A COMPARATIVE STUDY ON CULTIVAR DIVERSITY AND MANAGEMENT OF *PHASEOLUS VULGARIS* L. (COMMON BEAN) IN SELECTED COMMUNITIES OF MITYANA DISTRICT, CENTRAL UGANDA

BY

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Declaration

I, Catherine Kiwuka, declare that this thesis has not been submitted before for any degree in this or any other University or Institution of higher learning. All the information presented herein represents my original work except where stated.

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Dedication

To my parents; Aarons Sebunza and Ephrance Nansubuga Sebunza,my sweet little brothers and all those to whom my success means something.

Acknowledgement

I would like to thank the almighty God for his grace and provision throughout this period. I also thank the Swedish International Development Authority (Sida) through the East African Plant Genetic Resources Network (EAPGREN) for the financial support in carrying out this study. I also convey my sincere thanks to my supervisors Prof. R. Bukenya-Ziraba and Dr. Mary Namaganda for the academic and technical guidance they provided through the course of the study.

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Abstract

Despite its importance as "poor man's meat" in Uganda, there is no substantial information on the amount of the common bean (*Phaseolus vulgaris* L.) diversity and its dynamics in the farming communities. In addition to that, the introduction of improved cultivars, urbanization, reduced farm-size as a result of population growth, and climate change have forced farmers to make critical decisions that may have restructured the diversity on-farm which may probably cause genetic erosion.

This study was conducted to investigate the amount of diversity of *P. vulgaris* and its associated management in the selected rural and peri-urban communities of Mityana district of central Uganda. The aim of the study was to determine the cultivar diversity of *P.vulgaris* and the associated management practices while the specific objectives were to; (i) determine the diversity *P. vulgaris* maintained by farmers, (ii) identify the management practices and (iii) examine the seed system (seed provision, selection and storage) of *P. vulgaris* in the communities. Data were purposefully collected from 120 households through household, surveys focus group discussions and direct field observations. Diversity measures; cultivar richness and evenness as estimated by Simpson's index of diversity (1-D), farmers' management practices and the seed system mechanisms for both rural and peri-urban communities were obtained.

A total of 24 common bean cultivars were identified in the whole study area and an equal cultivar richness of 21 cultivars was observed in both communities. Although both communities had equal cultivar richness, the farmers in the peri-urban communities had a significantly higher number of cultivars per household than their counterparts in rural communities. Both communities had substantial cultivar evenness (0.81 and 0.82 in rural and peri-urban, respectively) though some cultivars (e.g. Nambaale-omuwanvu, Nambale-omumpi, Yellow and Kanyeebwa (A) were grown in relatively larger proportions. Both communities had at least 30% of the total farms nurturing different sets of cultivars. Using morphological evidence of taxonomy, farmers' use of specific traits to

identify and manage cultivars highly coincided with the characters that grouped the diversity in cluster analysis and principal component analysis. There were no variations in the management practices employed by the rural and peri-urban farmers. Both seed systems seemed stressed as most of the cultivars except Nambaale-omumpi, Nambaale-omuwanvu and Yellow-omumpi, with in the communities had limited seed sources.

This study thus recommended that there is need to put in place incentive mechanisms that can encourage a section of the farming community to continue conserving the diversity of *P.vulgaris* on-farm to ensure its continued evolution and adaptation to changing biotic and abiotic factors. Alternative strategies also need to be put in place and these include; establishment of community gene banks to improve local seed systems, strengthening participatory crop improvement that will add value to the least grown cultivars.

INTRODUCTION

1.1 Background

The common bean (*Phaseolus vulgaris* L.) is one of the 10 most important crops in the world, with a production of almost 8 million tons per year on 13 million hectares (Tohme *et al.*, 1996; Beebe *et al.*, 2000). It plays a principal role in human nutrition and market economies throughout East Africa. It provides the second most important source of protein after maize and the third most important source of calories after maize and cassava (Pachico, 1993). Due to its great nutritional quality (high protein content, soluble fibre, vitamin B complex, iron, zinc and potassium and complex carbohydrates with high calorific value), it has been described as the perfect food or as 'the meat' for the wider community of Uganda (CIAT, 2001).

Bean genetic diversity is a fundamental source of sustenance of livelihoods and agro-ecosystems for more than 100 million people in Africa with important economic and socio-political dimensions (CIAT, 2005). Like in any other crop, this diversity has been perpetuated by farmers over time and space through observation, selection, multiplication, exchange, trade, and conservation. Through their management strategies, farmers make significant decisions that affect the genetic diversity of the crop populations and over time modify the structure of a population as farmers select for plants with preferred agro-morphological characteristics (Jarvis and Hodgkin, 2000).

Despite the tremendous effort applied by our farming communities in perpetuating the common bean diversity, there is relatively low appreciation of their works as reflected by the lack of concrete information on the diversity of the common bean in Uganda. Most of the work on the common bean has been revolving around developing high yielding, drought resistant, pest and disease tolerant cultivars. As socio-economic and environmental changes set in, these cultivars lose their efficiency (i.e the ability to resist pest and diseases) thus a need arises to develop other cultivars that will suite the situation. This can easily be achieved if there is a relatively diverse genetic base with sufficient adaptation to provide the required genes.

This study aimed at examining the distribution of the common bean diversity in two socio-economically different communities and the management practices employed by the farmers in rural and peri-urban communities. The information generated would then be used to design efficient strategies for conservation and ensuring sustainable utilisation of the common bean diversity for improved livelihoods among the farming communities. The results of the study will also form an important source of information towards formulation of conducive policies for enhancing the conservation of plant genetic resources on-farm.

On-farm conservation empowers farmers and communities to control the genetic resources in their fields and it recognizes them as the curators of local genetic diversity and the indigenous knowledge to which it is linked. In turn, farmers are likely to reap more benefits that arise from the genetic material they have conserved (Jarvis *et al.*, 2000). On-farm cultivar diversity is measured by richness and evenness; thus locating this diversity and measuring its amount and distribution are important as diversity is not distributed evenly in any geographic region (Bajracharya *et al.*, 2003). Richness refers to the number of different kinds of individuals regardless of their frequencies. Evenness, however, measures how similar the frequencies of the different variants are, with low evenness indicating dominance by one or a few types (Jarvis *et al.*, 2008).

1.2 Research Problem

Despite its importance as the major source of dietary protein in most communities coupled with the tremendous research and development as regards developing highly yielding, pest and disease resistant varieties, there is no adequate information on the diversity and dynamics of the common bean on-farm in Uganda. Farmers make decisions during the process of planting, managing, harvesting and processing their crops that affect the genetic diversity of crop populations. This, over time, modifies the genetic structure of a population as farmers keep selecting plants with preferred agro-morphological characteristics (Jarvis and Hodgkin, 2000) as well as other attributes of importance at a given time and circumstances. This is likely to lead to better adapted diversity being continuously developed in farmers' fields. This diversity can not be optimally utilized unless a clear understanding of its amount, distribution and dynamics as managed by the farmers is obtained.

1.3 Aim

The aim of this study was to determine the diversity cultivar of the common bean and the associated management practices. This was achieved through the following specific objectives:

1.4 Specific objectives

The specific objectives of study were to:

i. determine the diversity of common bean (*Phaseolus vulgaris* L.) maintained by farmers.
ii. identify the management practices of the common bean on-farm.
iii. examine the seed system (seed provision, selection and storage) of *Phaseolus vulgaris* L. in the communities.

1.5 Study Hypotheses

The study set out to test the following hypotheses

i. There is no difference in the level of diversity of common bean cultivars managed between the farmers in the rural and peri-urban communities.
ii. Farmers in the rural communities employ similar management practices as their counterparts in the peri-urban communities.
iii. There is no difference in the seed systems within and between rural and peri-urban communities.

1.6 Justification

Understanding the amount and distribution of diversity is the key to understanding which varieties are most likely to be threatened by genetic erosion and what factors actually affect this distribution on-farm (Jarvis *et al.*, 2000). The investigation into the infra-specific diversity and its dynamics on-farm provides an understanding of the amount, distribution and the complexities underlying farmers' decisions in conserving and utilizing the common bean in the communities. The information can then be used to design appropriate strategies to conserve and sustainably utilize the diversity. Through these strategies, farmers can be empowered in ways that improve their management practices and thus increase their efficiency as curators of on-farm diversity.

Further more, the highly adapted diversity in farmers' fields can be used in crop improvement to cope with the erratic climatic changes, prevalence of pests and diseases and other needs as defined by the socio-economic changes within the communities. It could also provide important information for designing benefit sharing mechanisms among and within communities as well as at national level. The study area (Mityana district) was selected as an entry point to the assessment and understanding the amount of diversity of *P.vulgaris* cultivars in farmers' community since no such study has been conducted. Secondly the study follows the need of Plant Genetic Resources Centre (PGRC) of the National Agricultural Research Organization (NARO) to support farmers in conserving and sustainably utilize Plant Genetic Resources for Food and Agriculture (PGRFA) on-farm/*in-situ*.

LITERATURE REVIEW

2.1 Classification, Domestication and Origin

Common beans belong to the genus *Phaseolus*, family Leguminosae, subfamily Papilionoideae, tribe Phaseoleae, and sub-tribe Phaseolinae. The genus *Phaseolus* is of American origin and comprises over 30 species (Debouck, 1991, 1999). Only five of these species, namely *P. acutifolius* A. Gray (tepary bean), *P. coccineus* L. (scarlet runnerbean), *P. lunatus* L. (Lima bean), *P. polyanthus* Greenman (year long bean), and *P. vulgaris* L. (common bean) were domesticated (Gepts and Debouck 1991). The common bean (*Phaseolus vulgaris* L. ($2n = 2x = 22$)), is the most economically important species of genus *Phaseolus*.

Of the 70-odd species that have been recognized in the genus (Freytag and Debouck, 2002), five have been domesticated and a few additional species show signs of incipient domestication (Delgado-Salinas *et al.*, 2006). The Common bean is believed to have been domesticated in two centers of origin, namely Middle-America (Meso-America) and South America (Andean) giving rise to two separate gene pools. The existence of the two gene pools is supported by differences in morphology (Debouck, 1999), phaseolin (major seed storage protein in common bean) seed protein (Gepts *et al.*, 1986; Gepts *et al.*, 1988), Singh, 1989 and Gepts, 1990), allozymes (Koenig and Gepts, 1989; Singh *et al.*, 1991), and DNA markers (Becerra -Velasquez and Gepts, 1994; Sonnante *et al.*, 1994; Blair *et al.*, 2006). These characters have been important in classifying the common bean diversity. The Andean (South America) and Mesoamerican (Middle America) gene pools have marked morphological differences. Andean types tend to have larger leaves with ovate or lanceolate central leaflets and lanceolate or triangular bracteoles, longer internodes in the main stem, larger seeds, a stripeless standard on white flower, and a central pod beak position (Duran *et al.*, 2005). Mesoamerican types, on the other hand, have striped standards and colored flowers, a placental pod beak position, and cordate or ovate bracteoles (Duran *et al.*, 2005).

According to Gepts *et al.* (1986), Gepts *et al.* (1988), Singh (1989) and Gepts (1990) the cultivars from the Andean center of domestication possess a set of phaseolin types namely; C, H, A, and T, which are not found in cultivars or wild types from the Mesoamerican center of domestication with S, Sb, and Sd. Molecular markers have also been applied to common bean diversity studies namely; isozymes, which were used to identify races within the gene pools (Singh *et al.*, 1991b, 1991c), as well as Random Amplified Polymorphic DNA (RAPD) (Johns *et al.*, 1997; Beebe *et al.*, 2000), and Amplified Fragment Length Polymorphism (AFLP) markers (Tohme *et al.*, 1996; Beebe *et al.*, 2001).

The Common bean became well established as a pulse crop in parts of Africa before the 16^{th}century and some genetic diversity is found in tropical Africa that is not found in the Americas (CIAT, 2001). The large-seeded types characteristic of the Andean gene pool accounts for 61% of cultivars; the rest are small and medium-seeded types typical of the meso-American gene pool (CIAT, 2001). Climbing types are largely restricted to high altitude areas, especially in south-western Uganda, Rwanda, Burundi and eastern parts of DR Congo, but they are also grown in northern and western Malawi, northern and southern Tanzania and northern Zambia. Indeterminate trailing or semi-climbing types are common in most bean growing areas and prevail under growing conditions that are marginal due to high temperatures, water deficits and low soil fertility. Red, mottled, large-seeded cultivars are most common in tropical Africa, followed by cultivars with red, small to medium-sized seed (CIAT, 2001).

2.2 Production and constraints

2.2.1 Common bean Production

The main production areas of common bean are Latin America (with Brazil and Mexico as the most important producers) and eastern Africa, where per capita consumption is the highest in the world in countries such as Burundi, Rwanda, and Uganda (Broughton *et al.*, 2003). Being the world's most important grain legume for direct human consumption, the common bean's total production exceeds 12 million metric ton, of which 7 million Metric Ton are produced in tropical Latin America and Africa. In Africa, production is concentrated in densely populated eastern Africa, the lakes region, and the highlands of southern Africa (CIAT, 2001). It is cultivated from sea level up to 3000 meters above sea level in monoculture, in association, or in rotations. It is largely produced for subsistence, mainly by women farmers; approximately 40% of production in sub-Saharan Africa is marketed at a retail market value of $452 million (Wortmann *et al.*, 1999). In Uganda, 545,000 tonnes were produced from yielding 671 kg/ha (FAO, 2008).

The Common bean production occurs with 250 mm mean rainfall during the growing season but 65% of the production is estimated to occur in areas with an average rainfall higher than 400 mm during the season (CIAT, 2001). In tropical Africa common bean is well adapted to elevations of 1200 – 2200 m, with mean temperatures during the growing season of 15 –23°C (CIAT, 2001). Still, 20% of the common bean production in tropical Africa takes place at a mean temperature higher than 23°C. The crop can withstand occasional day time temperatures of 35°C, but this often results in flower abortion (CIAT, 2001).Growth stops below 10°C and the plant is killed by frost. At latitudes higher than 10°, *P. vulgaris* may be grown at low altitudes during cooler months, generally with irrigation, and usually for immature pod harvest (CIAT, 2001).

2.2.2 Production constraints

The production of the common bean is affected by both abiotic and biotic production constraints (Singh, 1992; Wortmann *et al.*, 1998). As noted by Wortmann *et al.* (1998) among the abiotic constraints, the most widely distributed are low soil fertility, particularly deficiency of nitrogen, phosphorus and zinc, as well as toxicities of aluminum and manganese. Drought is also reported as a widely distributed and endemic abiotic problem affecting bean production in many regions of the world, especially in East Africa.

Common bacterial blight (CBB) is a widespread problem from tropical to temperate bean growing environments. In relatively cooler and wetter areas, halo-blight and bacterial brown spot may cause severe yield losses (Wortmann *et al.*, 1998). Angular leaf spot, anthracnose, and rust are considered among the most widely distributed foliar fungal diseases that cause severe yield losses of common bean in the Americas, Africa, and other parts of the world (Wortmann *et al.*, 1998).

Root rots and other soil borne pathogens in most bean growing environments, web blight in the warm humid tropics, and white mold and ascochyta blight in cool wet regions, occasionally become severe on common bean. Bean common mosaic virus (BCMV), in most bean production regions of the world, and Bean golden mosaic virus (BGMV) are reported to cause severe yield losses in susceptible cultivars. Other biotic constraints include the leaf hoppers (*Empoasca ekraemeri* Ross & Moore), bean pod weevil (*Apiongodmani* Wagner and *A. aurichalceum* Wagner) , bean beetle (*Epilachna varivestis* Mulsant), bean fly (*Ophiomyia phaseoli* Tryon) and bean weevil (*Zabrotes subfasciatus* Boheman), which are reported to cause severe losses in common bean yields (Singh, 2001).

2.3 Common bean research in Uganda

Common bean research in Uganda and Eastern Africa, as implemented under the umbrella of the Uganda National Bean Program (UNBP) and the Pan-African Bean Research Alliance (PABRA) has the broad goal of "contributing to poverty alleviation and the incomes of rural populations in Africa and, for both rural and urban populations, improving food security including protein availability" (CIAT, 1998). PABRA seeks to increase the productivity and commercialization of beans through the adoption of sustainable production technologies with the basic assumption that higher production of beans will translate into higher incomes and improved food security (David *et al.*, 2000).

The Ministry of Agriculture initiated the bean research programme at Kawanda Research Station in 1960's to check the high levels of malnutrition in the rural poor communities reported by the Ministry of health (David, *et. al.*, 2000). The programme responded by releasing a bush variety K20 in 1968 which is widely grown in Uganda, Kenya and Tanzania (Grisley, 1994) for its marketability and yield stability. In 1994, twenty six years after the release of K20, the Uganda National Bean Program released two CIAT bred lines: K132, a Calima seed type similar to K20, and K131, a Carioca seed type, previously unknown in Uganda. K132, a determinate bush type (Type 1), characterized by dark red mottled, large seeds, though highly marketable, is susceptible to many production constraints. K132, an indeterminate bush type (Type II), characterized by small beige seeds mainly preferred in the east and north of Uganda, has resistance to bean common mosaic virus (BCMV), a moderately important production constraint (David *et. al.*, 2000).

2.4 Farmer's management of on-farm diversity

As Bellon (1996) defined it, farmers' management of crop diversity refers to the cultivation of a diverse set of more or less specialized crop populations. These populations are named and recognized as units by the farmers that are usually segregated in space, time and/or use. Farmers shape the distribution and degree of genetic diversity in their crops both directly, through selection, and indirectly, through management of biotic and abiotic agro ecosystem components (Jarvis and Hodgkin, 2000).

In the process of selecting for varieties based on preferred agro-morphological characteristics, the practices farmers use may be a factor influencing the maintenance of genetic diversity on-farm. Practices associated with seed selection that may influence the genetic structure of varieties over time include selection; (i) in the field (ii) at post-harvest storage, (iii) from a particular plot or designated area of a plot and (iv) if all pods are used for seed. These practices may exert a selection force on the seed lot or crop population, influencing the survival of seeds for the next planting season, and thus affecting the genetic basis of the variety over time (Jarvis *et al.*, 2000).

The process of variety selection can be seen as the farmer's decision to maintain, incorporate or discard a variety to be planted in a particular growing season. The diversity of varieties present in the farmer's fields is the outcome of this decision. Diversity should increase, if the number of varieties incorporated and maintained is larger than the ones discarded, and vice versa. Farmers continually evaluate each variety they have and the process has two components; first to find out how a variety performs with respect to each concern or selection criterion, such as its performance under drought or flood conditions and secondly is to rank the performance of the varieties in terms of each of the different selection criterion (Bellon, 1996).

2.5 Seed system and on-farm diversity

Following McGuire (2001), there are various processes involved in seed provision; selection and storage can be considered as constituting a system. Clearly, understanding the nature and operations of seed systems is central to effective support for maintenance of diversity on-farm. Analysis of the seed system can provide essential information on population sizes of varieties, on local management and exchange practices, on the relative importance of individual farmer maintenance as against seed flow and market factors, as well as many other aspects (Hodgkin and Jarvis, 2005).

Seed systems are classified as either formal or informal. Formal systems are commercial oriented, under the control of national and/or international and multinational seed companies established basing on scientific principles and are committed to providing quality seeds to the farmers (Baniya *et al.*, 2003). In contrast, informal seed systems cover method of local seed selection, production and diffusion. Such a system is described as traditional, informal and operates at community level through exchange mechanisms involving limited quantities of seed in each transaction (Mekbib, 1999). The informal seed system fundamentally occurs through a social network where a set of persons is connected through flow of information, goods or implementation of joint activities or other social bonds of one kind or another (Subedi *et al.*, 1999).

Farmers count on the diversity present in other farms, to get new seed lots when they need them. Seed exchange may even extend as far as cyclic renewal of seed lots (seed change), a frequent feature in traditional agricultural systems (Louette *et al.*, 1997; Zeven, 1999; Louette and Smale, 2000). According Magurran (1988) and Begon *et al.*, (1996), diversity measures not only depend on richness but also on evenness (sometimes equitability). Evenness compares how equally abundant kinds (in this case cultivars) are. Based on morphological characterization, the standardized units of the cultivars were grouped to reveal the diversity in the communities.

METHODS

3.1 Study Area

The study was conducted in Mityana district situated in the central region of Uganda (Fig.1). The district lies between latitude 0.30° above Equator and longitude 32° East of the Greenwich, 69km west of Kampala the Capital City of Uganda, along Kampala - Mubende Road. The total area of Mityana district is about 1953.36 Km^2. The district comprises gentle slopes with open U-shaped valleys and it lies close to L. Victoria. Rainfall ranges between 1279 mm and 1524 mm per annum with high rainfall periods in March to June and August to November, and with temperatures ranging from 15°C to 28°C.

Based on 2002 population and housing census, total population of Mityana Ddistrict was 265,994 of which 132,989 are males and 133,005 females with a 2.8% growth rate. (Mityana District Local Government, 2008). This region falls under the banana and coffee agriculture system where banana and coffee have over the decades been the major staple and cash crop respectively. Presently, due to the fusarium wilt in bananas and coffee wilt, the common bean has been increasingly grown for cash and domestic consumption.

Mityana district has two counties (Busujju and Mityana), which are subdivided into eight sub-counties and one town council. The district has a total of 64 parishes and 513 villages. Data were collected from four sub-counties; two sub-counties from each county, i.e., Maanyi and Kakindu from Busujju county and Busimbi and Kikandwa from Mityana county. The densely populated (157-207 persons/km^2) sub-counties that were near the town council represented the peri-urban communities while the sparsely populated (118-123 persons/km^2) and distant sub-counties represented the rural communities. These communities were selected to encompass differences in the seed systems and management practices.

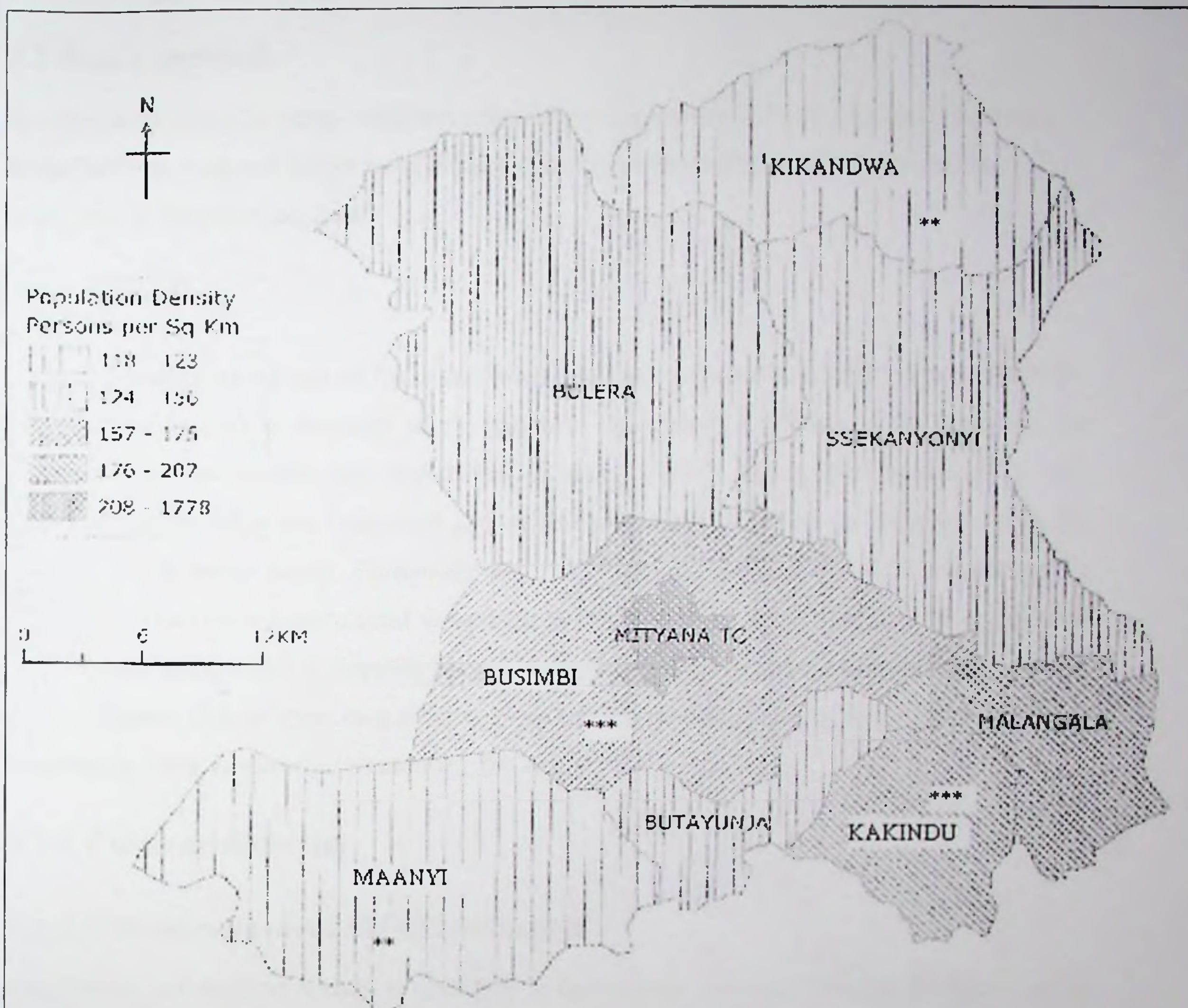

Figure 1. Map of Mityana district showing the study area.

Note: The study was conducted in the marked sub-counties; ** and *** representing rural and peri-urban communities respectively

Source: Mityana local council headquarters

3.2 Study methods

In order to answer the study objectives the following methods; focus group discussions, household surveys and direct field observation/experimentation were employed as described in the next sections.

3.2.1 Sampling

Purposive sampling by use of the snowball technique was used to identify knowledgeable farmers maintaining a diversity of *P. vulgaris*. Snowball sampling is an approach for locating information-rich key informants (Patton, 1990). Using this approach, a few potential respondents are contacted and asked whether they know of anybody with the characteristics under study. Following this, 10 potential respondents were contacted by the help of the area Agricultural extension worker in each sub-county. These potential respondents were asked to identify all the knowledgeable farmers maintaining a diversity of *P. vulgaris* (i.e. at least two cultivars) in their area and its from this list that 30 key informants were randomly selected for the study.

3.2.2 Cultivar diversity

3.2.2.1 Nomenclatural Standardization

Consistency of cultivar names is essential to the proper analysis of diversity data (Jarvis *et al.*, 2008). Thus, prior to data collection from individual farms, focus group discussions were held with farmers from each of the study sub-counties. The focus groups were purposively selected to ensure fair representation with respect to age and gender across the parishes in the study sub-counties. Following the procedure described by Jarvis *et al.*, 2000, the name each farmer gave to each cultivar, together with the traits he/she used to identify the cultivar in question were recorded.

These sets of traits, together with the names used by different farmers, and photos of the cultivars were used to arrive at the "basic diversity units" for the crop (Jarvis *et al.*, 2008). The diversity units were based on agreement among farmers that the units at hand were different. The process of arriving at distinguishable units included the removal of synonyms (i.e., two cultivars with different names that the farmers agree are actually the same items) and separating larger units into discrete units (i.e., two cultivars referred to with the same name by two or more different farmers but recognized as different units) (Jarvis and Campilan, 2006). These "basic diversity units" were used in this study to calculate cultivar richness.

3.2.2.2 Household cultivar diversity

Data on cultivar diversity were collected by use of structured and semi-structured interviews during household surveys, focus group discussions and direct field observations (see appendix 1). A total of 120 house-holds and/ farms (a farm was taken as the sum of all plots allocated to common bean cultivars where a plot is a homogeneous portion owned by an individual farmer) were surveyed in the study; 30 house holds and/ farms from each sub-county. From each house-hold, the number of cultivars (as identified by farmers) was recorded and the area of the farm allocated to each cultivar was measured to estimate richness and evenness respectively (Jarvis *et al.*, 2008).

3.2.2.3 Field observation of the morphological diversity

The structure of phenotypic diversity of *Phaseolus vulgaris* was studied both within a cultivar (among seed lots of a cultivar) and across cultivars (among sets of seed lots bearing different names). Cultivars identified by farmers were standardized and selected for analysis based on their respective rural or peri-urban communities. A standard *Phaseolus vulgaris* descriptor provided by the International Plant Genetic Resources Institute (IPGRI, 2001) was used to obtain both qualitative and quantitative data for a sample from each cultivar representative of all sampled farms (see Appendix 2).

All the 24 common bean cultivars observed during the household surveys, were planted in field trials at Namulonge Crop Resources and Livestock Research Institute in October 2008. The seeds were obtained from farmers during the focus group discussions and following Duran *et al.* (2005), the cultivars were planted in a randomized complete block design with two replications. The Experimental units consisted of single 1 m row lengths for each cultivar and spacing of 0.5 m between rows and 6cm between plants within rows making a total of at least 20 plants and utmost 25 plants per cultivar.

Most of the morphological traits were measured at the R1 (initiation of flowering) stage of development because at this stage there are no further changes in the vegetative traits of the plant (CIAT, 1987). *P. vulgaris* being a predominantly an in-breeding crop, with minor morphological variation within cultivars, measurements were taken from five plants that were chosen at random from each row. All plants in each row were harvested to estimate seed yield per plant and seed yield components (number of pods per plant, number of seed per pod, and 100-seed weight). Two phenological traits, i.e. days to flowering and days to harvest maturity (when pods are beginning to dry), were recorded on the basis of the average of the entire plot's growth stage (CIAT, 1987). A total of eighteen morphological traits (see Appendix 2) were measured for taxonomic analysis.

3.2.3 Farmers' management practices and seed system

To identify farmer's management practices in the study sites, data on the practices employed including those that constituted the seed system were collected. House-hold interviews were conducted within each community with the pre-sampled farmers per sub-county. The key informant interviews as guided by structured and semi-structured questionnaires were carried out separately with each person, to avoid collective answers that rarely reflect individual strategies. For each farmer, gender and age, which cultivars he/she cultivates and the area allocated to each cultivar, were recorded (see Appendix: 1). The inquiries were focusing on determining the key factors that are partially or completely dependent on farmer's practices, capable of modifying selection pressures and the crop's population structure on-farm.

To determine the seed flows, selection and storage practices of the common bean in each community, data depicting seed system mechanisms was collected from each pre-sampled farmer. The data was collected through household interviews as guided by the semi-structured questionnaire (see Appendix: 1). The seed source was classified into six classes; (i) bought from the market, (ii) bought from shops, (iii) bought from farmers, (iv) own stock, (v) free from farmers (gift) and (vi) NGOs (National or International). The origin of a seed lot was defined independently of the origin of the previous generation of seed. A seed lot was considered "own seed" if the pods from which the seeds are selected was harvested by the farmer from his field, even though the seed that produced those pods (i.e., the previous generation of seed) may have originated in another community. By detailing the geographic origin of each farmer's seed lots for each cultivar, the frequency and characterization of seed exchange among farmers, the pattern of cultivar diffusion was determined.

3.3 Data analysis

Cultivar accumulation curves as generated by BiodiversityR package in R 2.6.1 software were used to analyze the sampling efficiency (Users manual). The curves presented the increment in the number of cultivars with the number of farms/ households sampled for the two study communities. In addition, the curves summarized the adequacy of the sampling effort in collecting all the cultivars grown in a community assuming the asymptotic value as the measure of the total number of the cultivars (Kindt and Coe, 2005).

Average farm richness was calculated as the average number of cultivars per farm. Total community richness was calculated by summing the number of distinct cultivars found across parishes in the community. The Simpson's index of diversity (1-D) being a measure of dominance was used as an estimate of evenness (Jarvis *et al.*, 2008). The index is relatively insensitive to the correct identification of rare cultivars but assumes the common cultivars are reliably identified.

BiodiversityR package in R 2.6.1 software was used to analyze the pattern of common bean diversity in the communities. The diversity pattern is interpreted based on the Rank-abundance curves generated. The technique first calculates the total number of individuals for each cultivar (in this study cultivars), it then ranks them from the most abundant to the least abundant, and a plot is constructed with the rank number on the horizontal axis and the abundance on the vertical axis (Kindt and Coe, 2005). Cultivar richness was provided by the width of the curve (the wider the curve the higher the cultivar richness) while the shape of curve is an indication of the evenness (the steeper the curve, the less evenly cultivars are distributed and completely horizontal curve is an indication of a completely evenly distributed system).

Following Rijal (2007), the extent and distribution of the common bean cultivars was assessed using four cell analysis technique. This involved calculating the total area covered by each cultivar and the number of households growing it. Cultivars were then categorized into groups that occupied large or small areas (based on average area), and those varieties that were grown by many or few households (based on number of households). The mean area in hectares per household for each cultivar grown in a sub-county was calculated to decide whether a cultivar is grown in a large or small area.

Cluster analysis by use of Gower's coefficient of dissimilarity and principle coordinate analysis of the morphological data were performed by BiodiversityR package in R 2.6.1 software and NTSYSpc21. Cluster analysis computed the dissimilarity matrix and provided its results in form of dendrogram by grouping cultivars according to the measured morphological characters. Principal Coordinate Analysis attempts to reduce the dimensionality of a spatial representation of a data set by creating new coordinate axes that are a combination of the originals, and projecting the data onto those new axes. Like Principal Component Analysis, it restructures the data sets containing many correlated variables into smaller sets of components of the original variables. Each set is uncorrelated with any other, but components within sets are related (Rohlf, 2005).

Data depicting farmers' selection criteria of cultivars were analyzed by calculating estimated weighted mean and matrix ranking. Other data reflecting the farming methods and seed systems were analyzed using descriptive statistics and the analysis of variance by SPSS program Version 10.0 for Windows (Users manual).

RESULTS

4.1 Sampling efficiency

Figures 1a and 1b show that the number of cultivars in all communities accumulated with increasing number of farms sampled. All the graphs tended to their asymptotic values where no new cultivars were expected with increased number of households. This is therefore an assurance that the communities were adequately sampled to represent the diversity managed by the two different communities. However, there is a possibility that more cultivars could be obtained with more extensive sampling effort in because communities because of the curves were just tending to their asymptotic values. This is confirmed by the Jack 1 and Jack 2 cultivar richness estimators which were 26.9 and 27.9 respectively in both communities as compared to the observed cultivar richness of 21 in both communities.

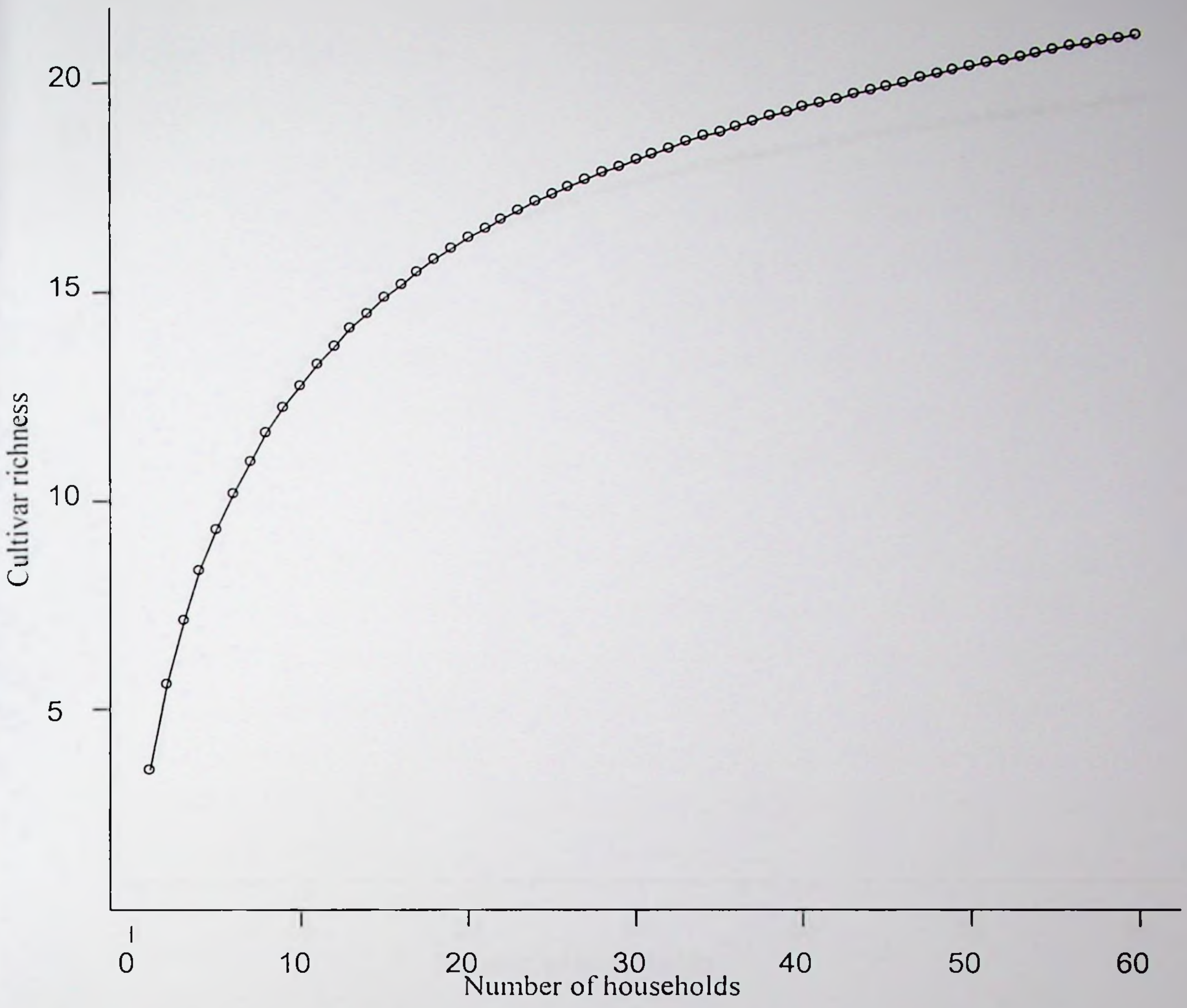

Figure 1a. Cultivar accumulation curve for rural communities

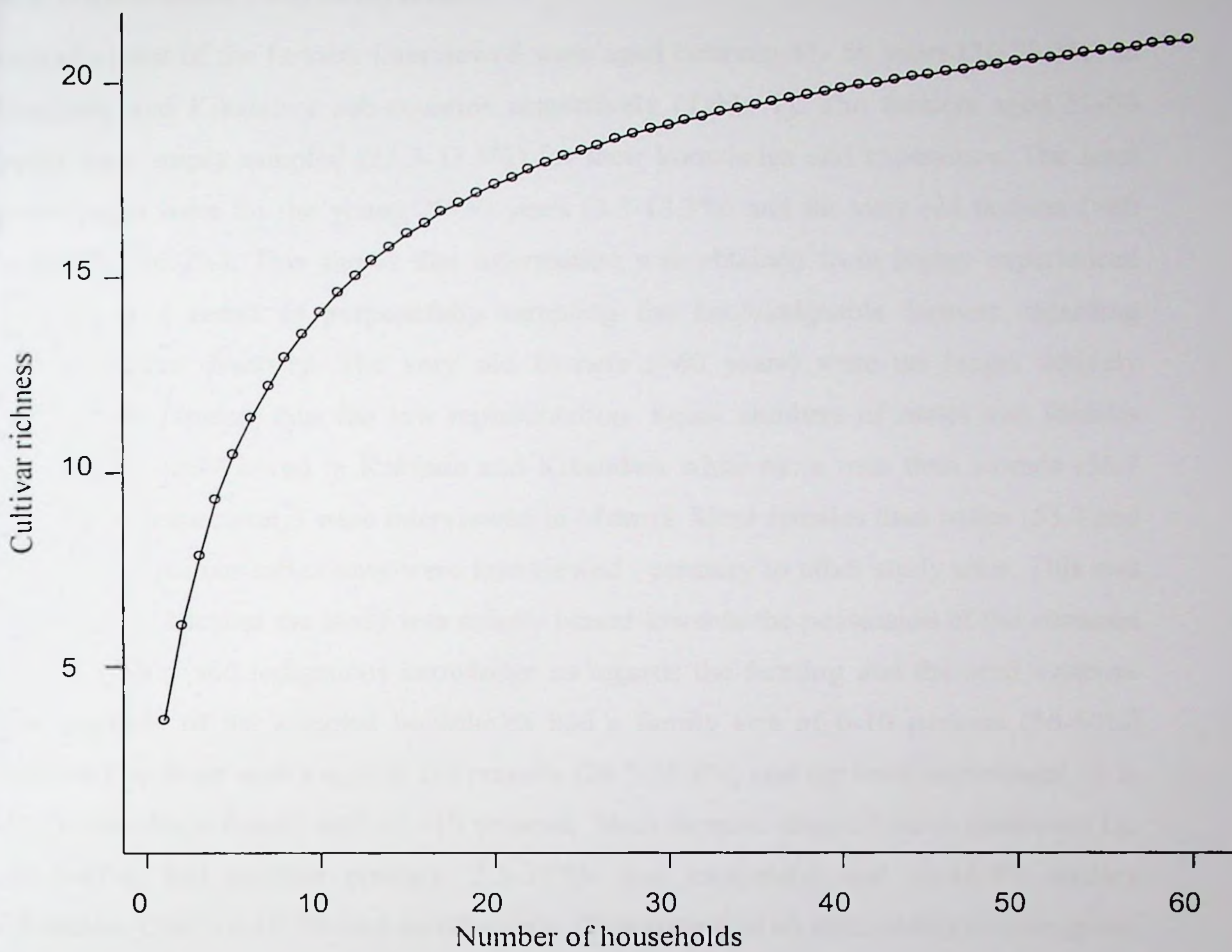

Figure1b. Cultivar accumulation curve for peri-urban communities

4.2 Households characteristics

enerally most of the farmers interviewed were aged between 41- 50 years (30-53.3%) in Busiimbi and Kikandwa sub-counties respectively (Table 1). The farmers aged 51-60 years were amply sampled (23.3-33.3%) for their knowledge and experience. The least percentages were for the young 20-30 years (3.3-13.3%) and the very old farmers (>60 years (3.3-16.7%). This shows that information was obtained from highly experienced farmers as a result of purposefully sampling the knowledgeable farmers regarding common bean diversity. The very old farmers (>60 years) were no longer actively involved in farming thus the low representation. Equal numbers of males and females (50%) were interviewed in Kakindu and Kikandwa while more men than women (56.7 and 43.3% respectively) were interviewed in Maanyi. More females than males (53.3 and 46.7%) in Busimbi sub-county were interviewed contrary to other study sites. This was not intended because the study was strictly biased towards the possession of the common bean diversity and indigenous knowledge as regards the farming and the seed systems. The majority of the sampled households had a family size of 6-10 persons (50-60%) followed by those with a size of 1-5 persons (26.7-36.7%) and the least percentages (3.3-23.3) were for a family size of >10 persons. Most farmers attained basic education i.e. (33.3-40%) had attained primary, 2.3-33.3% had secondary, and 10-16.7% tertiary education. Only 10-16.7% had no education. This portrayed an appreciably literate group of farmers that can easily be empowered in best conservation and management practices of the plant diversity on their farms and communities. Generally a higher percentage (40-60%) of the farmers interviewed have lived in the area for more than thirty years; 21-30% of the farmers had stayed in the locality for 21-30 years and only 0-13.3% of them have lived in the area for 1-10 years. As purposefully chosen, the interviewed farmers were managing substantial amounts of the common bean diversity, 43.3-63.3% had 2-3 local cultivars on their farms, 23.3-50% of the farmers were managing 4-5 cultivars and 6.7-20% had ≥6 cultivars in their farms.

Table 1: House-hold characteristics of common bean farmers in the study sites

Characteristic	Percent number of respondents per study site			
	Kakindu	Busimbi	Maanyi	Kikandwa
Communities	Peri-urban		Rural	
Age (years)				
20-30	3.3	13.3	3.3	6.7
31-40	13.3	20	13.3	13.3
41-50	46.7	30	33.3	53.3
51-60	33.3	26.7	33.3	23.3
>60	3.3	10	16.7	3.3
Sex				
Male	50	46.7	56.7	50
Female	50	53.3	43.3	50
Marital Status				
Married	86.7	83.3	76.7	73.3
Single	0	0	0	3.3
Widowed	10	10	20	13.3
Separated	3.3	6.7	3.3	10
Family size (persons)				
1-5	36.7	26.7	26.7	36.7
6-10	50	56.7	50	60
>10	13.3	16.7	23.3	3.3
Education level				
None	10	16.7	16.7	13.3
Primary	33.3	40	40	46.7
Secondary	33.3	33.3	26.7	2.3
Tertiary	23.3	10	16.7	16.7
Length of residence (Years)				
1-10	0	13.3	0	10
20-Nov	10	30	3.3	3.3
21-30	30	16.7	40	43.3
>30	60	40	56.7	43.3

Number of varieties				
2-3	63.3	56.7	46.7	43.3
4-5	30	23.3	43.3	50
≥6	6.7	20	10	6.7

4.3 Cultivar identification

4.3.1 Basic diversity units

Farmers distinguished common bean cultivars basing on seven agro-morphological traits; colour of mature seed, seed size, seed shape, number of seeds per pod, leaf colour, colour of mature pod, and main stem color (Table 2). Since the study was carried out in the central region of Uganda, where the predominant ethnic group is Ganda, the cultivar names are thus reported in Luganda because it's the dominant language in the area.

Table 2: The main distinguishing traits of the cultivars

ivar name	Seed color mature	Seed size (length)	Seed shape	No. of seeds /pod	Leaf color	Pod color (mature)	Main stem color
yewogola	Maroon with white speckles	Large(1.6 -≥2cm)	Kidney	few (2-3)	Green	Cream with red and purple stripes	Purple& green
myufu (A)	Red	Small (0.5-0.9 cm)	Round	very many (6-8)	Dark green	Purple	Purple
ddugavu	Small	Small	Oval	very many	Green	Yellow	Green
ow-omumpi	Yellow	Medium (1-1.5cm)	Oval	few	Green	Yellow with red stripes	Green
yeebwa (A)	Pink with maroon speckles	Medium	Oval	many	Green	Yellow with red stripes	Green
olankubalire	Orange	Medium	Round	few	Light green	Yellow	Green
aki / MP	Cream	Small	Round	many (4-5)	Dark green	Yellow	Green
weru (A)	White	Small	Kidney	few	Green	Yellow	Green
olina	Red	Small	Round	very many	Green	Red	Red
udu	Brown with white stripes	Medium	Oval	many	Green	Yellow with purple stripes	Green
yeebwa (B)	Cream with red stripes	Medium	Oval	few	Green	Yellow with red stripes	Green

baale- ldugavu	Purple with white stripes	Large	Kidney	many	Green	Yellow with purple stripes	Green
nyufu (B)	Red	Medium	Round	few	Green	Yellow with purple stripes	Green
unye (L)	Cream with maroon stripes	Large	Kidney	few	Green	Yellow	Green
te	Black with white speckles	Large	Kidney	few	Green	Yellow with red stripes	Green
kke- myufu	Red	Large	Kidney	few	Green	Yellow	Green
myufu (C)	Red	Medium	Kidney	few	Dark green	Purple	Red
baale- mpi	Calima	Medium	Oval	many	Green	Yellow	Green
baale- wanvu	Calima	Large	Kidney	many	Dark green	Yellow with red stripes	Green
ow- wanvu	Yellow	Large	Kidney	many	Green	Yellow	Green
eru (B)	White	Medium	Round	few	Green	Yellow	Green
ike-purple	Purple with white speckles	Large	Kidney	many	Green	Yellow with red stripes	Green & pink
unye (M)	Brown with maroon stripes	Medium	Round	many	Green	Cream	Green & pink
o	White	Large	Kidney	many	Green	Yellow	Green

Most farmers (71.0% in rural and 71.5% in peri-urban communities) use seed traits; color, size and shape as the key distinguishing characters between and within cultivars. Most cultivar names (61.9% and 52.4% in rural and peri-urban communities respectively) were reflecting the seed color. For similar seed colour, farmers used the seed size to differentiate and name cultivars for instance 'Nambaale-omuwanvu' and 'Nambaale-omumpii' literarily meaning long Nambaale and short Nambaale respectively. Other names were in honor of some leaders (e.g. Obote and MP in respect of the Member of Parliament and places were the seed originated from (e.g. Congo and Nambaale). There were significant differences (ANOVA $0.03=p< 0.05$) in the levels of consistency regarding cultivar identification among farmers with-in and between communities. This was reflected by the variation in cultivar names within and across the study areas. The lowest levels of consistency were mostly observed in the use of traits like number of seeds per pod, leaf colour, mature pod color and main stem color (Figure 2).

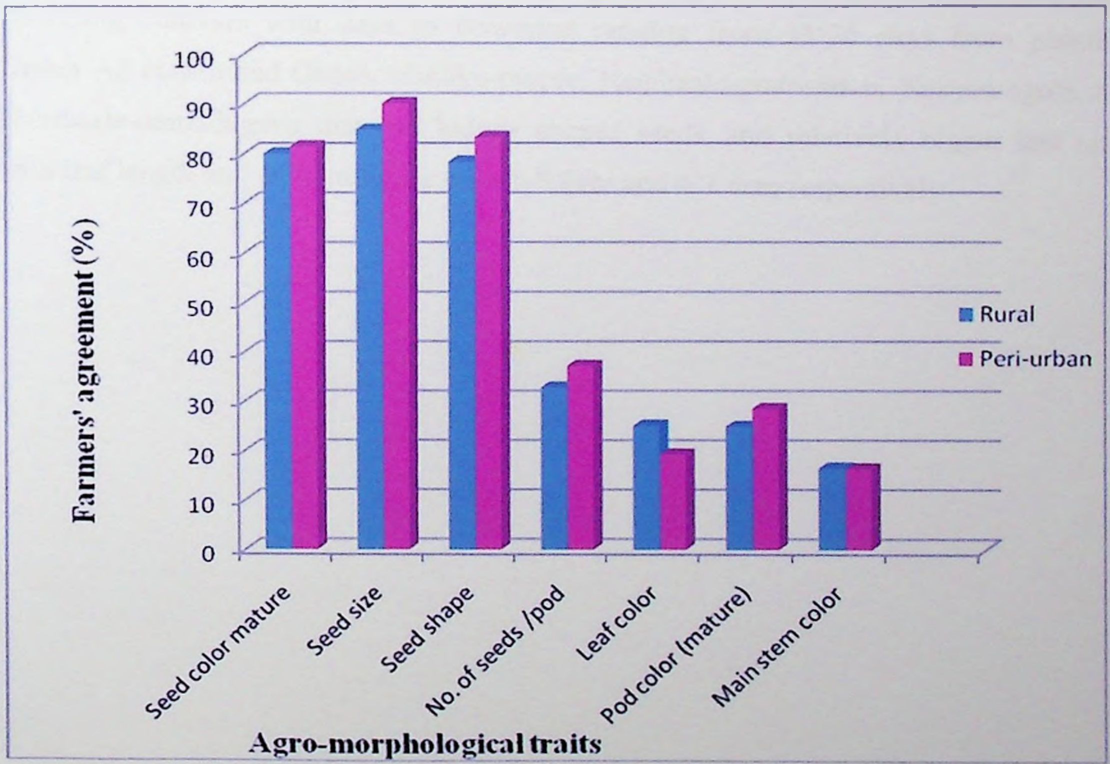

Figure 2: Farmers' consistency in identifying cultivars.

4.3.2 Morphological characterization of cultivars in the communities

Similar groupings were observed among cultivars in rural and peri-urban communities with two distinct groups A and B, where cluster A was the biggest with two sub-groups as presented by the dendrograms in Figures 3a and 3b. The two main groups were due to the differences in the growth habit where group A consisted of the indeterminate bush while cluster B group mainly consisted of the determinate bush. Group A was further divided into two sub-groups basing on seed size and shape with group A 1 being medium (1-1.5cm) in size and oval in shape, while group A 2 consisted mostly of large (1.6 - ≥2cm) seeded cultivars with a kidney seed shape. Group A mainly composed of 4 cultivars (Obumyufu (A), Obumyufu (C), Khaki/MP and Carolina except Obweru (A) appeared in the rural community grouping). These were small (0.5-0.9 cm) seeded cultivars with slightly curved pod shapes. Group A1 consisted of Yellow-omumpi , Obumyufu (B), Nambaale-omumpi, Kanyeebwa (A), Kanyeebwa (B), Obuddugavu and Kifudu. These mainly had oval seed shapes, green immature pods and were early flowering cultivars with days to flowering ranging from 33-36 days from planting. Group A2 constituted Obote, Mutiike-purple, Nambaale-omuwanvu, Nakyewogola, and Nambaale-omuddugavu that had kidney shaped seeds, and relatively bigger leaf sizes with leaf length and width ranging from 5-9.8cm and 4-7.5cm respectively.

Key for Cluster analysis and principal coordinate analysis

Name used for analysis	Cultivar name
Nakyew	Nakyewogola
Obumya	Obumyufu (A)
Obudug	Obuddugavu
Yelows	Yellow -omumpi
Kanyea	Kanyeebwa (A)
Nkolan	Nkoolankubalire
Khakmp	Khaki / MP
Obwela	Obweru (A)
Caroli	Carolina
Kifudu	Kifudu
Kanymb	Kanyeebwa (B)
Namgvu	Nambaale-omuddugavu
Obumyb	Obumyufu (B)
Namnyl	Namunye (L)
Obote	Obote
Mutifu	Mutikke-omumyufu
Obumfc	Obumyufu (C)
Nampii	Nambaale-omumpi
Namnvu	Nambaale-omuwanvu
Yelowl	Yellow-omuwanvu
Obwelb	Obweru (B)
Mutkep	Mutiike -purple
Namnye	Namunye(M)
Congoo	Congo

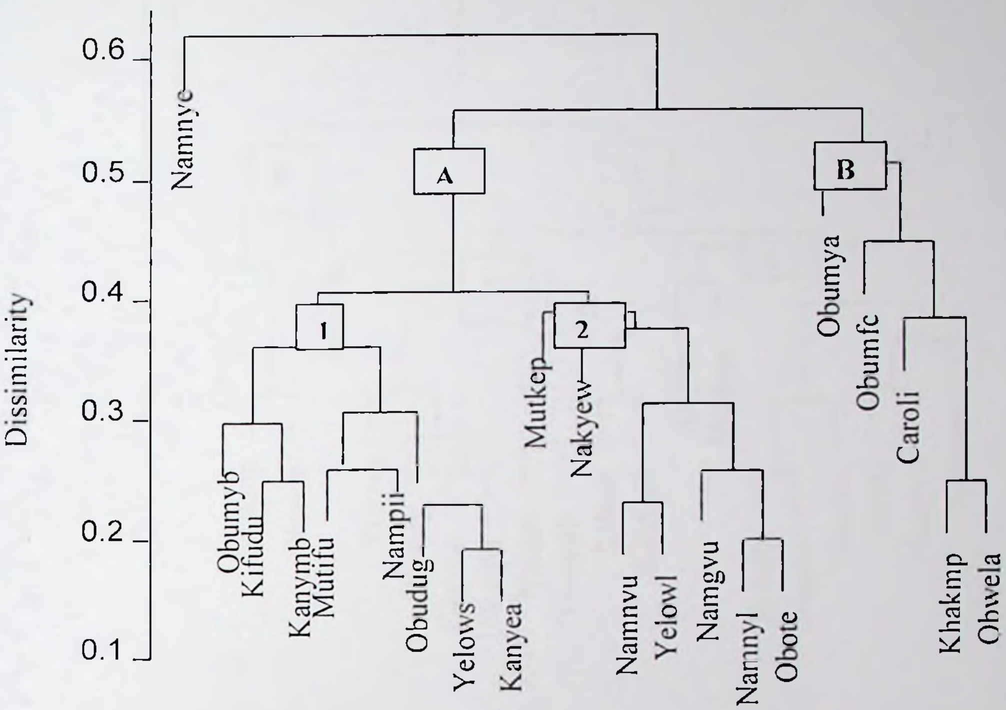

Figure 3a: Dendrogram showing the clustering of cultivars in the rural communities

Dendrogram pruned to major clusters

Mantel statistic based on Pearson's product-moment correlation (Mantel statistic r: 0.8436

Significance level: 0.001, Based on 999 permutations)

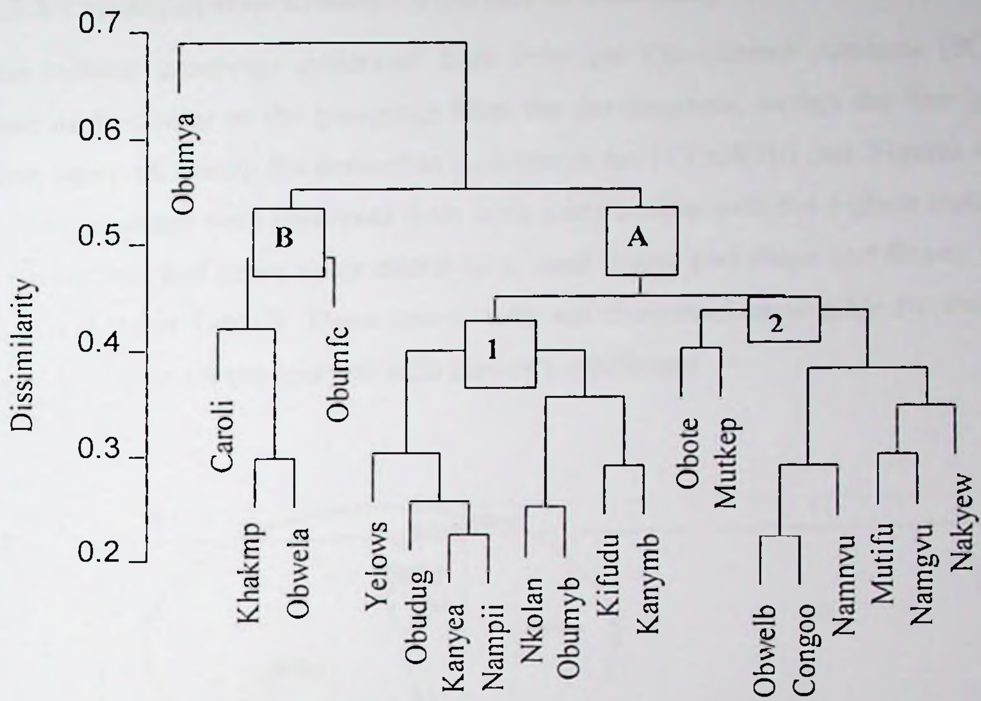

Figure 3b: Dendrogram showing the clustering of cultivars in the peri-urban communities
Dendrogram pruned to major clusters
Mantel statistic based on Pearson's product-moment correlation (Mantel statistic r: 0.8512 Significance: 0.001, Based on 999 permutations)

4.3.3 Principal coordinates Analysis of cultivars

The cultivar groupings generated from Principal Coordinates Analysis (PCOORDA) were quite similar to the groupings from the dendrograms, except the four groups that were observed among the peri-urban cultivars in the PCOORDA (see Figures 4a and 4b). Similar loadings were generated from both communities with the highest loadings being for immature pod color, color distribution, seed shape, pod shape and flower wing color as presented in Table 3. These concur with the characters responsible for the groupings generated from cluster analysis with Gower's coefficient.

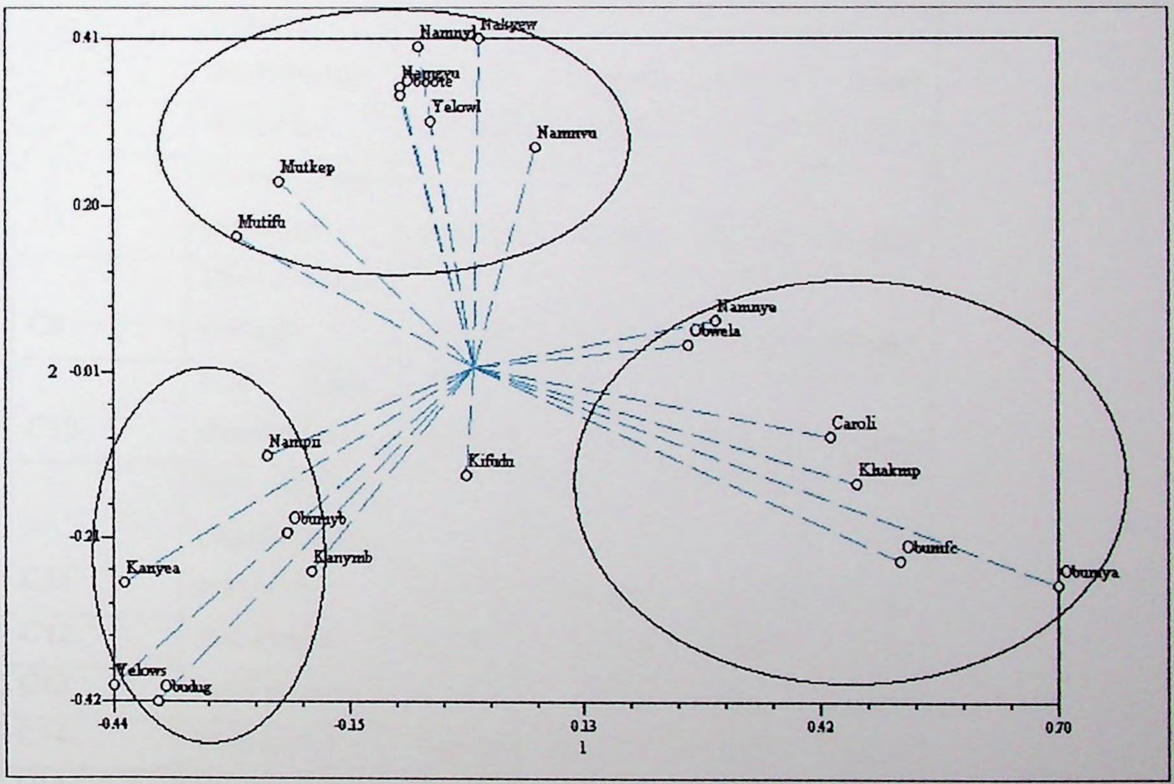

Figure 4a: Principal Coordinates Analysis of cultivars in the rural communities

Table 3: Character loadings from the Principal Coordinates Analysis

Character code	Character	PC 1	PC 2	PC 3	PC 4
C1	Cotyledon color	0.1598	0.0576	0.0394	0.1429
C2	Growth habit	0.0687	0.0324	0.0376	0.2812
C3	Hypocotyl color	0.0708	-0.2815	0.1745	0.0247
C4	Leaf color	0.0712	-0.2081	0.1421	0.0379
C5	Main stem color	0.0934	-0.2212	0.1604	-0.0036
C6	**Color distribution**	0.1107	**0.6054**	-0.1878	**0.487**
C7	Hairiness	-0.0366	0.3265	-0.1924	-0.4231
C8	Flower color (standard)	0.0128	0.053	-0.0448	-0.3622
C9	**Flower color (Wing)**	0.2661	0.0196	-0.0064	**-0.5007**
C10	**Pod color (immature)**	-0.8809	-0.027	-0.2355	-0.0239
C11	**Pod color at physiological maturity**	-0.1174	**-0.4446**	0.1225	0.2282
C12	**Pod shape**	-0.1081	0.289	**0.5907**	-0.1023
C13	**Seed shape**	0.2469	-0.254	**-0.6523**	0.0211
C14	Seed color	0.0611	0.0247	0.0306	0.1917
C15	Seed size	-0.0184	0.028	0.0214	0.0014

N.B: Bolded characters/figures contributed greatly to the grouping of the cultivars

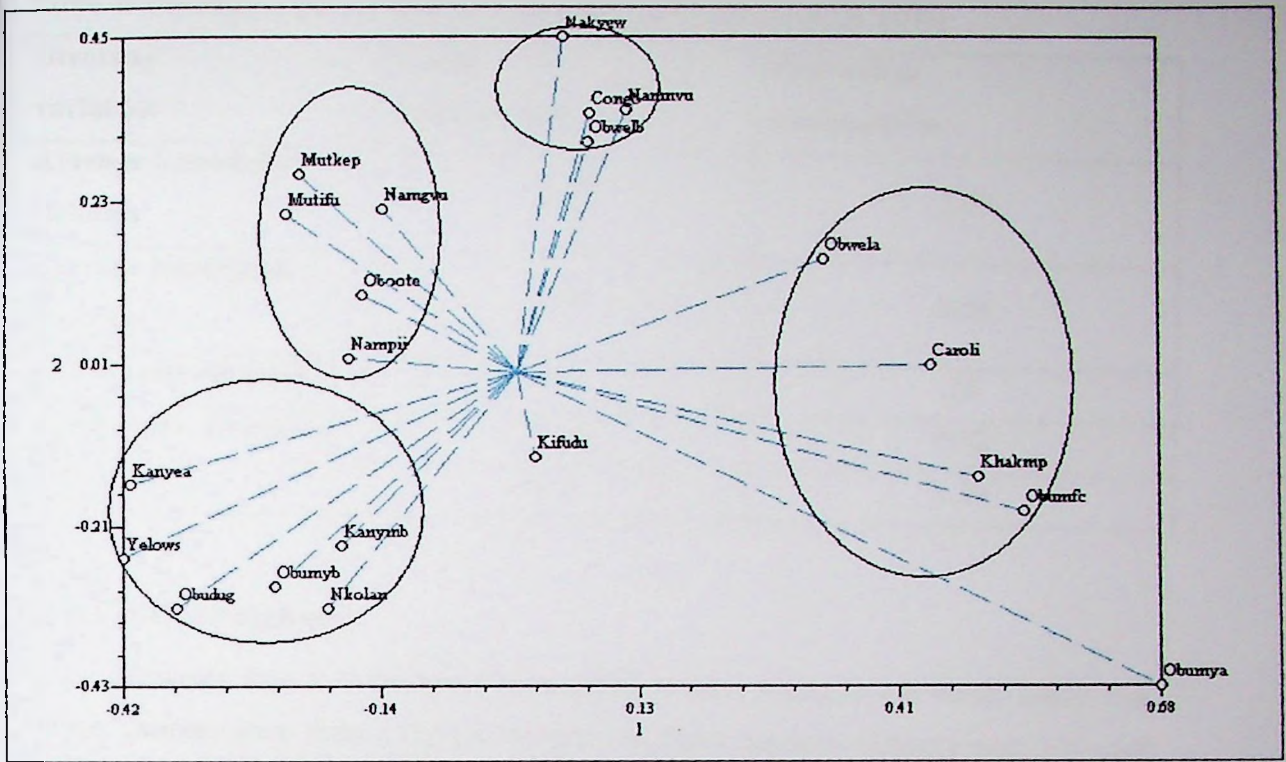

Figure 4b: Principal coordinates of cultivars in the peri-urban communities

4.4 Cultivar distribution in communities

4.5 Diversity estimates

There was no significant difference between the morphological diversity of the common bean in the peri-urban and the rural communities (ANOVA, $0.12=p>0.05$). This can be seen from the very slight differences between the diversity indices of the communities in Table 4. All the communities were managing an appreciable amount of diversity with equal cultivar richness of 21 cultivars and evenness of 0.81and 0.82 in rural and peri-urban communities, respectively.

Table 4: Diversity as estimated by Simpson's index of diversity (1-D)

Diversity variables	Rural communities	Peri-urban communities
Average household richness	3.55	3.63
Average household evenness	0.55	0.54
Community richness	21	21
Community Evenness	0.81	0.82
Divergence	0.32	0.35

4.5.1 Cultivar richness

A total of twenty four (24) common bean cultivars were found in the whole study. On average, farmers grew three cultivars because the mean on-farm richness was 3.55 and 3.63 in rural and peri-urban communities respectively. There was significantly(ANOVA, $0.03=p<0.05$) higer number of cultivars grown per household differed in peri-urban than in rural communities although both communities had an equal cultivar richness of 21 cultivars at the community level. The cultivar composition of the communities was quite similar with only 14.3% of the total cultivar richness being localized. The localized cultivars were; Nkoolankubalire, Obweru (B) and Congo were found in only the peri-urban communities while Yellow-omuwanvu, Namunye (L) and Namunye (M) were localized in the rural communities.

4.5.2 Cultivar Evenness

Generally, farmers in the peri-urban and rural both communities planted their cultivars in considerable proportions. There was appreciable cultivar evenness at farm level (0.55 in rural and 0.54 in peri-urban) and most especially at community level (0.81 in rural and 0.82 peri-urban). This indicated that farm diversity was not made up of one dominant cultivar and the other very rare thus any two samples drawn at random on farm level differed in kind in at least 50% of the cases while at the community level it differed in at least 80% of the cases. Divergence being a measure of the difference in the cultivar combinations across the communities was fairly impressive as it was 32% and 35% in rural and peri-urban communities respectively.

4.5.3 Diversity patterns of the common bean in the communities

There was equal cultivar richness and substantial evenness in both the peri-urban and rural communities as demonstrated by the rank abundance curves. (Figures 5a and 5b)
In all communities, farmers tended to grow some cultivars namely; Nambaale-omumpi, Nambaale-omuwanvu and Yellow-omumpi in relatively bigger proportions. These were the most highly ranked cultivars in both communities.

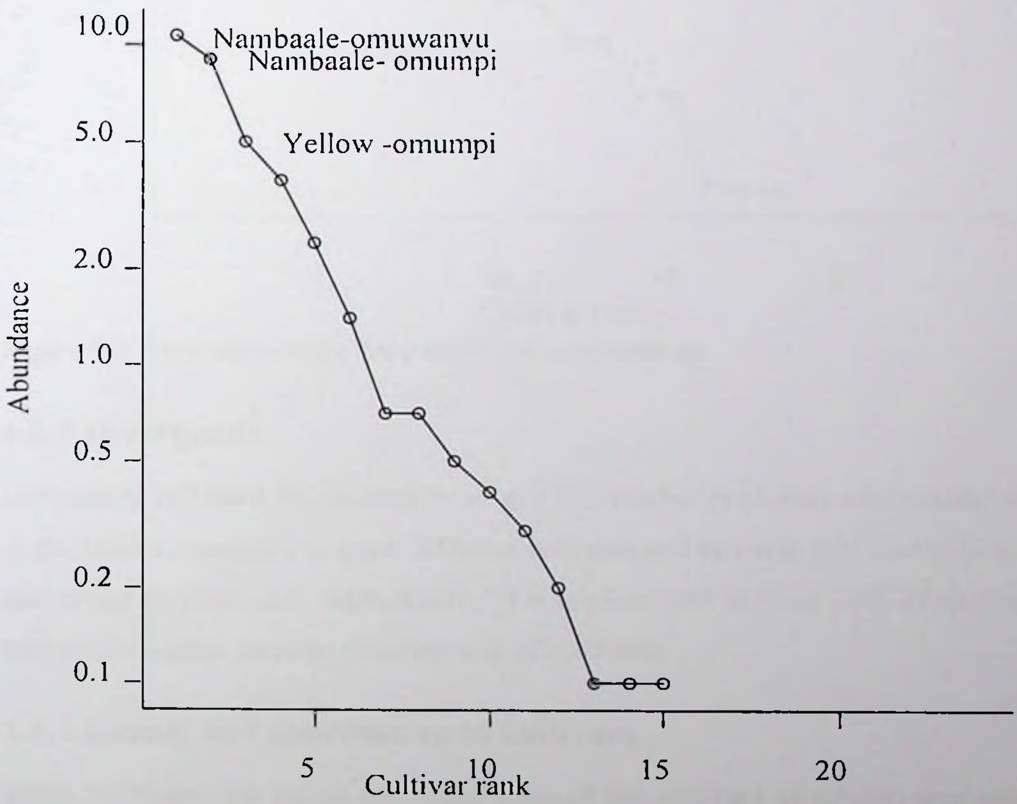

Figure 5a: Rank-abundance for rural communities

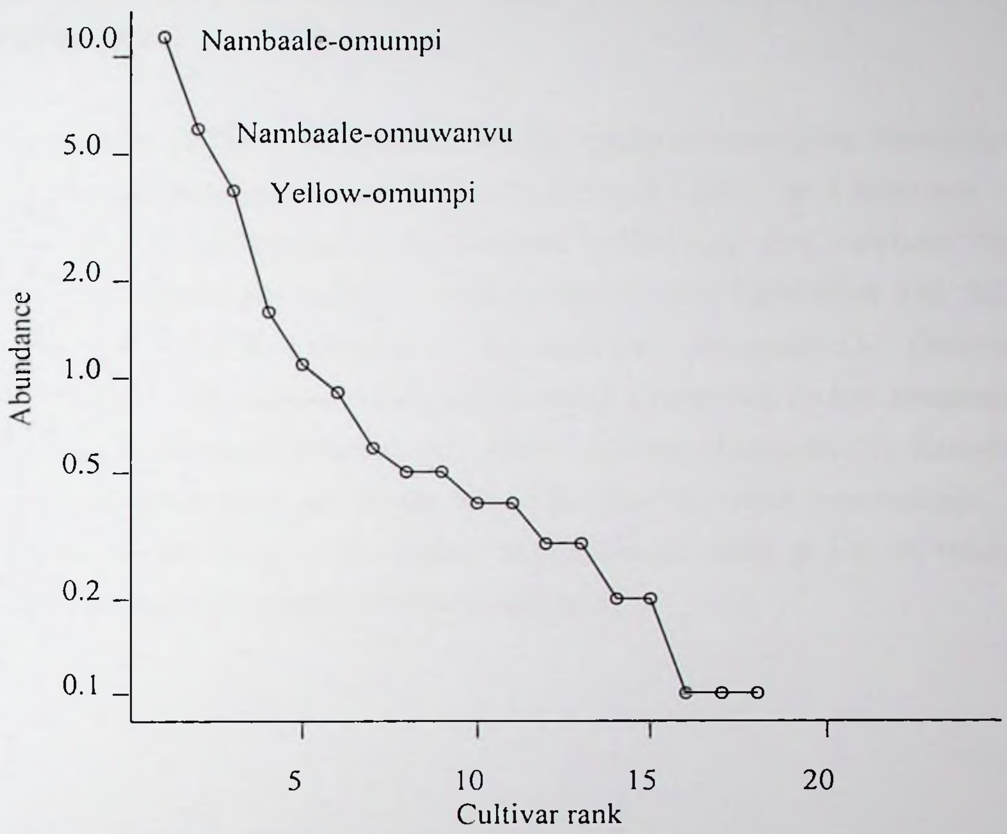

Figure 5b: Rank-abundance for peri-urban communities

4.5.3 Divergence

Divergence reflected the possibility of any two randomly chosen households/ farms with in the same community to grow different cultivars and this was 0.32 and 0.35 in rural and peri-urban communities respectively. This implied that at least 30% of all the farms in both communities manage different sets of cultivars.

4.4.1 Extent and distribution of cultivars

Table 5 presents the extent and distribution of the cultivars by relative area coverage and frequency of farmers growing the cultivar in both rural and peri-urban communities to the total area allocated to common bean in the study areas. Since the common bean is mostly

(70-83.4%) grown as an intercrop, precise cultivar coverage were obtained from households growing the crop in relatively small sized plots while standardized area estimates were obtained from all inter cropped systems depending on to the composition of the system.

As seen from Table 5, only three cultivars; Nambaale-omuwanvu, Nambaale-omumpi and Yellow-omumpi out of twenty one cultivars are grown on a large area by many households in the peri-urban communities while only five cultivars; Nambaale-omuwanvu, Nambaale-omumpi, Yellow-omumpi and Kanyeebwa (A) fall in this category in the rural communities. Four cultivars; Obumyufu (A), Obumyufu (B), Obumyufu (C) and Kanyeebwa (A) are grown on a large area by few households in the peri-urban communities whereas only three cultivars; Obumyufu (B), Kanyeebwa (B) and Yellow-omuwanvu are in the same cell from the rural communities. In both communities, the highest (14) number of cultivars are either grown on small area by many households or on small area few households.

Table 5: Extent and distribution of cultivars in the communities

ivar name	% of households	Percentage coverage of the cultivar to total area allocated to common beans (%)	Cultivar name	% of households	Percentage coverage of the cultivar to total area allocated to common beans (%)
Peri-urban community			Rural community		
e by many households					
baale-omumpi	68	39.80	Nambaale-omuwanvu	83	29.83
baale-wanvu	50	20.70	Nambaale-omumpi	58	25.37
ow -omumpi	35	13.40	Yellow-omumpi	45	14.04
			Kanyeebwa (A)	25	10.62
e by few households					
nyufu (C)	5	1.28	Obumyufu (B)	2	1.93
nyufu (B)	3	1.54	Kanyeebwa (B)	7	1.37
nyufu (A)	10	3.72	Yellow-omuwanvu	3	0.1
olankubalire	10	1.78			
ll by many households					
ike -purple	13	0.47	Obweru (A)	30	7.25

yewogola	17	0.83	Mutikke-omumyufu	10	0.21
)lina	33	1.79	Nakyewogola	10	0.41
ikke-omumyufu	17	1.01	Carolina	15	0.88
ki / MP	20	2.03	Khaki / MP	12	1.3
yebwa A	30	5.6	Obuddugavu	12	1.87
'eru (A)	20	3.2	Obumyufu (A)	18	3.97
ddugavu	13	1.27			
ıll by few households					
go	2	0.01	Obote	2	0.01
yeebwa (B)	2	0.08	Namunye (L)	2	0.01
ıdu	7	0.36	Nambaale-omuddugavu	3	0.06
'eru (B)	7	0.57	Namunye(M)	2	0.03
)te	2	0.16	Obumyufu (C)	3	0.14
ıbaale-ıddugavu	3	0.43	Mutiikepurple	7	0.16
			Kifudu	8	0.46

%s exceed 100 because one household/ farm could have more than one cultivar.

4.6 Farming management practices of the common bean

The farming system in all the study sites was characterized by traditional-non mechanized agricultural system that use little or no purchased agricultural in-puts. Farmers planted the seeds by hand; using a garden hoe. They lightly dig into the soil, chop and plant 2-3 seeds in a hole. The common bean is planted twice a year; Feb-March as the major season and August –September as a minor season, with the Feb-March season being more desirable because of more reliable rainfall. Table 6 presents the summary of the management practices in the common bean farming system of the study sites.

Table 6: Percentage distribution of management practices

Management practices	Rural		Peri-urban	
Cropping system	Number	Percentage	N	Percentage
Sole crop (beans only on a plot)	12	20	20	33.3
Maize intercropped with beans	39	65.0	34	56.7
Banana intercropped with beans	9	14.0	6	10.0
Cultivar Identification				
Seed color	51	85	45	75.0
Growth Habit	1	1.7	1	1.7
Flower color	8	13.3	14	23.3
Years spent with the seed				
<1year	4	6.7	5	8.3
1-5yrs	21	35.0	24	40.0
6-10yrs	24	40.0	24	40.0
>10yrs	11	18.3	7	11.7
Effect of growing the same cultivar composition on yield				
Reduction in yield	25	41.7	20	33.3
No reduction in yield	35	58.3	40	66.7
Crop husbandry				
Plant in fine soil and weed at 2-3 leaf stage	43	71.7	37	61.7
Plant in fine soil and weed at 4-5 leaf stage	17	28.3	23	38.3
Something missing here?				
Employ traditional practices to control pests and diseases	48	80	53	88.3
Apply pesticides	12	20	7	11.7

Farmers commonly grew the common bean as an intercrop with maize and bananas or in plots as a sole crop ranging from 0.0008-1.402 hectares. The main reasons provided by farmers for intercropping were to; diversify food production, efficiently use their land and to maximize labor inputs. 65.0% and 56.7% of farmers intercropped beans with maize while 14.8% and 10% intercropped beans with bananas in rural and peri-urban communities respectively. A relatively large percentage of farmers (20% and 10% rural and peri-urban respectively) grew common beans as a sole crop in a plot. All farmers in both communities planted beans on finely tilled land despite the variation in the control of weeds. 71.7% and 28.3% of farmers in the rural communities weeded their beans at 2-3 and 4-5 leaf stage respectively while 61.7% and 38.3% of farmers in peri-urban employed the same practices respectively.

Eighty percent of farmers in rural communities used traditional practices (applying ash and red pepper and urine) and 20% of farmers sprayed their common bean fields to control pest and diseases and improve on their yields. Despite the accessibility to pesticides and agro-chemicals, most farmers (88.3%) in peri-urban communities employ traditional practices and only 11.7% of farmers spray their common bean fields. In the rural communities, most households (40%) surveyed had spent 6-10 years with the same cultivar composition followed by farmers who spent 1-5 years(35.0%), those who had spent >10years (18.3%) and the least number of households (6.7%) had spent less than one year with their cultivar composition. In contrast, equal number of households (40.0%) had spent 1-5 and 6-10 years with the same cultivar composition in the peri-urban communities followed by farmers who had spent more than ten years with the same composition (11.7%) and similar to rural communities very few households had spent less than one year with their cultivar composition.

A great percentage of farmers (58.3% and 66.7%) in both peri-urban and rural communities respectively agreed that there is no profound effect in cultivating the same cultivars year after year if you rotate and finely till the fields. These farmers rotated the common bean in their fields purposely to restore soil fertility and to manage pests and pathogens. A substantial percentage (33.3% and 41.7%) in peri-urban and rural communities respectively argued that there is a reduction in the cultivar vigor and reduced yield irrespective of the rotation and fine fields thus there is need to change either the seed source or cultivar composition.

4.7 Seed system of the common bean in the communities

In the study the analysis of the seed system focused on the seed sources, selection and storage.

4.7.1 Seed sources

Farmer's seed sources were categorized into six classes; (i) bought from the market, (ii) bought from shops, (iii) bought from farmers, (iv) own stock, (v) free from farmers (gift) and (vi) NGOs (National or International). Table 7 presents a summary of the seed sources in sub-counties and communities.

Table 7: Summary of percentage seed sources in sub counties and communities

ed source	**Sub-counties**		**Communities**	**Sub-counties**		**Communities**
	Maanyi	Kikandwa	Average for rural communities	Kakindu	Busimbi	Average for peri-urban communities
ught from the arket	4.6	1.9	**3.3**	2.9	6.9	**5**
ught from ops	3.7	4.7	**4.2**	5.8	11.2	**8.7**
ught from rmers	13.9	9.4	**11.7**	1.9	0.9	**1.4**
vn stock	71.3	76.4	**73.8**	79.6	71.6	**75.3**
ee from other rmers/gifts	4.6	7.5	**6.1**	9.7	9.5	**9.6**
GOs/ ational/Internati al programs	1.9	0	**0.9**	0	0	**0**

Majority of the farmers (73.8% and 75.3%) in rural and peri-urban communities respectively sourced their seed from the previous harvest i.e. own stock. They always saved a portion for the next season irrespective of how good or bad the previous season was. Very few farmers obtained seed from NGOs (0.9%) and these were only found in rural communities. Generally a substantial percentage of farmers (6.1% and 9.6% in rural and peri-urban areas respectively) obtained seed as a gift from others in comparison to the farmers who bought seed from the market (3.3% and 5% in rural and peri-urban areas respectively). 4.2% of the farmers in rural communities bought their seed from shops in contrast to 8.7 % of farmers in peri-urban communities. More farmers (11.7%) in rural communities bought their seeds from other farmers compared to the 1.4% in peri-urban communities.

4.7.2 Seed flows

There were significant differences (ANOVA, $0.0002=p<0.05$) between communities and within communities in the mode of receiving and donating seed among farmers. The highest level of giving out seed to more farmers was observed among peri-urban farmers than the rural farmers. This is represented in Figure 6. Comparatively a substantial percentage of farmers (51.6%) in the peri-urban communities gave seed to at least one farmer in contrast to the 36.5% farmers in the rural community. Furthermore the peri-urban community had more farmers (20%) giving seed to at least three farmers as compared to those in the rural communities (15%).

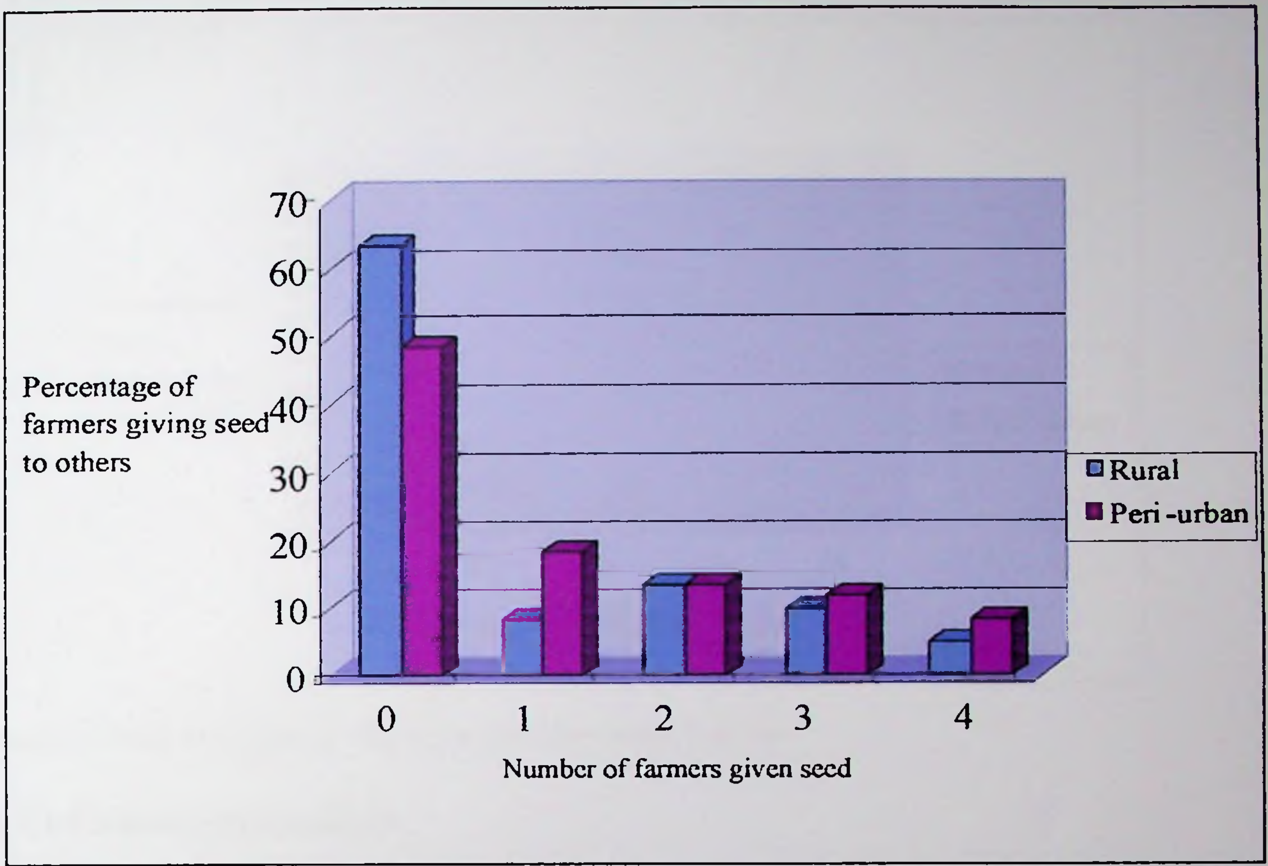

Figure 6: Extent of seed donation among farmers

Generally more farmers received seed from others in the peri-urban than in the rural community. Fifteen per cent of the farmers in the peri-urban communities received seed from at least one to utmost three farmers in contrast to 13% of the rural farmers who received seed from at least one to at most two farmers (Figure 7).

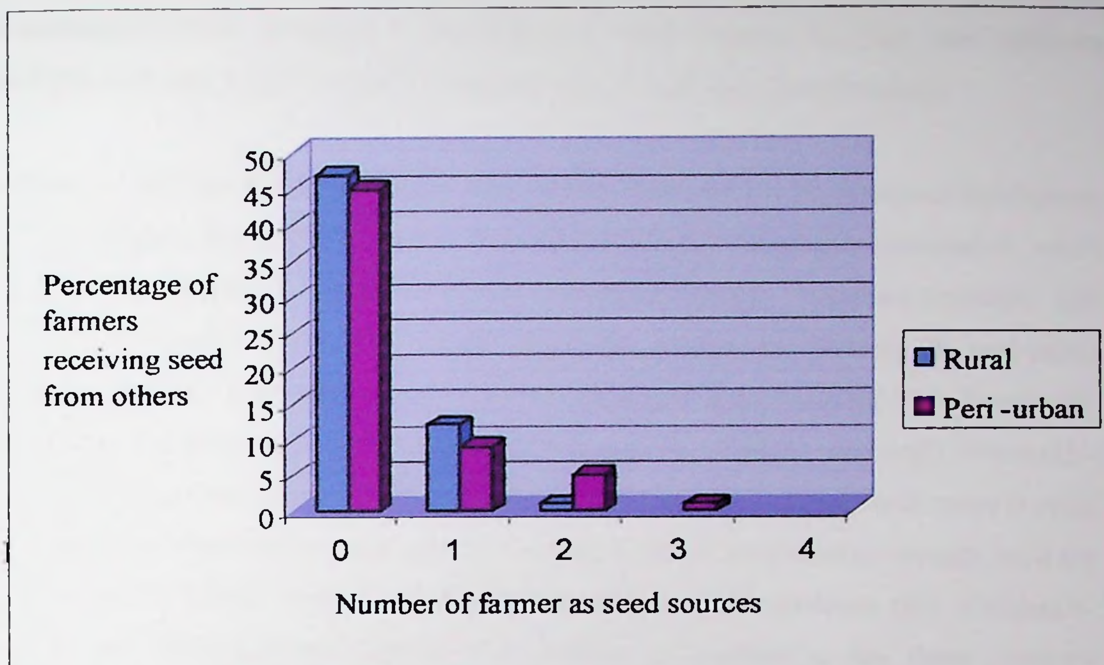

Figure 7: Number of farmers receiving seed from other farmers

4.7.3 Cultivar seed sources

Of the 21 cultivars found in each community only three cultivars i.e. Yellow(S), Nambaale-omumpi and Nambaale-omuwanvu had well distributed seed sources. Their seed lots could be obtained from nearly all the categorized sources in the study (Table 8). The seed sources for nine cultivars i.e. (Obumyufu (A), Obuddugaavu, Kifudu, Obumyufu (B), Namunye (L), Obote, Mutiike-omyuffu, Obumyufu (C) and Yellow-omuwanvu) in rural communities and seven cultivars i.e. (Obumyufu (A), Kanyeebwa (A) Kanyeebwa (A), Kifudu, Kanyeebwa (B), Nambaale-omuddugavu, Obote and Obwelu (B) in peri-urban communities were exclusively obtained from the farmers previous harvests (own stock). Other sources like free from farmers (gift) were solely important for Namunye (M) and Congo in rural and peri-urban communities respectively. Farmers also obtained seed as gifts for seven cultivars i.e. Mutiike-purple, Carolina Carolina, Nakyewogola, Obweru (A),Yellow-omumpi, Nambaale-omumpi and Nambaale-omuwanvu in rural communities while 10 cultivars i.e. Obudugaavu, Nkoolankubalire, Nakyewogola, Obweru (A), Carolina, Obumyufu (B), Mutiike-omumyufu, Obumyufu (C), Nambale-omumpi and Mutiike-purple in peri-urban communities. NGOs (National / International) were sources for just two cultivars Nambaale-omumpi and Nambaale-omuwanvu and in only rural communities.

Farmers in rural communities bought seed of five cultivars i.e. Nambaale-omuddugavu, Yellow-omumpi, Kanyeembwa (A), Nambaale-omumpi, Nambaale-omuwanvu while cultivars; Obudugaavu, Yellow-omumpi, Nkoolankubalire, Nambale-omumpi and Nambaale-omuwanvu were also bought from the market by farmers in peri-urban communities. Only four cultivars i.e. (Yellow-omumpi, Kanyeembwa (A), Nambaale-omumpi and Nambale-omuwanvu) and three cultivars i.e. (Yellow -omumpi), Nambaale-omumpi and Nambale-omuwanvu) were sourced from the shops by some farmers in rural and peri-urban communities respectively. Farmers in rural communities bought seed for six cultivars i.e. (Yellow-omumpi), Khaki/MP, Carolina, Kanyeebwa (B), Nambaale-omumpi, and Nambaale-omuwanvu) from farmers in contrast to the three cultivars (Mutiike-omumyufu, Nambaale-omumpi and Nambaale-omuwanvu) for farmers in peri-urban communities.

Table 8: Percentage of farmers obtaining seed of particular cultivars from the studied sources

Cultivars	Bought from the market		Bought from shops		Bought from farmers		Own stock		Free from other farmers		NGOs/ National/International programs	
	Rural	Peri-urban	Rural	Peri-urban	Rural	Peri-urban	Rural	Peri-urban	Rural	Peri-urban	Rural	Peri-urban
Nakyewogola	0	0	0	0	0	0	83	90	17	10	0	0
Obumyufu(A)	0	0	0	0	0	0	100	100	0	0	0	0
Obuddugavu	0	13	0	0	0	0	100	24	0	63	0	0
Yellow-omuwanvu	7	14	4	19	22		59	67	7	0	0	0
Kanyeembwa (A)	7	0	7	0	0	0	87	100	0	0	0	0
Nkoolankubalire	0	17	0	0	0	0	0	67		17	0	0
Khaki / MP	0	0	0	0	14		86	0	0	0	0	0
Obweru (A)	0	0	0	0	0	0	89	55	11	45	0	0

Carolina	0	0	0	0	11		67	90	22	10	0	0
Kifudu	0	0	0	0	0	0	100	100	0	0	0	0
Kanyeebwa (B)	0	0	0	0	25	0	75	100	0	0	0	0
Nambaale-omuddugavu	50	0	0	0	0	0	50	100	0	0	0	0
Obumyufu (B)	0	0	0	0	0	0	100	67		33	0	0
Namunye (L)	0	0	0	0	0	0	100	0	0	0	0	0
Obote	0	0	0	0	0	0	100	100	0	0	0	0
Mutiike-omumyuffu	0	0	0	0	0	10	100	70	0	20	0	0
Obumyufu (C)	0	0	0	0	0	0	100	67		33	0	0
Nambaale-omumpi	3	7	9	17	26	2	54	71	6	2	3	0

Nambaale-omuwanvu	4	10	8	27	14	2	70	60	2		2	0
Yellow-omuwanvu	0	0	0	0	0	0	100	0	0	0	0	0
Obweru (B)	0	0	0	0	0	0	0	100	0	0	0	0
Mutiike-purple	0	0	0	0	0	0	50	88	50	13	0	0
Namunye (M)	0	0	0	0	0	0	0	0	100	0	0	0
Congo	0	0	0	0	0	0	0	0	0	100	0	0

4.7.4 Farmer's selection criteria

In both communities, seed selection was a gradual process as it first involved farmers' selection of a set of cultivars among those in the system and later selection for good quality and healthy seeds from the preferred cultivar to be planted for the next generation. Farmers in both communities unanimously agreed that the quality of seed was judged basing on its potential to regenerate. They selected their cultivars basing on a number of criteria; market demand, tolerance to weather changes, tolerance to storage pests, taste, cook-ability, yield and growth rate while seed quality was mainly based on healthy (non-diseased, with no weevils, non-wrinkled) and distinct colour. Seed selection was always done at storage and planting time.

4.7.4.1 Selection criteria of the cultivars

Of the seven criteria examined in the study, various sets of cultivars were prioritized for each criterion in both communities. Table 9 presents the cultivar performance per selection criteria. Generally similar sets of cultivars per criterion were obtained from the communities irrespective of the order of priority.

Table 9: Prioritization of cultivars per selection criteria in the communities

Selection criterion	Cultivar name	Rank	Cultivar name	Rank
	Rural-communities		**Peri-urban communities**	
Market demand	Kanyeebwa (A)	10	Yellow-omumpi	9
	Yellow-omumpi	7	Kanyeebwa (A)	8
	Nambaale-omumpi	7	Nambaale-omumpi	7
Taste	Yellow-omumpi	8	Yellow-omumpi	8
	Nambaale-omumpi	5	Carolina	8
	Obumyufu (A)	5	Nambaale-omumpi	7
Tolerance to weather changes	Nambaale-omuwanvu	10	Nambaale-omuwanvu	8
	Khaki / MP	5	Obumyufu (B)	5
Growth rate	Yellow-omumpi	9	Kanyeebwa (A)	9
	Nambaale-omumpi	9	Nambaale-omumpi	8
	Kanyeebwa (A)	5	Yellow-omumpi	7
Tolerance to storage pests	Nambaale-omuwanvu	8	Nambaale-omuwanvu	9
	Obudugavu	5	Carolina	5
	Khaki /MP	5		
Cook- ability	Nambaale-omumpi	9	Nambaale-omumpi	8
	Obweru (A)	9	Yellow-omumpi	7
	Yellow-omumpi	6	Obweru (A)	5
Yield	Nambaale-omuwanvu	5	Nambaale-omuwanvu	7
	Obuddugavu	5	Carolina	7
	Obumyufu (A)	5	Obuddugavu	5

N.B: Ranks ranged from 10-1 as the level of importance was decreasing

Regarding market demand, farmers in both communities prioritized similar sets of cultivars (Kanyeebwa (A), Yellow-omumpi and Nambaale-omumpi) despite the differences in the order of priority where Kanyeebwa (A) and Yellow-omumpi ranked highest in rural and peri-urban communities respectively. Considering taste, Yellow-omumpi ranked the best in both communities. Carolina also obtained the same rank as Yellow-omumpi in peri-urban communities and followed by Nambaale-omumpi while the farmers in rural communities expressed similar preference for Nambaale-omumpi and Obumyufu (A).

Nambaale-omuwanvu ranked the best as regards tolerance to weather changes in both communities followed by Khaki / MP and Obumyufu (B) in rural and peri-urban communities respectively. Looking at Growth rate, farmers in both communities prioritized similar cultivars despite the differences in the order of priority. The farmers in rural communities expressed equally higher preferences for Yellow-omumpi and Nambaale-omumpi thus giving Kanyeebwa (A) relatively lower rank while the farmers in peri-urban communities preferred Kanyeebwa (A) followed by Nambaale-omumpi and Yellow-omumpi.

Cultivar Nambaale-omuwanvu was ranked highest in relation to tolerance to storage pests in both rural and peri-urban communities. Both cultivars Obuddugavu and Khaki / MP were equally preferred after Nambaale-omuwanvu by farmers in the rural communities as those in the peri-urban communities preferred Carolina Carolina. Similar cultivars; Nambaale-omumpi, Obweru (A) and Yellow-omumpi were preferred as regards cook-ability. Nambaale-omumpi was highly ranked followed by Obweru (A) and Yellow-omumpiin rural and peri-urban communities. Looking at yield, all the cultivars (Nambaale-omuwanvu, Obuddugavu and Obumyufu (A) were equally preferred by the farmers in the rural communities while the farmers in peri-urban communities ranked the quite similar cultivars in this order; Nambaale-omuwanvu being highly preferred to Carolina and Obuddugavu.

4.7.4.2 Relative importance of the cultivars across all criteria

Table 10 shows the overall relative importance of the cultivars across the selection criteria in the two communities. Similar to the prioritization per criterion, the cultivar sets for the overall relative importance across selection criteria are quite alike in both communities. The highly ranked cultivars across criteria in the rural communities include; Nambaale-omumpi, Nambaale-omuwanvu and Yellow-omumpi while the peri-urban farmers appreciated Nambaale-omuwanvu, Yellow-omumpi , Nambaale-omumpi and Carolina.

Table 10: Relative importance of the cultivars across all criteria in the communities

Most important cultivars across criteria			
Rural	**Ranks**	**Peri-urban**	**Ranks**
Nambaale-omumpi	38	Nambaale-omuwanvu	40
Nambaale-omuwanvu	36	Yellow-omumpi)	38
Yellow (S)	31	Nambaale-omumpi	38
		Carolina	26
Moderately important cultivars across criteria			
Kanyeebwa (A)	19	Kanyeebwa (A)	23
Obumyufu (A)	17	Obumyufu (A)	11
Carolina	17	Obuddugavu	11
Obweru (A)	17		
Khaki / MP	16		
Obuddugavu	13		
Least important cultivars across criteria			
Obweru (B)	4	Khaki / MP	8
Mutiike-purple	3	Obweru (A)	5
Mutikke-omumyufu	1	Obumyufu (B)	5
		Mutiike-purple	4
		Nambaale-omuddugavu	1

N.B: The higher the rank the most important the cultivar

Farmers in the rural communities had the biggest (six cultivars) set of moderately important cultivars across criteria and these comprised; Kanyeebwa (A), Obumyufu (A), Carolina, Obweru (A), Khaki / MP and Obuddugavu in contrast to the three cultivars (Kanyeebwa (A), Obumyufu (A) and Obuddugavu) in the peri-urban communities. Looking at the composition of moderately important cultivars, the farmers in the rural and peri-urban areas seem to highly concur with each other as regards the importance of the common three cultivars (Kanyeebwa (A), Obumyufu (A) and Obuddugavu).

Despite the similarity in most of the prioritized categories, the composition of the least important cultivars across criteria is quite different in both communities except Mutiike-purple that appears in all the communities. Three cultivars (Obweru (B), Mutiike-purple , and Mutikke-omumyufu) were categorized as least important across all criteria in the rural community while a set of five cultivars (Khaki / Mp, Obweru (A), Obumyufu (B), Mutiike-purple and Nambaale-omuddugavu) fell into the same category as prioritized by the farmers in the peri-urban communities.

4.7.4.3 Seed selection for quality

Both rural and peri-urban farmers selected their seed prior to planting as they have all learned from experience that a selected seed lot performs higher than a non-sorted one. Generally most farmers agreed that a good seed lot should be healthy with distinct seed color, seed size and growth habit. Table 11 shows the seed selection measures as employed by the farmers in the study communities.

Table 11: Farmers selection measures for good quality seeds

Selection practices	Communities	
	Rural (%)	Peri-urban (%)
Selection measures		
1a. Plants in the field	16.7	8.3
1b. At storage	83.0	91.7
2a. Distinct seed color	88.0	95.0
2b. Faint seed color	12.0	5.0
3a. Healthy seeds(with no weevils and non-shriveled)	98.0	94.0
3b. Semi-wrinkled and shriveled	2.0	6.0
Who sorts		
Women	90.0	88.0
Men	10.0	12.0

There were significant differences (chi square, 1df, 26.67=p>0.05) in farmers selection measures. Most farmers (83% and 91.7%) in rural and peri-urban communities selected their seed lots at storage as the sowing season was approaching in contrast to those who marked and selected their seeds from the field (16.7% in rural and 8.3 % in peri-urban). Only 5% and 12% of the farmers in peri-urban and rural communities respectively could take chances to plant seed with a faint color in relation to its distinctive color and the highest percentage could not risk and planted only seeds with a distinct color (95% and 88% in peri-urban and rural communities). Almost all farmers (98% in rural and 94% in peri-urban) planted healthy seeds with no weevils and non shriveled. As regards seed lot sorting, women were principally the major selectors in both communities (90% and 88% in rural and peri-urban communities respectively) in comparison to men farmers (10% in rural and 12% in peri-urban).

4.7.5 Seed Storage

Before storing their seed, all the farmers in both rural and peri-urban communities first threshed the pods and then employed various practices to level the moisture content, temperature, and relative humidity that would adversely affect the action of fungi and insects thus ensuring healthy and viable seed lots. Table 12 shows farmers' storage practices as used in the two communities.

Table 12: Farmers' storage practices of the common bean.

Practices	**Communities**	
	Rural	**Peri-urban**
	Percentage	Percentage
Practices prior to seed storage		
Thresh pods, winnow and dry subsequently	18.3	31.7
Thresh pods, do not winnow and dry subsequently	31.7	15
Thresh pods, winnow and add pesticides	8.3	6.7
Thresh pods, do not winnow and add pesticides	1.7	0
Thresh pods, winnow and add other additives and dry subsequently (e.g. *Capsicum* spp, *Tephrosia* spp, soil from an anti-hill, paraffin, Banana juice)	36.7	38.3
Thresh pods, do not winnow and add other additives and dry subsequently (e.g. *Capsicum* spp, *Tephrosia* spp, soil from an anti-hill, paraffin, Banana juice)	3.3	8.3
Storage materials		
Big metallic tins	40.7	18.7
Sacs	23.5	60.8
Old Jerricans	35.8	20.5
Placement of the storage material with seeds		
On the floor	5.4	5
On a piece of wood(25-30cm) above the floor	89.3	86.1
Hanged ≥50cm above the floor	5.3	8.9

Generally majority of the farmers (36.7% in rural and 38.3% in peri-urban) finely winnowed their seeds, added some additives like red paper (Capsicum spp), concentrated Banana juice (Musa spp), Omujjaaja (Ocimum gratissimum), Muluku (Tephrosia vogellii), ash and others paraffin. Of all, these additives, most (30-60%) farmers used either red pepper, ash or both in all the communities. A substantial percentage (31.7%) of farmers in the rural communities stored their seeds with the husks and dried subsequently to conserve the seed's viability in contrast to the 15% of the farmers in peri-urban communities who employed similar practices. Addition of pesticides either after winnowing or without winnowing was highly employed by the farmers in the rural communities (8.3% and 1.7% respectively) as compared to the (6.7% and 0% respectively) in the peri-urban communities. The pesticides commonly used were ambush and rocket.

There were no significant differences (Chi-square, 2df, $2.8=p<0.05$) in the seed storage materials used by the rural and peri-urban farmers. Farmers in the rural communities used big metallic tins (Edebbe) (40.7%), old jerricans (35.8%) and sacs (23.5%) while those in the peri-urban communities mostly used sacs (60.8%), old jerricans (20.5%) and only 18.7% used tins (Edebbe). There were significant differences (Chi-square, 2df, $20.05=p>0.05$) in the placement of the storage materials between the communities. Most farmers (89.3% in rural and 86.1% in peri-urban) placed their seeds at least above 25cm from the floor, a few stored / placed them either at the floor (5.4% in rural and 5% in peri-urban) or hanged them $\geq$100m above the floor (5.3% in rural and 8.9% in peri-urban areas).

DISCUSSION AND CONCLUSION

5.1 Discussion

The farmers in both communities maintained appreciable amount of the common bean diversity as portrayed by Simpson's index of diversity although most cultivars were grown on relatively small proportions as clearly portrayed by the rank abundance curves the four cell analysis. Equal cultivar richness in both communities expressed the zeal for all the farmers to maintain a variable amount of diversity probably owing to the ever changing needs and preferences like taste, market demand and environmental conditions. This finding is also crucial as it expresses the active engagement of the peri-urban communities in the growing and managing diverse populations of the common bean probably as means in diversifying household incomes. From the results, farmers in the peri-urban communities maintained a higher number of cultivars per house-hold than their counterparts in the rural communities. This could be influenced by the access of peri-urban farmers to markets that serve as sources of new cultivars.

Both rural and peri-urban communities had low cultivar evenness as presented by the steep rank-abundance, four cell analysis and the Simpson's index of diversity. A few cultivars (just 14.3%) of the total richness were grown on relatively larger areas than other cultivars. Both systems were dominated by only three cultivars; Nambaale-omuwaanvu, Nambaale-omumpi and Yellow-omumpi at the expense of other cultivars. These cultivars were grown on large areas and by many households mainly due to their over all performance as examined and ranked by the farmers.

A substantial number of cultivars were grown by either few households on a large scale or by many households on a small scale and by few households on small scale. These cultivars had relatively low over-all rankings as examined for the selected set of criteria but the farmers kept them in their systems. Farmers argued that most of these cultivars were very good at a particular criterion to a degree that cannot be met by other cultivars.

This shows that farmers were not content with just a few cultivars that ranked highly for all the criteria thus expressing their need for diversified systems.

Further more the results could be reflecting probable genetic erosion as the majority of the cultivars are either managed by either few households or many households in small proportions. This situation could also be likened to Rijal's (2007) reasoning that farmers may maintain some cultivars in small proportions for specific reasons thus they will continue to exist in the system or these cultivars could be possibly grown more widely if demand is created through improved access to information and planting materials locally, ultimately restructuring the present diversity as cultivars grown on the large scales could be greatly affected. On-farm diversity is greatly if not wholly defined by the farmers' decisions as directed by the socio-economic needs. The choices that farmers make in maintaining a particular number of cultivars in varying or equal proportions directly structures the diversity in any given community.

Farmers' consistency in identifying and naming cultivars was highly variable among traits used and communities, and the levels of consistency depended upon the trait in question. The highest levels of consistency were observed when highly distinctive traits like mature seed color, size and shapes were used. This was further confirmed by the names given to most cultivars as they could clearly reflect these traits Obwelu (small white), Obumyufu (small red), Obuddugavu (small black), Kifudu (tortoise like), Namunye (insect), Nambaale-omuwanvu (long Nambaale) and Nambaale-omumpi (short Nambaale).

Farmers' classifications of cultivars were largely in agreement with the results obtained from morphological characterization. Just like the farmers, the groupings generated by cluster analysis were based on characters like seed size and shape while these similar cultivar groups were produced by the Principal Coordinate Analysis that in addition to seed shape was based on other traits like immature pod color, pod shape, flower color and color distribution. This therefore affirms that standardized farmers' names of the common bean cultivars were reliable management units of diversity. There were generally low variations in the farmer's names since the study was in the same district with the majority of farmers belonging to one ethnic group.

From this study, farmers' selection criteria seem to define the cultivar composition of the communities. Through selection, farmers ensured that they always pass on the best genes to the next generation. Farmers had profound reasons why they grew particular cultivars in specific proportions. Cultivars with good performance across selection criteria (market demand, tolerance to weather changes and storage pests, growth rate, yield and cookability) tended to dominate farmers' fields at the expense of the cultivars that were only very good at specific criteria. This conforms to Jarvis *et al.* (2000) who noted that studying the criteria or management practices farmers use to select characteristics for the next generation can help one ascertain the extent selection of seeds for the next generation limits gene flow.

Cox and Wood (1999) also state that farmers' decisions as influenced by economic, social, cultural, natural and historical factors, are the principal determinants of crop diversity. In addition Bellon (1996) stressed that the process of variety selection can be seen as the farmer's decision to maintain, incorporate or discard a variety to be planted in a particular growing season ultimately shaping the diversity present in farmers' fields. Having selected the cultivars for the next generation, farmers further ensured that they planted seeds of the best quality. This is evident in Table 13 where most farmers selected healthy seeds with a distinct seed color and size from the seed lots. In this way farmers passed on the best genes with better competitive potential to survive all the challenges in the ecosystem.

Farmers were the main sources of their seed for the next generation although the results showed a tremendous decline in the percentages as compared to the previous studies. David (2003) stated that Ugandan farmers, and indeed most small-scale farmers in other African countries, rely largely on home saved bean "seed" (actually seed saved from previous seasons) because of the self-pollinating nature of beans there are no major variations between the original seed lot and new seed lot . A high percentage of farmers, 73.8% and 75.3% in rural and peri-urban communities respectively, used their own stock as seed source for the next generation. This percentage is significantly lower than 84% and 95% of farmers reported by David (2003) in central Uganda; Mubende district. Buying seed from other farmers within the same community was second in importance among the farmers in the rural communities in contrast to the gifts (free from other farmers) among farmers in the peri-urban communities. This was probably due the fact that most peri-urban farmers are encouraging others to actively engage in agriculture by giving small samples of seed to others which is quite different among the rural communities where every one seems to depend on agriculture and seed is taken as a capital that cannot be given out for free. This concurs with what Sperling and Loevinsohn (1993); David and Sperling (1999) David (2003) who documented, that there is a decline in the amount of seed bean farmers obtain from other farmers and they suggested some degree of negative correlation between commercialization and gift giving.

Shops and markets were of great importance among farmers in the peri-urban than those in the rural communities possibly due to the ease in accessing them and may be the peri-urban farmers are richer. This is due to the suitable conditions and infrastructure in the peri-urban communities that favor the sustainability of markets and shops. Other studies have reported markets as substantial sources of genetic diversity (David, 2001, David and Sperling, 1999) and from this study, farmers in the peri-urban had a significantly higher number of cultivars per house hold than their counterparts in rural communities because they are probably have improved access to markets and shops that probably serve as sources of seed to these farmers.

David (2001) noted that commercial seed sources (shops and markets) were next in importance after farmers' own seed in Uganda although the source ranks low in terms of quality. David and Sperling (1999) reported that farmers in Uganda, Rwanda, Burundi, and the Democratic Republic of the Congo (DRC) ranked seed purchased from shops or markets lower in quality than their own and that of other farmers, and consider it potentially riskier to sow. The history of the seed seemed to be crucial among farmers as through seasons different farmers subject their seed to different selection and storage practices which are not usually dispatched with a newly acquired seed lot. Results from this study also show that most farmers tended to keep seed from any origin for as long as 5-10 years. Farmers reasoned that the change in seed management practices greatly affects their yields for example if a farmer continuously sprays and treats his seed with chemicals and then sells seed to another farmer who uses traditional practices, the performance of the seed lot usually depreciates.

From the results, it is quite clear that seed net works are changing considerably, Since previous studies reported 80-95% of farmers in bean farming communities to be relying on own seed (David, 2003). A substantial reduction in the number of farmers depending on their own stock as source of seed for the next generation is an indication of stress with in the seed system as the situation renders almost 30% of the farmers prone to lack seed for the next season. Farmers attributed this to erratic environmental changes that greatly affect their produce in addition to the increased standards of living that force them to consume and sell all their produce.

Farmers in both communities employed a number of practices as a measure in ensuring quality seed at the planting season. Most of the practices were traditional (applying red pepper, Paraffin and ash to the seeds) and farmers reported satisfactorily about them. Farmers' seed storage practices in the study were in line with McGuire (2001) findings; farmers expressed valuable awareness about the storage pests and diseases and hence apply efficient mitigation measures. Most farmers mentioned bruchids and fungal infestations as the major storage problems; this therefore calls for modifications in farmers' storage practices as a way of improving seed quality and quantity in the communities.

All the management practices employed by the farmers in both communities were backed with concrete reasons that were aiming at revitalizing the soils, pest and weed control and also safeguards against environmental changes. Practices like timely planting could probably guard against probable changes in the environmental conditions while early weeding reduced competitors and ensured higher yields as intercropping and crop rotations revitalized the soils and checked pest and disease infestations. Most farmers (79% in rural and 66.7% in peri-urban) intercropped their common bean fields mainly to optimize production and labor costs, guard against crop failure in variable environmental conditions and to enhance supply of nutrients in the soil as almost all believed that legumes like common beans revitalize soils.

The farmers who grew the beans as a sole crop were basically growing for commercial purposes but also believed in spatial and temporal rotation of their fields as a way of conserving the soils for high yields. These practices were also documented by in David (1999) the bean farming system of other communities while the efficiency of spatial and temporal crop rotations were recommended within organic farming as a mechanism in revitalizing soils and in control of pest infestation as seen in Lampkin (1990) and IFOAM (1998). Other works by McLaughlin and Mineau (1995), Altieri (1999) and Mäder *et al.* (2002) also credited farmers' practices like intercropping, mixed land use in time and space, and organic manuring in enhancing diversity of flora and fauna in and above soil. This reflects the wealth of knowledge embedded in farmers' management practices in perpetuating the common diversity in their fields.

In conclusion, both rural and peri-urban communities manage substantial amounts of the common bean diversity despite the differences in the cultivar proportions that could probably lead to the disappearance of some cultivars that are managed by very few households and on small area. This also depicts an impressive increase in the level of diversity managed by peri-urban communities to the extent that one can't clearly differentiate between the levels managed by the ever thought highly diversified rural communities

There was also an expression of a seemingly stressed seed system within the communities as a great percentage (almost 30%) of farmers was relying on unreliable sources of seed. The sources are unreliable because the farmers were always uncertain of the availability of the preferred seed in type (specific cultivar), quality and quantity. Both communities employed similar management practices in perpetuating the diversity although differences existed among farmers within communities. These practices seemed efficient although farmers had some limitations like adaptation of the storage pests to the practices hence one had to employ alternative strategies.

RECOMMENDATIONS

Basing on the results from this study it is quite evident that valuable diversity of the common bean is being carefully managed by the farmers in both rural and peri-urban communities. Despite their tireless effort in perpetuating this diversity, most cultivars are probably at the verge of disappearing. This therefore calls for efficient interventions and collaborations among farmers, scientists, socio-economists and policy makers to design ways of restructuring the conservation of the common bean diversity in farming communities. This can probably be achieved through participatory approaches that wholly appreciate the farmers' effort and knowledge in ensuring that this diversity continuously evolves.

There is need to put in place incentive mechanisms that can encourage a section of the farming community to continue conserving the diversity on-farm to ensure its continued evolution and adaptation to changing biotic and a biotic factors. Alternative strategies also need to be put in place and these include; establishment of community gene banks to improve local seed systems, strengthening participatory crop improvement that will add value to the least grown cultivars.

Finally there is need for similar studies regarding distribution of the diversity and the dynamics of other Plant Genetic Resources (PGR) in the farming communities of Uganda so that better conservation and optimal utilization measures can be designed and implemented.

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APPENDICIES

Appendix 1: Questionnaire

1. Location

County.....................................Sub-county.............................Parish........................

Village......................................

Altitude....................................Longitude.............................Latitude.......................

Date of interview..

2. Identification of person interviewed

Name..

Sex	**Family size**	**Length of residence**
a) Male	a) 1-5	a) 1-10
b) Female	b) 6-10	b) 11-20
	c) >10	c) 21-30
		d)>30 years

Age	**Marital status**	**Education level**
a) 20-30	a) Married	a) None
b) 31-40	b) Single	b) Primary
c) 41-50	c) Widowed	c) Secondary
d) 51-60	d) Separated	d) Tertiary
e) >60 years		

Ethnic group	**Land tenure**
a) Baganda	a) Customary
b) Banyarwanda	b) Mailo
c) Banyankole	c) Lease
d) Banyoro	d) Freehold

3. On-farm diversity

Which Cultivars do you grow?

Name of variety	Planted area (give actual area planted	Rank areas from largest (1) to smallest	Criterion1 ________	Criterion 2 ________	Criterion 3 ________	Criterion4 ________	Criterion 5 ________

4. How are these cultivars distinguished from each other?

....

....

5. Why did you plant this much/ these proportions for the different cultivars?

....

....

6. How many years have you been growing the same cultivars in your farm?

....

....

7. Is there any effect in growing the same cultivars for a long time?

....

4. In the last 10 - 20 years, the number of local cultivars has:

In your farm	**In your village**
a) Increased	a) Increased
b) Decreased	b) Decreased
c) Stayed the same	c) Stayed the same

5. If the number has decreased, which local cultivars did you drop in the last few years?

Which?	**When did it happen?**	**Why did it happen?**

6. Does it matter to you that these cultivars are lost?

....

....

....

7. What do you think are the causes of cultivar losses?

a) Shortage of land b) Change in weather c) Diseases d) Lack of market e) Pests

f) Introduction of new varieties g) Loss of soil fertility h) Shortage of labor

i) Others (specify)

8. Do you think it is possible to trace the lost cultivars?

....

....

....

9. What are your sources for?

Traditional seeds?	**Modern seeds?**
a) Cash purchase from market	a) Cash purchase from market
b) Cash purchase from shops	b) Cash purchase from shops
c) Cash purchase from other farmers	c) Cash purchase from other farmers
d) Own stock	d) Own stock
e) Free from other farmers	e) Free from other farmers
f) Exchange for other seeds	f) Exchange for other seeds
g) NGOs/National/International programs	g) NGOs/National/International programs

10. How many farmers did you give seeds to during the past year?

Traditional seeds?	**Modern seeds?**
a) None	a) None
b) 1	b) 1
c) 2	c) 2
d) 3	d) 3
e) 4	e) 4
f) >4	f) >4

11. How many farmers did you receive seeds from during the past year?

Traditional seeds?	**Modern seeds?**
a) None	a) None
b) 1	b) 1
c) 2	c) 2
d) 3	d) 3
e) 4	e) 4
f) >4	f) >4

12. How do you distinguish good seed from bad seed?

....

....

13. What is the impact of modern cultivars on traditional ones?

....

....

....

14. What are the advantages and disadvantages of modern common bean cultivars?

....

....

15. What are the advantages and disadvantages of traditional Common bean cultivars?

....

....

....

16. Are there any practices aimed at conserving these cultivars? What are they?

....

....

18. Are there any hindrances to conserving these cultivars? What are they?

....

....

Appendix 2: Characters for the morphometric study

1. **First flower days:** days from sowing to 50% of plants in flower.

2. **Plant type** 1. Determinate bush, 2. Indeterminate bush, with erect stems, 3. Indeterminate prostrate, with many lateral guides, 4. Indeterminate climber.

LEAF

3. **Shape** 1. Triangular, 2. Quadrangular, 3. Round, 4. Ovate, 5. Ovate / lanceolate, 6. Lanceolate, 7. Hastate

FLOWER

4. **Colour of standard** 1. White, 2. Green, 3. Lilac, 4. White with lilac edge, 5. White with lilac stripes, 6. Dark lilac with purple outer edge, 7. Dark lilac with purplish spots, 8. Carmine red, 9. Purple, 10. Others

5. **Colour of wings** 1. White, 2. Green, 3. Lilac, 4. White with carmine stripes, 5. Strongly veined in red to dark lilac, 6. Plain red to dark lilac, 7. Lilac with dark lilac vein, 8. Purple, 9. Others

6. **Veins in the standard** 1. Present, 2. Absent

POD

7. **Position in the plant** 1. Base, 2. Centre, 3. Top, 4. Combination of 1, 2 and 3, 5. Others

8. **Fibre hardness** 1. Absent, 2. Present.

9. **Colour (fresh pod)** 1. Green, 2. Yellow, 3. Green with purple stripes, 4. Yellow with purple stripes

10. **Colour (mature pod)** 1. White, 2. Brownish-yellow, 3. Yellow-brownish 4. Green, 5. Violet, 6. Pink mottled, 7. Red mottled, 8. Red stripped, 9. Violet mottled, 10. Lilac mottled, 11. Violet stripped

SEED

11. **Size: average (mm) of 10 seeds**

Length, measured parallel to the hilum

Width

Height, measured from the hilum to the opposite side

2. **Shape** 1. Round/circular, 2. Oval/circular to elliptic, 3. Cuboid/elliptic, 4. Kidney aped, 5. Truncated

3. **100 seeds weight**

4. **Colour (primary and secondary)**

5. Primary seed colour (PSC) (Background seed colour) 1. White, 2. Cream-beige, 3. ellow, 4. Coffee, 5. Pink, 6. Red, 7. Purple, 8. Black, 9. Other

6. Secondary seed colour (SSC) (colour of pattern) 1. White, 2. Cream-beige, 3. Yellow, . Coffee, 5. Pink, 6. Red, 7. Purple, 8. Black, 9. Other

17. Seed coat pattern (SCP) 1. Plain, 2. Mottled, 3. Striped, 4. Spotted, 5. Specked, . Ringed

18. Seed coat luster (Brilliance) 1. Dull (matt), 2. Medium, 3. Shinny

Appendix 3: Names of farmers who were interviewed

Household Code	Farmer's name	County	Sub-county
Ka01	Mr Sebuliba Simeon	Busujju	Kakindu
Ka02	Muwalimu Dirisa Kakooza	Busujju	Kakindu
Ka03	Mrs Sekatawa Teopista	Busujju	Kakindu
Ka04	Mr Makuumbi Corinerio	Busujju	Kakindu
Ka05	Mr Kasasa	Busujju	Kakindu
Ka06	Mrs Beatrice Mitala	Busujju	Kakindu
Ka07	Mrs Billy Giita	Busujju	Kakindu
Ka08	Mrs Hasifa Nakanyike Kaliba	Busujju	Kakindu
Ka09	Mr Paul Muwanga	Busujju	Kakindu
Ka10	Mr Sebwato Sameul	Busujju	Kakindu
Ka11	Mr Makubuya Joseph Kigozi	Busujju	Kakindu
Ka12	Mrs Semujju Harmon	Busujju	Kakindu
Ka13	Mrs Nuwaba Musisi	Busujju	Kakindu
Ka14	Mr Sempebwa Dauda	Busujju	Kakindu
Ka15	Ms Josephine Nakanyike	Busujju	Kakindu
Ka16	Ms Teddy Namayanja	Busujju	Kakindu
Ka17	Mr Magezi Joseph	Busujju	Kakindu
Ka18	Mrs Betty Wasswa Magobwe	Busujju	Kakindu
Ka19	Mrs Nabawanuka Ntabanja	Busujju	Kakindu
Ka20	Mr Paul Mugerwa	Busujju	Kakindu
Ka21	Ms. Yudaya Nankabirwa	Busujju	Kakindu
Ka22	Ms Nanawa Betty	Busujju	Kakindu
Ka23	Mr Nawuba George William	Busujju	Kakindu
Ka24	Mr Semuwemba David	Busujju	Kakindu
Ka25	Mr Nviri George	Busujju	Kakindu
Ka26	Mr Rogers Mayanja	Busujju	Kakindu
Ka27	Mrs Ruth Semugenyi	Busujju	Kakindu
Ka28	Mrs Teo Kagwa	Busujju	Kakindu
Ka29	Mr Zilaye	Busujju	Kakindu
Ka30	Ms Nakayima Magret	Busujju	Kakindu
Ma01	Mr Matovu Stanely	Busujju	Maanyi
Ma02	Mr Erushama Nsereko	Busujju	Maanyi
Ma03	Ms Gladys Nsereko	Busujju	Maanyi

Ma04	Mr Moses Kasakwa	Busujju	Maanyi
Ma05	Ms Eva Namatovu	Busujju	Maanyi
Ma06	Mr Kagimu Louis	Busujju	Maanyi
Ma07	Mr Sebabenga Diito	Busujju	Maanyi
Ma08	Mr Seremba Lawrence	Busujju	Maanyi
Ma09	Mr Koseya Munyanzinza	Busujju	Maanyi
Ma10	Ms Nakywegwe	Busujju	Maanyi
Ma11	Mr Patrice Lutagalama	Busujju	Maanyi
Ma12	Mr Siraje Walugembe	Busujju	Maanyi
Ma13	Mr Ndyanabo William	Busujju	Maanyi
Ma14	Mrs Nyirabagande Veronica	Busujju	Maanyi
Ma15	Mrs Perusi Nsirembere Sentale	Busujju	Maanyi
Ma16	Mrs Sarah Setumba	Busujju	Maanyi
Ma17	Mr sejjugya Steven	Busujju	Maanyi
Ma18	Mrs Thereza Bukenya	Busujju	Maanyi
Ma19	Mrs Anastazia Mukarugina	Busujju	Maanyi
Ma20	Mr Wasajja William	Busujju	Maanyi
Ma21	Mr Majid Serwada	Busujju	Maanyi
Ma22	Mr Bwekwanso John Chrisetom	Busujju	Maanyi
Ma23	Mr Wesige Lawrence	Busujju	Maanyi
Ma24	Mrs Nantale Deslanta	Busujju	Maanyi
Ma25	Mrs Luwaga Rosemary Nakitedde	Busujju	Maanyi
Ma26	Ms Nakubulwa Rosemary	Busujju	Maanyi
Ma27	Ms Nantale Christine	Busujju	Maanyi
Ma28	Mr Kigozi Annatoli	Busujju	Maanyi
Ma29	Ms Kigongo Jane	Busujju	Maanyi
Ma30	Mr Sewakiryanga Paul	Busujju	Maanyi
Bu01	Mr Matia Mubiru	Mityana	Busimbi
Bu02	Salongo Mukasa	Mityana	Busimbi
Bu03	Mr Sentubilo Fred	Mityana	Busimbi
Bu04	Mrs Nankabirwa Maria	Mityana	Busimbi
Bu05	Mrs Sekagya Dodo	Mityana	Busimbi
Bu06	Mrs Senkubuge Percy	Mityana	Busimbi
Bu07	Mrs Nsubuga Joyce	Mityana	Busimbi
Bu08	Ms Kolaniyi Nsidayigaya	Mityana	Busimbi
Bu09	Mrs Kizza Faridah	Mityana	Busimbi
Bu10	Ms Nantume Resty	Mityana	Busimbi

11	Ms Nanjonjo Joyce	Mityana	Busimbi
12	Mr Kizito Charles	Mityana	Busimbi
13	Mr Mbazira Tadeo	Mityana	Busimbi
14	Mr Yawe John	Mityana	Busimbi
15	Mr Kalega Joseph	Mityana	Busimbi
16	Mr Matiya Ssemugooma	Mityana	Busimbi
17	Kakooza Aaron	Mityana	Busimbi
18	Mrs Mubiru Victoria	Mityana	Busimbi
19	Mr Kazibwe Mulindwa	Mityana	Busimbi
20	Mrs Kakande	Mityana	Busimbi
21	Mrs Namutebi Regina Kibuuka	Mityana	Busimbi
22	Mr Kiwanuka Francis	Mityana	Busimbi
23	Mr Kaaya	Mityana	Busimbi
24	Sheik Muwonge Abdul	Mityana	Busimbi
25	Ms Nakafeero Gorret	Mityana	Busimbi
26	Mrs Juliet Kawuki	Mityana	Busimbi
27	Mrs Juliet Kavuma	Mityana	Busimbi
28	Mrs Nanono Florence	Mityana	Busimbi
29	Mrs Scovia Kiwanuka	Mityana	Busimbi
30	Ms Nakasujja Rose	Mityana	Busimbi
01	Mr Kyazze Hamis	Mityana	Kikandwa
02	Ms Namuli Rehema	Mityana	Kikandwa
03	Ms Nakigudde Joyce	Mityana	Kikandwa
04	Mr Muli Isaac	Mityana	Kikandwa
05	Ms Benadeeta Kabalisa	Mityana	Kikandwa
06	Ms Noerine Nazziwa	Mityana	Kikandwa
07	Mr Nsubuga Chrizestom	Mityana	Kikandwa
08	Mr. Kigozi Hormis	Mityana	Kikandwa
09	Mr. Kasozi Wilson	Mityana	Kikandwa
10	Ms Namusisi Janet	Mityana	Kikandwa
11	Ms Namuddu Cotida	Mityana	Kikandwa
12	Mr Musisi Billy	Mityana	Kikandwa
13	Mr Kiwanda Joshua	Mityana	Kikandwa
14	Mrs Namagembe Gertrude	Mityana	Kikandwa
15	Ms Nakimuli Mariam	Mityana	Kikandwa
16	Mr Mukasa Emmaneul	Mityana	Kikandwa
17	Mrs Sarah Kawoya	Mityana	Kikandwa
18	Ms Rosemary Nagadya	Mityana	Kikandwa
19	Mr Mulindwa Paddy	Mityana	Kikandwa

20	Mr Munyaneza Dirisa	Mityana	Kikandwa
21	Ms Nanteza Teopista	Mityana	Kikandwa
22	Ms Nakamanya Edrisa	Mityana	Kikandwa
23	Mr Kiseke Christopher	Mityana	Kikandwa
24	Mr Kinyata Moses	Mityana	Kikandwa
25	Ms Nalutaya Rita	Mityana	Kikandwa
26	Ms Namakula Dimitiria	Mityana	Kikandwa
27	Ms Nakagwa Milly	Mityana	Kikandwa
28	Mr setumba	Mityana	Kikandwa
29	Ms Nabacwa Eseri	Mityana	Kikandwa
30	Mr Kasuma Juma	Mityana	Kikandwa

x 4: Diversity estimates of the communities

estimates ; richness, eveness and divergence of the rural

Nakyew	Obumya	Obudug	Yelows	Kanyea	Khakmp	Obwela	Caroli
0	0	0	0.164558	0	0	0	0
0	0	0	0	0.802077	0	0	0
0	0.071272	0	0	0.09718	0	0	0
0	0	0	0.407988	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0.124191	0	0	0	0	0
0	0	0	0	0	0	0	0.287504
0	0	0	0.223839	0	0	0.451836	0
0	0	0	0.157407	0	0	0	0.464425
0.016633	0.110659	0	0.27427	0	0	0	0
0	0	0	0.282601	0	0	0	0
0	0.113686	0.014635	0	0.077794	0	0.284171	0
0	0	0	0.809733	0	0	0	0
0	0	0	0.364456	0	0	0	0
0	0.186958	0	0	0.314815	0	0.196414	0
0	0	0	0.400149	0.044103	0	0.040387	0
0	0	0	0.245366	0	0	0	0
0.006051	0	0.208599	0	0	0	0	0
0	0	0	0.089249	0	0	0.181126	0.001107
0	0	0	0.605446	0.134085	0	0.03061	0
0	0	0	0.27706	0.152505	0	0.419948	0
0	0	0.313494	0.388675	0.042651	0	0	0
0	0	0	0.169831	0	0	0	0.208861
0	0	0	0	0.499064	0	0	0.103933
0	0	0	0	0	0	0	0.076299
0.203608	0	0	0	0	0	0	0.237113
0.357388	0	0	0	0	0	0	0.189003
0	0.197961	0.198325	0	0	0	0	0
0	0	0.17734	0	0	0	0.184408	0
0	0	0	0.045474	0.503579	0	0	0
0	0	0	0.043684	0.48039	0	0	0
0	0	0	0.057392	0	0	0.1672	0
0	0	0	0	0	0.220568	0	0.186739
0	0	0	0	0	0.236133	0.202045	0
0	0	0	0	0	0.357495	0	0
0	0	0	0.072513	0.638332	0	0	0
0	0	0	0	0	0.394206	0	0
0	0	0	0	0	0	0	0
0.108276	0.127042	0	0.08708	0	0	0.084785	0
0	0	0	0	0	0	0	0
0	0.30936	0	0	0	0	0	0
0	0	0	0.062865	0	0	0.306043	0
0	0	0	0.121212	0	0	0	0
0	0.318458	0	0	0	0	0	0
0	0	0	0	0	0	0.099237	0
0	0	0	0	0	0	0	0
0	0	0	0.213903	0.469438	0	0.107778	0

...mates ; richness, eveness and divergence of the rural

	Nakyew	Obumya	Obudug	Yelows	Kanyea	Khakmp	Obwela	Caroli
	0	0.163287	0	0.209828	0	0	0.169527	0
	0	0	0	0.733757	0	0	0	0
	0	0	0	0	0	0	0.065649	0
	0	0.202294	0	0	0	0	0	0
	0	0	0	0	0	0	0	0
	0	0	0.099664	0	0.271782	0	0.19199	0
	0	0	0	0.188889	0	0.37076	0	0
	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0
	0	0.01735	0	0.341338	0	0.053848	0	0
	0	0	0	0	0	0.404459	0	0
	0.064686	0	0	0	0.046805	0	0	0
	0.012611	0.030305	0.018937	0.117309	0.076243	0.033958	0.053053	0.02925
...oportion								
	0.012611	0.030305	0.018937	0.117309	0.076243	0.033958	0.053053	0.02925

ates ; richness, eveness and divergence of the rural

Kifudu	Kanymb	Namgvu	Obumyb	Namnyl	Oboote	Mutifu	Obumfc
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0.875809	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0.092593	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0.172944	0	0	0	0	0	0.006194	0.048315
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0.040127	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0.009577	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0.174157	0.098315	0	0.048689	0	0.075843	0
0	0	0	0	0	0	0	0
0.282646	0	0	0	0	0	0.207904	0
0.453608	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0.051528
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0.039003	0.526769	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0.057018	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

...ersity estimates ; richness, eveness and divergence of the rural

...use hold	Kifudu	Kanymb	Namgvu	Obumyb	Namnyl	Oboote	Mutifu	Obumfc
...H46	0	0	0	0	0	0	0	0
...H47	0.015463	0	0	0	0	0	0	0
...H48	0	0	0	0	0	0	0	0
...H49	0	0	0	0	0	0	0	0
...H50	0	0	0	0	0	0	0.017144	0
...H51	0	0	0	0	0	0	0	0
...H52	0	0	0	0	0	0	0	0
...H53	0	0	0	0	0	0	0	0
...H54	0	0	0	0	0	0	0	0
...H55	0	0	0	0	0	0	0	0
...H56	0	0.061608	0	0	0	0	0	0
...H57	0	0	0	0	0	0	0	0
...H58	0	0	0	0	0	0	0	0
...H59	0	0	0	0	0	0	0	0
...H60	0	0.117013	0	0	0	0	0	0
...verage	0.016061	0.014659	0.002589	0.014597	0.000811	0.00016	0.00733	0.001664
...verage proportion								
	0.016061	0.014659	0.002589	0.014597	0.000811	0.00016	0.00733	0.001664

versity estimates ; richness, eveness and divergence of the rural

ouse hold	Nampii	Namnvu	Yelowl	Mutkep	Namnye	SUM	Richness	Simpsons' eveness
H1	0.35758	0.477862	0	0	0	1	3	0.6167053
H2	0.197923	0	0	0	0	1	2	0.3174984
H3	0.575536	0.256012	0	0	0	1	4	0.5886928
H4	0	0.592012	0	0	0	1	2	0.4830675
H5	0.157696	0.842304	0	0	0	1	2	0.2656556
H6	0	0	0	0	0	1	2	0.2175356
H7	0.304908	0.407588	0	0	0	1	3	0.6582446
H8	0	0.324324	0	0	0	1	3	0.6405536
H9	0	0.285575	0	0	0	1	4	0.6694059
H10	0	0.598439	0	0	0	1	4	0.5541252
H11	0	0.717399	0	0	0	1	2	0.4054754
H12	0.30534	0.204373	0	0	0	1	6	0.7650551
H13	0	0.190267	0	0	0	1	2	0.3081313
H14	0	0.635544	0	0	0	1	2	0.4632559
H15	0.069543	0.23227	0	0	0	1	5	0.7685743
H16	0	0.287909	0	0	0	1	7	0.7211312
H17	0	0.754634	0	0	0	1	2	0.3703233
H18	0	0.745223	0	0	0	1	4	0.3994825
H19	0	0.728518	0	0	0	1	4	0.4284881
HH20	0	0.220282	0	0	0	1	5	0.5659037
HH21	0.150487	0	0	0	0	1	4	0.7009776
HH22	0	0.255181	0	0	0	1	4	0.6837172
HH23	0	0.621308	0	0	0	1	3	0.5415109
H24	0	0	0	0	0	1	6	0.6920142
H25	0.620231	0.30347	0	0	0	1	3	0.5173977
H26	0	0	0	0.068729	0	1	5	0.7744845
H27	0	0	0	0	0	1	3	0.6307909
H28	0.319092	0.284622	0	0	0	1	4	0.7386492
H29	0.381103	0.257149	0	0	0	1	4	0.7231793
H30	0.204211	0.246737	0	0	0	1	4	0.6417594
H31	0.238301	0.237625	0	0	0	1	4	0.6540644
H32	0.632374	0.062367	0	0.02914	0	1	6	0.5614599
H33	0.592693	0	0	0	0	1	3	0.5651934
HH34	0.27146	0.290363	0	0	0	1	4	0.7454184
HH35	0.308234	0.247009	0	0	0.087262	1	4	0.7085613
HH36	0.078713	0.210441	0	0	0	1	4	0.5367924
HH37	0	0.605794	0	0	0	1	2	0.4776152
HH38	0.259973	0.174255	0	0	0	1	4	0.6230428
HH39	0	0.592818	0	0	0	1	5	0.6059326
HH40	0.937416	0.062584	0	0	0	1	2	0.1173337
HH41	0.69064	0	0	0	0	1	2	0.4273125
HH42	0	0.574074	0	0	0	1	4	0.5695736

versity estimates ; richness, eveness and divergence of the rural

ouse hol	Nampii	Namnvu	Yelowl	Mutkep	Namnye	SUM	Richness	Simpsons' eveness
H44	0	0.475152	0.123225	0.083164	0	1	4	0.65071395
H45	0.447837	0.29771	0.155216	0	0	1	4	0.67687068
H46	0.599521	0.400479	0	0	0	1	2	0.48019106
H47	0.115773	0.077645	0	0	0	1	6	0.70258627
H48	0	0.457358	0	0	0	1	4	0.69139362
H49	0	0.266243	0	0	0	1	2	0.39071497
H50	0.549655	0.367552	0	0	0	1	4	0.55818133
H51	0.434661	0.363044	0	0	0	1	3	0.63834531
H52	0.271965	0.728035	0	0	0	1	2	0.39600029
H53	0.257414	0.17915	0	0	0	1	5	0.78098473
H54	0	0.344444	0	0.095906	0	1	4	0.69901782
H55	0.332827	0.667173	0	0	0	1	2	0.4441063
H56	0.938392	0	0	0	0	1	2	0.11562423
H57	0.600136	0.399864	0	0	0	1	2	0.47994537
H58	0.463581	0.123883	0	0	0	1	5	0.65003325
H59	0.446497	0.149045	0	0	0	1	3	0.61483955
H60	0.46253	0.308967	0	0	0	1	5	0.67053904
verage	0.240884	0.318868	0.004641	0.004616	0.001454	1	3.55	0.55495357
Average proportion							Average HH richness	Average HH Simpson
	0.240884	0.318868	0.004641	0.004616	0.001454	1	3.55	0.55495357

Community richness	Community Simpson index	Divergence
21	0.81366963	0.32