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A study on the management and quality of farmers' home-saved bean seeds in Lira and Masindi Districts

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Abstract

A baseline study was conducted in Lira and Masindi districts to determine farmers' practices of harvesting, drying, processing, storage and protection of home-saved bean seeds. Two parishes from two sub-counties in each district were selected as study sites. Farmers' bean seed source; seed preparation and planting practices; seed harvesting techniques; seed primary processing, storage and protection methods were investigated. Representative seed samples were obtained from farmers in March and in August 1999, the months proceeding the first and second planting seasons respectively, and were tested for quality in the laboratory. The results showed the predominant reliance on home-saved seeds as source of planting materials by farmers. Seeds were salvaged from grains, only at the time of planting. The quality of farmers' home-saved seeds was poor and this was compensated for panting using a high seed rate. The main constraint to bean seed quality was wet weather during harvesting, drying and threshing, which promoted retention of high seed moisture content, seed invasion by microflora and infestation by bruchids. These factors adversely affected the germination capacity of seeds. Improved grain drying, processing, storage and protection technologies that are "seed friendly" are recommended for application on home-saved seeds.

Key Words: Post-harvest, farmers' seeds, home-saved seeds, quality, management, pests and diseases, and beans

Introduction

In Uganda certified seeds have been produced for nearly 30 years but only 5-10% of it is sown. Certified seed of most traditional crops like field peas, pigeon pea, cowpea, green grams, *Amaranthus*, etc. have not been produced. The inadequate supply of improved and high quality seeds, especially at planting time is therefore considered a major setback in Uganda's subsistence economy. These factors impact negatively on the efforts being made to increase crop productivity and eradicate poverty through improved farming practices.

Most Ugandan farmers, especially small-scale rural producers do not differentiate between grain for food and seed for sowing. What they harvest is what they eat, sow or sell. The majority of farmers therefore sow home-saved seeds from the previous seasons' crop harvest. ADC/IDEA (1996) reported that the other major sources of seed are village markets and retail shop where the seeds sold are basically the bulked grain from many small-scale farmers.

Results of a baseline survey conducted in Masindi, Kasese, Iganga and Kapchorwa indicated poor field seedling emergence of home-saved bean seeds (Akwang *et al.* 1997). Acasio and Borsdorf (1994) reported several factors, especially the handling and storage methods that result in poor grain quality, and presumably these are the same factors that constrain availability of good seed for sowing. Production of home-saved bean seeds is being encouraged by CIAT (Buruchara and David, 1995; David and Kasozi, 1997). There is, however, paucity of information on factors affecting quality of home-saved, for example, germination capacity, tolerance to pests, diseases, edaphic factors, yield and indigenous knowledge on seed management.

Currently, there are improved technologies that have been generated by NARO, especially on grain processing, storage and protection. It is envisaged that these technologies are relevant for seeds, and thus the need for a baseline study and subsequently on-farm validation, demonstration and/or dissemination. This study was conducted to appraise constraints, techniques and practices that impact on the quality of home-saved seeds in Lira and Masindi districts. The findings of the study provide greater insight on areas of focus for a sustainable supply of high quality seed to smallholder farmers, leading to increased crop productivity and income generation.

The main objective was to underscore the economic importance of farmers' home-saved seeds in Lira and Masindi district and specifically to investigate farmers' practices in processing, handling and storage of home-saved seeds determine the quality of home-saved seeds determine the major constraints affecting the quality of home-saved seeds

Materials and Methods

The study was conducted in Lira and Masindi districts in which farming is the major pre-occupation. The two districts fall within different agroecological zones. Two sub-counties were selected for the study in each district. The "fish bowl" (Dillon and Hardaker, 1993) sampling method was used to randomly select the study sites. In Masindi, these were Kahembe and Kyankende parishes in Bwijanga and Kigumba sub-counties, respectively, while in Lira, they were Omarari and Abalang parishes in Moroto and Dokolo sub-counties, respectively.

A formal survey was conducted in March and early April (March), the months proceeding the first planting season of 1999. During the survey, a structured questionnaire was used to obtain information on farmers' home-saved seeds. Target respondents (126 farmers) included both men and women, especially those engaged in farming, and/or trade of agricultural produce. Aspects of seed source, crop production, harvesting, processing, storage and seed preparation and sowing were addressed. Post-harvest constraints and, constraint-mitigating factors and processes were underscored.

During the formal survey, a total of 123 bean seed samples each weighing 1-2 kg were obtained from either farmers' stores, village markets or trading centres, in March and August (months preceding next season's planting dates) for laboratory seed quality analysis. Seed moisture content (MC) was determined by the oven method using 5-g ground bean samples at 130 °C for 1 hour (ISTA, 1996) in an electric oven. Germination was determined by planting 200 seeds in moistened lake sand contained in plastic bowls, and 9 days were allowed for normal seedling development to occur (ISTA, 1996). Mechanical and weevil damages were determined and scored separately. Weevil damaged grains had neat round holes, unlike the mechanically damaged ones that were irregular or had cracks.

Seed health status was determined by the blotter method (Neergaard, 1979). Two hundred surface disinfected and non-surface disinfected seeds were tested and examined for field and storage fungi (Neergaard, 1979). Except *Bacillus subtilis* which was identified by its wrinkled, butter-like appearance (Kabeere, 1977), other bacteria were not studied

The MC and seed germination results were compared with standards of the National Seed Certification Service (NSCS) of Ministry of Agriculture, Animal Industry and Fisheries

(NSCS, unpublished). There are no established standards for seed health, insect or mechanical damage for Uganda seeds. The number of replicates for each analysis equaled the number of bean samples collected from individual farmers. The data were analysed using SPSS and MSTAT-C statistical package to obtain means, standard deviations and frequencies and percentages.

Results

Bean cultivation, seed source and varieties grown

Very few farmers in Lira (11.7%) and in Masindi (6.5%) cultivated beans solely for seed purpose. The majority of farmers interviewed (farmers) (Lira = 88.3%, Masindi = 93.5%) cultivated beans for food and income generation.

In Lira, 69% of the farmers obtained seeds from own savings of the previous harvest and 31% of the farmers supplemented home-saved seed by buying from the local market. None of the farmers bought or planted certified seeds from Uganda Seed Project. In Masindi, the majority of farmers (87.5%) relied predominantly on their home-saved seed for planting, and only one farmer planted certified seeds from the Uganda Seed Project. In both districts, a small percentage of farmers bought seed from the market to mitigate inadequacy.

Farmers in both districts preferred home-saved seeds because of the following reasons: (a) ease of availability, (b) lack of money to buy other seeds, (c) seeds are of better quality, (d) assurance of variety of choice, (e) no any other source during planting time, and (f) no added cost.

Different varieties of beans were grown in Lira and Masindi districts. Variety names, varied in some instances, depending on colour, origin of variety and local sentiments. The most widely grown bean varieties in Lira were Mudugavu (small black beans) and Kibula (small white beans) while in Masindi it was Yellow/Kagusuru/Kanzari (Table 1). Beans were commonly of mixed varieties, and this was especially true of those from Lira. Farmers' choice for any particular variety depended on the availability of planting materials, market demand, storability, cooking duration and organoleptic taste.

Seed preparation, planting and seedling emergence in the field

The majority of farmers in Lira (62.3%) and in Masindi (78.6%) re-dried and/or sorted the seeds prior to sowing. Re-drying and the removal of weevilled and shrivelled seeds ensured high germination percentage and seedling emergence.

Planting methods used were chop and plant (Lira = 45%, Masindi = 93.1%), and broadcast (Lira = 75%, Masindi = 6.9%). Where broadcast method was practised, especially in Lira district, farmers were not able to quantify how much seed is sown per unit area. The majority of farmers in Lira (57.1%) and in Masindi (70.2%) planted 3 seeds per hole. In Lira. The mean number of seeds planted per hole was 3 ±1 with a range of 2 to 5 seeds while in Masindi the mean was 3 ±1 seeds with a range of 1 to 6 seeds. Farmers planted more than the recommended 2 seeds per hole to: (a) insure against poor germination and, soil-borne pests and diseases, (b) obtain optimal plant density, and (c) adhere to traditional norms. The majority of farmers in Lira (73.9%) and in Masindi (62.5%) indicated that poor germination was the main overriding factor for planting many seeds per hole.

Bean harvest, harvest techniques and period

Farmers used bean crop maturity characteristics to determine the harvest time. These included, yellowing and shedding of leaves (Lira = 96.5%, Masindi = 94.6%), drying of pods (Lira = 50.9%, Masindi = 33.9%) and shattering of mature pods (Lira = 10.5%, Masindi = 16.1%).

Almost all the farmers (Lira = 98.3, Masindi = 100%) carried the beans home immediately after uprooting them. Harvest period varied between 1 and 14 days. Farmers spent on average 5.4 ±4.0 and 4.2 ±3.7 days to harvest the whole garden in Lira and Masindi, respectively. Harvested beans were not dried immediately but delayed until the all crop has been brought home. Delayed harvesting was attributed to labour competition with other crops, non-uniformity of maturity, ill health and drudgery.

Table 1. Percentage of farmers growing different bean varieties in Lira and Masindi districts

Bean variety	Farmers growing variety in Lira (%)	
Mudugavu	64.4	5.3
White haricot/Kibula	62.7	14.0
Yellow/Kagusuru/Kanzari	0.0	77.7
Mwetweke/Mutike	0.0	22.8
Kanyebwa	1.7	3.7
Chwara chwara	3.4	0.0
Bujwagole	0.0	1.8
Brown	0.0	1.8
Grey	0.0	1.8
Tanzania	0.0	1.7
K20/Bukalasa	20.3	28.1
K131 (MCM5001)	1.7	3.5
K132 (CAL96)	1.7	0.0

In both districts bean harvesting began in May and continued until January the next year. The peak months of bean harvest were June for Masindi and September for Lira (Fig 1). Bean harvest months were more evenly spread in Masindi than in Lira.

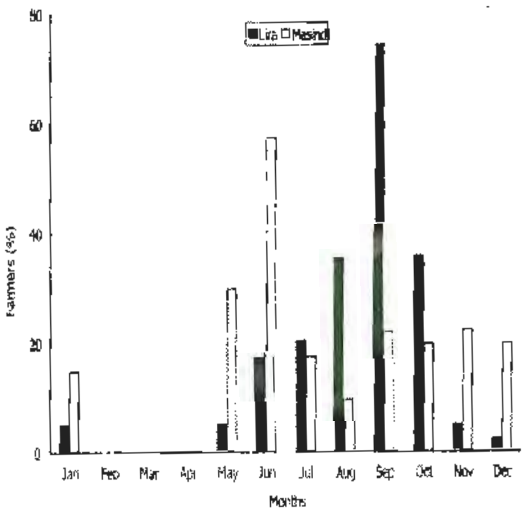
Primary processing of harvested beans In both districts the unthreshed beans were dried prior to threshing. In Lira and Masindi, drying was conducted for 3.7 ±2.1 days, and for 3.5 ±3.0 days, respectively in a period ranging from 1 to 14 days. The majority of farmers (88% in Lira and 78% in Masindi) used open sun drying on bare ground. Other methods of drying included use of biomass driers, cribs (in Masindi district), hanging on the eaves of the veranda or above the fire place.

Farmers used different methods to determine the dryness of bean pods prior to threshing. These included pod shattering (Lira = 35.7%, Masind = 37.8%), rattling of seeds within the pods (Lira = 33.9%, Masindi = 26.7%), ease of threshing (Lira =32.1%, Masindi= 26.7%) and changes in pod colour and/or texture (Lira =17.9%, Masindi = 11.1%). Once threshed and cleaned, the dryness of bean seeds was determined by biting between the teeth, squeezing between fingers or the ease with which the bean kernel could be ground (in Lira district). The majority of farmers (Lira = 65%, Masindi = 92%) preferred the seed biting method.

In both Lira and Masindi districts, the farmers faced several problems while drying beans. Generic problems included rain, contamination from dust, soil, stones or animal droppings, drudgery and termites (Table 2). Frequent rain, however, posed the greatest problem. The majority of farmers did not have a solution to these problems.

Figure 1.

Figure. 1 Percent of farmers harvesting beans at different months in Lira and Masindi districts



The traditional norm of threshing beans by beating with a stick on bare ground was practised by the majority of farmers in Lira (95.2%) and in Masindi (94.5%). A very small fraction of farmers packed the unthreshed beans into bags and threshed by beating with a stick.

The major problems faced by farmers while threshing beans included drudgery, soil contamination, health hazards (dust inhalation, blisters on hands, itching), kernel damage, and rain. Whereas drudgery was mentioned as the greatest setback in Lira (56.6%), in Masindi was the greatest setback soil contamination. A small percentage of farmers in Lira smeared the threshing yard with cow dung to reduce this problem. The majority of the farmers did not have any counter measures to the problems.

Table 2. Percentage of farmers facing different problems during drying of beans in Lira and Masindi districts

Constraint	Farmers affected (%) Lira	Masindi
Rain	49.9	73.5
Seed contamination	18.0	14.3
Moulding	8.2	0
Drudgery	16.4	23.8
Lack of storage space	3.2	2.0
Termites	11.5	2.0
Thieves	1.6	0.0
Domestic animals	3.3	0
Itching	1.6	0
Shattering/spillage	0	6

Immediately after threshing, beans were winnowed using traditional winnowing trays in order to remove the chaff and small-shrivelled seeds. Beans were hand sorted to clean them further (Masindi =, 66.7%, Lira = 41.3%). The main reasons for sorting was to remove extraneous materials, obtain single coloured varieties, and a relatively uniform size and, to meet market demand for clean seeds and /or single coloured varieties. Discoloured, rotten and immature seeds, soil and stone contaminants, damaged seeds, chaff, other varieties and weeds were sorted out (Table 3). Reasons given by farmers who did not sort the grain/seeds included: a) winnowing was a thorough process, b) lack of time c) preference for mixed varieties d) being sure of good seed germination and 25.9 % of the farmers in Lira and 27% in Masindi stored beans as mixed varieties. The reasons why bean varieties were stored separately are presented in Table 4. The main reason is to maintain variety purity, satisfy market requirements and minimise insect damage.

Table 3. Percentage of farmers sorting seeds in Lira and Masindi districts

Materials sorted out	Farmers sorting (%)	
	Lira	Masindi
Soil and stone particles	44.4	17.4
Immature seeds	18.5	22.6
Discoloured	7.4	54.8
Rotten seeds	51.9	67.7
Mechanically damaged seeds	25.9	16.1
Other varieties	3.7	0
Chaff	14.8	0
Weeds	7.4	0

Table 4. Percentage of farmers with different reasons on choice of bean storage

Reasons	Farmer respondents (%)	
	Lira	Masindi
Maintain varietal purity	46.6	84.2
Prevent insect damage	13.8	1.8
Differences in maturity periods	19.0	0
Market preferences/demand	12.1	12.8
Taste differences	1.7	1.8

Most of the farmers stored their beans in sacks (Lira = 90%, Masindi = 84.2%). Other storage methods included sealed pots (4% in Lira) and cribs (2%), on-the-floor (2%), baskets (2%) and granary (9.8% in Masindi). The mean storage duration of beans seeds was 6 and 5±2.7 months in Lira and Masindi districts, respectively, and the storage period ranged from 1 to 12 months.

Farmers mentioned several problems that contribute to bean losses while in storage. The loss cansative factors included weevils, moulds, rats, termites and pilferage. More than 96% of the farmers in Lira and Masindi district observed that bean weevils posed the greatest threat for protracted bean storage duration. To contain and /or control storage losses, farmers in both districts used several strategies that included physical, ethnobotanicals and insecticides (Table 5). In Lira, more farmers conducted regular inspection and re-drying, hut in Masindi, more farmers preferred ash treatment (Table 5).

Table 5. Percentage of farmers using different control methods against loss causative factors of stored beans

Control method	Farmers using control methods (%)	
	Lira	Masindi
Regular inspection and re-drying	55.6	30.2
Actellic 1% dust	11.2	28.3
Tobacco	7.4	1.9
Pepper	29.6	22.6
Ash	16.7	35.9
Millet husk	0	1.9
Sell of grain	0	7.6
Rodenticide	7.4	3.8
Rat trap	1.9	0
Termiticide	1.9	0

Seed quality: moisture content, insect and mechanical damage, germination and health

The quality of farmers' home-saved seeds varied between districts and seasnns (Table 6). The MC of seeds sampled during March was within the acceptable recommended level of 13%, unlike that of seeds sampled during August. Seeds from Masindi had higher insect damage levels than those obtained from Lira. Likewise, the germination of seeds received from Lira was superior to those from Masindi. Higher percentages (86% and 70%) of March and August bean samples from Lira passed the 80% NSCS standard compared to only 63% and 56% of samples from Masindi in the same periods.

Table 6. Quality of home-saved seeds obtained from Lira and Masindi

Quality parameter	Seed quality (Mean ± SD) (%)				Recommended NSCS level (%)
	Lira		Masindi		
	March	August	March	August	
Moisture content	12.4 ± 1.2	16.1± 2.5	12.9 ± 1.7	15.0 ± 2.5	13.0
Insect damage	2.2 ± 0.7	4.0 ± 2.4	4.5 ±1.6	8.4 ± 2.7	NA
Mechanical damage	0.9 ± 0.2	0.2 ± 0.1	1.7 ± 0.3	0.6 ± 0.1	NA
Germination	82.7 ± 16.4	79.1 ± 18.5	75.2 ± 23.2	72 ± 24	80

Seed health status also varied between districts (Table 7). Eight field and four storage fungi, and one bacterium (*Bacillus subtillis*) were detected on bean seed samples from Lira and Masindi. Pathogenic field fungi detected were *Colletotrichum lindemuthianum*, *Botriodiplodia theobramae*, *Macrophomina phaseolina*, *Fusarium solani* and *F. oxysporum*. Of the field fungi, *F. solani* had the highest incidence (0.5 to 16.5%). Storage fungi had higher incidences (0.5 to 54%), than field fungi, with *A. niger* having the highest occurrence (0.5 to 54%) levels (Table 7). Most of the fungi and *Bacillus subtillis* were internally borne, since they persisted in seeds after surface disinfection. *Fusarium* spp., storage fungi and *Bacillus subtillis* were commonly associated with dead seeds.

Table 7. Percentage incidence of microflora on bean seeds collected from Lira and Masindi districts in March 1999

Microflora	Lira (n=29)				Masindi (n=33)			
	Non-surface disinfected		Surfacedisinfected		Non-surfacedisinfected		Surface disinfected	
	Infection (%)	Range (%)	Infection (%)	Range (%)	Infection (%)	Range (%)	Infection (%)	Range (%)
Bacterium								
Bacillus subtillis	**6.3**	**0.5 – 39.5**	**12.2**	**0.5 - 49**	**2.0**	**0.5 – 18.5**	**4.0**	**0.5 – 23.5**
Field fungi								
Botrydiplodia theobramae	**0.2**	**0.5 – 3.5**	**0.2**	**0.5 – 2.0**	**0.4**	**0.5 – 4.5**	**0.2**	**0.5 – 4.0**
Cladosporium spp.	0.1	0.5 – 1.0	0	0	0.2	0.5 – 2.5	0	0.0 – 0.5
Colletotrichum lindemuthianum	0.1	0.5 – 1.0	0.1	0.5 – 1.5	0.1	0.5 – 2.5	0.1	0.5 – 1.0
Fusarium oxysporium	0.1	0.0 – 4.0	0	0.0 – 0.5	0.2	0.5 – 1.5	0.2	1.0 – 4.5
Fusarium solani	2.2	0.5 – 8.0	1.5	0.5 - 5.5	4.0	0.5 – 16.5	3.0	0.5-15.0
Macrophomina phaseolina	0.4	0.5 – 1.5	0.4	0.5 – 1.5	1.0	0.0 – 6.5	0.4	0.5 – 3.0
Phoma spp.	0.1	0.5 – 3.0	0.1	0.5 – 1.0	0	0.0 – 0.5	0	0
Storage/Saprophytic fungi								
Aspergillus flavus	**1.4**	**0.5 – 11.5**	**2.0**	**0.5 – 12.5**	**4.0**	**0.5 – 22.5**	**3.0**	**0.5- 21.5**
Aspergillus niger	2.1	0.5 – 22.0	1.4	0.5 – 22.0	6.3	2.0 – 54.0	2.0	0.5 - 9.5
Penicillium spp.	2.1	0.5 – 32.0	0.1	1.0 – 1.5	7.2	0.5 – 43.0	1.0	0.5 – 7.0
Rhizopus spp.	4.0	0.5 – 19.0	2.1	0.5 – 19.5	3.5	0.5 – 28.5	2.0	0.5 – 7.0

Discussion

The results indicate that seed processing, haudling, storage and sowing methods in Lira and Masindi districts were equable to that of grain for food on-farm. This was demonstrated by the lack of special treatments to seeds that were characteristically different from those giveu to grains. It is therefore apparent that the same factors that affect grains are also the same for seeds. It is suggested that the technologies currently available for grain constraint mitigation be availed to farmers in the two districts, and also be validated on seeds. The effects of the grain protection technologies should be determined on seed germination and seeds borne diseases. Agona and Silim-Nahdy (1998) noted that solarisation was only suitable for grain protection but it highly impaired seed germination. The use of ethnobotanicals, e.g. neem products, especially neem oil and neem kernel powder, should also be treated with caution since they are also easily invaded by *Aspergillus flavus*, fungi that adversely affect germination (Christensen and Kaufmann, 1969; Christeusen, 1972).

It was noted that the germination of seeds from Masindi was lower than that of seeds from Lira. Considering all the seed quality parameters determined, in relation to germination, the results suggest that germination capacity was more influenced by the level of insect damage than any other factor. Bruchid infestation of beans is known to reduce the seed germination by selectively feeding on the germ tissues. The use of ethnobotanicals, especially, tobacco powder as grain admixture (Silim and Agona, 1993; Silim and Agona, 1996; Agona *et al.*, in Press; NRI Report No. 2551) is recommended for seed treatment.

Farmers' practice of heaping beans for some time at home and only start drying when harvesting is completed prolongs high moisture conditions in seeds. This situation, 16 particularly during wet weather encouraged development and invasion of seeds by storage fungi and saprophytic bacteria (Christensen and Kaufmann, 1969), as indicated by the different storage fungi and *Bacillus subtilis* detected on/in seeds..

Other reasons for the high levels of occurrence of storage/saprophytic microflora in bean seeds could have been due to the delay in harvesting of beans after physiolngical maturity, drying and threshing on bare ground, and threshing of beans using the beating-with-stick method that led to the bruising of kernels (Christensen, 1972.).

It was noted that the moisture content of the first season beans was much higher than that of the second season, and was above the recommended level. This could possibly be due to inadequate drying during the long first rains. The use of biomass dryers or cribs is suggested for alleviation of this constraint. **Furthermore, to improve the quality of seeds, drying and threshing of beans should be done on stabilised platform drier and threshed using the KARI bean thresher (Mutyaba *et al.*, unpublished).**

It was observed that the seed issue becomes very important to the majority of farmers at planting time. This was particularly true when they eitber salvaged planting materials from the damaged grain stock mainly by sorting out damaged and/or rotten seeds or supplemented them by buying from the market. It is therefore suggested that farmers' confidence in home-saved seeds be built by availing modern techniques of seed handling, storage and protection immediately after bean harvest.

Conclusion

The study has showed that to the majority of farmers, the grain only becomes seed at planting time, and as such there are no special treatments seeds are subjected to during processing and handling and storage. Secondly, the quality of farmers' home-saved seeds is poor, and farmers buffer the problem by using high seeding rates, despite the cleaning and sorting. This results in loss of grain which would otherwise be used for improving food security and income generation.

The main problems that limit protracted seed storage and that results into poor seed germination are bruchid infestation and probably microfloral seed invasion. It is therefore recommended that pest management technologies that reduce and/or control insect infestation, e.g. use of tobacco admixtures be availed to farmers. In addition, practices that promote prompt bean drying such as drying them in bean cribs or on platform dryers; and threshing using the KARI bean thresher are recommended. A similar study should be carried out in other agro-ecological zones to give an overall strategy of improving home-saved bean seed quality in Uganda.

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References

Acasio, U. and Borsdorf, R. 1994. Post-harvest handling of maize and beans in Uganda. Food and Feed Grain Institute, Kansas State University, Manhattan, Kansas, USA.

ADC/IDEA (Agribusiness Development Centre/Uganda Investment in Developing Export Agriculture Project). 1996. A Seed usage survey of maize and beans in six districts of Uganda. USAID, Chemonics International Inc. Contract NO.623-0125-C-00-5040-00

Agona, J.A., Kyamanywa, S., Silim-Nahdy, M., Willson, H.R., Owera-Odom, F. and Nakkazi, J. Integrated management of bean and cowpea bruchids on-farm. *(In Press. Uganda Journal of* Agricultural Sciences).

Agona, J.A. and Silim-Nahdy, M. 1998. Effect of solar drying period on beans on seed viability, cooking time and injuriousness of *Acanthoscelides obtectus* Say. *African Crop Science Journal,* 6 (4): 417-421.

Akwang, A.A., Kabeere, F., Mutyaba, C. J. and Koljin, S. 1997. Interventions identified for the Low Value' Produce: maize and beans in districts of Iganga, Kapchorwa, Kasese and Masindi. *A Technical Report of the Post-Harvest Programme, NARO*

Buruchara, R. and David, S. 1995. Seed quality: Issues in small-scale farmer bean seed production. A paper Presented at the *SDAC Regional Bean Resource Network Workshop*, Postchefshoon, South Africa, 1-4 October 1995.

Christensen, C.M. 1972. Microflora and seed deterioration. In: E.H. Roberts (Editor), *Viability of seeds*, 57-93. Chapman & Hall Ltd. London Christensen , C.M. and Kaufmann, H. H. 1969. *Grain storage: The role of fungi in quality loss*. 153 pp. University of Minnesota Press. Minneapolis.

David, S. and Kasozi, S. 1997. Designing sustainable, commercial-farmer-seed production systems in Africa: Case studies from Uganda. A paper presented at the workshop *CIAT's Experience with Systems Research and Future Directions"*, Cali, Columbia, December 1-2, 1997.

Dillon, J.L. and Hardaker, J.B. 1993. Farm management research for small farmer development. *FAO Farm Systems Management Series No. 6*. pp. 48-50.

ISTA (International Seed Testing Association). 1996. *Seed Science and Technology: Rules – International Rules for Seed Testing*, 1996, Volume 24, Snpplement, Rules, 1996.

Mutyaba, C.J., Kabeere, F. and Magara, E. Effect of threshing methods on bean grain and seed quality. 1999. In: *Post-Harvest Research Programme Annual Report*, 812. pp. NARO.

Kabeere, F. 1977. Thesis: *"Effect of Microflora on the Germination of Soyabeans* (*Glycine max*) (L.) Merrill. MSc. thesis. Makerere University, Kampala, Uganda, 222 pp.

National Seed Certification Service. *Seed Certification Handbook for Uganda.*. National Seed Certification Service, P.O box 7065, Kampala.

Neergaard, P. 1979. Incubation Tests I: Procedures. In :*Seed Pathology*, Volume I, p. 738-743. The Macmillan Press Ltd. London and Basingstoke Companies.

Natural Resources Institute (NRI). 2000. Post harvest needs assessment in the Teso and Lango farming systems of Uganda. *NRI Report no. 2551.*

Silim, M.N. and Agona, J.A. 1996. On-farm integrated bean bruchid management. A paper Presented at the 3rd *Meeting of the Pan-African Working Group* *on Bean Entomology*, Arusha, Tanzania, November 3rd –7th 1996. International Centre for Tropical Agriculture (CIAT), 8 pp.

Silim, M.N. and Agona, J.A. 1993. Studies on the bean bruchids: *Acanthoscelides obtectus* (Say) and *Zabrotes subfasciatus* (Boheman) (Coleoptera: Bruchidae) in the East African region. In: *Proceedings of 2nd Meeting of the Pan-African Working Group on Bean Entomology*, Harare, Zimbabwe, September 19th –22nd 1993. CIAT-African-Working- Series. No. 25, pp. 50-59.

Wortmann, C.S. and Eledu, C.A. 1999. *Uganda's Agroecological Zones: A Guide for Planners and Policy Makers*. CIAT. 56 pp.