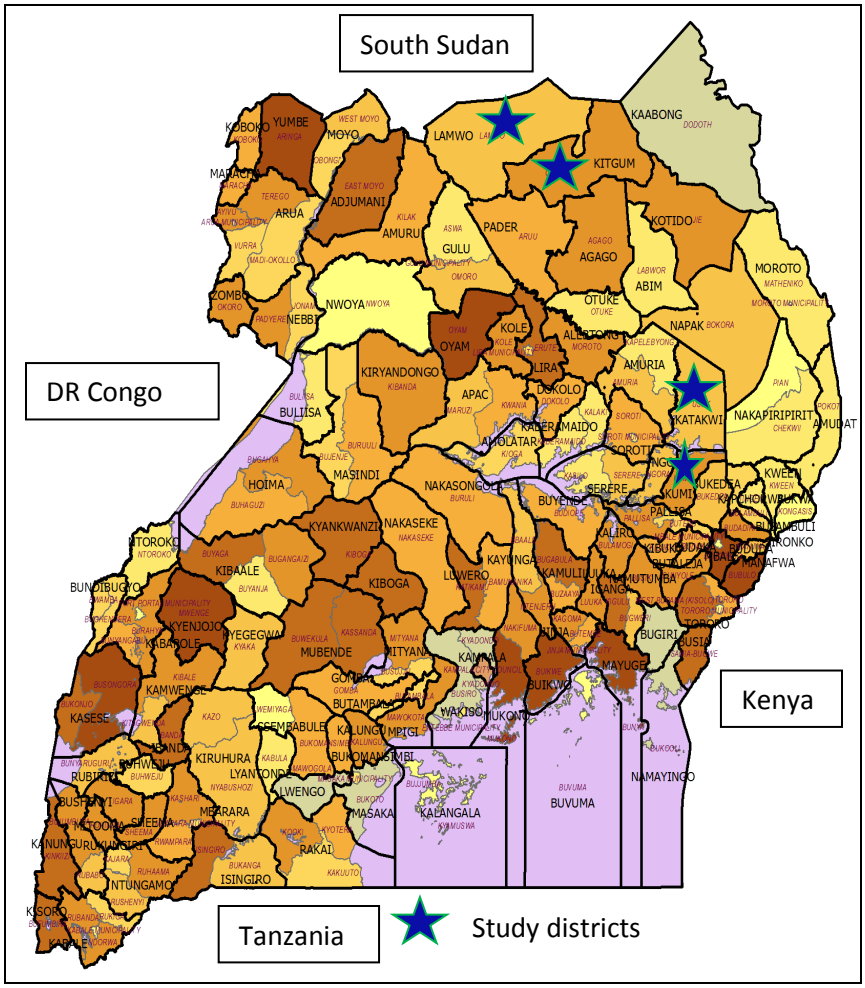


Fig 1.1: Map of Uganda showing location of the study areas
Source: http://en.wikipedia.org/wiki/Districts of Uganda, accessed on 19/03/2011

1.4.2 Selection of farmers and enumerators

Pearl millet production is localised in a few places in northern, eastern and northeastern Uganda. Therefore, purposive selection of the study area was done basing on how widely the crop was grown in the districts. In eastern Uganda the farmers were selected basing on the fact that they had grown pearl millet in the last two years. In northern Uganda some respondents who had grown the crop in the last one year were considered for the interview because most farmers were still settling for normal farming after over twenty years of being in the war zone. In all the study districts a five-stage stratified selection criteria was adopted in order to identify respondents. The strata were 1) the farming systems, 2) the districts, 3) the sub-counties, 4) the villages and 5) the respondents. Two categories of respondents were considered; the first being that of the household respondents upon whom a household questionnaire was administered to gather information about pearl millet at household level. The households were randomly

selected with the help of local council leaders. After selecting about one hundred households that grew pearl millet, random selection of those to participate in the study was done to come up with the number of households needed for the study. This number varied per village depending on the willingness of households to participate in the study. The second category of respondents was a group of about 10-15 key informants who constituted a community focus group discussion. This group comprised of ardent pearl millet growers who provided information about the village socioeconomic characteristics in relation to pearl millet production. Selection of the enumerators was based mainly on the ability to speak the local language in addition to having at least a degree in sociology, agricultural extension or agriculture. In Teso region (eastern) those selected to conduct the interviews knew Ateso (the local language) while in the north Luo (Acholi or Langi) speakers were selected for data collection.

1.4.3 Data collection

Data were collected using various participatory rural appraisal techniques (PRA). The PRA techniques used included; transect walks, problem listing and analysis, and problem ranking (Lelo et al., 1995) with key informants (Fig 1.2) which were corroborated by household formal interviews using a semi-structured questionnaire (Fig 1.3). The key informants were interviewed about the pearl millet production aspects like constraints, preferred traits, economic activities in the village and uses/importance. In addition, informal data collection techniques like observations were adopted in order to better understand the pearl millet cropping system at the farm level. The informal PRA techniques were used because they help to elucidate the relevant local knowledge (Mergeai et al., 2001) which in turn helps to achieve high precision with the formal techniques (Chambers, 1992). Data were collected by two teams each of three members and a supervisor with the help of the village local council leaders and the extension workers at the sub county level. One team worked in the eastern region covering eighty households while the other worked in northern Uganda covering sixty households. The household crop and animal productivity was estimated using the 'farmer recall' (Fermont et al., 2009; Smale et al., 2010) and 'prediction' methods (Singh, 2003).

1.4.4 Data analysis and quality control

Data collected from the focus groups discussion and household interviews were entered and analysed using the Statistical Package for Social Scientists version 20 (IBM SPSS Inc., 2011). Average scores and ranks were calculated from the quantitative and qualitative data.

Descriptive statistics were used for analysis to identify general patterns (Pender et al., 2002) and tests, analyses of variance and mean comparison were computed and conclusions drawn basing on the findings.



Fig 1.2: Using charts to identify constraints with a group of key informants



Fig 1.3: Interviewing a household head

Section 2 Demography

Demographic factors are important in determining rate of technology adoption. Anogie et al. (2009) reported gender (marginalisation of women), marital status, education and cultural belief as being the major constraints to adoption of new pearl millet varieties. In addition age of farmers, household size, formal education level and farm size are also important in adoption of new crop varieties (Macaver, 2002; Ogungbile et al., 2002).

2.1 Age of household members

Age of the heads of households is important in agricultural technology adoption (El-Osta and Morehart, 1999). It may positively (McNamara et al., 1991) or negatively (Baidu-Forson, 1999) influence agricultural technology adoption. Younger farmers are dynamic and more likely to adopt new agricultural technologies faster than relatively old farmers (Bisande et al., 1998; Mugisha et al., 2012; Namara et al., 2005; Neil and Lee, 2001). The average age of heads of households growing pearl millet in Uganda was 45.78 years while that of their spouses was 37.22 years. This compares with the 46.50 years of those involved in pearl millet marketing in Africa (Baba and Maina, 2013). On the contrary the pearl millet farmers in Uganda were relatively younger than those elsewhere in Africa who were about 50 years (Ndjeunga et al., 2011). The results show that the average age of farmers in Uganda was that of still able-bodied persons expected to adopt new agricultural technologies faster than those in many African countries growing pearl millet. Basing on the age group interval of 10 years, the results in Fig 2.1 further indicate that majority (25.90%) of the heads of households were between 31-40 years while majority of their spouses were up to 30 years. The results also show that most of the household heads (63.31%) were between 21-50 years old; an indication that most households selected for the interview were still in the working age group with a wide experience in pearl millet cultivation of 6.93 years and could thus provide reliable information. Contrary, majority of the spouses (mostly female) were in 21-30 years age group; implying that most of the spouses were relatively younger and thus able to adopt new technologies much faster than the heads of households. The age group 41-50 years shows more spouses because most men in that group had more than one spouse.

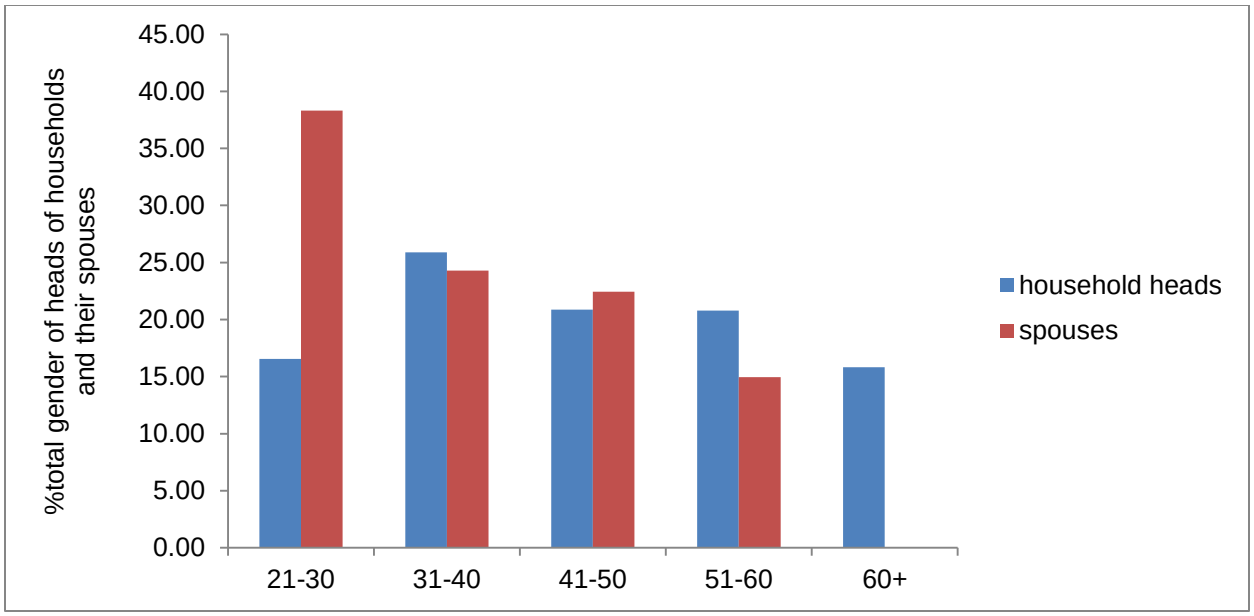


Fig 2.1: Age groups of heads of households and their spouses

Results in Table 2.1 show that majority of the household members were below 15 years followed by the actively working group (15-64 years) and a few being more than 65 years. This is close to the national figures where majority of Uganda's population is below 15 years old followed by the working group and lastly the elderly (UBOS, 2010). However, the dependence ratio of 1.11 is higher than the national ratio of 1.04 (World Bank, 2012). Further, the dependency ratio in both regions was still higher than at national level; implying that the economically productive age group supports a relatively larger non-economically productive group. Kumi district had the highest dependency ratio followed by Lamwo and Katakwi districts, respectively. Table 2.2 results show that majority (48.01%) of household members were children followed by the youths; implying they can easily adopt new technologies. The results slightly vary from the national figures where the youth form the majority of the Ugandan population (UBOS, 2010). This implies that more children were involved in providing farm labour for agricultural production than the youth and elderly combined. However, the availability of the youth population to provide labour for agricultural activities is not assured as trends show a continuous exodus of rural population to urban areas in the last twelve consecutive years (AGRA, 2013). This implies that less labour-intensive technologies are more likely to be adopted than those that need a lot of manual labour.

Table 2.1: Age groups of household members and dependency ratios

	Age (years) range			Dependency	Dependency
Districts	0-14	15-64	65+	Ratio	ratio by region
Katakwi	122	161	9	0.81	
Kumi	145	149	11	1.05	1.86
Kitgum	104	171	8	0.65	
Lamwo	58	70	3	0.87	1.53
Total	429	413	31	1.11	

Table 2.2: Broad age grouping of household members

	Age groups			
Districts	Children (0-17years)	Youth (18-30 years)	Working group(31-60 years)	Old age (≤61+years)
Katakwi	13.69	6.29	5.92	1.11
Kumi	15.08	6.66	5.27	1.20
Kitgum	12.95	7.22	5.09	0.93
Lamwo	6.29	3.61	1.94	0.28
Total percent	48.01	25.44	23.03	3.52

2.2 Gender of household members

Gender affects crop productivity and rate of technology adoption. Doss and Morris (2001) reported that gender positively impacted on the adoption of new maize technologies in Ghana. However, studies conducted in Nigeria showed a negative effect of gender on adoption of new pearl millet varieties while studies on coffee production in Papua indicated that gender had no significant effect on technology adoption (Overfield and Fleming, 2001). In India female labour per unit area is generally more expensive than male labour (Ramasamy et al., 2000). In Uganda female headed households have been associated with low crop productivity and less likely to adopt new technologies relative to male-headed households (Peterman et al., 2010). This implies that the role of gender in agriculture should not be under estimated when developing new pearl millet technologies for farmers.

Results from this study show that households had more females than males which is the same as national ratio of 49% male and 51% female (Table 2.3) (UBOS, 2010). However, more male-headed households (84.89%) were involved in the study than female-headed households (15.11%). This implies that pearl millet farmers in Uganda were more likely to adopt new

technologies. In terms of gender of respondents, still the majority were male (62.59%) while the female accounted for 37.41% (Table 2.3). It was easier to get more male respondents than female because the study was conducted at harvest time when women spend more time in the field than men. This can be confirmed in the labour section where women dominated the harvesting and threshing activities (Fig 8.4 and Fig 8.5). The same reason may explain why fewer female respondents were interviewed in Lamwo district. This shows that proper timing for dissemination of new agricultural technologies is important, especially where women are involved.

Table 2.3: Gender of household members

Districts	Gender of heads of households		Gender of respondents		Gender of household members	
	Male	Female	Male	Female	Male	Female
Katakwi	22.3	5.76	16.55	11.51	13.77	14.75
Kumi	27.34	1.44	20.86	7.91	15.54	15.14
Kitgum	19.42	7.91	10.07	17.27	13.37	14.26
Lamwo	15.83	0.00	15.11	0.72	6.59	6.59
Total percent	84.89	15.11	62.59	37.41	49.26	50.74

2.3 Marital status and relation to heads households

Marital status is one of the demographic features determining technology adoption among pearl millet farmers (Ndjeunga et al., 2011). Most of the heads of the households that participated in the study were married (82.73%) followed by the widow/widowers, divorced/separated and a few singles (Table 2.4). The pattern was the same across all the districts except for Lamwo where all the heads of households were married. Farmer communities having mostly married heads of households have been reported in many studies conducted in Uganda (Mpiira et al., 2013). However, at household level (Table 2.5) most household members (40.15%) were below marriage age and they were mainly children of the heads of households (Table 2.6). Results in Table 2.6 further show that households in eastern region had more children, spouses and servants related to heads of households than those in the north.

Table 2.4: Marital status of heads of households

Districts	Married	Widow/ Widowed	Divorced/ Separated	Single
Katakwi	21.58	3.60	1.44	1.44
Kumi	26.62	2.16	0.00	0.00
Kitgum	18.71	7.19	1.44	0.00
Lamwo	15.83	0.00	0.00	0.00
Total percent	82.73	12.95	2.88	1.44

Table 2.5: Marital status of household members

Districts	Below Marriage Age	Married	Single	Widow	Divorced
Katakwi	14.15	7.74	5.93	0.67	0.67
Kumi	16.63	9.27	3.15	1.24	0.29
Kitgum	5.83	5.64	12.91	1.53	1.43
Lamwo	3.54	4.68	4.49	0.1	0.10
Total percent	40.15	27.34	26.48	3.54	2.49

Table 2.6: Relation of household members to heads of households

Districts	Child	Spouse	Grandchild	Servants	Others	Parent	In-Laws
Katakwi	21.48	3.99	0.89	1.77	0.33	0.55	0.00
Kumi	21.26	5.54	1.22	1.33	0.78	0.89	0.33
Kitgum	16.72	2.99	4.32	0.66	1.11	0.22	1.22
Lamwo	8.31	2.66	0.55	0.00	0.78	0.11	0.00
Total Percent	67.77	15.17	6.98	3.77	2.99	1.77	1.55

2.4 Education level of the household members

Education level is key in adoption of improved technologies related to agriculture (El-Osta and Morehart, 1999; Caswell, et al., 2001; Siddiqui and Mirani, 2012) and important in increasing household farm income in Uganda (Nkonya et al., 2002). Lack of education has been associated with negative impact on technology adoption (Harper et al., 1990) while more years of education positively influenced adoption of information (Namara et al., 2005) and agricultural technologies that required intensive management skills (Caswell et al., 2001). For example in Nigeria where 73% of pearl millet farmers are illiterate, a low adoption rate of new pearl millet varieties has been reported (Ndjeunga et al., 2011). It is thus perceived that the higher the education level the lower the complexity involved in understanding the technology packages (Bonabana-Wabbi, 2002).

Generally majority (42.45%) of the heads of households had attained some primary level education (Table 2.7) with mean of 5.7 years of education experience while 46.36% (Table 2.8) of their spouses had attained some primary education with an average of 3.9 years of education. The pattern of education experience is consistent with national level where male adults have a higher education experience than the female (UBOS, 2010). However, basing on the indicators of the multi-dimensional poverty index (MPI) developed by The Economist (2010) the education experience of the heads of households met the minimum of five years where one is considered to be literate while their spouses failed; implying that generally the heads of households were literate (could read and write) while their spouses were illiterate. Thus new technology packages developed should be simple or visuals should be used especially for the female as they form majority of the spouses.

Table 2.7: Education level of heads of households

Districts	Never attended school	Some primary	Completed primary	Some 'O' level	Completed 'O' level	Completed 'A' level
Katakwi	3.60	12.23	4.32	2.88	3.60	1.44
Kumi	2.16	14.39	7.91	2.16	1.44	0.72
Kitgum	3.60	7.91	3.60	5.04	3.60	3.60
Lamwo	0.00	7.91	2.88	2.88	0.72	1.44
Total percent	9.35	42.45	18.71	12.95	9.35	7.19

Table 2.8: Education level of spouses

Districts	Never attended formal education	Some primary	Completed primary	Some 'O' level	Completed 'O' level	Completed 'A' level
Katakwi	7.97	13.77	2.17	2.90	0.00	0.72
Kumi	3.62	18.84	3.62	2.17	0.72	0.00
Kitgum	5.07	10.14	4.35	4.35	2.17	0.72
Lamwo	6.52	3.62	5.07	0.72	0.00	0.00
Total percentage	23.19	46.38	15.22	10.14	2.90	1.45

Table 2.9: Highest education level attained by household members

Districts	Never attended school	Not yet school age	Some primary	Completed primary	Some 'O' level	Completed 'O' level	Completed 'A' level	Tertiary institution
katakwi	4.63	2.32	14.38	2.32	3.28	0.97	1.06	0.10
Kumi	4.15	3.38	15.44	2.41	3.76	0.97	0.39	0.10
Kitgum	4.25	1.45	10.71	2.70	2.61	2.32	3.19	0.19
Lamwo	2.70	1.45	5.60	1.83	0.97	0.10	0.29	0.00
Total percent	15.73	8.59	46.14	9.27	10.62	4.34	4.92	0.39

2.5 Human population in households

The average number of persons per household was 7.54 with a minimum of one member and a maximum of fifteen persons per household. Most households had 6-10 persons (64.75%). This is higher than the national level of 5 persons per household (UBOS, 2010). Over 23.02% households had 1-5 persons while 12.23% had between 11-15 persons (Table 2.10). The large number of household members is a good source of on-farm labour. However, in this case it may not be an incentive because majority of the household members were young up to 17 years.

Table 2.10: Response about number of household members

	Range of household members		
Districts	1-5 persons	6-10 persons	11-15persons
Katakwi	6.47	16.55	5.04
Kumi	6.47	17.99	4.32
Kitgum	4.32	20.14	2.88
Lamwo	5.76	10.07	0.00
Total percent	23.02	64.75	12.23

2.6 Housing conditions and sanitation

Majority of the households had low standards of living as shown by there being no household with electricity and staying in temporary (83.45%) houses (Table 2.11). Majority of the pearl millet farmers stayed in single room houses built with mud and wattle or iron sheets/tins and roofed mainly with grass or papyrus reeds (Fig 2.2). Most houses had their floor made of mud or cow dung smear. The single room houses seem to be over crowded as most households had more than six members; which is higher than the two persons per room recommended by Macro International Inc. (2007). The living conditions are lower than the national level reported by UBOS (2010).

Presence of pit latrine was a good sanitation indicator where 79.14% of the households had access to pit latrines. This was slightly above the national level of 68.00% reported by the Ministry of Health (as quoted in the New Vision, 02.12.13 page 49). Both regions had high percentage of households with pit latrines (75.95% and 83.33% in eastern and northern region respectively). However, the 20.86% of households without pit latrines is much higher than the 10% reported by UBOS (2010) for the rural areas. Sensitisation should be done to inform people about the health dangers of not having a pit latrine and the advantage of having one.

Table 2.11: Housing conditions for pearl millet farmers

Districts	Type of house			Type of wall		Type of roofing materials		Type of floor materials		Number of rooms				Presence of pit latrine	
	Temporary	Permanent	Semi-permanent	Mud and wattle	Bricks	Grass	Iron sheets	Mud/cow dung	Cement	1	2	3	4+	yes	no
Katakwi	27.34	0.72	0.00	20.86	7.19	27.34	0.72	27.34	0.72	27	1	0	1	17.99	10.07
Kumi	20.14	5.76	2.88	14.39	14.39	20.86	7.91	21.58	7.19	19	2	4	3	25.18	3.6
Kitgum	20.14	2.88	4.32	12.95	14.39	19.42	7.91	21.58	5.76	8	8	6	6	22.3	5.04
Lamwo	15.83	0.00	0.00	11.51	4.32	15.83	0.00	15.83	0.00	3	7	4	1	13.67	2.16
%total	83.45	9.35	7.19	59.71	40.29	83.45	16.55	86.33	13.67	57	18	14	11	79.14	20.86



Fig 2.2: Typical homestead of pearl millet farmers

2.7 Economic activities of the household members

Economic activities are important in determining technology adoption. For example off-farm and non-farm income provides additional cash for purchasing new technology requirements (Namara et al., 2005). Namara et al. (2005) still reported that the other income sources may also negatively affect adoption of agricultural technologies because agriculture then ceases to be a major source of income. Considering the main economic activity as being one that takes most of the farmers' time of the day, it was observed that farming (51.50%) was the lead economic activity for heads of households in the surveyed districts (Table 2.12). The farming activities included crop production and livestock rearing. This is lower than the national figure of 70% of rural people being employed in agriculture (UBOS, 2010). However, at household level the household chores ranked first among the economic activities followed by farming and studying respectively (Table 2.13). Results in Table 2.13 further show that 11.01% of the household members did not participate in any economic activity due to old age, being too young or because of sickness. It is still observed that 64.45% of the household members did not contribute directly to household income but depended on the 35.55% who had a direct income. The dependants include those studying, those involved in household chores and those who could not contribute to household income.

Table 2.12: Economic activities for heads of households

	%household response about economic activities for head of households									
Districts	Farming (crop + livestock)	Household chores	Retail business	Brewing	Teacher	Brick making	Carpentry/metal fabrication	Building/construction	Casual labour on-farm	Driver
Katakwi	14.66	8.65	2.26	1.50	1.13	0.75	0.00	0.00	0.00	0.00
Kumi	15.04	11.28	3.01	0.00	0.00	0.38	0.00	0.00	0.38	0.00
Kitgum	13.53	5.26	1.50	1.13	1.13	0.38	1.13	0.75	0.38	0.75
Lamwo	8.27	4.51	0.00	0.00	0.00	0.38	0.75	0.75	0.38	0.00
Total percent	51.50	29.70	6.77	2.63	2.26	1.88	1.88	1.50	1.13	0.75

Table 2.13: Economic activities of household members

	Percentage household response about economic activities												Dependence	
Districts	Household chores	Farming	Studying	Cannot work	Retail business	Formal work	Brick making	Brewing	Crafting	On-Farm casual labour	Building/ construction	Driver	Direct income source	Dependent
Katakwi	8.45	9.43	5.56	3.16	0.87	0.49	0.33	0.27	0.05	0.05	0.00	0.00	11.50	17.18
Kumi	10.91	8.67	6.43	3.60	0.93	0.22	0.11	0.00	0.00	0.22	0.00	0.00	10.14	20.94
Kitgum	8.34	6.92	7.42	2.62	0.93	0.49	0.22	0.33	0.49	0.16	0.22	0.11	9.87	18.38
Lamwo	3.98	3.82	2.34	1.64	0.00	0.00	0.05	0.00	0.05	0.00	0.11	0.00	4.03	7.96
Total percent	31.68	28.84	21.76	11.01	2.73	1.20	0.71	0.60	0.60	0.44	0.33	0.11	35.55	64.45

2.8 Household food security situation

A household is food secure when it has access to adequate food needed for a healthy life for all its members (adequate in terms of quality, quantity, safety and cultural acceptability); and when it is not at risk of losing such access. However, in this study emphasis was put on the aspect of food quantity and availability. This is based on Bahiigwa's (1999) findings that households in Uganda were considered to be food secure if they had enough to eat at all times in terms of availability and quantity. Bahiigwa (1999) further reported that to the farmers in the rural households food quality was a secondary aspect of food security. Thus questions were asked about food availability, quantity, meals eaten daily, shortage and causes, coping strategies and whether pearl millet was an important food security crop.

2.8.1 Food availability in households

Respondents were asked whether their households faced fluctuations of food availability and if they suffered from food shortage. It was observed that majority (60%) of the respondents had an improvement in food availability while 23.57% of the households indicated reduced food availability and 16.43% noticed no change (Table 2.14). Results in Table 2.14 further show majority indicating an increase in food quantity in their households. However, a large percentage (43.21%) of farmers talked of a reduction in food quantity in their households. This implies that much as food availability increased, the quantity may have actually reduced; predisposing households to the 'quantity' type of food insecurity. Results in Fig 2.3 confirm this, as majority (74.29%) of the households responded having faced food shortage in their households. The pattern was the same across all districts except Lamwo. Fig 2.3 results may also imply that respondents exaggerated having an improvement in food situation. This is further confirmed by results in Fig 2.4 which shows that majority (48.09%) of the households could afford only one meal in a day and only 18.03% had three meals in a day. Results further show that having only one meal daily was more pronounced in the eastern region especially Katakwi district while in the northern region Kitgum district had more households having only one meal daily. Generally results point to households both in the eastern and northern region being food insecure in term of availability and quantity. Due to the proof of food shortage indicated in Fig 2.3, respondents identified possible causes of food shortage (Table 2.15) and coping strategies during food scarcity (Table 2.16).

Table 2.14: Household responses about changes in food availability and quantity

Districts	Changes in household food availability			Changes in household food quantity	
	Improved	Declined	No change	Quantity of food increased	Quantity of food reduced
Katakwi	15.71	5.00	7.14	13.21	14.64
Kumi	23.57	2.14	3.57	17.50	11.79
Kitgum	11.43	12.14	3.57	14.64	12.50
Lamwo	9.29	4.29	2.14	11.43	4.29
Total percent	60.00	23.57	16.43	56.79	43.21

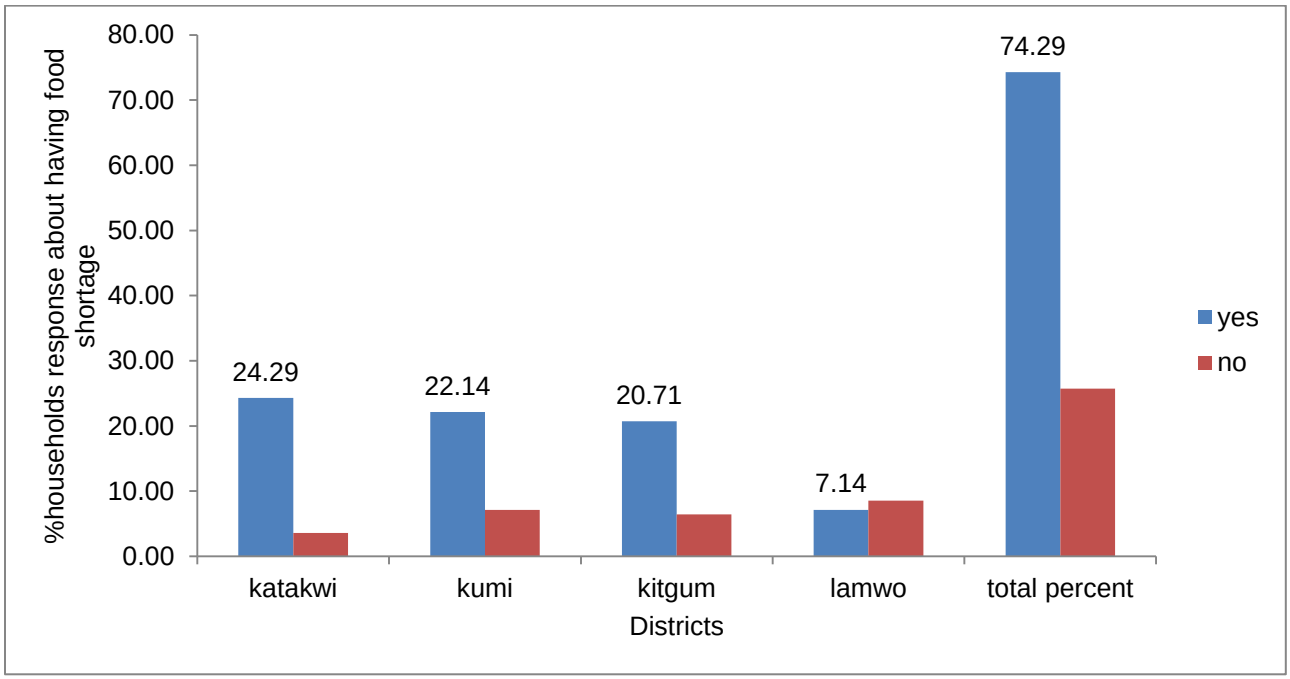


Fig 2.3: Household response about experiencing food shortage

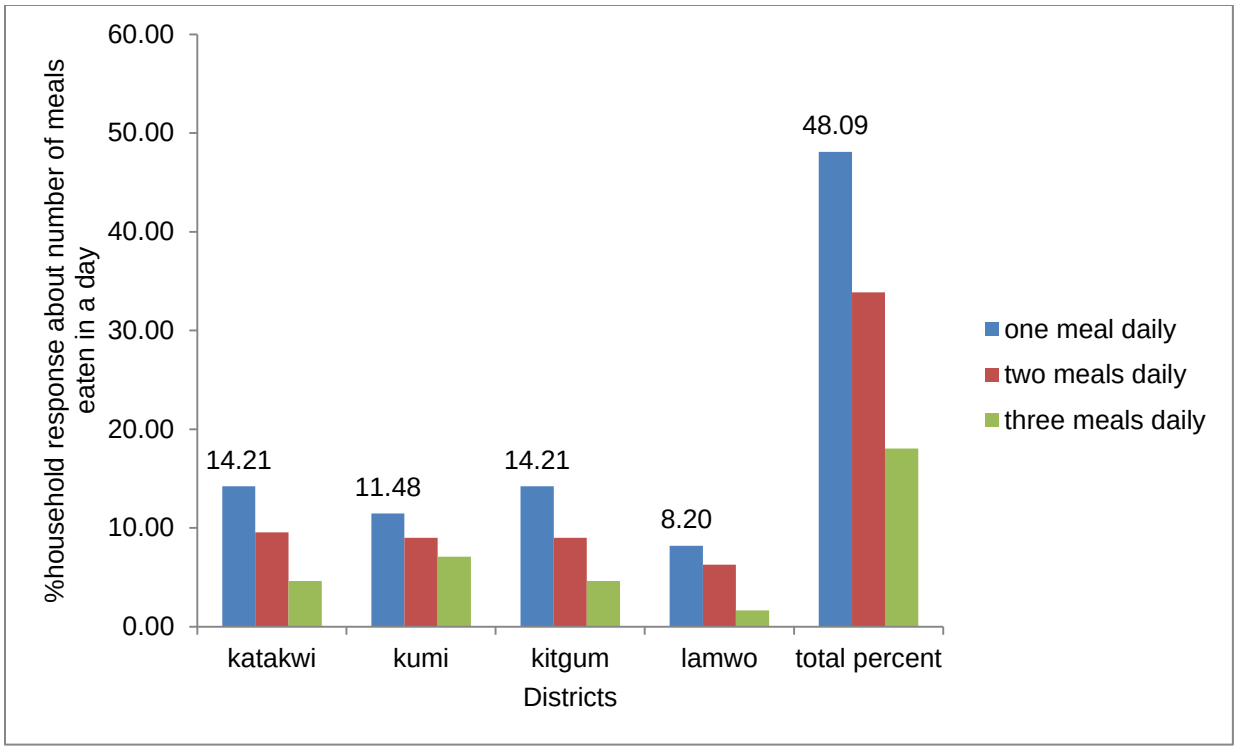


Fig 2.4: Household response about number of meals eaten per day

2.8.2 Causes of food shortage and coping strategies

As indicated in Table 2.15, the causes of food shortage in households identified by farmers were; drought, crop insect pests and diseases, lack of improved planting materials, low soil fertility, lack of off-farm income, floods and lack of enough land. Drought, insect pests and diseases and lack of improved planting materials were respectively ranked as the first, second and third cause of food insecurity. Still observed from Table 2.15 poor soil fertility, lack of off-farm income, floods and lack of enough land were also significant contributors to food shortage in households of pearl millet growers. Sickness of household members and labour shortage to a lesser extent were reported as being other causes of food shortage. In addition, possible coping strategies adopted during food shortage were; buying food as the most important followed by working for food and visiting food-secure relatives. Borrowing food, reducing number of meals and planting early to avoid drought were also identified by farmers as being important coping strategies to avoid food scarcity (Table 2.16).

Table 2.15: Causes of food shortage in households

Districts	Drought	Plant pests and diseases	Lack of planting materials	Poor soils	Lack of off-farm income	Land shortage	Floods	Weeds	Sickness of household members	Labour shortage for cultivation
Katakwi	22.76	3.25	1.63	1.63	0.00	0.00	4.07	0.00	0.00	0.81
Kumi	15.45	0.81	4.07	0.81	0.81	2.44	0.00	0.00	1.63	0.00
Kitgum	7.32	4.88	4.07	7.32	3.25	1.63	0.00	4.07	0.81	0.81
Lamwo	4.07	2.44	0.00	0.00	1.63	0.81	0.00	0.00	0.81	0.00
Total percent	49.59	11.38	9.76	9.76	5.69	4.88	4.07	4.07	3.25	1.63

Table 2.16: Coping strategies during food shortage

Districts	Buy food	Work for that food	Visiting food secure relatives	Borrowing food	Reduce daily number of meals	Early planting to avoid drought	Rent land for food production	Provide off-farm labour
Katakwi	8.88	5.33	5.33	3.55	2.96	0.00	0.00	0.00
Kumi	9.47	2.37	5.92	2.37	2.96	0.59	0.59	0.00
Kitgum	12.43	6.51	4.14	2.37	2.96	1.78	0.59	0.00
Lamwo	8.88	4.14	2.37	1.78	0.00	0.59	0.00	1.18
Total percent	39.64	18.34	17.75	10.06	8.88	2.96	1.18	1.18

Section 3 Socioeconomic capital and technology adoption

In this section socioeconomic empowerment was assessed where pearl millet farmers were asked about access to credit, agricultural trainings received, extension visits, sources of information and membership in groups or organisations.

3.1.1 Access to credit

Credit is one of the sources of capital that can be used for investment in agriculture. Kapwong et al. (2012) identified access to microcredit to invest in agriculture and agribusiness as the most important factor needed to improve livelihood conditions in rural areas. Borrowed money may be used to carry out time-bound agricultural activities such as planting, weeding and harvesting and thus ease with which it can be received being critically important. Under access to credit farmers were asked whether they accessed credit or not, purpose for which credit was sought and reasons why they could not access credit. Information was sought about credit sources, range of amount normally borrowed, interest rate and payback period.

Generally majority (83.57%) of the households interviewed did not access credit in the last two years compared with only 16.43% that received credit (Fig 3.1). The households that did not access credit identified absence of credit source in their villages (39.69%) as the main cause followed by lack of collateral, high interest rates and there being no need to borrow money (Table 3.1). Stringent terms and conditions, not being certain of harvest to pay back, fear to lose assets due to failure to pay back and lack of information about credit were among the other reasons for not accessing credit (Table 3.1). Mpiira et al. (2013) also reported lack of information, high interest rates, and fears as some of the reasons for not accessing credit in Uganda.

However, the trend varied slightly at regional level where in the northern region lack of collateral to offer as security and there being no need to borrow were the most important reasons for not accessing credit but in the east absence of credit source in the village and high interest rates were the most important reasons for not accessing credit to fund agricultural activities. While lack of collateral was the most important reason for not accessing credit in Kitgum district, farmers in Lamwo district expressed there being no need to access credit as the most important reason for not accessing credit.

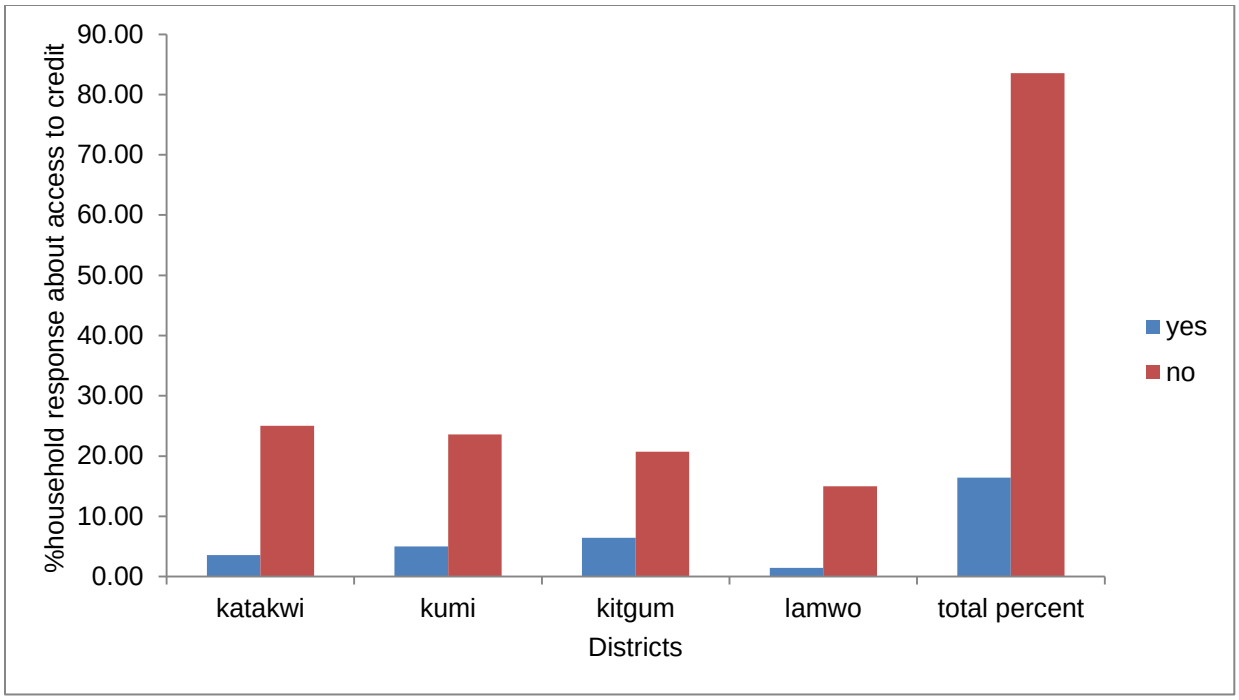


Fig 3.1: Household response about access to financial credit

Table 3.1: Reasons for not accessing financial credit

Districts	Absence of credit source in village	Lack of collateral	High interest rates	No need	Stringent terms and conditions	Not uncertain of harvest	Fears losing assets	Lack of information where to get credit
Katakwi	18.32	0.76	6.11	0.76	0.00	0.00	0.76	0.00
Kumi	16.79	0.76	6.11	0.76	0.00	0.76	0.76	0.76
Kitgum	0.00	9.92	0.76	4.58	5.60	5.34	2.29	0.00
Lamwo	4.58	3.05	0.00	6.11	2.40	1.53	0.76	0.00
Total percent	39.69	14.50	12.98	12.21	8.00	7.63	4.58	0.76

3.1.2 Sources of financial credit

The most important sources of credit for financing agricultural activities were generally informal low-capital organisations or groups operating as village banks (Table 3.2). These were followed by the relatively well organised non-governmental organisations and large banks like Centenary Bank. However, the banks in Kumi and Kitgum districts are near urban areas. This may imply that the formal credit sources operate within or near town areas; further confirming there being no credit facilities in rural areas as a major reason for not accessing financial credit.

Table 3.2: Sources of credit

Districts	Village banks	BRAC	SACCO	Centenary Bank
Katakwi	19.05	0.00	0.00	4.76
Kumi	19.05	4.76	9.52	0.00
Kitgum	9.52	14.29	4.76	9.52
Lamwo	4.76	0.00	0.00	0.00
Total percent	52.38	19.05	14.29	14.29

3.1.3 Reasons for accessing financial credit and related transactions

Reasons for accessing credit included paying for labour for on-farm activities, paying school fees, financing businesses and purchase of livestock as the most important although paying for medical bills and construction were also mentioned (Table 3.3). Most of the activities for which credit was sought were short term, which were mainly season based. This may justify why the majority of the pearl millet farmers borrowed small amounts of money in the range Ugx 20000-200000 (<USD 100) (Table 3.4) and paid back within three months at mainly 10% interest rate (Table 3.5).

Table 3.3: Reasons for accessing credit

Regions	Labour for farming activities	Pay school fees	Finance business activities	Purchase livestock	Medical bills payment	Construction
Eastern	27.00	5.25	3.33	0.00	4.00	0.00
Northern	18.00	2.00	2.00	5.00	0.00	2.00
Total percent	45.45	7.02	5.26	5.26	3.51	2.00

Table 3.4: Percentage response and range of amount of money borrowed by region

Regions	amount of money borrowed ('000')			
	20-100	100-200	250-300	400+
Eastern	16.00	21.00	9.00	14.00
Northern	16.00	21.00	5.00	0.00
Total percentage	32.00	41.00	14.00	14.00

Table 3.5: Interest rate per month and payback period

Percentage by	Interest rate per month			Payback period (months)			
regions	1-10	10-20	20-30	1-3	4-6	7-9	10-12
Eastern	40.76	4.31	9.09	40.91	0.00	0.00	13.64
Northern	36.51	9.33	0.00	31.82	9.09	4.55	0.00
Grand percentage	77.27	13.64	9.09	72.73	9.09	4.55	13.64

3.2 Access to agricultural training

3.2.1 Participation in selected agricultural training

Agricultural training is one of the processes of empowering rural farmers to operate profitably. Almost half (49%) of the households had received some training (Fig 3.2). However, more farmers in the northern region were trained than those in the eastern region. In addition results in Fig 3.3 show that those trained were either heads of households or spouses. The results also show that more heads of households were trained than the spouses. Since majority (Table 2.3) of the heads of households was that of men, it implies that most participants in the agricultural trainings were men and very few women. This is expected especially when trainings are held at time when women are involved in on-farm activities like weeding, harvesting or threshing.

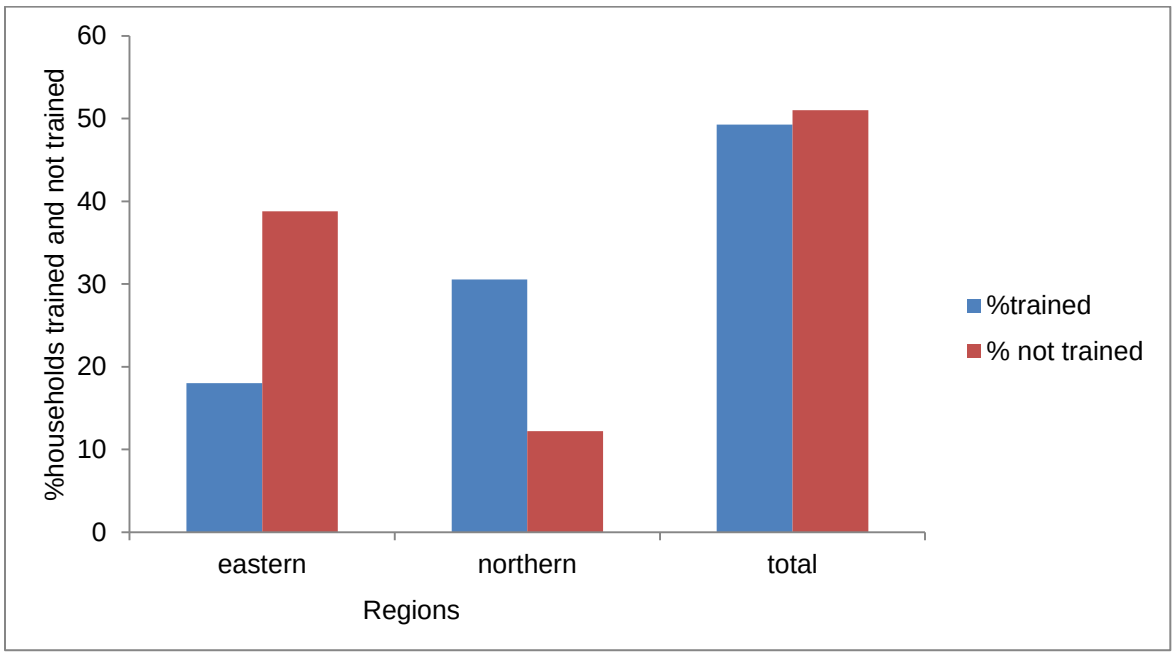


Fig 3.2: Response about access to agricultural training

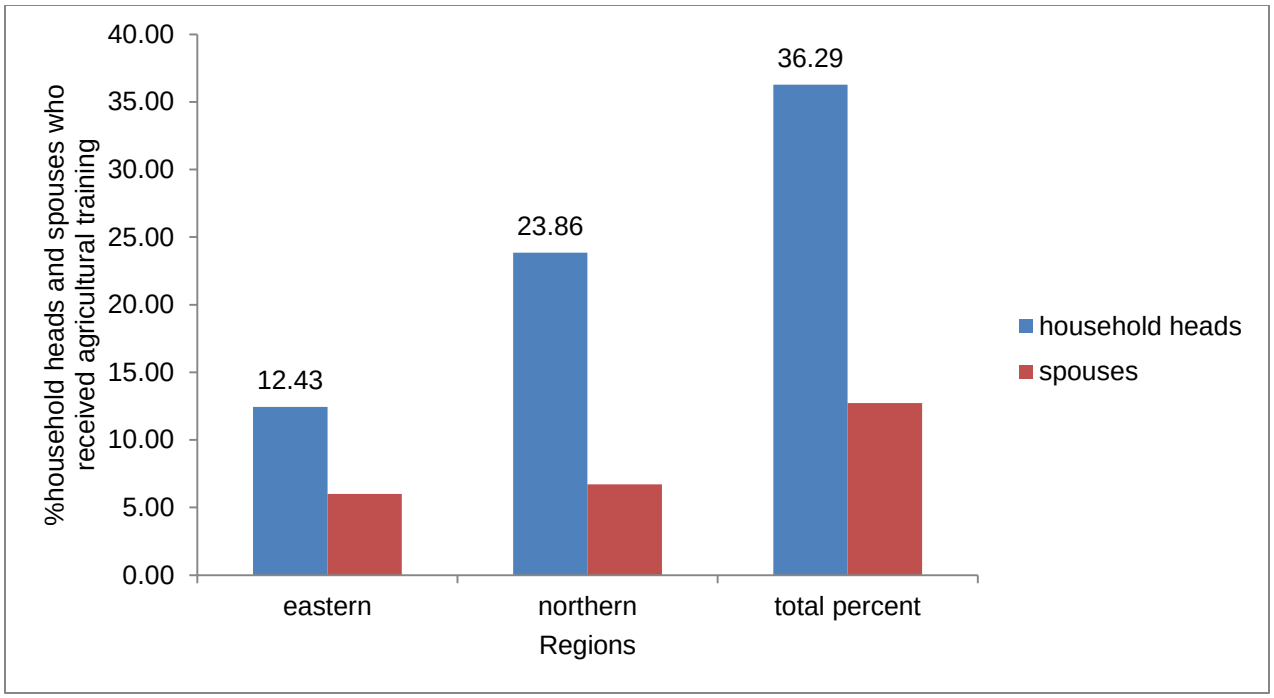


Fig 3.3: Response about heads of households and spouses who accessed to agricultural training

3.2.2 Types of trainings received and training organisations

Trainings related to modern agriculture were the most common that the pearl millet farmers received followed by marketing, vegetable production, pest and disease control and livestock rearing (Table 3.6). Trainings related to modern agriculture included row planting and proper spacing, agronomy of new varieties, vegetable production, proper harvesting and post-harvest technologies. Other trainings not indicated in Table 3.6 were record keeping, savings and credit, enterprise selection and agro-forestry. These were short term trainings taking up to only two days (Table 3.7); with NAADS and NGOs being the lead trainers (Table 3.8). Among the NGOs, LWF was the most frequent trainer while others included IRC, TEDO, BRAC, URCS, A2N, World Vision Uganda and UNAFFE. NAADS was the most prominent government-aided organisation that frequently offered agricultural trainings and to a lesser extent NARO.

Table 3.6: Types of training received by household members

Districts	Modern agriculture	Marketing	Pests control	Training of trainers (TOT)	Livestock rearing
Katakwi	16.67	0.00	3.70	1.85	0.00
Kumi	18.52	0.00	0.00	0.00	0.00
Kitgum	25.93	1.85	0.00	1.85	1.85
Lamwo	22.22	3.70	0.00	0.00	1.85
Total percent	83.33	5.56	3.70	3.70	3.70

Table 3.7: Duration of trainings

Districts	Duration of trainings in days						
	1	2	3	4	5	6-10	12-21
Katakwi	5	3	0	0	1	2	1
Kumi	5	7	0	0	0	1	0
Kitgum	3	8	4	2	0	1	2
Lamwo	6	7	4	1	2	0	0
Total frequency	19	25	8	3	3	4	3

Table 3.8: Major organisations that trained the pearl millet farmers

Districts	Frequency of occurrence of organisations that trained respondents		
	NAADS	NGOs	NARO
Katakwi	2	19	0
Kumi	8	2	2
Kitgum	12	6	0
Lamwo	12	7	0
Total frequency	34	34	2

3.2.3 Technology adoption for selected enterprises

Respondents were asked if they applied the knowledge acquired from the training sessions they attended and majority (82.61%) showed a positive response to applying the skills learnt while a few (17.39%) did not apply the skills learnt (Fig 3.4). Reasons advanced for failing to use the skills included; being trained off-season, lack of materials needed to apply the skills, strict terms and having no time to apply the knowledge acquired.

The high level of adoption reported by the trained pearl millet farmers may be due to the type of enterprises targeted by the trainers. Farmers received training in modern technologies for production of ground nuts, vegetables, cassava, beans, maize and to a lesser extent pearl millet (Table 3.9). Ground nuts and cassava were ranked first and third respectively in terms of importance. Unfortunately farmers were not trained in modern sesame technologies yet the crop ranked second in terms of importance. The crops in which trainings were received were ranked as high priority by the farmers in the eastern and northern regions for food and income generation. Farmers were also trained in production of common beans in the north but not in the

east still because beans are an important food crop mainly in the north. However some farmers received pearl millet trainings in the eastern region mainly because it is an important cash crop in that region.

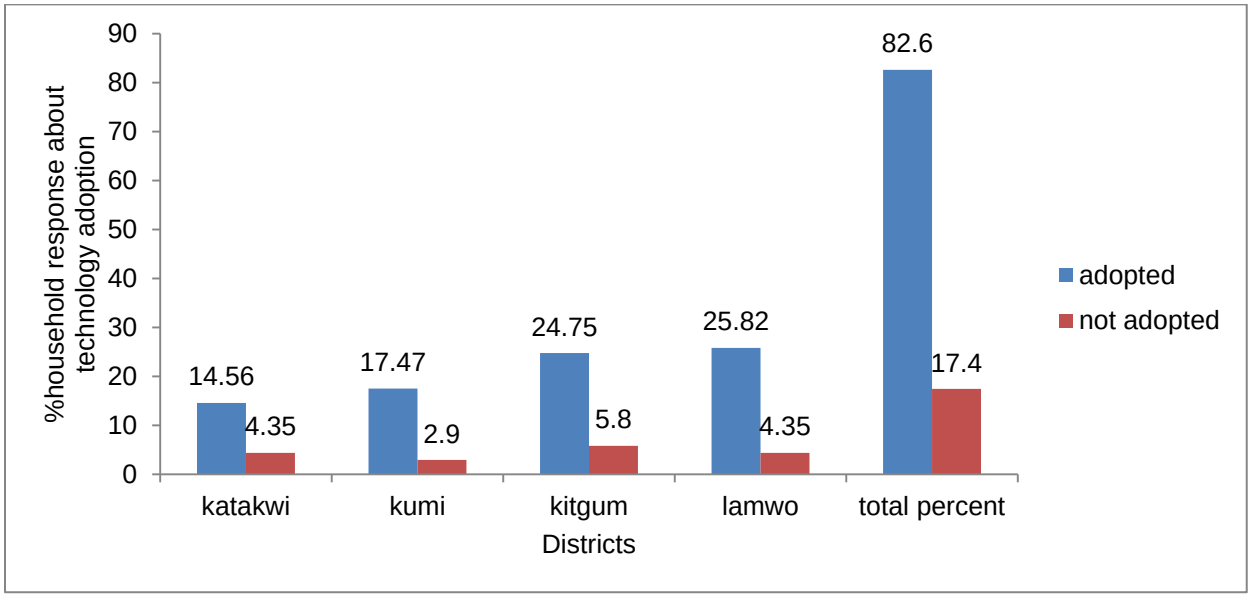


Fig 3.4: Household response about technology adoption

Technologies adopted (Table 3.10) were related to the enterprises affected by the training and the crops commonly grown in the pearl millet cropping system. The technologies adopted were related to agronomy of the most important crops and testing of new varieties of the favourite crops. This shows that the adoption rate was also based on the crop importance as long as the factors in Table 3.11 are fulfilled. Reasons for success were; using the technology as recommended (91.30%) and planting at the right time (9.70%) while reasons for failure of technology success were drought (37.50%), being labour intensive (37.50%) and farmers being used to old technology (laggards) (25.00%).

Table 3.9: Enterprises affected by training

Districts	Frequencies of enterprises for which technology was adopted after training												
	Ground nuts	Cassava	Vegetables	Beans	Maize	Pearl millet	Livestock	Sorghum	Other oil crops	Trees	Rice	Finger millet	Oranges
Katakwi	7	3	6	0	0	1	0	1	0	1	1	0	0
Kumi	9	4	5	0	2	2	0	0	1	1	0	1	0
Kitgum	6	8	0	2	2	1	2	1	0	0	0	1	2
Lamwo	10	3	2	4	1	0	2	1	2	0	1	0	0
Total frequency	32	18	13	6	5	4	4	3	3	2	2	2	2

Table 3.10: Technologies adopted and response about success

Technologies adopted	Percentage	Percentage response for success or not	
		Yes	No
Agronomy of important crops	67.65	45.45	21.21
Testing of new varieties	11.77	12.12	0.00
Tree plating	5.88	3.03	3.03
Spraying against pests	5.88	6.06	0.00
Animal traction	2.94	3.03	0.00
Vegetable production	2.94	3.03	0.00
Piggery management	2.94	3.03	0.00
Total percent	100	75.76	24.24

Table 3.11: Factors considered for technology adoption

Factors	Percentage response
Availability of necessary inputs	36.43
Market demand/should be marketable	15.71
Affordability	12.86
Adaptability	7.86
Yielding ability and maturity period	6.42
Resistance to diseases	5.00
Duration of learning technology	4.29
Ease to implement	2.86
Sustainability	2.86
Cultural acceptance	2.86
Demonstration	1.43
Availability of trainers	0.71
Being used as food	0.71

3.2.4 Access to extension services for selected agricultural activities

Access to extension services is one way of ensuring that the farmers appropriately implement the skills acquired from the agricultural trainings. Activities where extension services were received included proper planting, thinning/proper crop spacing, harvesting, crop and animal pest and disease control, new crop varieties, soil and water conservation, food storage, marketing and processing, market prices for produce and inputs, and climatic/weather conditions. The access to extension services was measured in terms of frequency of visits of by both the NGOs and government extension agents. The frequency was coded as 1) regular visits for up to 4 visits and more (4+), 2) irregular visits from 1 to 3 visits and 3) no visit where the farmers did not receive any extension visit in the last two years.

Results show that generally majority of the farmers (more than 70%) did not receive any extension advise in 2010 and 2011 for the selected agricultural activities while a few received irregular visits from both the NGOs and the government agencies (Table 3.12 and Table 3.13). This implies that normally after training the farmers there is no follow up to ensure that farmers correctly implement the skills acquired. Surprising, the percentage for ‘no visit’ (Fig. 3.5) was higher for the NGOs than that of the government agencies for all the selected activities yet the NGOs provided more trainings than the government aided institutions. This may imply that the NGOs, after spending a lot of resources in training, do not provide any support in form of extension advice. It further shows that government supported agencies provided more extension advise to the pearl millet farmers than the private NGOs; which is further corroborated

by government agencies performing better than the NGOs in both the irregular and regular categories of extension visits. However, this differs from Bashasha et al. (2011) findings that NGOs improved extension service delivery in the respective areas where they operated.

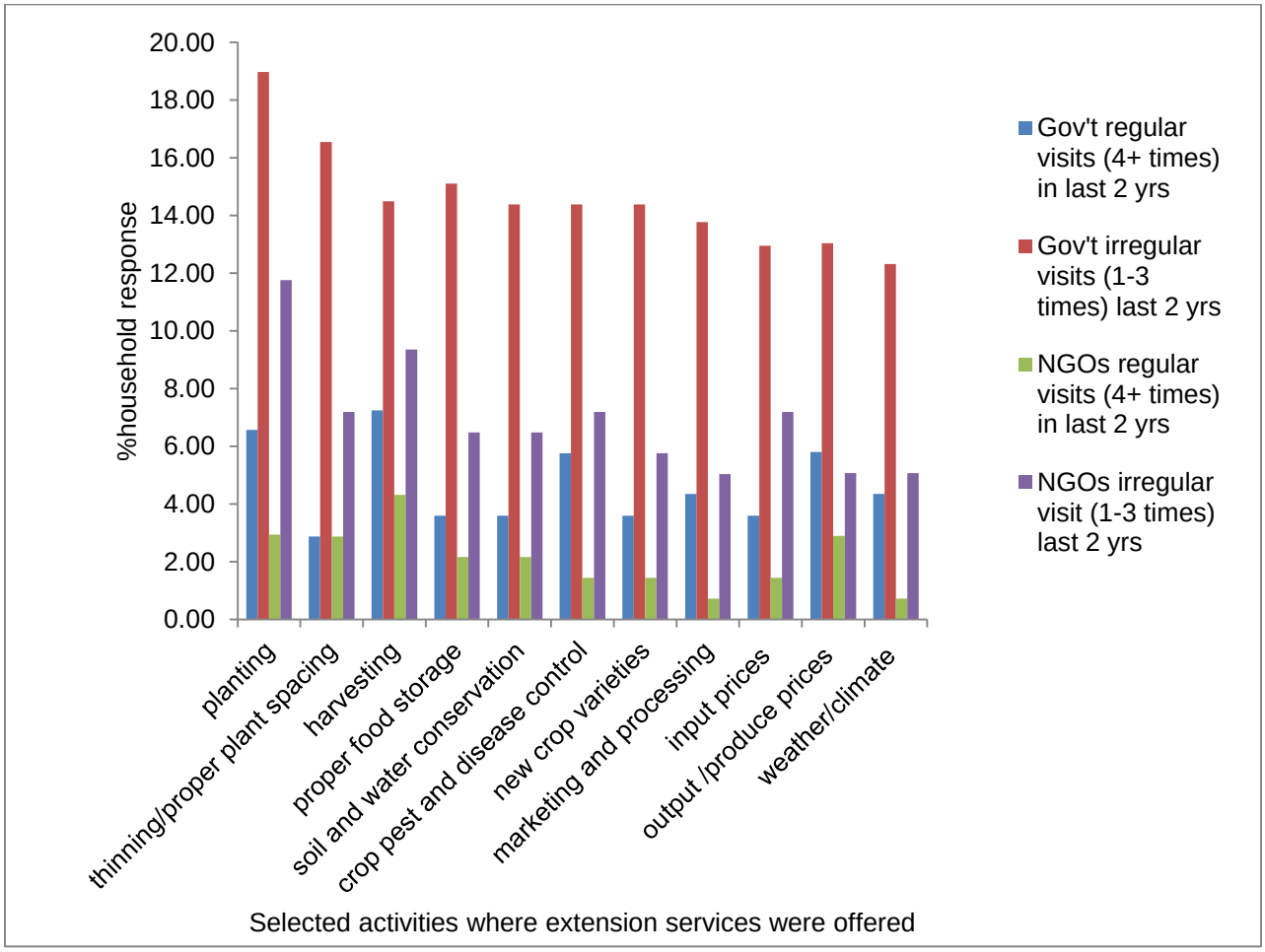


Fig 3.5: Comparison of frequency of extension visits by Government and NGO agencies for selected activities

Table 3.12: Visits by extension agents for selected pre-harvest activities

Districts	Selected pre-harvest agronomic activities					
	Extension visits by Gov't			Extension visits by NGOs		
	Regular visits (4+ times) in 2010 and 2011	Irregular (1-3 times) in 2010 and 2011	No visit in 2010 and 2011	Regular visits (4+ times) in 2010 and 2011	Irregular (1-3 times) in 2010 and 2011	No visit in 2010 and 2011
			Planting			
Katakwi	1.46	4.38	21.9	0	3.68	24.26
Kumi	2.92	7.3	18.25	0	0	28.68
Kitgum	2.19	2.19	23.36	1.47	5.15	20.59
Lamwo	0	5.11	10.95	1.47	2.94	11.76
Total percent	6.57	18.98	74.45	2.94	11.76	85.29
			Thinning/proper plant spacing			
Katakwi	0	5.04	23.02	2.16	2.88	23.02
Kumi	2.88	4.32	21.58	0	0	28.78
Kitgum	0	2.16	25.18	0.72	1.44	25.18
Lamwo	0	5.04	10.79	0	2.88	12.95
Total percent	2.88	16.55	80.58	2.88	7.19	89.93
			Harvesting			
Katakwi	2.17	4.35	21.74	0.72	3.6	23.74
Kumi	3.62	4.35	20.29	0	0	28.78
Kitgum	1.45	1.45	24.64	2.88	2.88	21.58
Lamwo	0	4.35	11.59	0.72	2.88	12.23
Total percent	7.25	14.49	78.26	4.32	9.35	86.33
			Proper food storage			
Katakwi	0.72	5.04	22.3	2.88	23.74	23.02
Kumi	2.88	5.04	20.86	0	28.78	28.78
Kitgum	0	2.16	25.18	1.44	25.18	25.9
Lamwo	0	2.88	12.95	2.16	13.67	13.67
Total percent	3.6	15.11	81.29	6.47	91.37	91.37
			Soil and water conservation			
Katakwi	0.72	4.32	23.02	2.16	2.88	23.02
Kumi	2.88	5.76	20.14	0	0	28.78
Kitgum	0	1.44	25.9	0	1.44	25.9
Lamwo	0	2.88	12.95	0	2.16	13.67
Total percent	3.6	14.39	82.01	2.16	6.47	91.37

Table 3.13: Visits by extension agents for selected post-harvest activities

Districts	Extension visits by Gov't			Extension visits by NGOs		
	Regular visits (4+ times) in 2010 and 2011	Irregular (1-3 times)in 2010 and 2011	No visit in 2010 and 2011	Regular visits (4+ times) in 2010 and 2011	Irregular (1-3 times) in 2010 and 2011	No visit in 2010 and 2011
Selected post-harvest agronomic activities						
Crop pest and disease control						
Katakwi	2.16	4.32	21.58	0.72	2.88	24.46
Kumi	2.88	5.76	20.14	0.00	0.00	28.78
Kitgum	0.72	1.44	25.18	0.72	2.16	24.46
Lamwo	0.00	2.88	12.95	0.00	2.16	13.67
Total percent	5.76	14.39	79.86	1.44	7.19	91.37
New crop varieties						
Katakwi	0.00	5.04	23.02	1.44	2.16	24.46
Kumi	1.44	5.76	21.58	0.00	0.00	28.78
Kitgum	2.16	1.44	23.74	0.00	1.44	25.9
Lamwo	0.00	2.16	13.67	0.00	2.16	13.67
Total percent	3.60	14.39	82.01	1.44	5.76	92.81
Input prices						
Katakwi	0.72	4.32	23.02	0.72	2.88	24.46
Kumi	1.44	5.04	22.30	0.00	0.00	28.78
Kitgum	1.44	1.44	24.46	0.00	0.00	27.34
Lamwo	0.00	2.16	13.67	0.00	2.16	13.67
Total percent	3.60	12.95	83.45	0.72	5.04	94.24
Output /produce prices						
Katakwi	1.45	4.35	21.74	2.17	2.17	23.19
Kumi	3.62	5.07	20.29	0.00	0.00	28.99
Kitgum	0.72	1.45	25.36	0.72	0.72	26.09
Lamwo	0.00	2.17	13.77	0.00	2.17	13.77
Total percent	5.80	13.04	81.16	2.90	5.07	92.03
Weather/climatic conditions						
Katakwi	1.45	4.35	21.74	0.72	2.9	23.91
Kumi	0.00	4.35	21.74	0.00	0.00	28.99
Kitgum	0.00	1.45	26.09	0.00	0.00	27.54
Lamwo	0.00	2.17	13.77	0.00	2.17	13.77
Total percent	4.35	12.32	83.33	0.72	5.07	94.20

3.2.5 Sources of information for selected agricultural activities

Sources of information were sought for farmer-selected agricultural activities like planting (sowing methods, planting depths, when to plant), thinning/proper plant spacing, harvesting (when and how), proper food storage, soil and water conservation, weather/climatic forecast, input and output/produce prices, processing and marketing, crop pest and disease control and new crop varieties. Results (Fig 3.6) indicate that much as there were various sources of information, a great number (22.48%) of the pearl millet farmers did not access any agricultural-related information. However, those who accessed information did that mainly through radio (31.41%). This is contrary in other pearl millet growing areas. For example, in India majority of the farmers accessed agricultural information from fellow farmers and neighbours (Asare-Marfo et al., 2010) but these were secondary in Uganda. Other sources of significant importance were friends or neighbours, extension agents, NGOs, training workshops, farmer field schools and farmers' field days. There was no major difference in the sources of information for the selected agricultural aspects at district level (Appendix) although upcoming sources of information (not in graph) included mobile phones, Local Council officials, newspapers and agro-produce buyers.

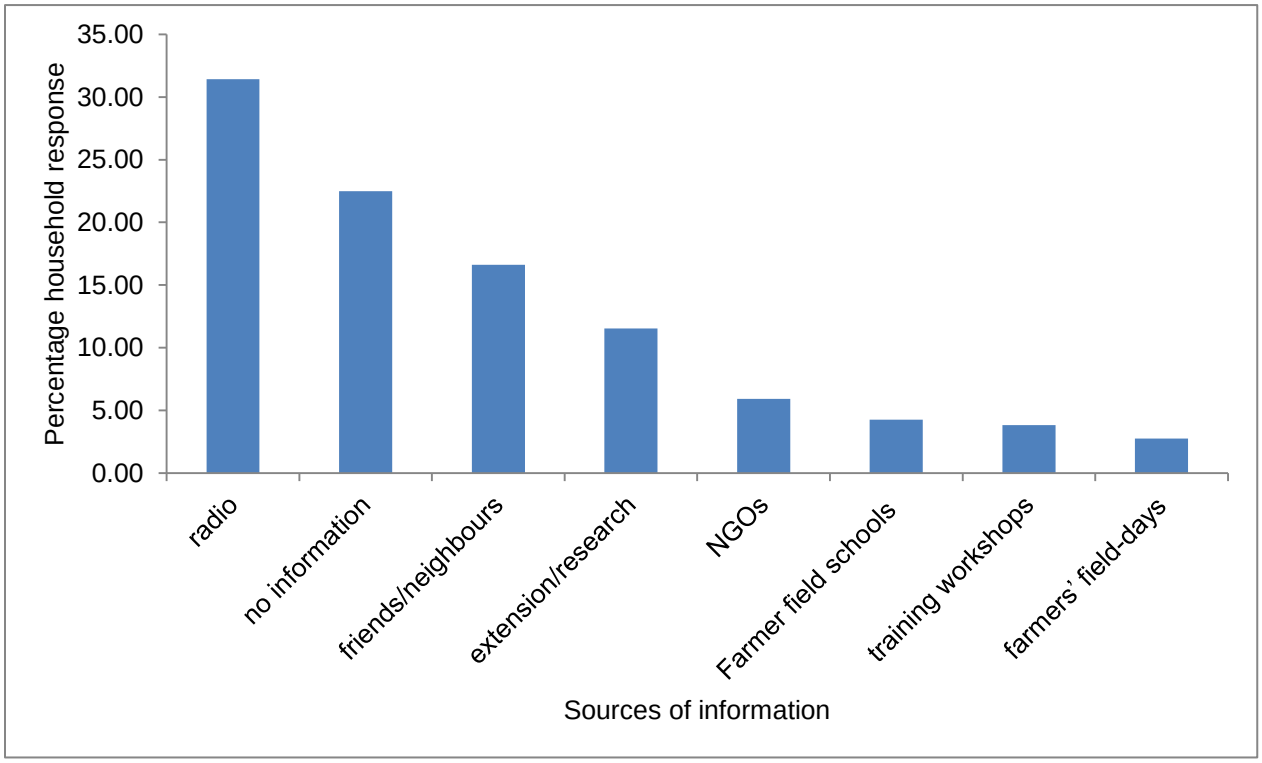


Fig 3.6: Common sources of agricultural information

3.3 Group dynamics

3.3.1 Membership in organisations or social groups and their main activities

Studies have shown that collective action has been important in poverty reduction in rural communities due to increased access to services (Kapwong et al., 2012). The result is improved productive capacity which transforms into human development and poverty reduction (World Bank, 2004). More than fifty percent (58.57%) of the households had at least an individual who was a member of a local social group when compared with 41.43% households that had no member involved in any group or organisation dynamics (Fig 3.7). This shows that many of the pearl millet farmers may be aware of the value of being members of groups/organisations as a social capital. Results (Table 3.14) show that the heads of households were the most active members involved in group activities followed by the spouses and lastly other members. However, most of the pearl millet farmers involved in group activities had no leadership roles followed by a few being chairpersons and general secretaries (Table 3.15); implying that there is need to train farmers about leadership. Results in Table 3.16 show that most farmers were involved in mutual support and labour provision groups. In addition, most members did not pay any registration or annual fee to join the mutual support groups (Table 3.17); implying that most of the farmers are involved in groups where they have no financial obligation for adherence.

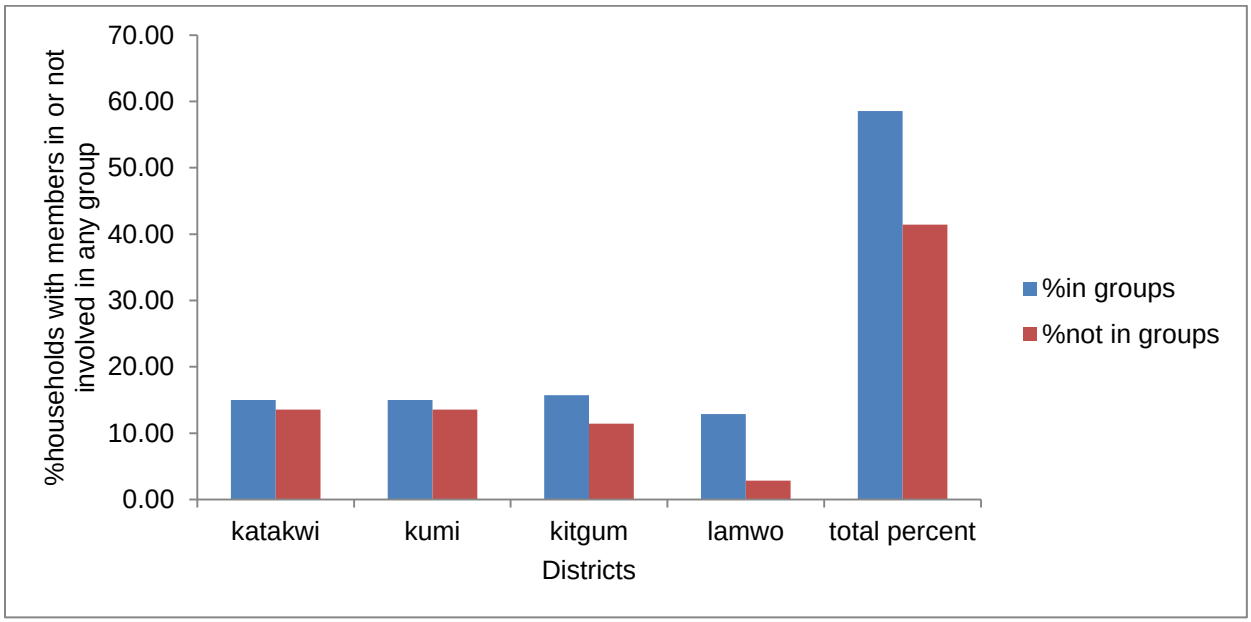


Fig 3.7: Household involvement in social organisations or groups

Table 3.14: Group membership by categories of household members

Districts	Household members in groups		
	Household head	Spouse	Other members
Katakwi	11	8	1
Kumi	10	7	4
Kitgum	16	4	2
Lamwo	16	2	0
Total number of group members	53	21	7

Table 3.15: Role of household members in groups

Districts	Role of household members in groups					
	Ordinary members	Chairpersons	General secretary	Finance secretary	Information secretary	Vice chairperson
Katakwi	16	3	0	1	0	1
Kumi	10	3	4	3	1	0
Kitgum	7	3	3	1	2	1
Lamwo	5	6	4	1	1	1
Total number of members	38	15	11	6	4	3

Table 3.16: Group main activities

Districts	Group main activities						
	Merry go round/savings	Group farming	Agric. labour provision	Produce marketing	Animal husbandry	Seed production	Stone quarrying
Katakwi	11	5	1	3	0	0	0
Kumi	11	5	1	3	1	0	0
Kitgum	3	3	8	1	3	2	1
Lamwo	1	7	7	1	2	0	0
Total frequency	26	20	17	8	6	2	1

Table 3.17: Registration and annual fee paid for membership

Districts	Fee paid for membership in groups											
	Registration fee							Annual fee				
	0	5000	2000	3000	1000	3500	500	0	1000	2000	3000	500
Katakwi	6	8	1	2	1	2	0	1	3	1	0	0
Kumi	3	2	1	0	0	2	0	1	0	2	1	0
Kitgum	6	3	6	2	1	0	1	12	2	2	2	1
Lamwo	8	0	2	2	2	0	2	11	1	0	1	1
Total number of members	23	13	10	6	4	4	3	25	6	5	4	2

Section 4 Importance and utilisation of pearl millet

4.1 Importance of pearl millet in terms of cultivation frequency and being food security crop

To establish the importance of pearl millet, farmers were asked how often they planted the crop in the last consecutive five years. Results showed that majority (56.02%) of the farmers planted pearl millet almost every year. In Table 4.1 it is further observed that farmers in the east had grown pearl millet more often than farmers in the north. Reasons advanced for the high frequency of pearl millet cultivation included being a food security crop and readily being accepted as food.

Table 4.1: Frequency of planting pearl millet

Districts	Frequencies pearl millet was planted in last five years				
	1	2	3	4	5
Katakwi	2.74	7.65	7.80	7.09	2.78
Kumi	1.37	3.13	12.06	14.18	4.51
Kitgum	4.10	5.56	4.96	2.48	4.51
Lamwo	1.03	0.70	3.55	3.90	4.51
Total percent	9.24	17.04	28.37	27.65	16.31

When asked if pearl millet was an important food security crop majority (97.86%) of the households responded 'yes' against only 2.2% who indicated 'no' (Fig 4.1). Results in Table 4.2 show that 'easily being sold to buy preferred food' and 'being readily accepted for food' were the most important reasons why the cereal was an important food security crop. However, the first reason was more important in the eastern region (29.72%); where the crop was mainly produced as a source of income. Having a 'high multiplier effect' when eaten, lack of market and being nutritious were important in the northern region where the crop was mainly grown for food. Contrary, reasons why pearl millet should not be promoted as food security crop included; low yielding, unstable prices at market and the fact that it could not readily be eaten unless mixed with other foodstuffs like cassava flour or tamarind. However, these reasons were given by respondents in Kumi where the crop is generally not eaten as food but primarily sold.

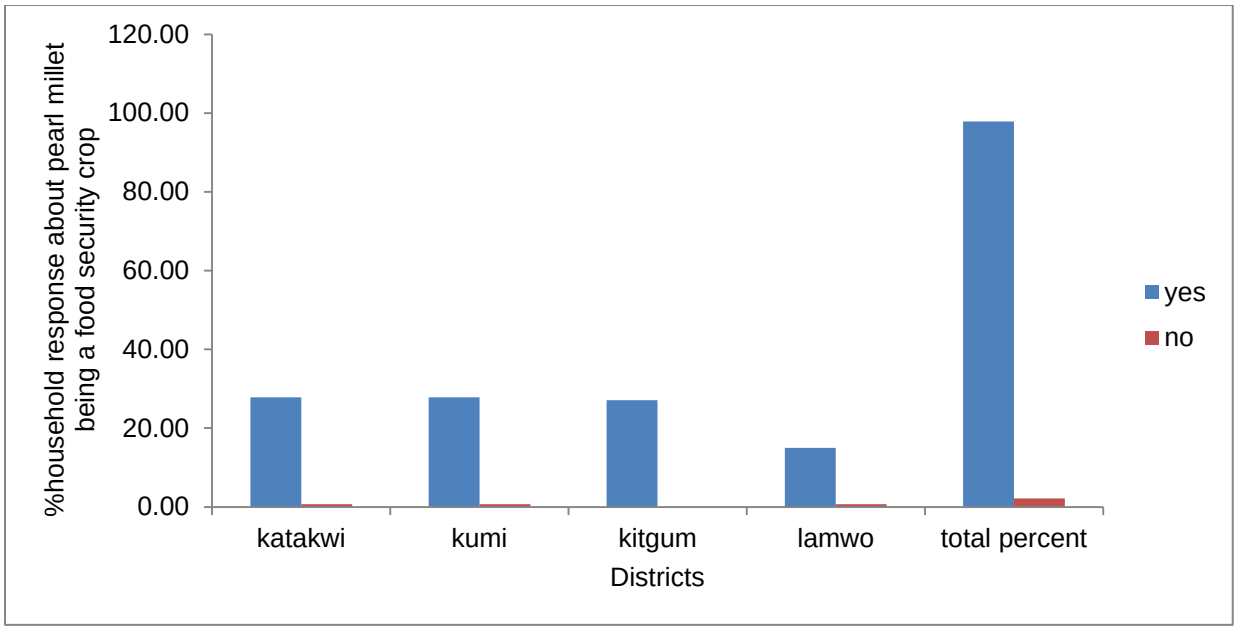


Fig 4.1: Pearl millet as a food security crop

Table 4.2: Reasons for pearl millet being a food security crop

Districts	Easily sold/bartered to buy preferred food	Readily accepted as food	High multiplier effect when eaten	No market	High yielding	Tolerant to drought	Early maturity	Nutritious	Not labour intensive when grown	harvested when no other food is available
Katakwi	12.74	8.96	0.00	0.00	1.42	0.47	0.47	0.00	0.94	0.00
Kumi	16.98	3.30	0.94	1.42	0.00	0.94	0.47	0.00	0.47	0.00
Kitgum	3.77	9.91	5.19	5.66	1.42	2.83	1.89	1.42	0.00	0.94
Lamwo	2.36	3.77	2.83	1.88	2.83	1.42	1.42	0.47	0.00	0.47
Total percent	35.85	25.94	8.96	8.96	5.66	5.66	4.25	1.89	1.42	1.42

4.2 Importance of pearl millet relative to other crops

The pearl millet cropping system comprised of crops grown by the farmers in categories of cereals, legumes, oil and fibre crops. The crops were grown for several reasons, the first being food followed by income (Table 4.3). The other reasons for growing the crops were mainly trait-based such as high yielding, early maturity, drought tolerance, adaptability and resistance to insect pests and diseases. This implies that yield *per se* may not be the most important trait to the farmers but yield stability to get what is enough to feed their families. Thus technologies targeting crops which are not readily accepted as food may not easily be adopted. Sorghum was mainly grown for food while pearl millet and ground nuts were grown mainly for food and cash. Basing on the importance of food and income, ranking for the common crops grown was

done (Table 4.4). Groundnuts were ranked first followed by sesame and cassava respectively. Pearl millet was ranked fourth and the fifth was sorghum. Surprisingly sesame ranked high mainly because it has high market demand and an ingredient in almost all types of local food dishes. Maize ranked low may be because it is not among the staple foods of most communities in study area. Ranking the crops based mainly on food and income looked unique for most crops that is why farmers were asked if there has been any change in the preference and if change is expected.

Table 4.3 Crops commonly grown and reasons why they were grown

Crops	main reasons why the crop is grown							
	Food	income	high yielding	early maturity	drought tolerant	available ready market	adapted to area	Resistant to pests and diseases
Sorghum	6.54	3.00	0.96	0.32	1.18	0.32	0.75	0.21
Pearl millet	5.79	5.14	0.86	1.71	0.75	0.54	2.89	0.11
Groundnuts	5.14	3.75	2.68	1.07	1.82	0.75	0.43	0.11
Cassava	4.50	2.04	1.39	0.86	0.43	0.21	0.43	0.43
Finger millet	3.64	2.04	0.86	1.18	1.07	0.00	0.21	0.21
Green gram	2.47	1.93	0.32	0.00	0.11	0.32	0.21	0.00
Sesame	2.14	2.25	0.43	0.54	0.00	0.11	0.11	0.00
Maize	2.04	0.86	0.75	0.75	0.11	0.11	0.43	0.11
Sweet potatoes	1.71	2.36	1.50	0.54	0.32	0.11	0.54	0.11
Field peas	1.50	1.39	0.21	0.21	0.21	0.21	0.32	0.11
Cow peas	1.07	0.54	0.11	0.11	0.11	0.11	0.11	0.00
Beans	0.54	0.32	0.00	0.00	0.00	0.00	0.00	0.00
Cotton	0.00	0.96	0.00	0.00	0.00	0.00	0.21	0.00
Pigeon peas	0.32	0.32	0.00	0.00	0.00	0.00	0.11	0.00
Rice	0.11	0.43	0.11	0.00	0.00	0.21	0.00	0.00
Sun flower	0.21	0.00	0.00	0.00	0.00	0.00	0.11	0.00
Total percent	37.73	27.33	10.18	7.29	6.11	3.00	6.86	1.39

Table 4.4: Ranking of most important crops

Crops	Percent	Rank
Groundnuts	26.59	1
Sesame	18.24	2
Cassava	16.82	3
Pearl millet	9.47	4
Sorghum	9.10	5
Maize	8.65	6
Finger millet	4.99	7
Green gram	3.24	8
Sweet potatoes	2.88	9

4.3 Changes in crop value and reasons for the changes

Majority of the farmers (70.6%) indicated an increase in change in rank for the common crops while 81.4% expect an increase in change in the crop rank (Fig 4.2) if the forces of change in Fig 4.3 were considered. In addition, results in Fig 4.2 show that some farmers did not notice any change in the crop rank and do not expect any whereas some farmers noticed a decrease and expect a change in the rank of the crops commonly grown. A few farmers could not tell which direction the rank took or will take.

The first reason advanced for the changes in crop rank was palatability preference (Fig 4.3). Some crops lost the preferred tastes and were ranked low by farmers. Fig 4.3 results further show source of income and marketability of the crops as the other causes of change in the crop rank in the last five years. Other factors were labour availability, being food security crop and yielding ability, increases in family size and yielding ability were also among the causes of change in crop rank.

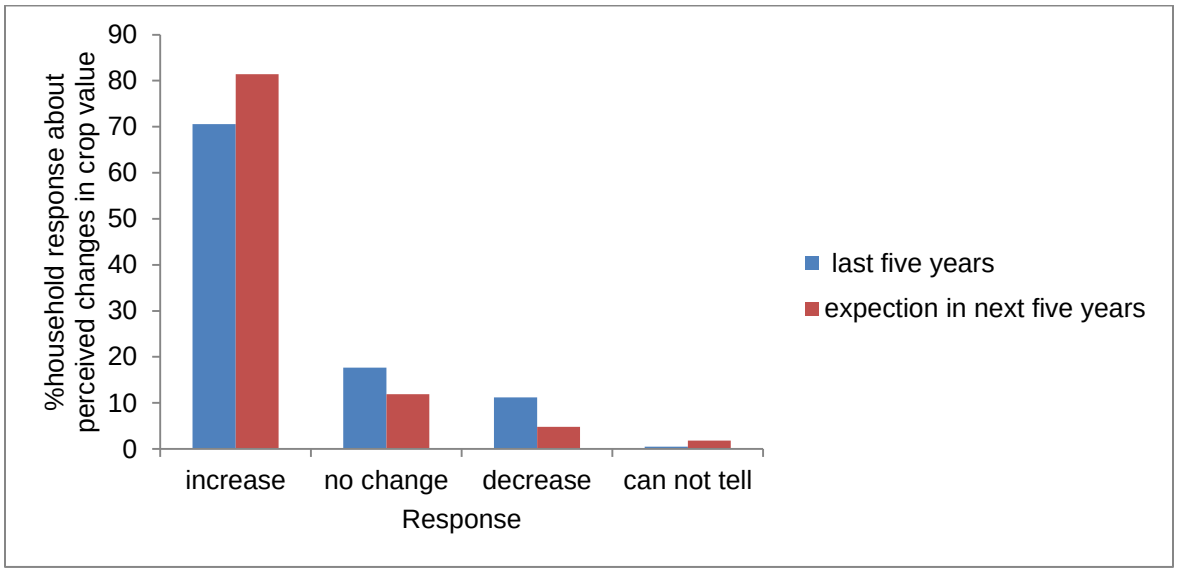


Fig 4.2: Perceived change in crop value

Reasons for the expected changes in crop rank did not differ much from those that caused change except the order of importance (Fig 4.3). Much as palatability was the most important character in determining change in crop importance, source of income, marketability, increase in family size, being stable food and drought tolerance may increasingly become more important in deciding which crops farmers will grow most. Seed availability and drought tolerance may also become important factors. Since the drought conditions have become more common, drought

tolerant crops like pearl millet may become more important to farmers; thus breeding for drought tolerance and yield stability should be given priority to increase acceptability of some drought prone crops in addition to providing markets for farmers' produce.

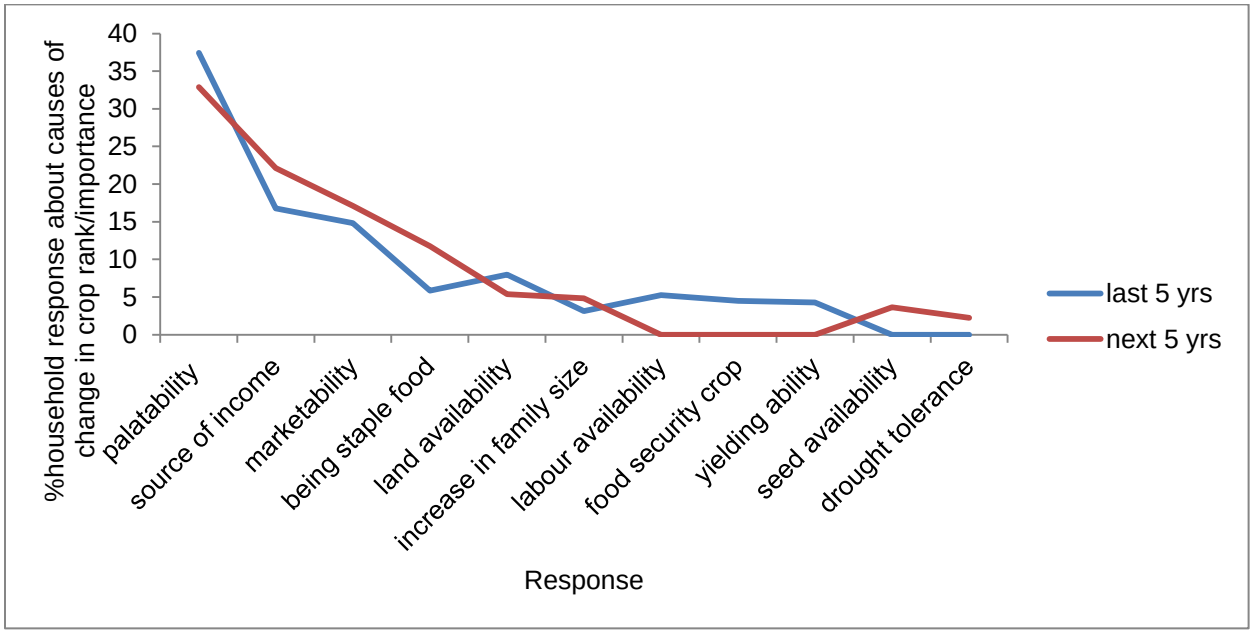


Fig 4.3: Causes of change in crop rank

4.4 Uses and utilization of pearl millet

Pearl millet has numerous uses both in developed and developing countries; a reason why farmers perpetually grow the cereal. While in developed countries it is grown for forage for livestock and an ingredient in the animal feeds (Basavaraj et al., 2010), it is a major food crop for the dry zones in many developing countries. In the developing countries the grain is mainly used as food while stover is fed to livestock (Kelley et al., 1996) and also used for building and as fuel for cooking (Vetriventhan et al., 2008).

Study results show that in Uganda pearl millet grain was majorly used as food (43.96%), source of income and being used in brewing as yeast respectively (Table 4.5). To a lesser extent the grain was bartered for other food commodities or fed to poultry while stover was fed to livestock. Bartering the grain for other food stuffs is one of the coping strategies for using pearl millet as food security crop. Farmers also claimed that pearl millet was strategically grown to control striga and to increase honey production. The use of pearl millet to control striga was confirmed by there being no striga in the pearl millet fields visited during the survey. To the contrary, many respondents indicated that the technology of using pearl millet in brewing was being abandoned

because the alcohol made from the millet led to severe headache and hangover. Results in Table 4.5 further show that pearl millet was more of a source of income and food in eastern region than the north. This implies that importance of pearl millet was region specific. In addition no household reported the use of pearl millet stover as building materials or as fuel for cooking as is the case in many developing countries.

Table 4.5: Uses of pearl millet in Uganda

Districts	%household response about uses and importance of pearl millet							
	food	Income	yeast for brewing	barter trade	livestock stover	poultry feed	killing striga	honey production
Katakwi	12.82	14.29	3.66	0.00	0.37	0.00	0.00	0.37
Kumi	8.79	13.55	6.96	0.00	0.37	0.00	0.37	0.00
Kitgum	13.92	5.13	4.03	1.10	0.00	0.37	0.00	0.00
Lamwo	8.42	2.56	2.56	0.37	0.00	0.00	0.00	0.00
Total percent	43.95	35.53	17.21	1.47	0.74	0.37	0.37	0.37

As food, pearl millet is consumed in numerous ways. In India the grain is an ingredient in many bakery products like flat bread commonly known as ”roti” while in West Africa pearl millet is mainly consumed as soft porridge (gruel) and leavened bread (Davis et al., 2003). On the contrary in Uganda whole grain (not decorticated) was pounded in a mortar or ground on a stone to make flour (Lubadde et al., 2014). This was then mingled in hot water to make either soft porridge or posho (Table 4.6). Whole grain is nutritionally excellent since most of the micro-nutrients concentrated in the outer layer of the grain are retained (Rai et al., 2008). Results in Table 4.6 further show that in the northern region the grains could be consumed when boiled (like rice), while in the eastern region flour was mixed with cassava flour and tamarind to make posho with a better taste. The results further show that consumption of pearl millet as food was district-specific with Katakwi in eastern and Kitgum in northern region as the leading consumers.

Unlike in India, in Uganda and in many African countries, pearl millet has less diverse forms in which it is processed and utilised. In India, the grain may be processed by de-hulling, milling, malting, blanching, acid or dry heat treated to increase the shelf life. Still in India many traditional food products like laddoo, chapati, suhali, bakli, khichri, and marti are made from pearl millet. In addition, baked products like chocolate cakes, cookies, biscuits (Singh, 2003) and extruded products like sev, sweet vermicelli and superior popped grains (Hadimani et al., 2001) are made from pearl millet. These technologies could be promoted and adopted in Uganda to increase the utilisation value of the cereal.

Table 4.6: Percent household response about utilisation of pearl millet as food in Uganda

	%household response about ways pearl millet is eaten				
Districts	Plain posho	Plain porridge	Grains boiled like rice	Cassava+ pearl millet posho	Pancake /bread
Katakwi	11.93	6.88	2.75	2.75	0.00
Kumi	7.34	6.88	0.46	1.38	0.00
Kitgum	12.84	15.60	8.26	0.00	0.92
Lamwo	8.72	7.80	4.59	0.00	0.92
Total percent	40.83	37.16	16.06	4.13	1.83

4.5 Unacceptable taste characteristics of pearl millet and coping strategies

Most farmers (90.00%) had no comment about taste inferiority except a few (10.00%). For those who commented indicated bitter taste (76.47%) as the main taste problem followed by the need to drink a lot of water after eating the food (Fig 4.4). To manage the unfavourable taste most farmers added tamarind when preparing the posho while others mixed pearl millet flour with cassava flour yet others did nothing to improve the taste. It is worth noting that the taste constraints were mainly indicated by farmers in eastern region where majority grew the crop for sale, implying that taste may not be a major constraint to warrant priority for research. The inferior taste may be related to the rancid odour developed 7-10 days after milling/grinding due to the high levels of lipids which lead to development of fat acidity, lipolytic acidity and accumulation of lipid peroxides (Yadav et al., 2012). It is thus advisable to grind what will be consumed in less than seven days.

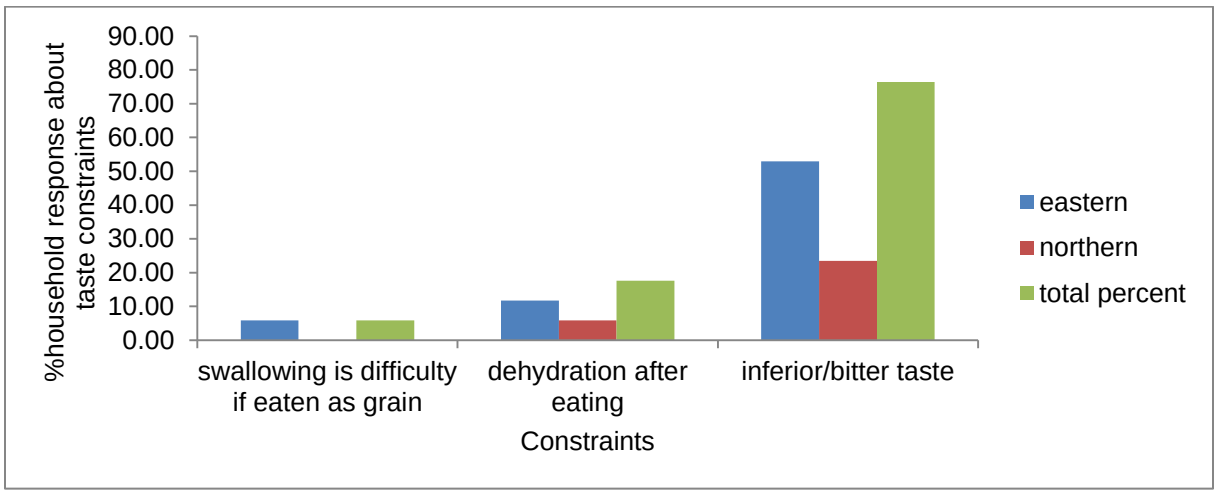


Fig 4.4: Response of households about taste constraints

Section 5 Agronomic characteristics

5.1 Types of pearl millet varieties planted by farmers in Uganda

Type of varieties (local, hybrid, OPVs) is important in increasing crop productivity. Hybrids and improved open pollinated varieties (OPVs) have proved to out yield the local land races (Shakoor and Naeem, 1999). In addition, under optimum growth conditions hybrids yield more than the (OPVs). The adoption of hybrids technology has led to increased pearl millet productivity in India while in Africa the OPVs are the cause of increased productivity. A 15% grain yield increase, with proper choice of parents , has been achieved in landrace based top cross hybrids while single cross hybrids give up to 25% higher grain yield than OPVs under drought stress (Yadav et al., 2012). In addition, higher yields have been achieved in varieties improved for drought tolerance (Vadez et al., 2010). However, in Uganda majority (95.71%) of the households responded to planting local varieties while few households planted improved varieties (Fig 5.1). No household indicated planting improved varieties in the northern region while in the eastern region Kumi district registered the lowest percentage (0.71%) of households that planted improved varieties. Pearl millet genotypes in northern Uganda and some parts of the east (Katakwi) were late maturing land races (maturing within five months) while those in Kumi district matured within three months. The most important reason advanced for planting local varieties was 'having no alternative varieties' (Fig 5.2). The results in Fig 5.2 further show that the local varieties also had good attributes like high tillering ability, early maturity, being drought tolerant and having spikes that scare birds.

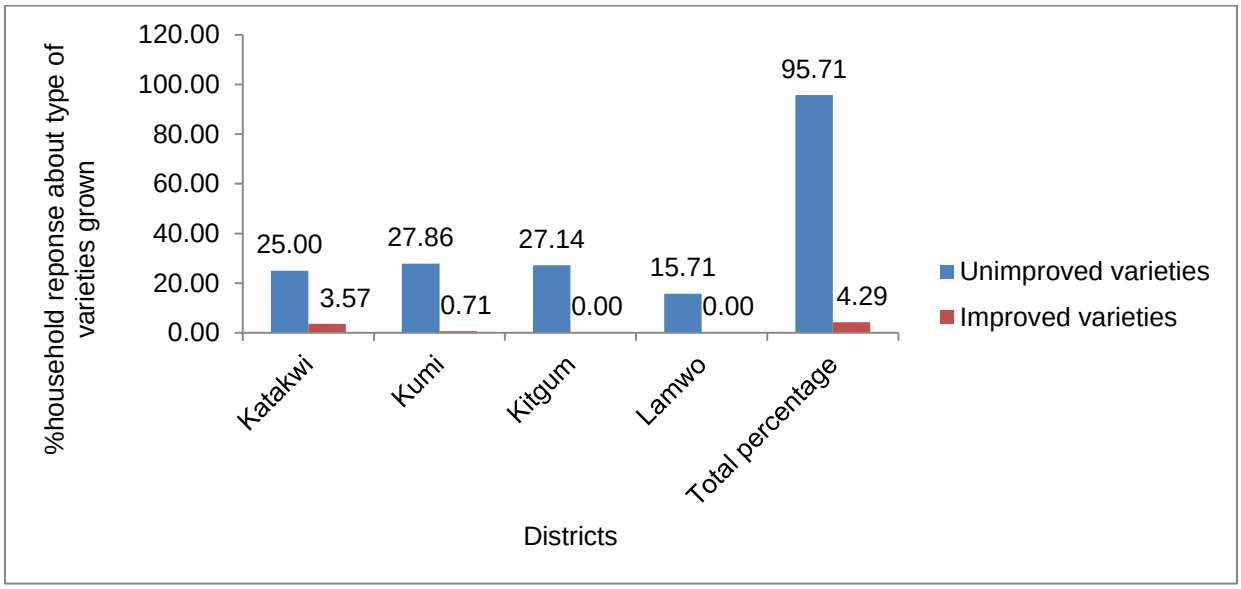


Fig. 5.1: Response of households about types of pearl millet varieties grown

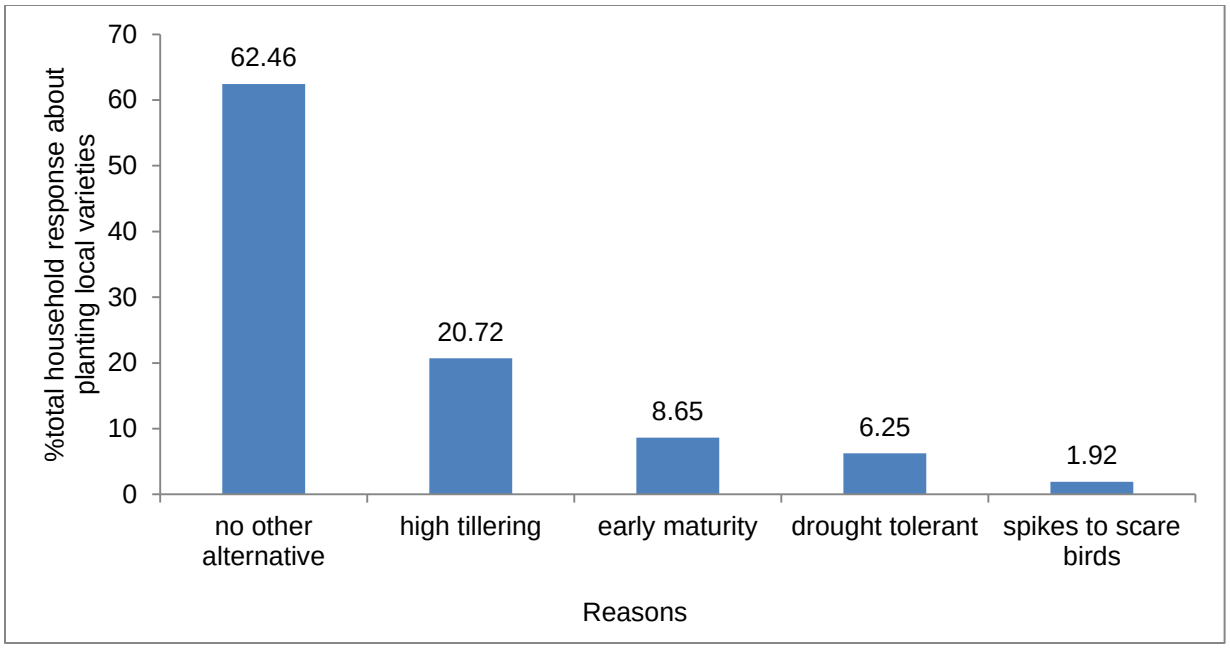


Fig 5.2: Reasons for planting unimproved local varieties

5.2 Season or time of planting pearl millet

Proper timing for planting is important in optimising yield especially under unpredictable climatic conditions. Drought has been reported to reduce grain and fodder yield of late planted pearl millet even under irrigation (Fontaneli et al., 2001; Hancock and Durham, 2010). Winkel et al. (1997) observed that drought negatively affected yield components when it sets in 30-60 days after emergence. They reported a negative effect on traits like grain yield, number of grains per panicle, single grain mass, number of productive tillers and booting time. Effect of insect pests and diseases may be pronounced in genotypes that are planted late (Mohamed Ali et al., 2013). It is thus advantageous to plant early than late (Deshmukh et al., 2009). However, some farmers may intentionally plant late in order to harvest at a time when there is less produce on the market in order to sell at premium price (Simtowe et al., 2010).

Basing on the importance planting time on yield, farmers were asked the appropriate season they mostly planted pearl millet in Uganda. Majority (92.14%) of the households indicated that they grew pearl millet in the second rainy season (September-January) (Table 5.1), an equivalent of Rabi (November-February) season in India (Mula et al., 2009), and harvested in January and February. In northern Uganda all households reported planting in the second rainy season starting in September. In eastern Uganda especially Kumi district where early maturing

genotypes are grown planting generally starts in October and November and harvesting done in January and February.

Table 5.1: Percentage household response about pearl millet planting season and type of varieties grown

	Planting season		
Districts	First season	Second season	Both seasons
Katakwi	3.57	24.29	0.71
Kumi	3.57	25.00	0.00
Kitgum	0.00	27.14	0.00
Lamwo	0.00	15.71	0.00
Total percent	7.14	92.14	0.71

The most important reason for planting late in the second season was escape from ergot disease which accounted for 76.65% as shown in Fig 5.3. Other reasons were; escape from birds, labour availability after planting other crops, land being available after harvesting other crops and farmers fetching high prices when selling their harvested grain (Fig 5.3). Ergot disease is very severe under too much rain which normally occurs in the first season. Farmers also reported severe bird effect during the first rainy season than in the second rains.

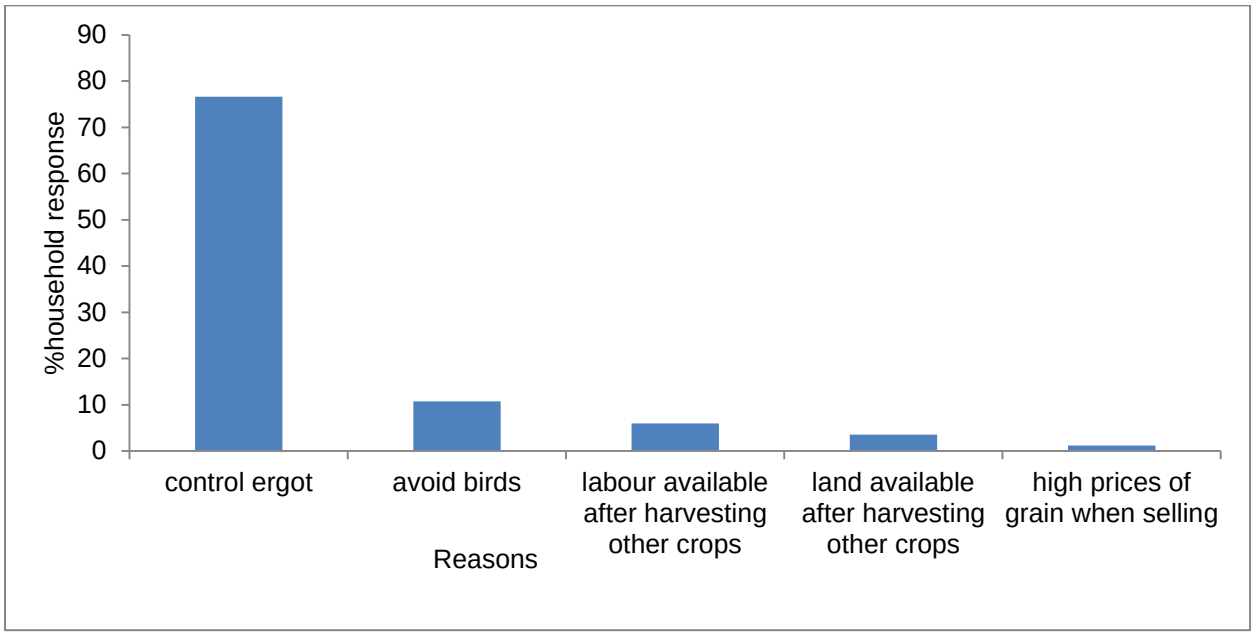


Fig 5.3: Reasons for planting in second season

5.3 Pearl millet crop production systems

Crop production systems are important in determining the type of technology adopted and rate of nutrient uptake and replenishment in the soils (Namara et al., 2005). Latha and Singh (2003) observed that nitrogen and phosphorous uptake was higher in the sole sorghum than sorghum-pearl millet cropping systems. In addition yield advantage and improvement in soil nutrients have been reported in the pearl millet-legume cropping system where cluster, cowpea and mung beans were components (Sarr et al., 2008; Singh and Joshi, 1994). Other beneficial legumes include; pigeon pea, green gram, soybean, ground nuts (Paraniappan and Sirivaman, 1996). Unfortunately such cropping systems have not been tested in Uganda for reference.

Two pearl millet crop production systems were identified in the northern and eastern regions of Uganda. Almost all households (90.81%) produced pearl millet as a sole crop in both regions (Fig 5.4). The sole cropping system was dominant in all the four districts surveyed but more in Kumi and Katakwi. In addition some mixed cropping was reported in the northern region especially Kitgum district where pearl millet was mixed with sorghum and finger millet (Fig 5.5).

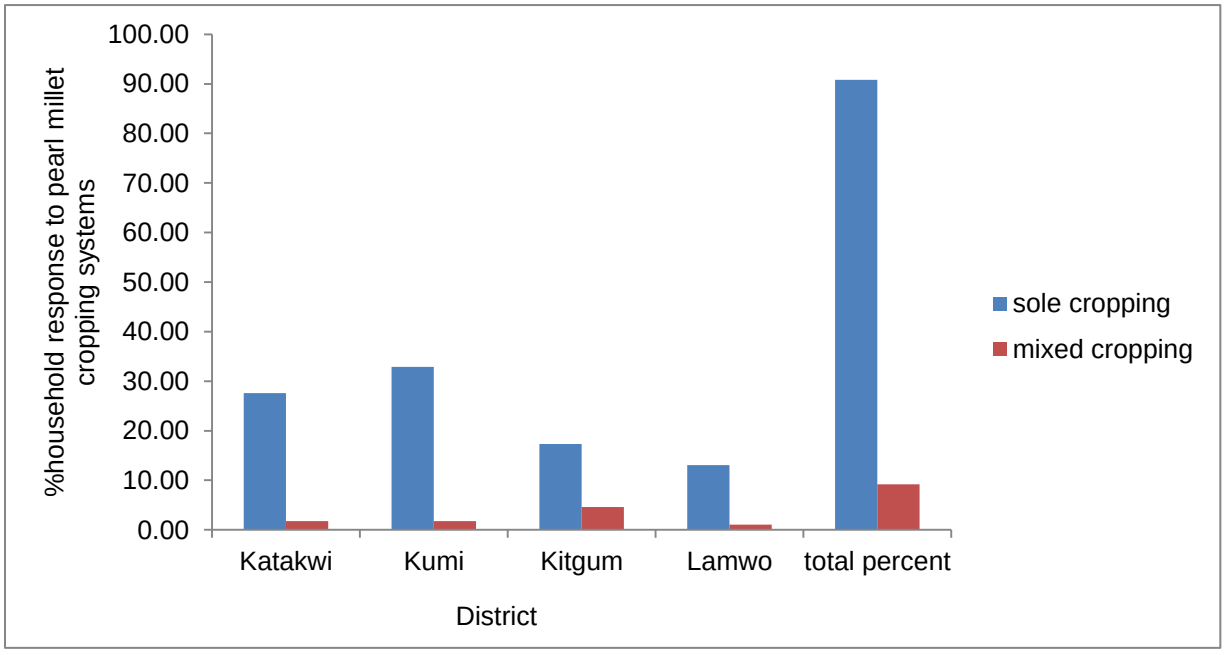


Fig 5.4: Household response about cropping systems

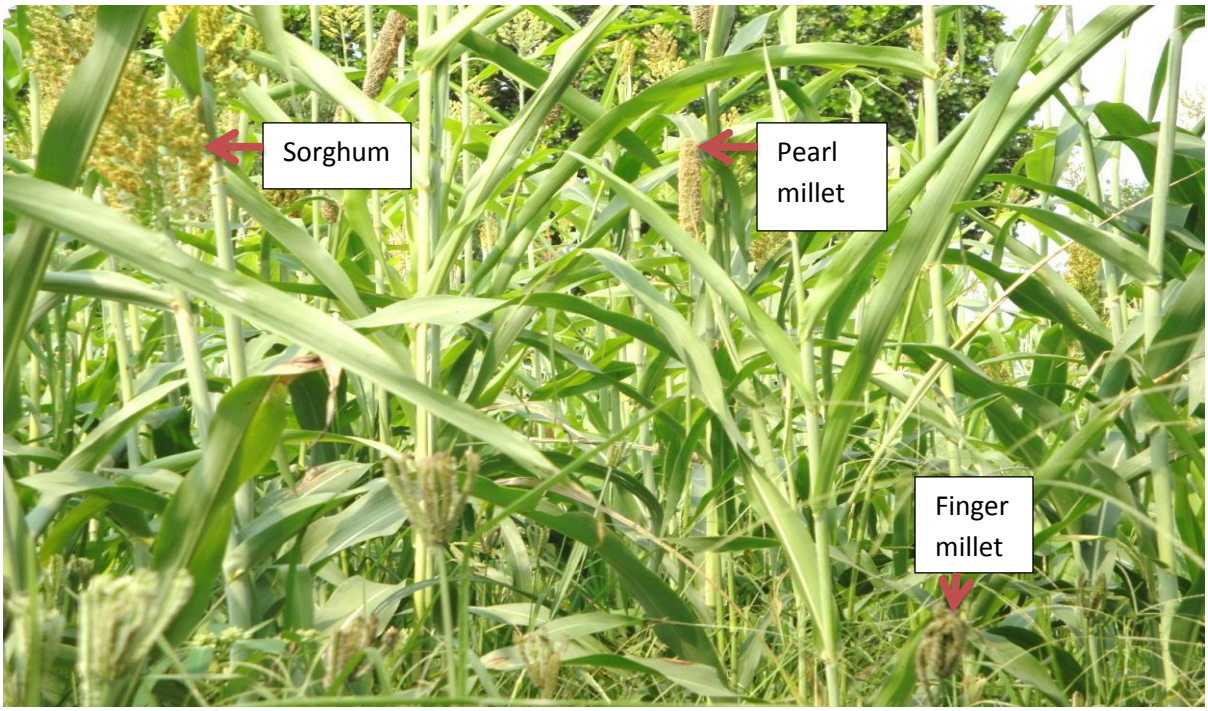


Fig 5.5: Mixed cropping system of pearl millet, sorghum and finger millet

5.4 Pearl millet planting methods

Studies have shown that sowing/planting methods affect the pearl millet yield-related traits (Bakht et al., 2007). De Gautam and Kaushir (1988) reported that row planting increased pearl millet grain yields under rain-fed conditions. In this study broadcasting and row planting were the planting methods reported by farmers (Fig 5.6). Broadcasting was the common method of planting in both regions (eastern and northern) in Uganda. The same trend was observed in districts where majority of the farmers in the northern and the eastern region sowed their pearl millet seed by broadcasting. However, broad casting results in uneven plant-to-plant spacing which translates into low yield due to reduced number and size of panicles (Soman et al., 1987). In addition, it was observed that broadcasting led to seed wastage since farmers planted 20Kgha^{-1} instead of the recommended 2-5Kgha^{-1} (Reddy Amarender , 2013). Thus farmers should adopt planting methods like row planting either on ridges or in furrows to minimise seed wastage and to obtain higher yield (Murty et al., 2007).

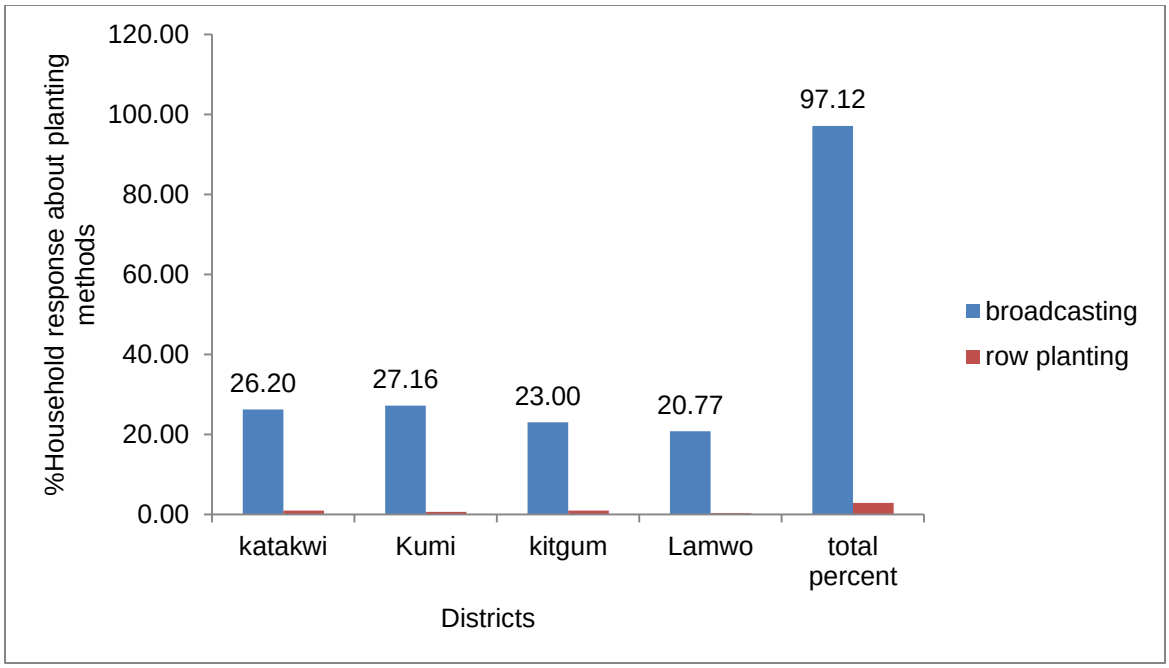


Fig 5.6: Pearl millet planting methods

5.5 Productivity and seed rates

Generally the farmers planted at a seed rate of 20.09Kgha^{-1} and harvested 658.49Kgha^{-1} under conditions of minimum inputs. The conditions included; strictly being rain-fed, late planting and weeding once. In addition, the crop was affected by ergot, rust, birds and other constraints. However, the realised productivity was relatively high compared with 150-200Kgha^{-1} of grain harvested in other developing countries like Namibia (Matanyaire, 1996) or the 400-600Kgha^{-1} realised in the Sahelian region (Winkel et al., 1997). Despite the productivity being high in Afica, it is low compared with 932Kgha^{-1} of grain realised in India (Yadav et al., 2012) or the 2000-3870Kgha^{-1} realised under favourable conditions (Matanyaire 1996; Murty et al., 2007). Under full adoption of hybrids and improved crop management, coupled with favourable climatic conditions grain yield potential of up to 5000Kgha^{-1} has been registered in India. Thus, improved technologies like use of hybrids and row planting, at recommended seed rate of 2-5Kgha^{-1}, need to be introduced to farmers in Uganda to increase productivity.

Section 6 Desirable and undesirable pearl millet traits

6.1 Traits of pearl millet genotypes grown by farmers

Pearl millet has various desirable and undesirable traits which determine characteristics of the varieties breeders should develop (Ndjeunga and Nelson, 2000). High vigor, early flowering, early maturity, plant height, high number of productive tillers, long and thick panicle, bold/large grains, high grain and fodder yield are desirable visual-appeal traits (Khairwal et al., 2007a) selected for to develop improved varieties like OPVs (Rai et al. 1999). However, the few traits that have received much research focus in developing commercial varieties include high grain and stover yield, early maturity, resistance to downy mildew, blast, rust and lodging (Yadav et al., 2012). Despite being important, the research-focused traits may not necessarily be desired by the end-users.

The pearl millet farmers in this study listed, in order of preference, the common traits of the pearl millet genotypes currently grown; noting the desirable traits, undesirable traits, and traits to be improved or introduced. The genotypes grown by farmers were tall, early maturing, late maturing, stay green, high yielding, big grain size, highly tillering, with small grains and strong thick stems. Being tall was the most common trait reported by farmers followed by white/grey coloured grains (Table 6.1). Results in Table 6.1 further show that most of the traits were common in both the northern and eastern regions. However, late maturity, small grain size and stay green were mostly reported in the north. Except early maturity and high yield, the other traits are typical of local landrace genotypes (Uno, 2005).

When compared with the desirable traits, the common traits of the currently grown pearl millet genotypes were almost similar but differed in order of preference. Table 6.2 results show stay green, being tall, high tillering ability, high yielding, early maturity and ergot resistance respectively, as traits desired by the farmers. The stay green is indirectly a trait associated with drought tolerance present in some genotypes mostly grown by farmers in the eastern region. Ergot resistance and thick/compact panicles are desirable traits lacking in the genotypes grown by farmers while small grain size, thin/small stems and brown seed colour are among the traits in currently grown pearl millet which are not mentioned among the desirable traits; an indication that these traits may not be desirable. Small-size grains lead to low yield while small/thin stems increase susceptibility to lodging.

The desirable traits are similar with those preferred by farmers living in drought-prone areas in other developing countries but differ in order of preference. In West Africa (Omanya, 2004) and Namibia pearl millet farmers consider early maturity as the most desired trait followed by high grain yield while grain size and plant height are some of the other important traits (Matanyaire, 1996). However, in Uganda these desirable traits ranked fifth and fourth respectively while tillering ability ranked third. Omanya (2004) also reported that farmers preferred improved varieties with long (30-100cm) and compact panicles and high tillering ability in addition to good taste and adaptation to drought. In Eritrea, women ranked grain yield as the most important trait followed by downy mildew resistance and then early maturity while men ranked grain yield as the third most important trait after drought tolerance and downy mildew resistance (Roden et al., 2007). This implies that desirable traits were also gender-specific (Weltzien et al. (1995). Apart from grain quality traits and early maturity, most of the traits desired by farmers lead to high biomass production, a quality that most farmers in Africa desire because they use straw for house construction and fuel wood. This is observed in Namibia where farmers have adopted new varieties like Okashana1 but still widely grew the local tall genotypes with high tillering ability (Uno, 2005).

6.2 Undesirable traits of the cultivated pearl millet

Pearl millet farmers were asked to indicate the undesirable traits in the genotypes grown. The majority of the farmers reported ergot susceptibility as the most undesirable trait followed by varieties being short and susceptibility to rust respectively (Table 6.3). Low tillering ability, late maturity and sterile panicles also ranked high among the undesirable traits especially in the northern region.

Table 6.1: Traits of pearl millet genotypes grown by farmers

Districts	Tall	White/grey grain	Early maturity	Late maturing	Stay green	High yielding	Big grains	High tillering	Small grains	Thin/small stems	Strong/large stems	Brown grains
Katakwi	5.63	2.11	2.82	0.00	4.93	1.06	0.35	1.06	0.00	0.00	0.00	0.35
Kumi	5.99	2.46	3.17	0.35	3.17	2.82	1.76	1.76	0.35	0.35	0.35	0.70
Kitgum	7.75	9.15	3.87	4.58	0.00	2.46	3.52	1.41	1.06	1.06	0.35	0.35
Lamwo	4.23	4.58	1.76	5.28	0.70	2.46	1.41	0.35	1.06	0.35	0.70	0.00
Total percent	23.59	18.31	11.62	10.21	8.80	8.80	7.04	4.58	2.46	1.76	1.41	1.41

Table 6.2: Desirable pearl millet traits

Districts	Stay green	Tall	High tillering	High yielding	Early maturity	Ergot resistant	Large/compact panicle	White/grey seeds or grains	Big/large seeds	Long panicle	Thick stems
Katakwi	5.52	5.52	3.45	2.41	3.79	1.38	1.72	0.69	0.34	0.34	0.00
Kumi	7.93	4.14	2.76	2.41	2.76	0.00	3.79	1.03	1.03	0.34	0.69
Kitgum	3.45	5.17	4.14	4.83	2.41	6.20	1.38	1.38	1.72	0.69	1.03
Lamwo	3.10	2.41	2.41	2.07	1.38	2.07	0.69	0.69	0.00	0.69	0.00
Total percentage	20.00	17.24	12.76	11.72	10.34	9.65	7.59	3.79	3.10	2.07	1.72

Table 6.3: Undesirable pearl millet characteristics

Districts	Susceptible to ergot	Short varieties	Susceptible to rust	Low yielding	Low tillering	Late maturing	Sterile panicles	Loose panicles	Difficult to thresh	Small panicles	No market demand	Small grains
Katakwi	5.05	4.04	3.03	3.03	2.02	2.02	2.02	0.00	0.00	0.00	0.00	0.00
Kumi	2.02	6.06	7.07	1.01	3.03	1.01	1.01	0.00	1.01	0.00	1.01	0.00
Kitgum	11.11	3.03	5.05	4.04	4.04	2.02	1.01	1.01	1.01	1.01	1.01	1.01
Lamwo	4.04	5.05	1.01	4.04	0.00	2.02	0.00	2.02	0.00	1.01	0.00	1.01
Total percentage	22.22	18.18	16.16	12.12	9.09	7.07	4.04	3.03	2.02	2.02	2.02	2.02

6.3 Attributes to be introduced or improved and related information for pearl millet improvement

After identifying the desirable and undesirable traits, farmers indicated which attributes they wanted introduced or improved upon. The highest ranked attribute was introduction of ergot resistant varieties, followed by introducing appropriate pesticides, high yielding varieties, providing stable market for grain and introducing large white grain genotypes (Fig 6.1). Training in fertliser/manure use, early maturity and developing non-itchy varieties were other attributes needed. Ergot susceptibility is one trait that farmers talked about mostly as the main determining factor leading to late planting in the second season and predisposing the crop to drought. Thus developing ergot resistant varieties may change the cropping pattern to growing the pearl millet at the on-set of rains. However, this may be achieved if other factors listed in Table 6.4 were considered. Table 6.4 results show that proper agronomic practices (row planting, proper spacing, right planting time), proper intercropping systems, proper storage techniques and market availability as other desirable attributes that may lead to increased pearl millet production and productivity.

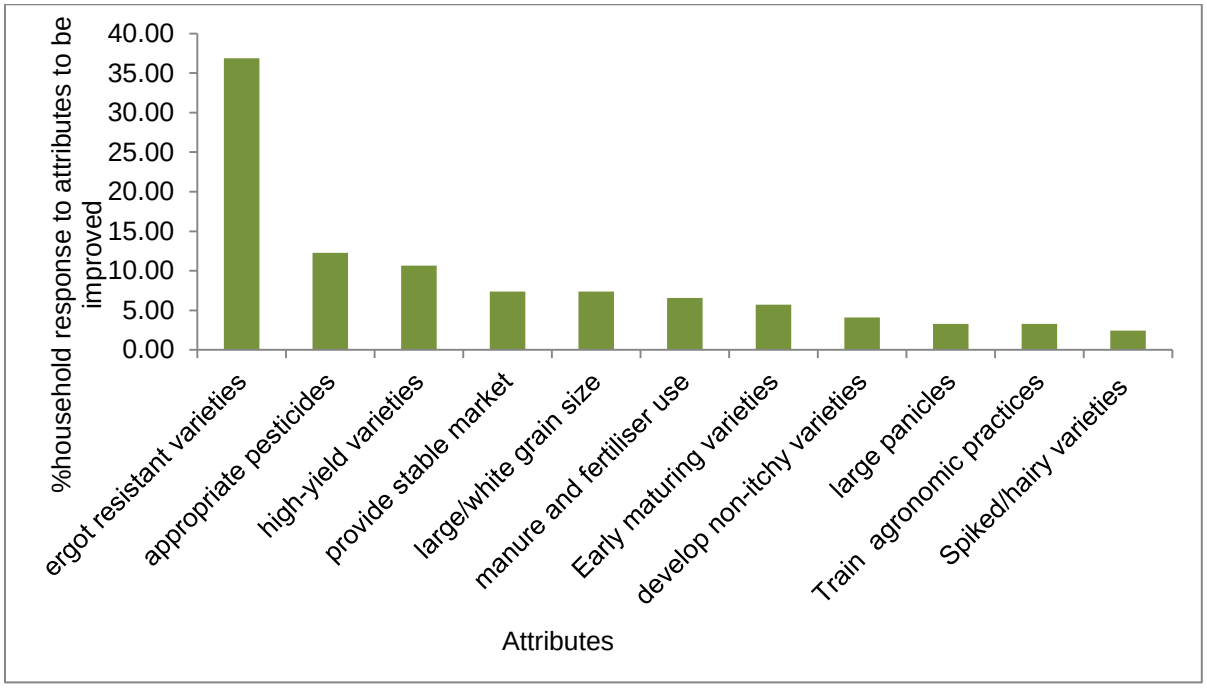


Fig 6.1: Pearl millet attributes to be introduced or improved

Table 6.4: Supplementary information important for pearl millet improvement

Any other Information	Percentage
Introduce modern techniques in pearl millet production (e.g. row planting)	51.13
Search for market for pearl millet	32.31
Advise farmers on right planting time	4.51
Develop/introduce different varieties so that farmers can have a choice	4.51
Train farmers in appropriate crops to intercrop with pearl millet	5.27
Information on appropriate preservatives for storage	2.25

Section 7 Factors of production in the pearl millet cropping system

The estimation of the contribution of factors of production is important when determining the value of agricultural production and thus deciding on the pricing of any agricultural output. Inputs like seed and family labour greatly determine what decisions to make in agricultural production (Emeades, 2005). In this study, factors of production focused on included; land, seed, fertiliser use, chemical use and labour incurred. The outputs considered were grain and animal production.

7.1 Crop production inputs

7.1.1.1 Land access, ownership and perception about soil fertility

Land is one of the main factors of agricultural production (Echevarria, 1998) on which over 60% of the active populations in rural areas in sub-Saharan Africa depend for livelihood (ECA, 2003). Ease with which land is accessed is then important to ensure sustainable production. Farmers' perception about ease to access land was sought where majority of the respondents indicated that it was easy to access land through hiring (49.64%) while still a large number (48.20%) negatively responded and a small number of the respondents indicated that it was not possible to access land through hiring (2.16%) (Table 7.1). Variation existed at regional level where majority in eastern reported that it was relatively easy to access land through hiring (35.98%). Contrary, in the northern region it was observed that accessing land for agriculture was more difficult (29.50%) compared with the eastern region (Table 7.1).

Table 7.1: Ease to hire land for agricultural production

Districts	Easy	Difficult	Not possible
Katakwi	17.99	9.35	0.72
Kumi	17.99	9.35	1.44
Kitgum	8.63	18.71	0.00
Lamwo	5.04	10.79	0.00
Total percent	49.64	48.20	2.16

Majority of the pearl millet farmers interviewed in northern and eastern Uganda (82.56%) owned the land for agricultural production (Table 7.2). Some farmers (13.08%) rented land for cultivation while a few (4.36%) just borrowed. The same pattern applies at district level where the pearl millet farmers owned the land for agricultural production while renting and borrowing were not popular forms of land acquisition. This is further supported by many farmers reporting that it was difficult to hire or rent land for agriculture.

In Uganda land was once considered the most fertile (Chenery, 1960) but of recent the rate of soil depletion is among the highest in sub-Saharan Africa (Stoorvogel and Smaling, 1990); being highest in highland areas (Zake and Magunda 1999) and resulting in low productivity. On the contrary, majority of the pearl millet farmers in both regions had a perception that their soil was fertile (46.09%) followed by others claiming it was very fertile (25.98%) (Table 7.2). At regional level, majority of the farmers in eastern Uganda reported that their soil was very fertile (41.40%) followed by many rating it as being fertile (38.14%) while the rest indicated that their soil was averagely fertile and the rest rated it as poor. In northern Uganda most pearl millet farmers rated their soil as being fertile (55.70%) while others rated it as having average fertility (27.52%). Basing on the farmers' perception about soil fertility, deduction can be made that the soils in the eastern and northern Uganda are still productive and this may limit farmers' ability to adopt use of fertility management technologies. However, the low average productivity of only 658.49Kgha^{-1} shows that farmers may not have a right perception about their soil fertility.

Table 7.2: Forms of land ownership and soil fertility perception

District	Forms of land ownership			Soil fertility of parcel			
	Owned	Rented	Borrowed	Poor	Average	Good	Very good
Katakwi	22.56	3.08	0.26	1.10	5.77	9.62	11.26
Kumi	30.26	6.41	1.54	3.02	2.20	12.91	13.19
Kitgum	16.67	3.08	2.05	3.02	8.24	9.89	1.65
Lamwo	13.08	0.51	0.51	1.10	3.02	12.91	1.10
Total percent	82.56	13.08	4.36	8.24	19.23	45.33	27.20

7.1.1.2 Size of land (acres) parcels owned or operated and distance to the land parcels

Farm size is another important factor in estimation of agricultural profitability (Cornia, 1985) and technology adoption. Farmers with larger farm sizes are more likely to adopt advanced farming systems such as irrigation (Gabre-Madhin and Haggblade, 2001). Cornia's (1985) analysis of developing countries, Uganda inclusive, showed that a decline in yield with increase in farm size existed due to decreasing returns to scale. However, smaller farms cannot adopt technologies that require high capital investment and thus cannot easily attract credit as a source of capital for investment (Abara and Singh, 1993). Cornia (1985) further noted that the increase in returns from small farms was due to higher factor inputs and surplus labour which leads to more intensive use of the small farm land. For Uganda's case, this is supported by Nkonya et al. (2002) and Pender et al. (2004) findings where households with less land were more productive

and earned more crop income per unit area of land than those with more land available for cultivation.

Findings from this study show that land area operated or owned by the pearl millet farmers varied depending on the region. Results in Table 7.3 show that majority of the farmers in both regions had up to one acre of land (61.56%) followed by those having between 1.00-3.00 acres (21.61%), then those with 3.00-10.00 acres (13.82%) and a few with more than 10.00ac of land for agricultural use. The majority of farmers having smaller farm sizes of up to 3.00ac (Bertz, 2009) may be an indicator of high population pressure in Uganda (Nkonya et al., 2002) and this compares well with pearl millet farmers in other developing countries like Nigeria (Idrisa et al., 2012). Results in Table 7.3 show that majority of the pearl millet farmers in the north (62.33%) had more than 1.00ac of land compared with 23.7% in the east with the same amount of land. The variation in land availability has been closely linked with high population pressure and improved housing conditions (Pender et al., 2002). This compares with findings of McDonagh and Bahiigwa (2002) where over 60% of the farmers in densely populated areas in eastern Uganda owned up to one acre of land. Results of this study further show that there may be more land available for agricultural use in the northern region than in the eastern region. The available land may support intensive rather than extensive agriculture. Thus, input-intensive or land-saving technologies may be the best alternatives to increase productivity (Yaron et al., 1992). This implies that technologies that increase productivity per unit area, such as use of fertilisers, should be promoted not those that encourage cultivation of more land; as is the case in Uganda (Pender et al., 2002). This further shows that to get positive returns the marginalised small scale farmers with such small pieces of land have to strictly own the land and use family labour to get positive returns (Singh and Joshi, 2008).

Distances to cultivated land is another measure of ease to access land (Table 7.3). Farmers estimated the distance to the land parcels operated for pearl millet production. In terms of distance to the cultivated land, most pearl millet farmers (67.89%) had land within 1.0Km from their homes followed by those having land within 1.00-4.00Km and the rest (12.79%) had land located more than 4.00Km (Table 7.3). Variation was observed at regional level where the majority of farmers (53.53%) in the east had their land for production located within 1.0Km compared with 14.36% in the north who had their land within the same distance. Thus, more farmers in the north spent more time traveling to their land for cultivation than those in the eastern region.

Table 7.3: Land availability and distance from home to the land

District	Area (ac) operated/owned by household				Distance (km) from home to parcel		
	0-1	1-3	3-10	10>	0-1	1-4	4>
Katakwi	15.83	6.53	1.76	1.26	21.15	3.66	1.56
Kumi	31.91	4.52	0.75	0.00	32.38	5.22	1.04
Kitgum	8.54	5.78	5.78	0.50	10.44	5.22	6.01
Lamwo	5.28	4.77	5.53	1.26	3.92	5.22	4.18
Total percent	61.56	21.61	13.82	3.02	67.89	19.32	12.79

7.1.2 Area planted, cost of seed and sources of seed

7.1.2.1 Area planted and cost of seed

Land and seed are important inputs in the pearl millet cropping system. During the survey, data about acreage planted with pearl millet in the last two years and the amount of seed that farmers used and its cost were collected. Frequency results show that majority of the households planted between 0.25ac and 1.00ac of land to pearl millet in both the eastern and northern region. However, more households planted 0.25-1.00ac in eastern (55.44%) when compared with 32.29% of the households in northern region (Fig 7.1). More households grew pearl millet on more than one acre in Lamwo district than any other district; implying that more pearl millet production may be registered in that district. It was generally observed that most households planted 1-5Kg of pearl millet grain in 0.25-1.00ac. The 1-5Kg amount of seed that farmers planted 0.25-1.00ac was higher than the 0.364-0.91Kgac^{-1} recommended by researchers as being optimum; an indicator of wastage of planting materials.

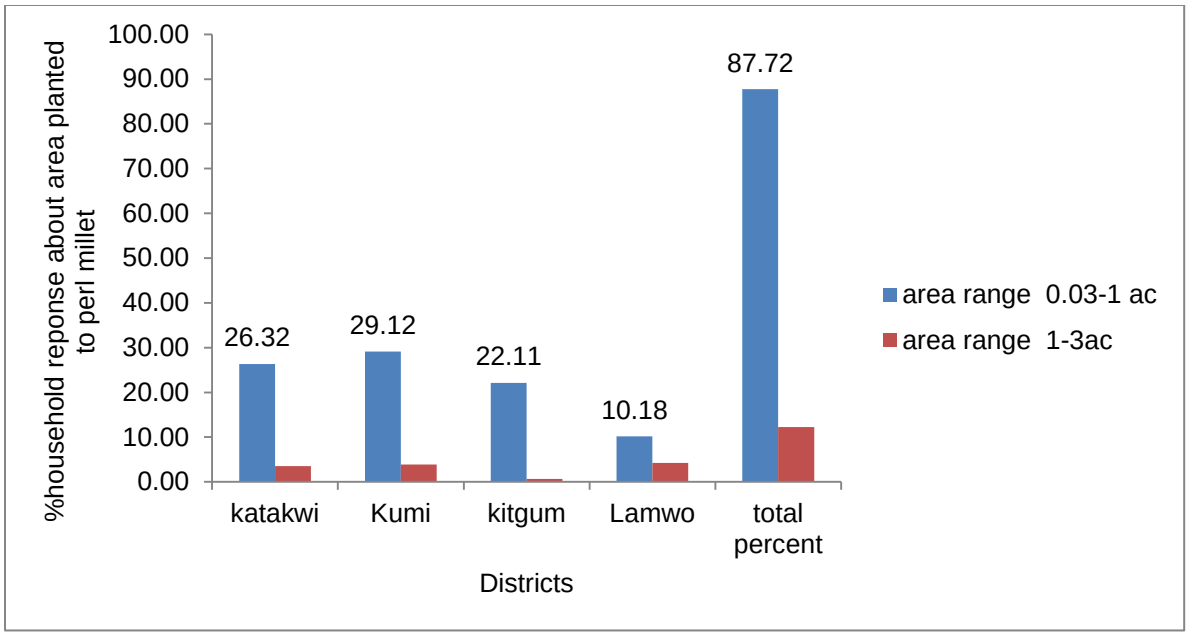


Fig 7.1: Response about area planted with pearl millet

7.1.2.2 Pearl millet sources of seed

The pearl millet seed system is not well developed in Uganda resulting in farmers planting food grain as seed. They keep part of the food grain, a practice done by many pearl millet farmers in many developing countries (Brocke et al., 2003). This is done shortly after winnowing and, like in India (Christinck, 2000), this is done by women. In India farmers categorise pearl millet seed into local and modern varieties (Tripp and Pal, 1998). However, in Uganda farmers did not categorise seed but they based on phenotypic characterisation especially high tillering ability and plant height (tall genotypes preferred).

Majority of the farmers (48.3%) bought seed grain followed by own farm-saved and a few borrowing and getting donations (Table 7.4). The own farm-saved seed grain is normally kept in plastic containers where preservatives like ash and red pepper are added (Fig 7.2). Borrowing and getting donated seed grain were mainly observed in the northern region especially in Kitgum district whereas in Katakwi and Kumi districts, in the east, the predominant modes of accessing pearl millet planting grain was through buying and using own farm-saved grain.

Table 7.4: Sources of pearl millet seed

Districts	Bought	Own farm saved	Borrowed	Donation
Katakwi	15.22	14.02	0.11	0.00
Kumi	16.10	15.99	0.11	0.00
Kitgum	11.50	9.42	1.75	1.97
Lamwo	5.48	7.67	0.44	0.22
Total percent	48.30	47.10	2.41	2.19



Fig 7.2: Storage of pearl millet grain for seed

7.1.2.3 Pearl millet units of measurement for seed grain and produce grain

The units of measurement are important in agricultural transactions because they are a basis to establish productivity and profitability. In the pearl millet crop production system, units for purchase of seed grain, produced grain and sold grain were determined. The frequency with which a unit appears was used to measure its relative importance in a particular district. Common units of measurement were; kilograms, cups, basins, bags/sacks, tins and plastic nomi containers. For seed grain the most important unit of measurement was the kilogram, followed by the ½litre cup and the 2Kg nomi container. In the eastern region the kilogram was the common unit followed by the nomi container whereas the cup was the mostly used in northern Uganda followed by the kilogram unit (Table 7.5).

Table 7.5: Units of measurement for seed grain

Districts	Kg	Cup	Nomi container	Basin	Tins
Katakwi	26.43	1.43	0.71	0.00	0.00
Kumi	27.14	0.00	5.71	0.71	0.00
Kitgum	7.50	13.21	0.71	0.71	1.07
Lamwo	7.14	7.50	0.00	0.00	0.00
Total percent	68.21	22.14	7.14	1.43	1.07

The common unit of measurement for grain produce was the 100Kg bag/sack followed by the 18-20litre basin and the kilogram respectively (Table 7.6). Cups and the 2Kg nomi containers were not commonly used to measure produce grain like it is for the grain seed. The cup, nomi, bag and basin are not standard units and thus if the farmer does not sell the produce the amount produced in a standard unit like kilogram will not be known; thus the farmer cannot accurately establish profitability of the harvest. However, most farmers used the kilogram unit to sell the produce; which minimizes the loss due to use of non-standardised units of measurement. The kilogram and bags are common units of measurement in eastern Uganda than in northern Uganda (Table 7.6); indicating that selling maybe done more in eastern than in northern region.

Table 7.6: Units of measurement of harvested and sold pearl millet grain

Districts	Units of harvest measurement					Units of measurement of pearl millet sold			
	Bags/sacks	Basin	Kg	Cups	Nomi tin	Kg	Bags/sacks	Nomi	Basin
Katakwi	21.90	4.38	0.73	0.73	0.73	20.95	3.38	0.00	0.00
Kumi	31.39	2.19	0.00	0.00	2.19	47.97	8.11	2.03	0.00
Kitgum	3.65	10.22	4.38	3.65	0.00	8.11	0.00	0.00	1.35
Lamwo	9.85	1.09	2.92	0.00	0.00	6.76	1.35	0.00	0.00
Total percent	66.79	17.88	8.03	4.38	2.92	83.78	12.84	2.03	1.35

7.1.3.1 Labour hours, sources and total cost for labour

Generally children contributed less (16.36%) to total on-farm labour followed by men (39.84%) while women contributed (43.80%) the largest amount of total labour hours for farming activities in the pearl millet crop production system (Fig 7.3). This is in agreement with Krona (2013) that women contributed most of the labour on small farms. It also conforms to FAO's reports indicating that women make crucial contributions to agriculture and central in households' food security and nutrition (FAO, 2013). Results also show that men provided more labour hours than women and children in land preparation and planting and second to children in bird scaring (Fig 7.3). The graph also shows that women dominated labour provision than men and children in weeding, harvesting and threshing as also reported by Rubin and Manfre (2010). In Fig 7.4 it is

shown that harvesting accounted for the highest percentage of women's total labour hours followed by threshing, weeding and land preparation respectively. In terms of labour contribution, women were mostly involved in more labour-intensive activities relative to men and children. Details of labour hour segregation by district are in Table 7.7.

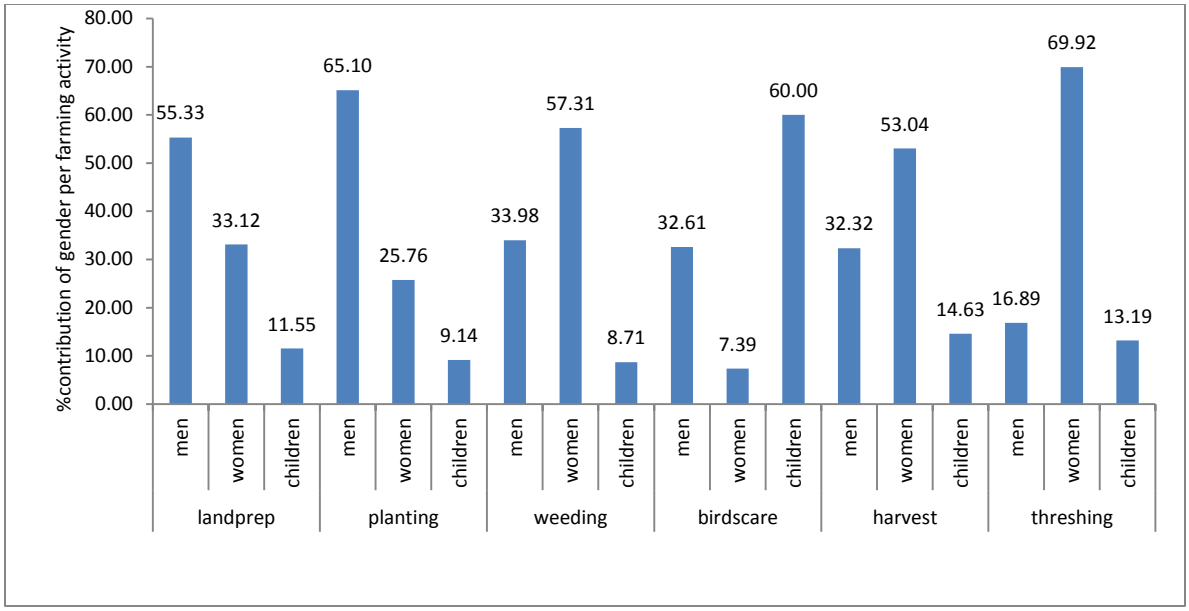


Fig 7.3: Farming activity by gender

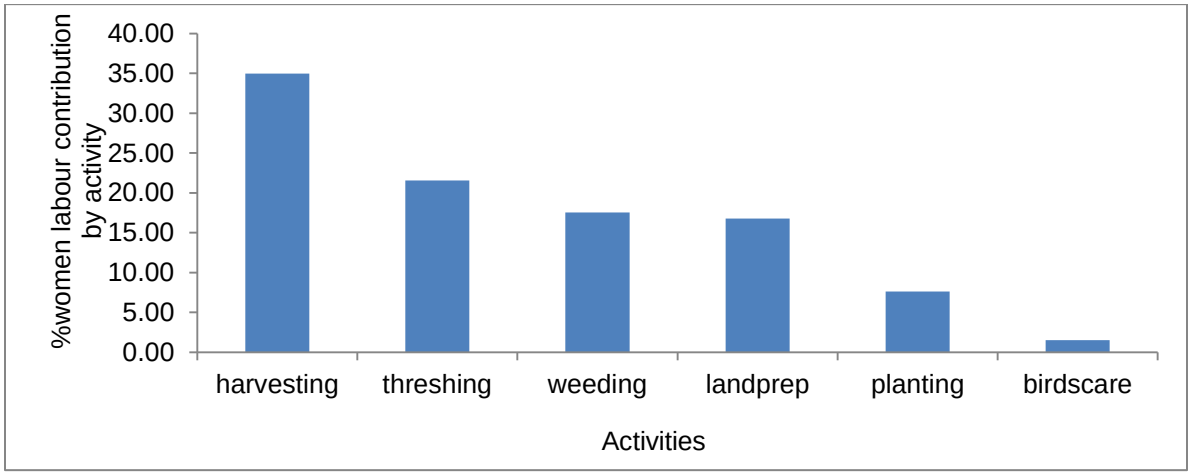


Fig 7.4: Farming activities done by women

7.1.3.2 Sources of labour for pearl millet activities

Generally the pearl millet farming activities were done using family labour when compared with hired labour. Results show that 76.80% of the farm labour was provided by household members while hired labour accounted for only 23.20%. Land preparation, harvesting, threshing and

weeding took more than 60% of the family labour (Fig 7.5); indicating that these are the labour-intensive farm activities done by households. This can be confirmed by the same activities being supplemented by hired labour.

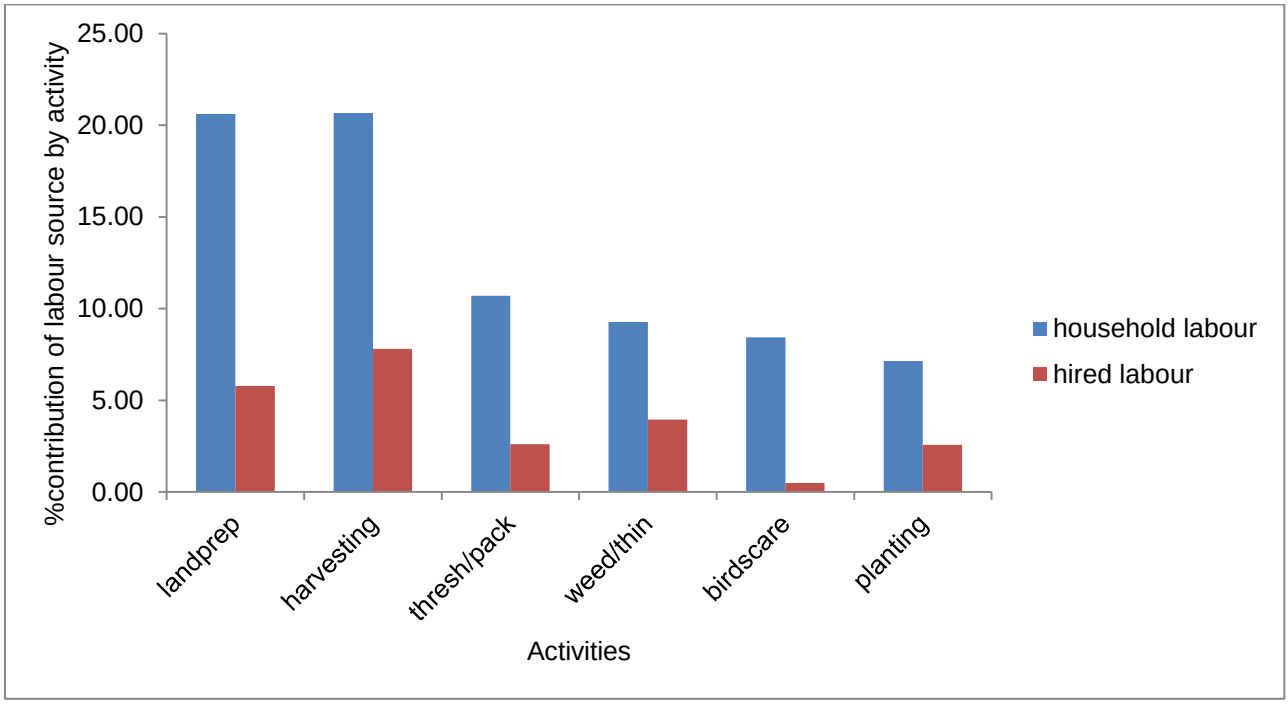


Fig 7.5: Farming activities by source of labour

Table 7.7: Gender contribution of labour hours and total labour cost for selected field activities

District	Household labour segregation by gender							
	Men	Women	Children	Total cost	Men	Women	Children	Total cost
	Land preparation				Bird scaring			
Katakwi	459.00	141.17	97.17	557821.33	45.50	36.00	77.00	147000.00
Kumi	554.17	241.17	106.83	820845.33	131.50	0.00	96.50	362500.00
Kitgum	524.67	482.83	160.67	632612.33	48.00	0.00	647.00	222500.00
Lamwo	317.83	245.50	22.83	694000.00	221.00	65.00	0.00	130000.00
Eastern	1013.17	382.33	204.00	1378666.70	177.00	36.00	173.50	509500.00
Northern	842.50	728.33	183.50	1326612.30	269.00	65.00	647.00	352500.00
Grand total	1855.67	1110.67	387.50	2705279.00	446.00	101.00	820.50	862000.00
	Planting				Harvesting			
Katakwi	317.50	56.80	54.65	303750.00	440.00	483.00	213.00	875500.00
Kumi	395.58	93.00	2.00	329250.00	495.50	797.50	145.50	1269000.00
Kitgum	364.33	282.25	122.00	461000.00	277.00	549.00	179.00	542750.00
Lamwo	194.92	71.50	0.00	199000.00	198.00	485.00	101.00	524000.00
East	713.08	149.80	56.65	633000.00	935.50	1280.50	358.50	2144500.00
North	559.25	353.75	122.00	660000.00	475.00	1034.00	280.00	1066750.00
Grand total	1272.33	503.55	178.65	1293000.00	1410.50	2314.50	638.50	3211250.00
	Thinning and weeding				Threshing and packing			
Katakwi	237.19	277.56	116.00	480750.00	94.00	294.00	78.50	375000.00
Kumi	218.63	399.75	27.56	525875.00	80.50	451.00	25.00	681750.00
Kitgum	92.88	243.5	28.75	281312.50	17.50	373.25	76.50	348250.00
Lamwo	139.75	240.25	4.13	188812.50	152.50	307.50	89.00	312650.00
Eastern	455.81	677.31	143.56	1006625.00	174.50	745.00	103.50	1056750.00
Northern	232.63	483.75	32.88	470125.00	170.00	680.75	165.50	660900.00
Grand total	688.44	1161.06	176.44	1476750.00	344.50	1425.75	269.00	1717650.00

7.1.4 Access to agricultural equipment

Equipment is important in hastening agricultural operations. Farmers were asked about the types of equipment they used in the pearl millet fields. It can be deduced from results in Table 7.8 that the pearl millet farmers used simple farm tools; a characteristic of subsistence farming. In addition, most of the equipment was accessed through purchase implying that it was owned by the farmers. The hand hoe was the only tool that farmers accessed in more than one unit. The bicycle and motor cycle were used for transport although the latter was mainly accessed through hiring. The ox-plough is one of the basic farm equipment that hastens farm operations during land preparation and weeding. Majority (59.29%) of the households interviewed did not have access to an ox-plough when compared with 40.71% who had access; yet the technology of using ox-ploughs is greatly adopted in the northern and eastern regions of Uganda. Some

farmers accessed the ox-plough services through hiring (34.38%) and a few through borrowing (9.38%) (Fig 7.6). By many farmers hiring implies that the ox-plough is an important farm tool for farm operations which is also reflected in purchasing (56.25%) being the main form of access to the equipment (Fig 7.6). The cost of hiring per day was about twenty thousand shillings (USD 8.00) on average and the majority (76.32%) hired the ox-plough for about 1-2 days. Hiring the ox-plough was equally important in all the districts unlike borrowing which was mainly reported in the eastern region; another indicator that the ox-plough is a critically important tool for farm operations.

Table 7.8: Percentage of households owning farm equipment and forms of access

Equipment accessed	Pieces accessed by majority	percentage form of access and ownership				
		Purchased	Hired	Borrowed	Donation	Households owning
Hand Hoe	4	76.82	0.00	11.92	11.26	95.71
Panga	1	79.44	2.80	6.54	11.21	70.00
Bicycle	1	84.00	10.00	3.00	3.00	62.14
Axes	1	70.65	3.26	19.57	6.52	52.86
Ox-plough	1	57.45	35.11	7.45	0.00	40.71
Sickle	1	75.00	1.92	19.23	3.85	29.29
Storage granary	1	27.78	5.56	0.00	66.67	24.29
Spades	1	72.50	5.00	17.50	5.00	22.86
Spray pump	1	53.57	35.71	10.71	0.00	12.86
Wheel burrows	1	41.94	25.81	25.81	6.45	10.71
Motorcycle	1	26.67	73.33	0.00	0.00	8.57

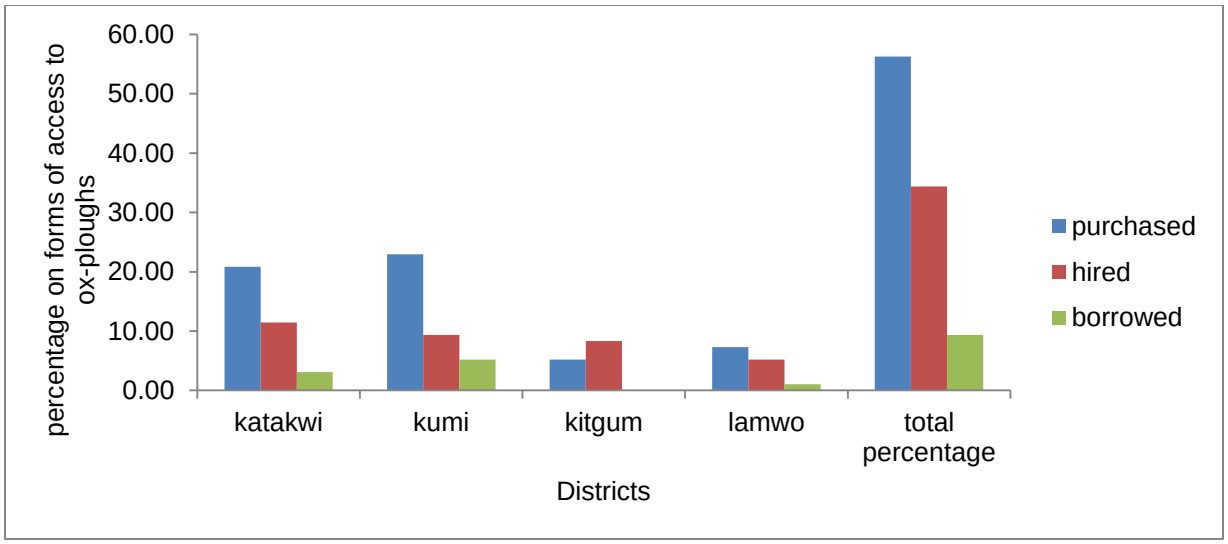


Fig 7.6: Forms of access to ox-plough

7.1.5 Expenses on selected inputs

Fertiliser application (organic and inorgaic) increases pearl millet productivity (Bationo et al., 1993). Bationo and Ntare (2000) reported a significant increase in pearl millet grain yield when nitrogen was applied to soil relative to no application. Fertilizer application also led to increased plant population to obtain optimum yield under proper crop management (Maman et al., 2000). Uganda is among countries with the highest rates of soil fertility mining in sub-Saharan Africa (Wortmann and Kaizzi, 1998) where use of fertilisers should be one of the best options to increase productivity. Despite being important in increasing productivity, majority (91.43%) of the pearl millet farmers did not use any of such inputs like fertilisers, manure, or pesticides compared with only 8.57% who indicated having used at least one of the inputs. No farmer used artificial fertilisers or pesticides on pearl millet but the inputs were applied by a few farmers on other crops especially vegetables. The results concur with Pender et al. (2001b) reports that few farmers use fertilisers in Uganda and those who used fertilisers applied the lowest rates reported in sub-Saharan Africa.

7.2 Livestock production and sales

Livestock farming is an important food security sector in developing countries. In Uganda the sector contributes 5% to the National GDP and about 17% of the Uganda agricultural GDP resulting in supporting about 4.5 million people (UIA, 2009). It comprises of cattle, goat, sheep, poultry and pigs with cattle being the most important component.

In terms of percentage of households rearing livestock, it was observed that majority (87.86%) owned at least one type of livestock. Results in Table 7.9 show that 84.17% of the households interviewed reared poultry (chicken, turkeys, ducks and pigeons) and small ruminants (goats and sheep) followed by more than 50% rearing cattle. However, few households produced some milk. Inadequate milk production is the major constraint affecting commercialising the diary sub-sectors (DANIDA, 2010). The livestock units are very few with low outputs; indicating typical subsistence farming system.

Table 7.9: Types of livestock owned, percentage owning, number owned by majority and value of livestock and products

Livestock types and products	%households owning livestock type	%of total livestock units owned	#livestock units owned by majority	Total value (Ugx)
Poultry	84.17	23.03	30	13,617,988
Small ruminants	84.17	15.83	7	36,184,988
Cattle	51.08	9.35	2	178,369,994
Eggs	17.28	2.16	12	135,700
Pigs	5.76	2.16	1	1,710,000
Milk	2.88	0.72	10	16,000

In this study, it was observed that poultry were the common livestock kept in terms of number followed by goats and cattle (Fig 7.7) but pigs were sold most followed by turkeys, chicken and goats (Fig 7.8). The same observations were made at national level (MAAIF, 2011) and in other rural districts (Tabuti and Lye, 2009); indicating that those livestock types were important in rural communities. Except for cattle, similar observations were made in other African countries like Malawi (Simtowe et al., 2010). Chicken were the most dominant poultry accounting for 89.22% (Fig 7.9) while at national level it accounts for 90% of the poultry sub sector (DANIDA, 2010). The chicken and goats are among the small animals identified to alleviate poverty in many developing countries (Pica-Ciamarra et al., 2011) and thus could be promoted in Uganda since many farmers are familiar with the livestock types.

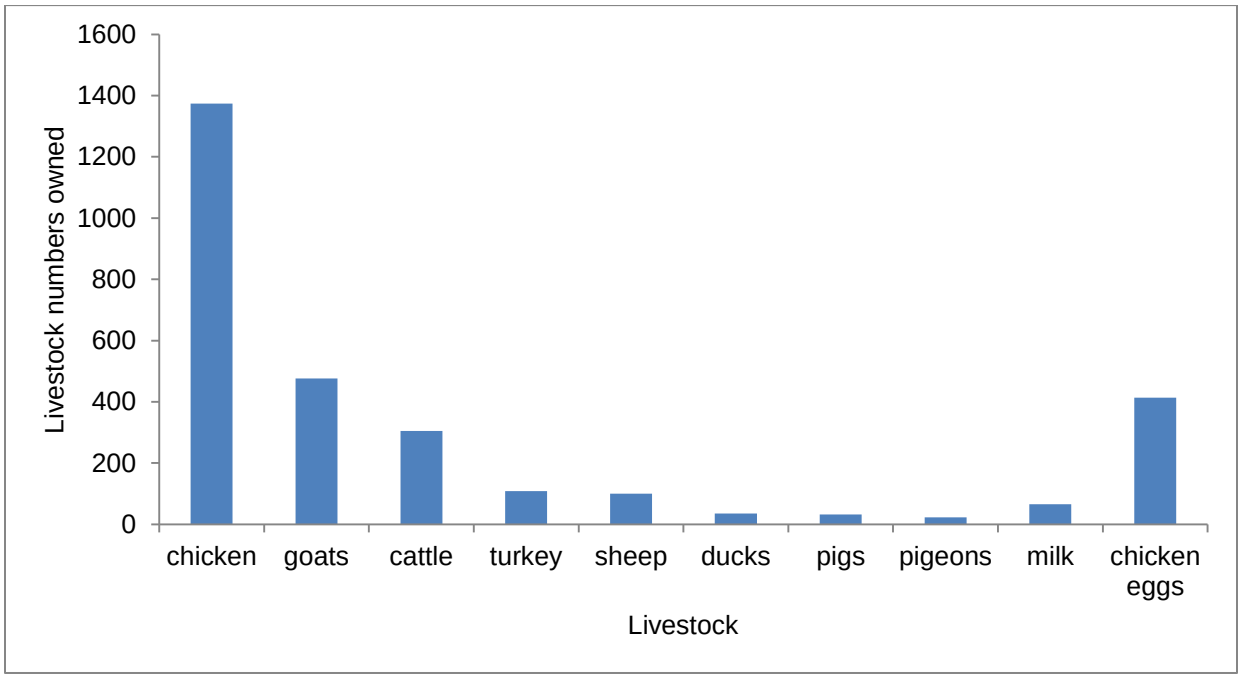


Fig 7.7: Types of livestock owned and products

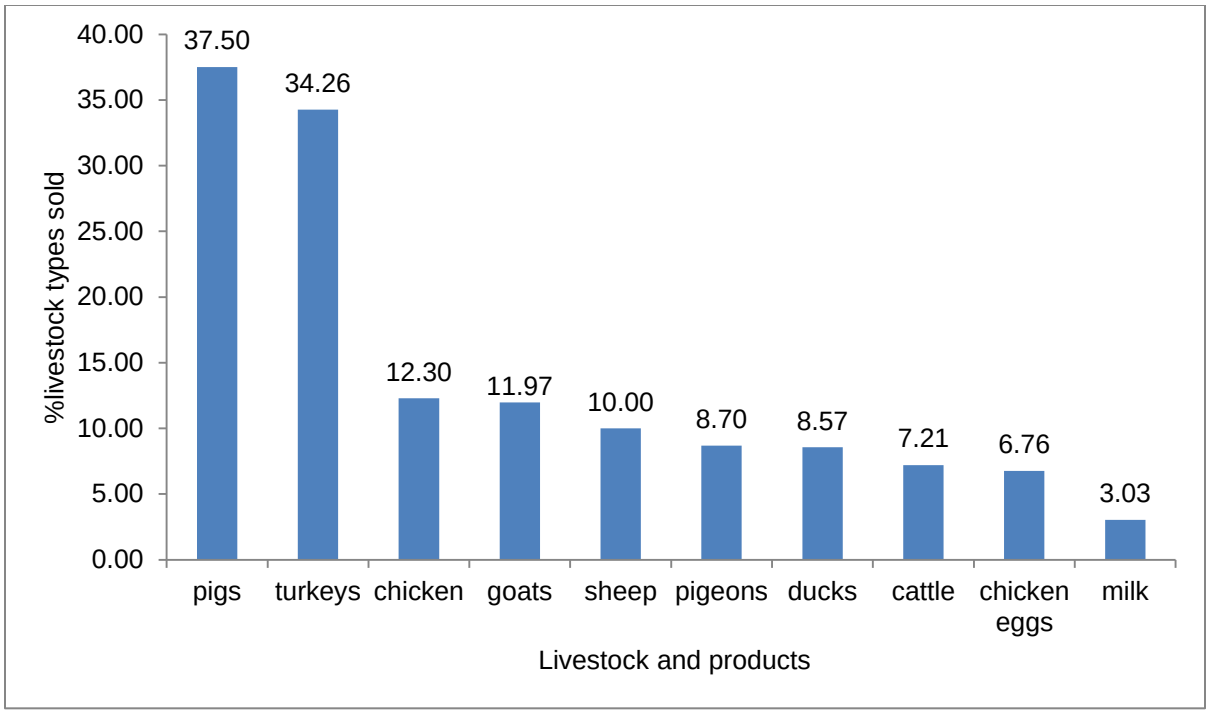


Fig 7.8: Livestock types and products sold

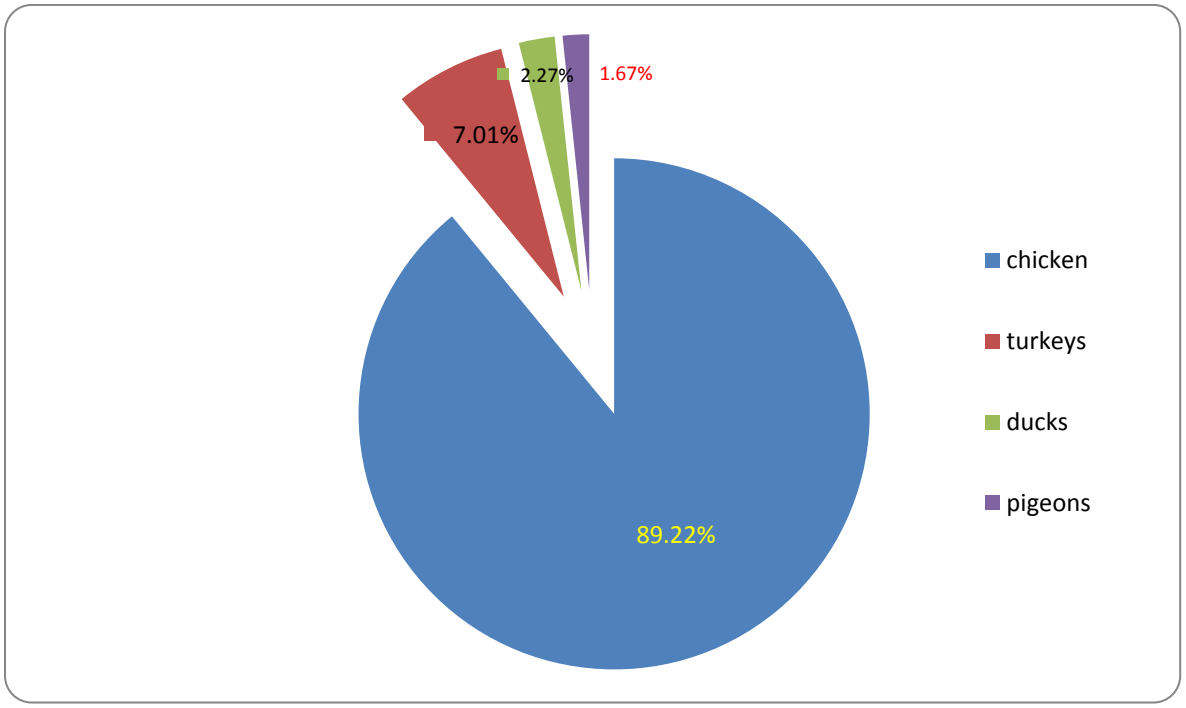


Fig 7.9: Percentage of poultry sub units

Section 8 Post-harvest handling of pearl millet and fate of grain

8.1 Harvesting, drying and threshing

Pearl millet farmers always waited for the crop to partially dry in the field before harvesting. During harvesting the panicles are cut using a knife and transported to the drying ground; which is usually at home. At the drying ground the millet is either put on drying mats (Fig 8.1) or dried on bare ground (Fig 8.2). Threshing is done by hitting the dry panicles followed by winnowing (Fig 8.3) to remove the chuff. Grain to be planted the following season may either be kept on the panicles or as threshed grain. However, many farmers did not keep grain for planting but bought whenever they wished to plant.



Fig 8.1: Drying of pearl millet on the mat



Fig 8.2: Drying of pearl millet on bare ground



Fig 8.3: Woman winnowing pearl millet after threshing

8.2 Storage of pearl millet

Farmers were asked about the storage facilities and the various forms pearl millet was stored. Majority (67.59%) indicated keeping the millet in their main houses (Table 8.1) in threshed (89.66%) form while a few kept unthreshed form or flour (Fig 8.4). Pearl millet kept in flour form losses taste shortly after grinding due to high level of anti-nutritional factors like fatty acids (Yadav et al., 2012). Thus it is better to keep pearl millet in grain form. Keeping pearl millet in the main house has implications of not easily adopting control measures like use of rat guards or poison because the health of family members may be at risk. The pounded and unthreshed forms were mainly stored in the northern region where it was kept both in the main house and kitchen. About use of preservatives in stored pearl millet, majority (93.71%) negatively responded while a few (6.29%) used some preservatives. Some of the preservatives used were smoking the grain, marathion and red pepper powder where majority still stored the produce for up to eight months.

Table 8.1: Storage facilities for various forms of pearl millet

	Facilities for pearl millet storage						
	Threshed form			Pounded form		Unthreshed form	
Districts	Main house	Granary	Kitchen	Main house	Kitchen	Main house	Kitchen
Katakwi	23.45	2.07	1.38	0.69	0.00	0.00	0.00
Kumi	18.62	1.38	7.59	0.00	0.00	0.00	0.00
Kitgum	18.62	2.07	0.69	4.14	0.69	1.38	0.69
Lamwo	6.90	6.21	0.69	0.00	0.00	0.69	2.07
Total percent	67.59	11.72	10.34	4.83	0.69	2.07	2.76

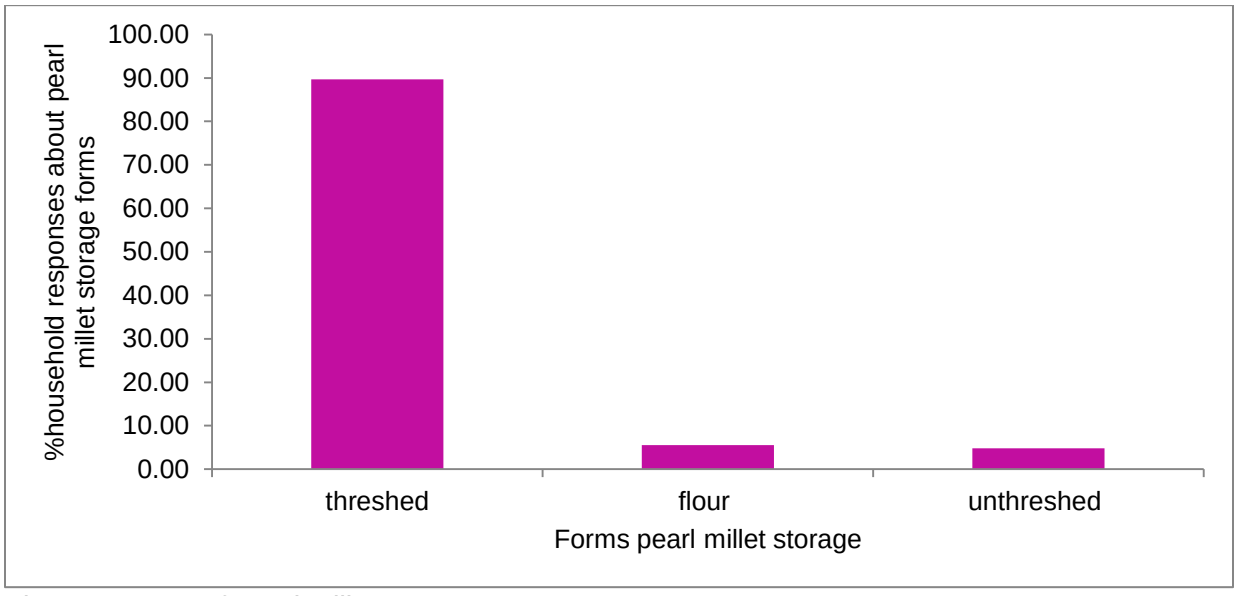


Fig 8.4: Forms of pearl millet storage

Further comparison of the fate of pearl millet grain harvested in Uganda relative to India shows a post-harvest grain loss of 10.6% incurred by farmers in Uganda (Fig 8.5). Fig 8.5 further shows that in Uganda more than 50% of the produced pearl millet grain is consumed by the producing households, but in India more than 50% is sold. In addition, less than 1% is kept for seed in India while in Uganda farmers store 1.42% of the produced grain for planting. The fate of harvested grain shows that post-harvest handling should be improved in Uganda to minimise losses and to increase marketability of pearl millet.

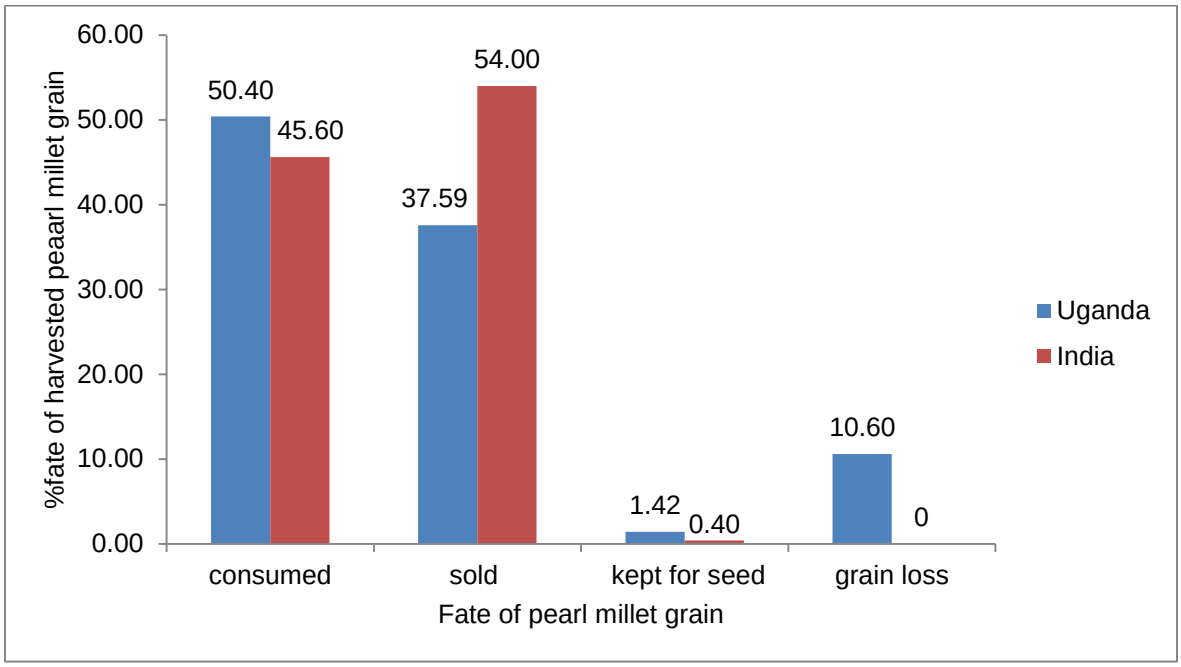


Fig 8.5: Fate of harvested pearl millet grain

Section 9 Pearl millet production constraints and coping strategies

9.1 Field constraints and control strategies

Rai et al. (1999) sites low soil fertility, erratic and inadequate rainfall, negligible use of external inputs, continued use of mostly unimproved cultivars as the most important constraints leading to low productivity of 500-700Kgha^{-1}. However, in Uganda results (Table 9.1) show that ergot (Fig 9.1) was the most important field production constraint (32.73%) reported by farmers followed by birds (Table 9.1). Results in Table 9.1 it show that weeds, rust (Fig 9.2), insect pests and animal destruction also ranked high as field production constraints. In the field it was observed that smut (Fig 9.3) was another disease affecting pearl millet but not mentioned by farmers. Sometimes the same panicle may be affected by both smut and ergot (Fig 9.4) but farmers fail to note the difference. However, the rank of rust may not be appropriate as majority (77.14%) of the farmers confessed that they did not know the symptoms of rust while 10% made a wrong diagnosis (Fig 9.5). Results further show that ergot was more prevalent in the northern region especially in Kitgum district whereas in the east it was more prevalent in Katakwi than in Kumi. Birds and weeds were reported mostly in the east than in the north while rust and insect pests were noted more in the northern region. The observations contrast with international research focus where downy mildew and drought were marked as the most important field production constraints and thus receiving much research attention (Yadav et al., 2012); implying that the research priority in Uganda should focus on ergot, birds and rust. If ergot resistant genotypes suitable for Uganda are developed, farmers may plant early at on-set of rains to escape drought and subsequently increase productivity.

Table 9.1: Percentage response of households about pearl millet field production constraints

Districts	Ergot	Birds	Weeds	Rust	Pests	Low yield	Animal destruction	Itching	Drought
Katakwi	8.18	4.09	3.64	0.91	1.82	0.91	4.09	1.36	0.00
Kumi	5.00	7.73	4.55	0.45	0.91	2.27	0.45	0.91	0.91
Kitgum	14.55	4.55	5.00	4.09	3.64	0.45	0.00	0.00	0.91
Lamwo	5.00	3.64	0.91	4.09	3.18	0.91	0.00	0.91	0.00
Total percent	32.73	20.00	14.09	9.55	9.55	4.55	4.55	3.18	1.82



Fig 9.1: Farmers' pearl millet infected by ergot



Fig 9.2: Farmers' pearl millet infected by rust disease



Fig 9.3: Farmers' pearl millet infected by smut disease



Fig 9.4: Farmers' pearl millet infected by both ergot and smut diseases

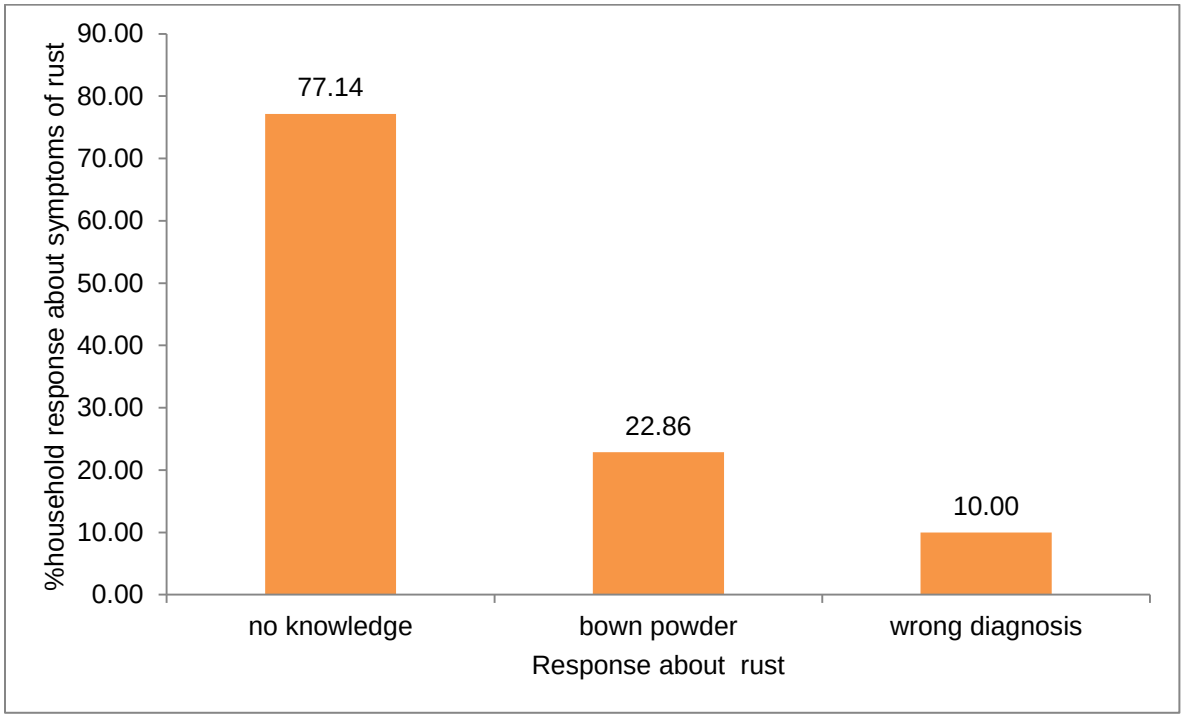


Fig 9.5: Knowledge about pearl millet rust symptoms

Majority (66.10%) of the farmers had no control strategy for ergot while others (33.90%) planted late in the second season to control the disease and birds. However, planting late predisposes the crop to late diseases like rust and drought. Drought is the most important abiotic constraint (Yadav et al., 2012) effecting pearl millet resulting in low seed set as shown in Fig 9.6. Thus the only effective control strategy for ergot is breeding for resistance (Yadav et al., 2012) such that farmers can plant early at the on-set of rains.



Fig 9.6: Sterile panicles affected by drought due to late planting

Crop damage by birds ranked as the second important field constraint destroying pearl millet from milk stage till maturity. The Quelea quelea birds were destructive at milk stage while the weaver birds destroyed the millet at all grain development stages. The birds were mainly reported in the eastern region especially in Kumi district and most farmers had no control over the birds; although some claimed that planting in the second rains minimised the effect of birds. Early weeding was noted as the best control against weeds whereas farmers had no control measures against rust and insect pests.

9.2 Marketing constraints, control strategies and access to markets

The most frequently reported market constraint was low prices (33.95%) followed by high market taxes, lack of transport to markets, lack of markets and unscrupulous middlemen (Table 9.2). Other market constraints of minor importance included; far away markets, high transport costs, and poor road conditions. To assess whether distance to markets was an important constraint, farmers were asked the distance to the nearest market. Majority (66.91%) indicated 0.03-1.00Km and taking 1-60 minutes to reach the market. Others (30.22%) indicated covering 1-3Km in 60-120 minutes and the rest covering more than 3.00Km and taking more than 120

minutes to the nearest market place. The distance covered by majority of the pearl millet farmers to markets does not seem to be inhibitory and that is why it ranked low among the market constraints. Much as Baba and Maina (2013) reported high transport costs as being the major constraint among traders, it ranked low among the farmers in Uganda; implying that those involved in the various pearl millet value chains may face different constraints.

Some pearl millet farmers suggested possible solutions to the major marketing constraints faced but many had no idea. Some farmers suggested government fixing prices for pearl millet annually (40.00%) and carrying out market research to create more markets for the produce in addition to forming farmer groups for collective marketing (Table 9.3). However, majority of the farmers had no idea (53.85%) on how to control the high market taxes although a few suggested carrying out market research before imposing the market taxes. Still about lack of transport to markets, majority of the farmers had no idea on fixing the constraint but some (30.77%) suggested provision of bicycles at reduced prices and promoting buying on-farm to minimise the need for transportation to markets. About lack of markets for pearl millet grain produce, majority (47.22%) of the farmers suggested carrying out market search to create more markets for pearl millet although still many had no idea on how the constraint could be managed. Some farmers suggested longer storage of produce till good market was got but this has cost implications of investing in control of storage constraints. The solution to cheating by unscrupulous middlemen could be solved by using well calibrated weighing scales standardised by UNBS but still the rest had no idea on how to solve the constraint.

Table 9.2: Common pearl millet marketing constraints

	%household response to market constraints							
Districts	Low prices for produce	High market taxes	Lack of transport to markets	Lack of markets	Unscrupulous middlemen	Far away markets	High transport costs	Poor road conditions
Katakwi	9.30	5.12	3.26	2.33	1.40	1.40	0.47	0.47
Kumi	9.77	7.91	2.79	3.26	3.26	0.47	3.26	0.93
Kitgum	9.30	2.79	6.98	6.05	0.47	2.33	0.47	0.00
Lamwo	5.58	1.86	4.19	4.19	0.00	0.00	0.00	0.47
Total percent	33.95	17.67	17.21	15.81	5.12	4.19	4.19	1.86

Table 9.3: Possible solutions to common pearl millet marketing constraints

	%household response about possible solutions to major marketing constraints									
Major market constraints	No idea	Carryout market research	Gov't should fix prices annually	Road repairs needed	Using UNBS calibrated weighing scales	Providing bicycles at reduced cost	Promote buying on-farm at good prices	Form farmer groups for collective marketing	Open nearby markets in villages	Storage of produce for longer periods
Low prices for produce	28.00	16.00	40.00	4.00	0.00	0.00	2.00	10.00	0.00	0.00
High market taxes	53.85	46.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lack of transport to markets	34.62	0.00	0.00	0.00	0.00	30.77	11.54	3.85	19.23	0.00
Lack of market	41.67	47.22	2.78	2.78	0.00	0.00	2.78	0.00	0.00	2.78
Unscrupulous middlemen	20.00	0.00	0.00	0.00	80.00	0.00	0.00	0.00	0.00	0.00

9.3 Storage constraints and control strategies

Storage constraints, which equally affected pearl millet farmers in eastern and northern regions, are shown in Table 9.4. Rodents (36.26%), especially rats, were the most important storage constraint followed by rotting or moulding. Most farmers (37.93%) used poison to solve the constraint of rodents while many used traps (31.04%) and others (31.03%) did nothing s. Failure to control storage pests may partly have contributed to the over 10% grain loss not accounted for in the fate of the harvested grain. Rotting and moulding ranked second among the storage constraints. Majority of the farmers (66.67%) controlled rotting/moulding by proper drying of the grain before storage while others (20.00%) sold their grain produce as soon as it was threshed in addition to the rest (13.33%) doing nothing to control the loss. Other constraints where majority of the farmers had no control strategy included; poultry (especially chicken), insects (especially termites and ants), weevils, red flour beetle and Indian Meal Moth.

Table 9.4: Storage constraints

Districts	%household response about common storage constraints			
	Rodents (especially rats)	Rotting and moulding	Insect pests (weevils, moths)	Poultry
Katakwi	8.79	6.59	14.38	4.4
Kumi	9.89	10.99	5.30	2.2
Kitgum	7.69	9.89	6.40	0.00
Lamwo	9.89	2.20	4.70	0.00
Total percent	36.26	29.67	27.47	6.59

Conclusion

The study highlights the socioeconomic and production characteristics of the pearl millet cropping system. It was observed that most of the production characteristics did not differ much, being typically subsistence, from those of farmers in developing countries in Africa where the cereal is grown. In terms of human capital the pearl millet farming households were endowed with vast experience in producing the crop in addition to readily available family labour but had low experience in education. They had access to trainings in agricultural technologies and good participation in group activities but limited access to credit for agricultural activities and perpetual exposure to food insecurity. The NGOs were the most important providers of the trainings while the government agencies provided the extension services. Despite these positive aspects, the farmers experienced low standards of living since the majority lived in temporary houses made of earthed walls and floors and no electricity. The farmers were further disadvantaged by having limited access to agricultural land as the majority owned and operated up to a unit acre of land on which they did not plant in time and failed to practice recommended agronomic practices like proper plant spacing, row planting and weeding twice. This led to failure to optimally utilise other factors of production like seed input and labour. The result is low productivity which is aggravated by failure to use improved inputs like fertilisers and seeds in addition to facing numerous constraints. The biotic (ergot disease) and marketing (low grain prices) constraints were the most important factors affecting production and sell of pearl millet respectively. Poor postharvest handling methods also contributed greatly to grain losses leading to 10% of threshed grain not being accounted for. Thus, basing on the importance of pearl millet as a food and cash crop the breeding strategy should focus on developing ergot resistant varieties and ensuring the desirable traits and market attributes are developed in order to promote the crop. The high nutrient value of pearl millet relative to other common cereals calls for creation of awareness in other communities with acute malnutrition problems especially in children. In addition, a pearl millet production and market value chain should be developed to increase productivity and marketability respectively. Above all technologies that improve the living standards of the pearl millet farmers should be promoted.

References

Abara, I.O.C., and S. Singh. 1993. Ethics and biases in technology adoption: The small farm argument. Technological Forecasting and Social Change 43:289-300.

Alliance for a Green Revolution in Africa (AGRA). 2013. Africa Agriculture Status Report: Focus on Staple Crops. Alliance for Green Revolution in Africa, West End Towers, Nairobi, Kenya.

Anogie, D.A., Z.G.S. Turaki, U.C. Undiandeye, J. Umar, B.A. Baba, and A.G. Adam. 2009. Studies into the constraints to cereals production in the North-East zone, Nigeria. Research Report. Lake Chad Research Institute (LCRI), Federal Ministry of Agriculture & Water Resources, Nigeria.

Asare-Marfo, D., E. Birol, and D. Roy. 2010. Investigating farmers' choice of pearl millet varieties in India to inform targeted biofortification interventions: Modalities of multi-stakeholder data collection. p. 33. Discussion paper: 51.2010, Department of Land Economy, University of Cambridge.

Baba, B.A., and Y.B. Maina. 2013. Marketing margin and transaction cost in pearl millet market supply in Borno State, Nigeria. Greener Journal of Business and Management Studies 3(5):201-206.

Bahiigwa, G.B.A. 1999. Household food security in Uganda: An empirical analysis. Economic Policy Research Center, Kampala Uganda.

Baidu-Forson, J. 1999. Factors influencing adoption of land-enhancing technology in the Sahel: Lessons from a case study in Niger. Journal of Agricultural Economics. 20:231-239.

Bashaasha, B., M.N. Mangheni, and E. Nkonya. 2011. Decentralization and rural service delivery in Uganda. IFPRI Discussion Paper 01063.

Bationo, A., C.B. Christianson, and M.C. Klaij. 1993. The effect of crop residue and fertilizer use on pearl millet yields in Niger. Fertilizer Research 34(3):251-258.

Bationo, A., and B.R. Ntare, 2000. Rotation and nitrogen fertilizer effects on pearl millet, cowpea and groundnut yield and soil chemical properties in a sandy soil in the semi-arid tropics, West Africa. Journal of Agricultural Science 134 (3):277-284.

Bakht, J., M.F. Siddique, M. Shafi, H. Akbar, M. Tariq, N. Khan, M. Zubair, and M. Yousef. 2007. Effect of planting methods and nitrogen levels on the yield and yield components of maize. Sarhad Journal of Agriculture 23(3):553-559.

Bertz, M. 2009. The effectiveness of agricultural extension with respect to farm size: The case of Uganda. Selected paper prepared for presentation at the Agricultural & Applied Economics Association 2009.

Bisande, S., W. Mwangi, A.J. Verkuijl, and P. Anandajayasekaram. 1998. Adoption of maize production technologies in Southern Highland of Tanzania. p. 29-31. The United

Republic of Tanzania and the Southern Africa Centre for Cooperation in Agricultural Research (SACCAR).

Bonabana-Wabbi, J. 2002. Assessing factors affecting adoption of agricultural technologies: The case of Integrated Pest Management (IPM) in Kumi District, Eastern Uganda. Msc Thesis, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Brocke, A., E. Weltzien, A. Christinck, T. Preseterl, and H.H. Geiger. 2003. Effects of farmers' seed management on performance and adaptation of pearl millet in Rajastan, India. Euphytica 130:267-280.

Basavaraj, G., P. Parthasarathy Rao, S. Bhagavatula, and W. Ahmed. 2010. Availability and utilization of pearl millet in India. Journal of SAT Agricultural Research 8:1-6.

Caswell, M., K. Fuglie, C. Ingram, S. Jans, and C. Kascak. 2001. Adoption of agricultural production practices: Lessons learned from the US. Department of Agriculture Area Studies Project. US Department of Agriculture, Resource Economics Division, Economic Research Service, Agriculture Economic Report No. 792. Washington DC.

Chambers, R. 1992. Rural appraisal: Rapid, Relaxed, and Participatory. p. 3-70. Institute of Development Studies Sussex: HELP, United Kingdom.

Christinck, A. 2002. This seed is like our-selves-a case study from Rajasthan on the social aspects of biodiversity and farmers' management of pearl millet seed. p. 190. Margraf Verlaf, Weikersheim, Germany.

Chenery, E. M. 1960. An introduction to the soils of the Uganda protectorate. Mem. Res. Div. Dep. Agric. Uganda, Series 1, No.1.

Cornia, G.A. 1985. Farm size, land yields and the agricultural production function: An analysis for fifteen developing countries. World Development 13(4):513-534.

DANIDA. 2010. Opportunities for investments in the Uganda dairy sector suitable for financing and support applying the Danida Business Development Instruments. Uganda Final Report.

Davis, A.J., N.M. Dale, and F.J. Ferreira. 2003. Pearl millet as an alternative feed ingredient in broiler diets. Applied Poultry Research 12:137-144.

De Gautam, R.C., and S.K. Kaushir. 1988. Maximisation of rainfed pearl millet. Journal of Agricultural Sciences 58:223-224.

Deshmukh, L.S., A.S. Jadhav, and S.K. Raskar. 2009. Effect of sowing dates on grain and fodder yield of pearl millet (*Pennisetum glaucum*) genotypes in summer season. Karnataka Journal of Agricultural Sciences 22(1):186-187.

Doss, C.R., and M.L. Morris. 2001. How does gender affect the adoption of agricultural innovation? the case of improved maize technologies in Ghana. Journal of Agricultural Economics 25:27-39.

Economic Commission for Africa (ECA). 2003. Land tenure systems and sustainable development in southern Africa. Economic Commission for Africa, Southern Africa, Lusaka, Zambia.

Echevarria, C. 1998. A Three-factor agricultural production function: The case of Canada. International Economic Journal 12(3):63-75.

Edmeades, S. 2006. A hedonic approach to estimating the supply of variety attributes of a subsistence crop. IFPRI, EPT Discussion Paper 148.

El-Osta, H.S., and M.J. Morehart. 1999. Technology adoption decisions in dairy production and the role of herd expansion. Agricultural and Resource Economics Review 28:84-95.

Fermont, A.M., P.J.A. van Asten, P. Tittonell, M.T. van Wijk, and K.E. Giller. 2009. Closing the cassava yield gap: An analysis from small-holder farms in East Africa. Field Crops Research 112:24-36.

Fontaneli, R.S., L.E. Sollenberger, and C.R. Staples. 2001. Yield, yield distribution, and nutritive value of intensively managed warm-season annual grasses. Agronomy Journal 93:1257-1262.

Food and Agriculture Organisation of the United Nations. 2013. FAO policy on Gender equality; attaining food security goals in agriculture and rural development. p. 24. FAO, Rome.

Gabre-Madhin, E.Z., and S. Haggblade. 2001. Success in African agriculture: Results of an expert survey. International Food Policy Research Institute, Washington DC.

Hancock, D.W., and R.G. Durham. 2010. Late planting date influences the yield and distribution of pearl millet forage. Online. Forage and Grazing Lands doi:10.1094/FG-2010-0706-01-RS. http://www.plantmanagementnetwork.org/pub/fg/research/2010/millet/.

Hadimani, N.A., G.M. Krishna, R.N. Tharanathan, and N.G. Malleshi. 2001. Nature of carbohydrates and proteins in three pearl millet varieties varying in processing characteristics and kernel texture. Journal of Cereal Science 32:17-25.

Harper, J.K., M.E. Rister, J.W. Mjelde, B.M. Drees, and M.O. Way. 1990. Factors influencing the adoption of insect management technology. American Journal of Agricultural Economics. 72(4):997-1005.

Idrisa, Y.L., B.O. Ogunbameru, and H. Shehu. 2012. Effects of adoption of improved maize seed on household food security in Gwoza Local Government area of Borno state, Nigeria. Agricultural Science Research Journal 2(2):70-76.

Ipinge, S.N.A. 1998. A proposal for release of pearl millet varieties SDMV 93032 (Okashana2) and SDMV 92040 (Kangara). p. 11. Namibia National Sorghum and Pearl Millet Improvement Programme, Windhoek Namibia.

Kelley, J.D., P. Parathasarathy Rao, E.R. Weltzien, and M.L. Purohit. 1996. Adoption of improved cultivars of pearl millet in an arid environment: Straw yield and quality considerations in western Rajasthan. Experimental Agriculture 32:161-172.

Khairwal, I.S., K.N. Rai, D.J. Andrews, and G. Harinarayana. 1999. Pearl millet breeding. Science Publishers, Inc., Enfield, New Hampshire.

Khairwal, I.S., K.N. Rai, D. Diwakar, Y.K. Sharma, B.S. Rajpurohit, B. Nirwan, and R. Bhattacharjee. 2007. Pearl millet: Crop management and seed production manual. p. 104. International Crops Research Institute for the Semi-Arid Tropics, Patancheru 502 324, Andhra Pradesh, India.

Khairwal, I.S., S.K. Yadav, K.N. Rai, H.D. Upadhyaya, D. Kachhawa, B. Nirwan, R. Bhattacharjee, B.S. Rajpurohit, C.J. Dangaria, and Srikant. 2007a. Evaluation and identification of promising pearl millet germplasm for grain and fodder traits. Journal of SAT Agricultural Research 5(1):1-5.

Krona, M. 2013. The role of women in small-holder agriculture: Status, trends, and opportunities. p. 139-149. In: Africa Agriculture Status Report: Focus on Staple Crops. Alliance for a Green Revolution in Africa (AGRA), Nairobi, Kenya.

Kwapong, A.N., J. Ilukor, M. Hanisch, and E. Nkonya. 2012. Making rural services work for the poor: Micro-level evidence from rural Uganda. World Rural Observations 4(1):3-12.

Latha, K.R., and R. D. Singh. 2003. Effect of cropping systems and fertiliser levels on the nutrient uptake and yield by sorghum in rainfed vertisols. Indian Journal of Agricultural Research 37(3):209-213.

Lelo, F., J. Ayieko, P. Makenzi, N. Muhia, D. Njeremani, H. Muiruri, J. Omollo, and W. Ochola. 1995. A PRA Field handbook for Participatory Rural Appraisal practitioners. Ergerton University.

Lubadde G., Tongoona P., Derera J., and Sibiya J. 2014. Major pearl millet diseases and their effects on on-farm grain yield in Uganda. African Journal of Agricultural Research 9(39):2911-2918.

Macaver, O.J. 2002. Economic impact assessment of public investments in sorghum research and extension in Katsina state, Nigeria. PhD Thesis, Department of Agricultural Economics and Rural Sociology, Ahmadu Bello University, 2002.

Maman, N., S.C. Mason, and S. Sirifi. 2000. Influence of variety and management level on pearl millet production in Niger. I. Yield and growth. African Crop Science Journal 8:25-34.

Matanyaire. C.M. 1996. Pearl millet production system(s) in the communal areas of Northern Namibia: Priority research foci arising from a diagnostic study. p. 43-58. In: Leuschner, K., and C.S. Mannthe (ed.) Drought-tolerant Crops of Southern Africa. Proceedings of the SADC/ICRISAT regional Sorghum and Pearl millet workshop 25-29 July, 1994, Gaborone, Botswana. International Crops Research Institute for the Semi Arid Tropics (ICRISAT), Patancheru, Andhra Pradesh, India.

McDonagh, J., and G. Bahiigwa. 2002. Crop-based farming systems and diverse livelihoods in Uganda. LADDER Working Paper No. 7

McNamara, K.T., M.E. Wetzstein, and G.K. Douce. 1991. Factors affecting peanut producer adoption of integrated pest management. Review of Agricultural Economics 13:129-139.

Mergeai, G., P. Kimani, A. Mwang'ombe, F. Olubayo, C. Smith, P. Audi, J.P. Baudoin, and A. Le Roi. 2001. Survey of pigeon pea production systems, utilisation and marketing in semi-arid lands of Kenya. Biotechnology, Agronomy, Society and Environment 5(3):145-153.

Ministry of Agriculture, Animal Industry and Fisheries (MAAIF). 2011. Statistical abstract.

Mohamed Ali, S.A., K.I. Adam, A.H. Bahar, and T.A. Hassan. 2013. Effect of sowing date and variety on growth and yield of pearl millet (*Pennisetum glaucum* L.) grown on two soil types under rain-fed condition at Zalingei area in Sudan. ARPN Journal of Science and Technology 3(4):340-344.

Mpiira, S., B. Kiiza, E. Katungi, C. Staver, J.S. Tabuti, M. Kyotalimye, P. Muwumba, E. Karamura, and W.K. Tushemereirwe. Factors influencing households participation in the Savings and Credit Cooperative (SACCO) programmes in Uganda. African Journal of Agricultural Research 8(43):5276-5284.

Mula, R.P., K.N. Rai, C.J. Dangaria, and M.P. Kulkharni. 2009. Pearl millet as a post-rainy cool season crop: case studies from Gujarat and Maharashtra, India. Journal of SAT Agricultural Research 7:1-7.

Multidimensional Poverty Index (MPI). 2010. The Economist, July 29, 2010. Retrieved on 2010-08-04.

Mugisha, J., B. Ajar, and G. Elepu, 2012. Contribution of Uganda Cooperative Alliance to farmers' adoption of improved agricultural technologies. Journal of Agricultural and Social Science 8:1-9.

Murty, D.S., and K.A. Kumar. 1995. Traditional uses of sorghum and millets. p. 185-221. In: Dendy, D.A.V. (ed.) Sorghum and millets: Chemistry and technology. American Association of Cereal Chemists, Inc., St. Paul, Minn.

Murty, M.V.R., P. Singh, S.P. Wani, I.S. Khairwal, and K. Srinivas. 2007. Yield gap analysis of sorghum and pearl millet in India using simulation modeling. p. 82. Global Theme on Agroecosystems Report no. 37. International Crops Research Institute for the Semi-Arid Tropics.

Mwebaze, S.M.N. 2006. Country pasture/forage resource profile. p. 17. FAO.

Namara, R.E., B. Upadhyay, and R.K. Nagar. 2005. Adoption and impacts of micro irrigation technologies: Empirical results from selected localities of Maharashtra and Gujarat states of India. Research Report 93. Colombo, Sri Lanka: International Water Management Institute.

Neil, S.P., and D.R. Lee. 2001. Explaining the adoption and dis-adoption of sustainable agriculture: The case of cover crops in northern Honduras. Economic Development and Cultural Change 49(4):793-820.

Ndjeunga, J. 1997. Constraints to variety release, seed multiplication and distribution of sorghum, pearl millet and groundnut in West and Central Africa. p. 34-46. In: Rohrbach, D.D., Z. Bishaw, and A.J.G. van Gastel, (eds.) Alternative Strategies for Smallholder Seed Supply: Proceedings of an International Conference on Options for Strengthening National and Regional Seed Systems in Africa and West Asia, 10-14 March 1997, Harare, Zimbabwe. International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh, India.

Ndjeunga, J., K. Anand Kumar, and B.R. Ntare. 2000. Comparative analysis of seed systems in Niger and Senegal. p. 36 Working Paper Series No. 3. International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh, India.

Ndjeunga, J., and C.H. Nelson. 2005. Towards understanding household preference for consumption characteristics of millet varieties: A case study from western Niger. Agricultural Economics 32:151-165.

Ndjeunga, J., J. Umar, B. Ahmed, A. Aba, A. Ibro, A. Abdoulaye, and K. Gwadi. 2011. Adoption and impacts of modern sorghum and pearl millet varieties in northern Nigeria. Working paper, International Crops Research Institute for the Semi-Arid Tropics.

Nkonya, E., J. Pender, P. Jagger, D. Sserunkuuma, and C.K. Kaizzi. 2002. Strategies for sustainable livelihoods and land management in Uganda. Research Report Manuscript Submitted to the IFPRI Publications Review Committee.

Ogungbile, A.G., Tabo, R., and S.A. Rahman. 2002. Factors affecting adoption of ICSV111 and ICSV400 sorghum varieties in the Guinea and Sudan savanna of Nigeria. The Plant Scientist 3:21-32.

Overfield, D., and E. Fleming. 2001. A note on the influence of gender relations on the technical efficiency of smallholder coffee production in Papua New Guinea. Journal of Agricultural Economics 153-156.

Paraniappan, S.P., and K. Sivaraman. 1996. Cropping systems in the Tropics: Principles and Management. 2nd Edition. New Age International Publishers.

Pender, J., P. Jagger, E. Nkonya, and D. Sserunkuuma. 2002. Development pathways and land management in Uganda: Causes and implications. Selected Paper to be presented at 2002 AAEA Annual Meeting, Long Beach, California.

Pender, J., S.J. Scherr, and G. Durón. 2001b. Pathways of development in the hillsides of Honduras: Causes and implications for agricultural production, poverty, and sustainable resource use. In Lee, D.R., and C.B. Barrett (eds.) Tradeoffs or Synergies? Agricultural Intensification, Economic Development and the Environment, CAB International, Wallingford, UK.

Pender, J., S. Ssewanyana, K. Edward, and E. Nkonya. 2004. Linkages between poverty and land management in rural Uganda: Evidence from the Uganda National Household Survey 1999/2000. Environment and Production Technology Division. Discussion Paper No. 122, International Food Policy Research Institute, Washington, D.C.

Peterman, A., A. Quisumbing, J. Behrman, and E. Nkonya. 2010. Understanding gender differences in agricultural productivity in Uganda and Nigeria. Poverty, Health, and Nutrition Division; IFPRI, Washington DC.

Pica-Ciamarra, U., L. Tasciotti, J. Otte, and A. Zezza. 2011. Livestock assets, livestock income and rural households: Cross-country evidence from household country surveys. p. 18. Joint paper of the World Bank, FAO, AU-IBAR, ILRI with support from the Gates Foundation.

Rai, K.N., C.L.L. Gowda, B.V.S. Reddy, and S. Sehgal. 2008. The potential of sorghum and pearl millet in alternative and health food uses. Comprehensive Reviews in Food Science and Food Safety 7:340-352.

Rai, K.N., D.S. Murty, D.J. Andrews, and P.J. Bramel-Cox. 1999. Genetic enhancement of pearl millet and sorghum for the semi-arid tropics of Asia and Africa. Genome 42:617-628.

Ramasamy, C., M.C.S. Bantilan, S. Elangovan, and M. Asokan. 2000. Improved cultivars of pearl millet in Tamil Nadu: Adoption, impact, and returns to research investment. Impact Series no. 7. p. 64. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), AP-India.

Reddy Amarender, A. 2013. Training manual on value chain analysis of dry land agricultural commodities. p. 88. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

Roden, P., N. Abraha, M. Debessai, M. Ghebreselassie, H. Beraki, and T. Kohler. 2007. Farmers' appraisal of pearl millet varieties in Eritrea. p. 47. Geographica Bernensia, Bern 2006.

Ronner, E., and K.E. Giller, 2012. Background information on agronomy, farming systems and ongoing projects on grain legumes in Uganda. p. 34. http://www.n2africa.org/sites/n2africa.org/files/images/images/N2Africa_Characterization%20Uganda.pdf.

Rubin, D., and C. Manfre. 2010. A guide to integrating gender into agriculture value chains. Bethesda, MD: Cultural practice LLC.

Sarr, P.S., M. Khouma, M. Sene, A. Guisse, A.N. Badiane, and T. Yamakawa. 2008. Effect of pearl millet-cowpea cropping systems on nitrogen recovery, nitrogen use efficiency and biological fixation using the ^{15}N tracer technique. Soil Science and Plant Nutrition 54:142-147.

Shakoor, A., and M. Naeem. 1999. Evaluation of farmers' vs improved pearl millet production for enhanced productivity and profitability under rainfed conditions. Pakistan Journal of Biological Sciences 2:1390-1393.

Siddiqui, A.A., and Z. Mirani. 2012. Farmer's perception of agricultural extension regarding diffusion of agricultural technology. Pakistan Journal of Agriculture 28(1):83-96.

Smale, M., L. Diatkite, A. Sidibe, M. Grum, H. Jones, I. Traore, and H. Guindo. 2010. The impact of participation in diversity field fora on farmer management of millet and sorghum varieties in Mali. African Journal of Agricultural Resource Economics 4(1):23-47.

Simtowe F., S. Asfaw, B. Shiferaw, M. Siambi, E. Monyo, G. Muricho, T. Abate, S. Silim, N.V.P.R. Ganga Rao, and O. Madzonga. 2010. Socioeconomic assessment of pigeonpea and groundnut production conditions-Farmer technology choice, market linkages, institutions and poverty in rural Malawi. p. 92. International Crops Research Institute for the Semi-Arid Tropics Research Report no.6, Patancheru 502 324, Andhra Pradesh, India.

Singh, G. 2003. Development and nutritional evaluation of value added products from pearl millet (*Pennisetum glaucum*). PhD Thesis, CCS Haryana Agricultural University, Hisar, Haryana, India.

Singh, M., and A.S. Joshi. 2008. Economic analysis of crop production and dairy farming on marginal and small farms in Punjab. Agricultural Economics Research Review 21:251-257.

Singh, R. 2003. Use of satellite data and farmers' eye estimate for crop yield modeling. New Delhi: Indian Agricultural Statistics Research Institute. www.gisdevelopment.net/application/agriculture/yield/mi04035pf.htm.

Singh, S.D., J.P. Wilson, S.S. Navi, B.S. Talukdar, D.E. Hess, and K.N. Reddy. 1997. Screening techniques and sources of resistance to downy mildew and rust in pearl millet. p. 27-30. Information bulletin no. 48. ICRISAT, Patancheru, India.

Soman. P., R. Jayachandran, and F.R. Bidinger. 1987. Uneven variation in plant-to-plant spacing in pearl millet. Agronomy Journal 79(5):891-895.

Stoorvogel, J.J., and E.M.A. Smaling. 1990. Assessment of soil nutrient depletion in sub-Saharan Africa: 1983-2000. Winand Staring Centre for Integrated Land, Soil and Water Research, Report 28, Wageningen, The Netherlands:

Tabuti, J.R.S., and K.A. Lye. 2009. Fodder plants for cattle in Kaliro district, Uganda. African Study Monographs 30(3):161-170.

The Economist. 2010. Multidimensional Poverty Index (MPI). July 29, 2010. Retrieved on 2010-08-04.

Tripp, R., and S. Pal. 1998. Information exchange in commercial seed markets in Rajasthan. AgREN Network Paper no.83. London: ODI.

Uganda Bureau of Statistics (UBOS) and Macro International Inc. 2007. Uganda demographic and health survey 2006. Calverton, Maryland, USA: UBOS and Macro International Inc.

Uganda Investment Authority (UIA). Livestock sector. 2009. http://www.ugandainvest.go.ug/index.php/agriculture/livestock.

Uno, D. 2005. farmer's selection of local and improved pearl millet varieties in Ovamboland, northern Namibia. African Study Monographs 30:107-117.

Vadez, V., T. Hash, F.R. Bidinger, and J. Kholova. 2012. Phenotyping pearl millet for adaptation to drought. Frontiers of Physiology 3:1-12. Methods Article doi: 10.3389/fphys.2012.00386.

Vetriventhan, M., A. Nirmalakumari, and S. Ganapathy. 2008. Heterosis for grain yield components in pearl millet (*Pennisetum glaucum* (L.) R. Br.). World Journal of Agricultural Sciences 4(5):657-660.

Weltzien, E.R., M.L. Whitaker, and M. Dhamotharan. 1995. Diagnostic methods for breeding pearl millet with farmers in Rajasthan. In: Sperling, L., and M. Loevinsohn (eds.) Proceedings of the workshop using diversity enhancing and maintaining genetic resources on-farm held on 19-21 June 1995 New Delhi, India. International Development Research Centre.

Winkel, T., J.F. Renno, and W.A. Payne. 1997. Effect of the timing of water deficit on growth, phenology and yield of pearl millet (*Pennisetum glaucum* (L.) R. Br.) grown in Sahelian conditions. Journal of Experimental Botany 48(310):1001-1009.

World Bank. 2004. World development report 2004: Making rural services work for poor people. The World Bank and Oxford University Press, Washington, D. C.

World Bank. 2012. http://data.worldbank.org/indicator/SP.POP.DPND.

Wortmann, C.S., and C.K. Kaizzi. 1998. Nutrient balances and expected effects of alternative practices in farming systems of Uganda. Agriculture, Ecosystems and Environment, 71:115-129.

Yadav, O.P., K.N. Rai, I.S. Khairwal, B.S. Rajpurohit, and R.S. Mahara. 2012. Breeding pearl millet for arid zones of North-Western India; constraints, opportunities and approaches. p 28. All Indian Coordinated Pearl Millet Improvement Project, Jodhpu, India.

Yaron, D., A. Dinar, and H. Voet. 1992. Innovations on family farms: The Nazareth Region in Israel. American Journal of Agricultural Economics 74:361-370.

Zake, J.Y.K., and M. Magunda, 1999. Soil conservation in the highlands of Uganda, In: McCulloch, A.K., S. Babu, and P. Hazell (eds.) Proceedings of the Strategies for Poverty Alleviation and Sustainable Resource Management in the Fragile Lands of Sub-Saharan Africa held from 25-29 May, 1998 in Entebbe, Uganda. International Food Policy Research Institute, National Agricultural Research Organization, Uganda, and the European Commission.

Appendix: Common sources of information for selected agricultural activities

common sources of information for selected agricultural activities

Planting

District	Radio	friends/neighbours	no information got	extension/researchers	FFS group members	NGOs	training workshops	farmers' field-days
Katakwi	6.51	3.26	4.65	0.93	2.79	1.40	0.00	0.00
Kumi	5.58	6.51	5.12	4.19	1.86	0.47	0.00	0.00
Kitgum	10.23	6.05	3.72	3.72	0.47	1.40	3.72	2.79
Lamwo	7.91	3.72	1.40	4.19	0.47	1.86	0.93	0.93
Grand total	30.23	19.53	14.88	13.02	5.58	5.12	4.65	3.72

thinning and plant spacing

	Radio	no information got	friends/neighbours	extension/researchers	NGOs	training workshops	FFS group members	farmers' field-days
Katakwi	4.66	7.25	3.63	2.07	2.07	0.00	3.63	0.52
Kumi	5.18	10.36	5.18	2.07	0.00	0.00	1.55	0.00
Kitgum	7.25	7.25	4.15	3.11	1.55	4.15		2.59
Lamwo	5.70	5.18	1.04	2.59	2.07	1.04		1.55
grand total	30.05	22.80	13.99	9.84	5.70	5.18	5.18	4.66

harvesting

	Radio	no information got	friends/neighbours	extension/researchers	NGOs	training workshops	FFS group members	farmers' field-days
Katakwi	3.77	7.08	2.83	2.83	1.42	0.00	2.83	0.47
Kumi	4.25	7.55	6.13	3.30	0.47	0.00	1.42	0.00
Kitgum	10.85	2.36	6.60	6.13	2.36	3.77	0.00	1.89
Lamwo	7.08	2.36	3.30	2.36	1.89	1.42	0.47	1.42
grand total	25.94	19.34	18.87	14.62	6.13	5.19	4.72	3.77

soil and water conservation

	Radio	no information got	friends/neighbours	extension/researchers	NGOs	training workshops	FFS group members	farmers' field-days
Katakwi	7.65	7.14	2.04	1.53	2.04	0.00	2.55	0.51
Kumi	6.12	8.16	6.12	3.06	1.02	0.00	1.02	0.00
Kitgum	8.67	6.12	3.57	5.10	1.53	3.06	0.51	2.04
Lamwo	5.61	4.59	1.53	2.55	2.04	1.02	0.00	0.00
grand total	28.06	26.02	13.27	12.24	6.63	4.08	4.08	2.55

marketing and processing

	Radio	no information got	friends/neighbours	extension/researchers	NGOs	training workshops	farmers' field-days	FFS group members
Katakwi	6.02	6.02	2.78	2.31	1.39	0.00	0.46	2.31
Kumi	5.09	6.94	5.56	3.24	0.93	0.00	0.00	0.93
Kitgum	11.57	3.70	5.56	3.70	1.85	3.24	2.31	0.00

Lamwo	7.41	1.85	3.70	2.31	1.85	1.39	1.39	0.00
grand total	30.09	18.52	17.59	11.57	6.02	4.63	4.17	3.24

pest and disease control

	Radio	no information got	friends/neighbours	extension/researchers	training workshops	NGOs	FFS group members	farmers' field-days
Katakwi	7.22	7.73	2.06	2.58	0.00	1.55	2.06	0.52
Kumi	5.67	8.25	5.67	3.61	0.00	0.52	1.03	0.00
Kitgum	8.25	5.15	5.67	5.15	4.12	1.55	0.00	0.52
Lamwo	6.19	4.12	2.06	2.06	2.06	2.06	0.52	0.00
grand total	27.32	25.26	15.46	13.40	6.19	5.67	3.61	1.03

new crop varieties

	radio	no information got	friends/neighbours	extension/researchers	NGOs	training workshops	FFS group members	farmers' field-days
Katakwi	9.05	5.53	3.52	2.01	1.51	0.00	2.51	0.00
Kumi	7.04	8.04	5.53	1.51	0.50	0.00	1.01	0.00
Kitgum	9.05	6.53	4.52	2.51	2.01	2.51	0.00	1.51
Lamwo	8.04	2.51	3.02	3.02	2.01	2.01	0.00	0.00
grand tota	33.17	22.61	16.58	9.05	6.03	4.52	3.52	1.51

source of input prices

	radio	no information got	friends/neighbours	extension/researchers	NGOs	FFS group members	mobile phones messages	input shops
Katakwi	8.47	6.88	2.12	2.12	1.59	2.65	0.00	0.00
Kumi	6.35	10.58	4.23	1.59	0.00	1.06	0.00	0.00
Kitgum	9.52	5.82	4.76	2.65	1.06	0.00	2.12	2.65
Lamwo	7.41	3.70	2.12	2.65	2.12	0.00	1.06	0.53
grand total	31.75	26.98	13.23	8.99	4.76	3.70	3.17	3.17

sources of produce prices

	radio	friends/neighbours	no information got	extension/researchers	NGOs	produce buyers	FFS group members	training workshops
Katakwi	8.99	4.76	2.65	0.53	1.59	0.53	2.65	0.00
K Kumi	6.88	5.82	5.82	3.17	0.53	2.12	1.06	0.00
K Kitgum	13.76	5.29	2.12	2.12	1.06	1.06	0.00	1.59
Lamwo	8.47	1.59	1.06	3.17	2.65	0.53	0.00	1.06
grand total	38.10	17.46	11.64	8.99	5.82	4.23	3.70	2.65

weather/climate

	radio	no information got	friends/neighbours	extension/researchers	NGOs	FFS group members	farmers' field-days	newspapers
Katakwi	10.44	4.95	2.20	1.10	1.65	2.20	0.55	0.00
Kumi	7.69	9.34	6.04	1.65	0.00	1.10	0.00	1.14

Kitgum						0.00	2.20	0.57
	10.44	6.59	3.85	2.20	1.10			
Lamwo						0.00	0.00	0.00
	7.69	3.85	1.65	2.20	2.20			
grand tota						3.30	2.75	1.70
	36.26	24.73	13.74	7.14	4.95			

proper food storage

	no information got	radio	friends/neighbours	extension/researchers	NGOs	FFS group members	training workshops	farmers' field-days
Katakwi	7.29	5.73	3.65	2.60	1.56	3.13	0.00	0.00
Kumi	8.85	3.65	7.81	3.13	0.52	1.56	0.00	0.00
Kitgum	5.73	7.81	4.69	4.69	2.08	0.00	3.13	2.08
Lamwo	4.69	6.25	1.04	3.65	2.08	0.00	0.52	0.52
grand total	26.56	23.44	17.19	14.06	6.25	4.69	3.65	2.60

About the NaSARRI: The National Semi Arid Resources Research Institute is one of the public agricultural research institutes under the National Agricultural Research Organisation mandated to develop and disseminate technologies suitable for drought-prone environments in Uganda. Other crops covered include: Cotton, Sorghum, Finger millet, Ground nuts, Sun flower, Sesame, Green gram, Cow pea and Pigeon peas.

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