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Evaluation of Common Bean Production Systems and Fertilizer use in Nandi South

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Abstract

High fertilizer cost and increased concern for ecological sustainability have led to improved interest on green manure and organic fertilizer. The study evaluated common bean production systems and organic fertilizer use by farmers in Nandi South. A semi structured questionnaire was administered to individual farmers in the form of interviews and the data was analyzed through descriptive statistics, frequency counts and percentages. Results showed that majority of the farmers were women with a mean age of 51.6 years. Many farmers 59% cultivated improved bean varieties sourced from their own farms and applied fertilizers albeit different quantities. The results further indicated that 67% of farmers in Koibem and 57% in Kapkerer applied green manure as a soil amendment. Addition of green manure to soils helps in improving soil conditions and increasing crop yields in low soil fertility areas. Green manure use as soil amendments is an ecologically sustainable way of increasing yield.

Relevance to innovation. Many modern agricultural practices have unintended negative consequences and therefore there is growing concern about sustainable and better agricultural systems. It is therefore time to assess the importance and future role that soil improving legumes may play in agricultural system. Application of lablab legume species as green manure is an important practice for sustainable agriculture production as the crops fix nitrogen and has deep and extensive root system that allows for nutrients extraction and recycling. Green manure has favourable N to P ratios and has predictable N activity hence its application will increase yield.

Key Words. Chemical fertilizers, Common beans, green manure, smallholder farmers.

Introduction

Common bean is an important source of dietary protein and calories, iron and supplementary amino acids (Mwangi et al., 2008). It is the most widely grown legume in Kenya and it is second to maize in importance as staple food. The crop is grown for its green leaves, green pods, and immature or dry seeds (Mwangi et al., 2008). In Kenya, beans are largely grown by small scale farmers with fewer than five acres and mostly intercropped with maize. They play an essential role in the sustainable livelihoods of smallholder farmers and their families by providing both food security and income generation (Spence, 2003).

The crop, however, is grown under challenging conditions, including marginal lands with infertile soils, prone to drought, pests, and diseases. Majority of the farmers do not have access to quality seeds and when they succeed in producing surpluses, they have difficulty accessing markets, and are therefore unable to extract sufficient profits from their labour. Drought and low soil fertility are primary constraints to crop production throughout the third world countries, and this is particularly true of common bean, which in poor countries is typically a smallholder crop grown in marginal environments with few inputs. Fertilizer use is negligible in many third world countries, especially in sub-Saharan Africa, which commonly have the poorest soils (Lynch et al., 2009). Incorporating green manure to the soil increases soil carbon, available nitrogen, concentration of nutrients near the soil in available form, and reduces N losses through leaching and soil erosion and organic matter (Talgre et al., 2009). Increases in soil organic matter due to green manure improves soil physical and biological properties by increasing the distribution and stability of the soil aggregates (Sultani et al., 2007). The use of organic fertilizers to replenish soil and reduce soil pollution which mostly occurs due to continuous use of chemical fertilizers is growing interest worldwide (Mamzing et al., 2016). Inorganic fertilizers are expensive and cannot be afforded by majority of small scale farmers. Organic manures are fertilizers made from cattle dung, urban and rural composts, crop residues and green manure.

The use of legume species as green manure is an important practice for sustainable agriculture production as the crops fix nitrogen and has deep and extensive root system (Carvallo et al., 2015) that allows for nutrients extraction and recycling. Several legume species used as green manure have different properties which affect soil properties differently. This study was therefore carried out to assess and evaluate the common bean production systems and the uptake level of green manure adoption amongst the small scale farmers.

Materials and methods

Selection and description of study area

The study was conducted in the Southern part of Nandi County, that covers Koibem (high fertility) and Kapkerer (low fertility). This area was selected because of its importance in Common beans production, due to its favourable environmental conditions. Furthermore, most of the dissemination efforts of improved Common beans varieties have focused in the area. Nandi County is in the North of Rift valley occupying an area of 2,884km2. Nandi

County is bound by the Equator to the south and extends to the North to latitude 0^o34'N. The Western boundary spreads to Longitude 34^o45'E, while the East boundary reaches Longitude 35^o25'E at an altitude of 1850-2040m above sea level (Nyberg et al., 2012). The climate is marked by two contrasting seasons; the long rain season which normally starts from March to August and the short rain season which lasts from September to December. The average annual precipitation is 1200mm to 2000mm with mean yearly temperature ranging from 18-25^{o}C and the soils are characterized by well drained clay loamy soils (FAO-UNESCO, 1997). The major crops grown are maize, beans, tea and also livestock farming.

Sampling technique and data collection

Data used in the study was obtained primarily from a survey that targeted project participating households. A semi structured questionnaire was administered to individual farmers in the form of interviews. The interviews covered the main common bean varieties grown, cropping systems, source of seed, and the fertilizer types applied. Additional data were collected on green manure utilization, time of incorporation and time after planting and yields. To ensure effective coverage of the study area, farmers in the project were systematically sampled in the two regions (Kapkerer and Koibem) by selecting the third farmer in a transect line. A total of 51 farmers were considered for the interview. The formula described by Barlett et al., (2001) was used to determine the number of farmers surveyed.

Data analysis

Quantitative data was processed, given a code and analyzed using Statistical Packages for the Social Sciences (S.P.S.S version 20). The results were presented by use of descriptive statistics, namely percentages and frequencies.

Results

Household socio-economic characteristics of the farmers

Results illustrate that most of the respondents were female (67%) across the two sites and the proportion of females was also higher in Koibem (76%) and Kapkerer (65%) (Table 1). The statistics also confirms that the proportion of male headed households was greater at 54% than that of female headed. Male headed household still formed the majority in Koibem (67%) and Kapkerer (56%). On average the farmers interviewed were 51.6 years of age, this ranged from 28 - 76 years (Table 1). The farmers in Koibem were slightly older (54.3 years) than those in Kapkerer (48.8 years). In terms of education, the results illustrates that farmers attained an average of eight years of education/schooling which is equivalent to attaining Kenya Certificate of Primary Education (KCPE). The farmers in Kapkerer had significantly higher means score on education (9 years) than those in Koibem (7 years)

Table 1. Socio-economic characteristics of bean farmers in Nandi South

	Pooled Sample			Koibem			Kapkerer		
Characteristics	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
Age of farmer (years)	51.0	51.6	2.8	18.0	54.3	9.8	23.0	48.8	12.9
Education level (Schooling years)	51.0	8.0	1.0	18.0	7.0	1.5	23.0	9.0	2.5
Total land size (acres)	51.0	4.5	0.4	18.0	4.9	3.0	23.0	4.1	2.5
Total land under beans (acres)	51.0	1.0	0.4	18.0	1.2	1.0	23.0	0.7	0.47
Duration of land use	51.0	23.7	5.0	18.0	20.1	8.9	23.0	27.2	6.1

Source: Field survey data, SD is Standard Deviation

Sources of bean seeds and farmer preferences for bean varieties

Farmers obtained their seeds for planting from various sources (Figure 1). Majority of farmers in Koibem (94%) and Kapkerer (61%) used their own seeds as planting material while other farmers obtained the seeds from their neighbours (Koibem 50% and Kapkerer 9%). The results showed that around 39% of the farmers in Kapkerer and 28% of the farmers in Koibem obtained their planting seeds from the market. However, no farmer from both Koibem and Kapkerer obtained seeds from the agro-shops. Majority (86%) of the farmers grew both local and improved bean varieties (Table 2). Majority of the farmers had adopted at least one of the improved varieties that were being promoted by the project while Nyayo (45% Koibem) was the most popular local variety grown in Nandi South. The same variety was the most popular local variety in Kapkerer (26%). KK8 was the most preferred improved variety in Koibem (67%) and in Kapkerer (52%) other improved varieties grown include KK15, Rosecoco.

Farmers preferred to grow improved bean varieties because of high yields, palatability, cooking time, and disease tolerance compared to the local cultivars. Variety KK8 and KK15 were the most preferred mainly because of their high yielding potential, and disease tolerance. Farmers interviewed owned on average about 4.5 acres out of which 1 acre was allocated to the production of beans (Table 1). The local varieties Nyayo, Alulu and Punda were mainly preferred by farmers due to their high yielding abilities and resistance to common bean diseases.

Fertilizer use by farmers

On the basis of the analyzed data inquiring about fertilizer application by the farmers in Nandi South, inorganic fertilizer and green manure were the main components used. Results of the survey show that all the farmers interviewed in the two sites applied inorganic fertilizer albeit in different quantities (Figure 3). All farmers in Koibem at least applied green manure from different sources, however, only 61% of the farmers in Kapkerer adopted the technology of green manuring. The average rate of fertilizer application was 30kg per ha against the recommendation of 120kg/ha as outlined by the manufacturer.

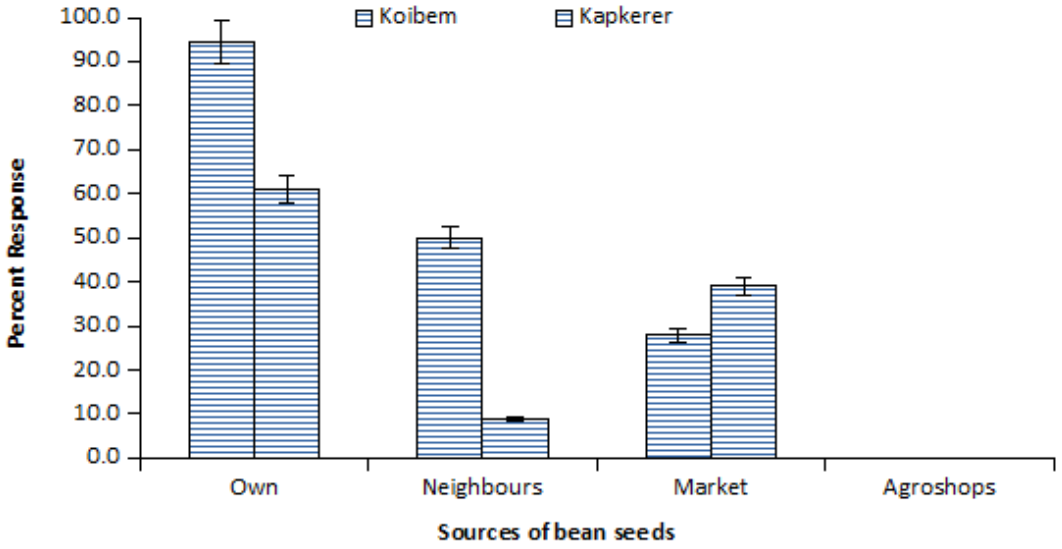

Figure 1: Sources of beans seeds to farmers in Nandi South

Table 2: Main local and improved bean varieties planted by farmers in Nandi South, Kenya

Proportion (%) of farmers growing local cultivars				**Proportion (%)of farmers growing improved variety**			
Local variety	**Total) (N=51)**	**Koibem (N=18)**	**Kapkere (N=23)**	**Improved variety**	**Total (N=51)**	**Koibem (N=18)**	**Kapkere (N=23)**
Alulu	13.7	5.6	21.7	KK8	59.5	66.7	52.2
Punda	6.5	0.0	13.0	KK15	47.4	55.6	39.1
Nyayo	35.3	44.5	26.1	Rosecoco	33.1	44.5	21.7

Source: Field survey data. Most percentages more than 100 due to multiple responses

Major crops grown by the farmers

Commonly grown crops by the farmers in the study area were maize, tea, sweet potatoes, cassava, groundnuts (Table 3). Majority of the respondents grow the following food crops: maize (100%), bananas (35%), sweet potatoes (27%) and groundnuts (23%). About 23% of the interviewed farmers grow tea. Other crops grown include soybean, cassava, tomatoes, and sorghum.

Green manure use and application methods

All the respondents from both sites applied inorganic fertilizer (Figure 3). All the farmers in Koibem agreed to have applied green manure. However, only 61% of the respondents in Kapkerer applied organic fertilizer. Farmers used different way of incorporating green manure in the soil (Figure 4). Majority of the farmers both in Koibem (67%) and

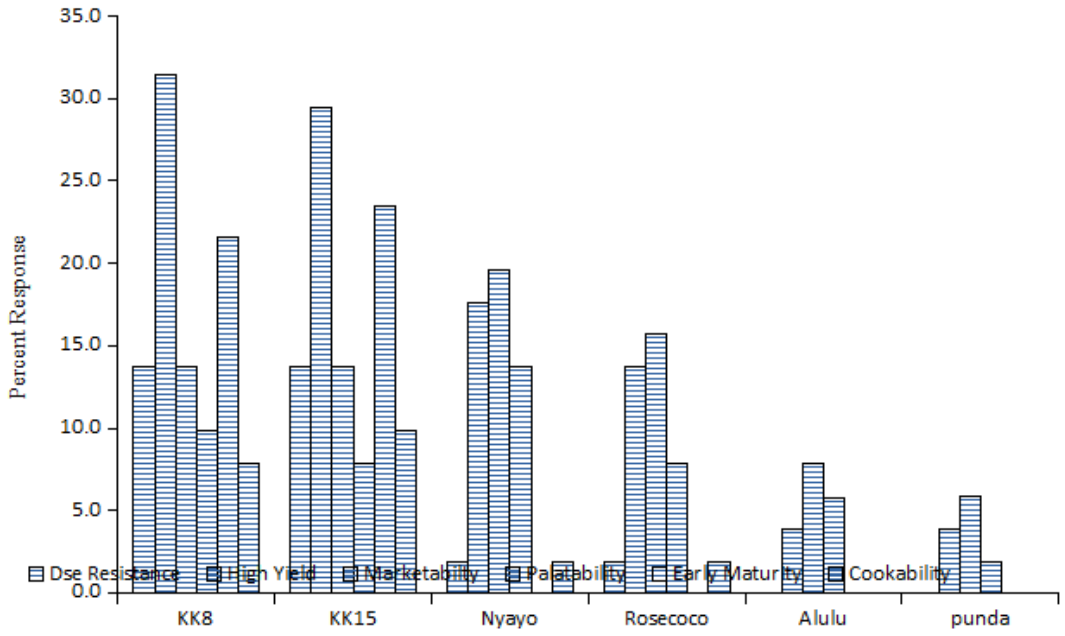

Figure 2. Main attributes influencing farmers' preferences/choice of selected common bean varieties in Nandi South

Table 3: Distribution of respondents based on type of crop grown

Crop	Frequency	Percentage (%)
Maize	51.0	100.0
Bananas	18.0	35.3
sweet potatoes	14.0	27.5
Tea	12.0	23.5
Groundnuts	12.0	23.5
Soybean	6.0	11.8
Cassava	6.0	11.8
Tomatoes	4.0	7.8
Sorghum	3.0	5.9

Most percentages more than 100 due to multiple responses

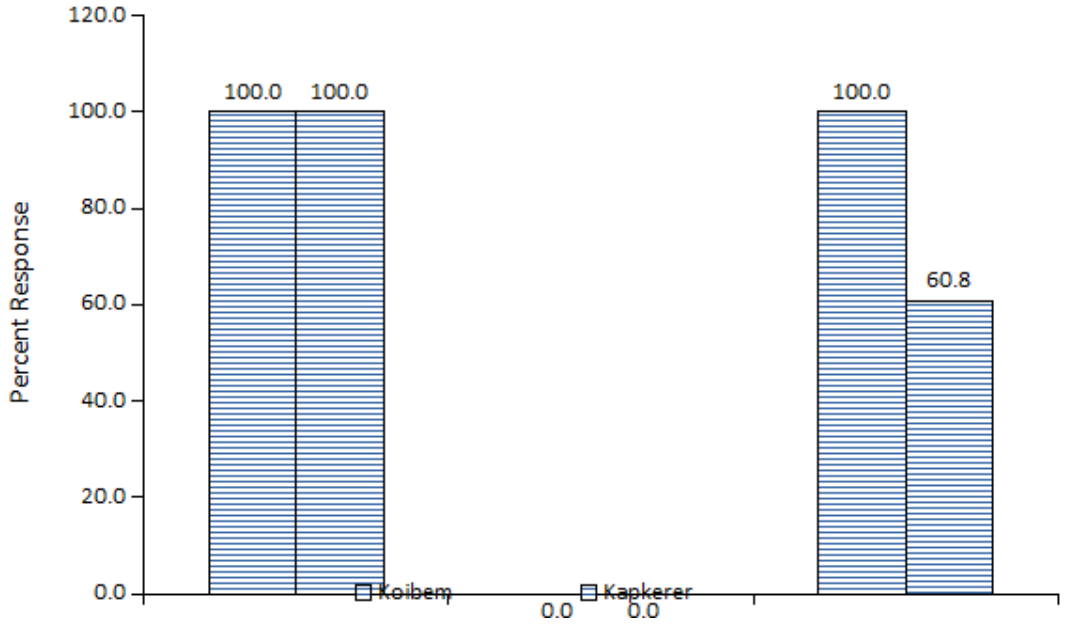

Figure 3. Fertilizer use among farmers in Kapkerer and Koibem, Nandi County

Kapkerer (57%) incorporated green manure by evenly spreading the residues over the farm and plough in. Other farmers in Koibem (28%) and Kapkerer (17%) ploughed in the remaining crop residue while still standing while others in Koibem (5%) and Kapkerer (26%) left the residues as mulch on the soil then ploughed later in the soil

Usage of green manure by the farmers

All the farmers who applied green manure used different application methods and they did this when the green manure crop had matured (Figure 4). Majority of the farmers in Koibem (66%) and Kapkerer (56%) evenly distributed green manure residues before incorporation. Other farmers in Koibem (27%) and Kapkerer (17%) incorporated the green manure while still standing in the field. A few other farmers left the residues in the field as mulch Majority of the farmers interviewed in Kapkerer (52%) and Koibem (44%) do planting two weeks after incorporation of green manure in the soil while others (33%) in Koibem and (35%) in Kapkerer planted three weeks after green manure incorporation (Figure 5). A few others from the two sites planted after four weeks of incorporation. However, it is interesting to note that no farmer planted immediately after incorporating green manure.

Benefits of green manure

Majority of the farmers in Koibem clearly understands the benefits associated with green manure to crop production (Figure 6). Majority of the farmers in Koibem indicated that incorporation of green manure in the soil improved soil fertility (72%), and therefore

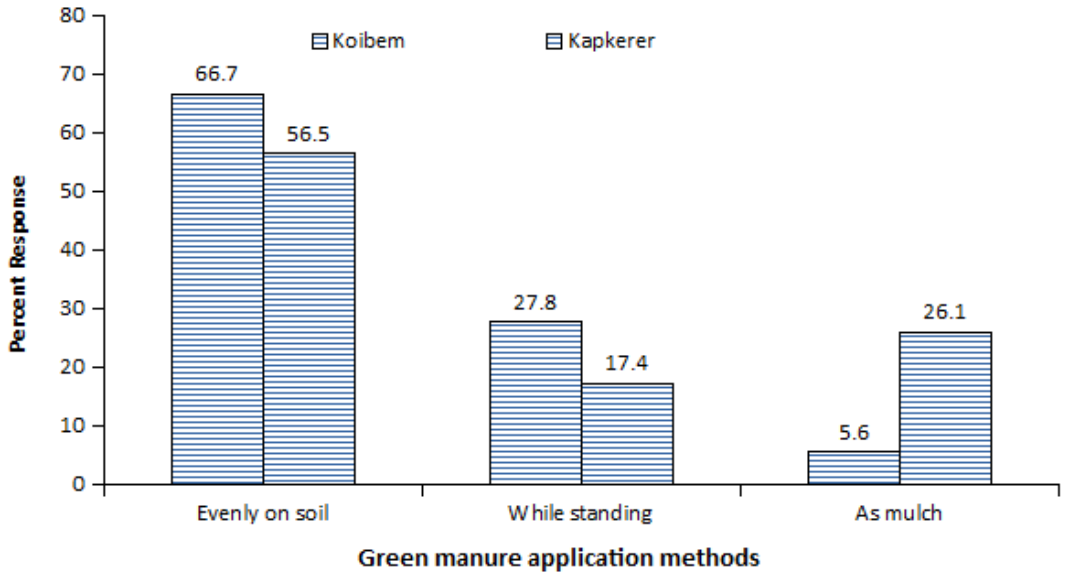

Figure 4: Methods of green manure application

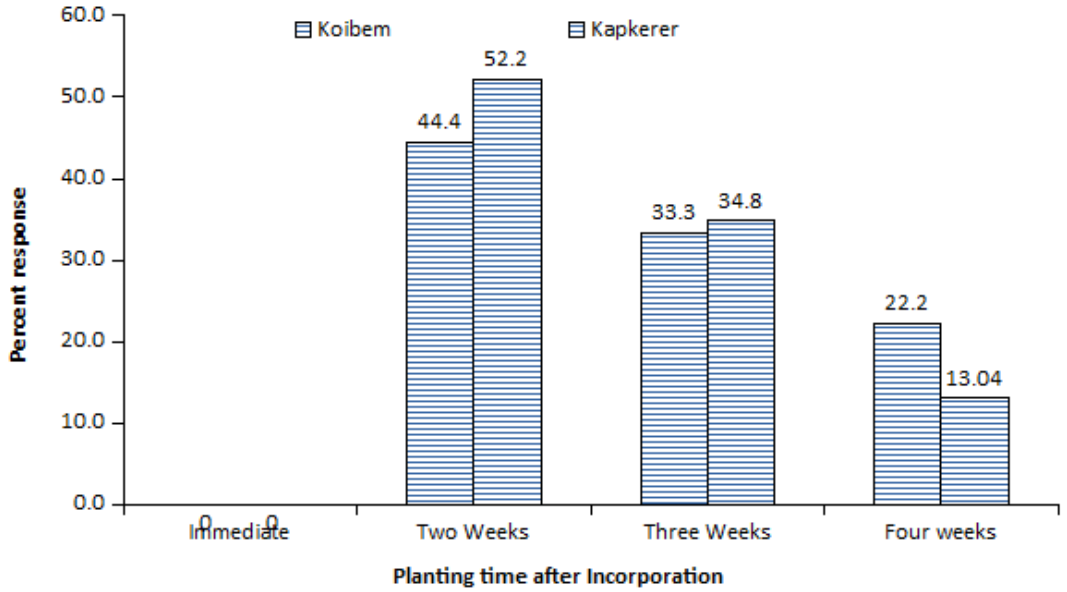

Figure 5: Planting time after green manure incorporation

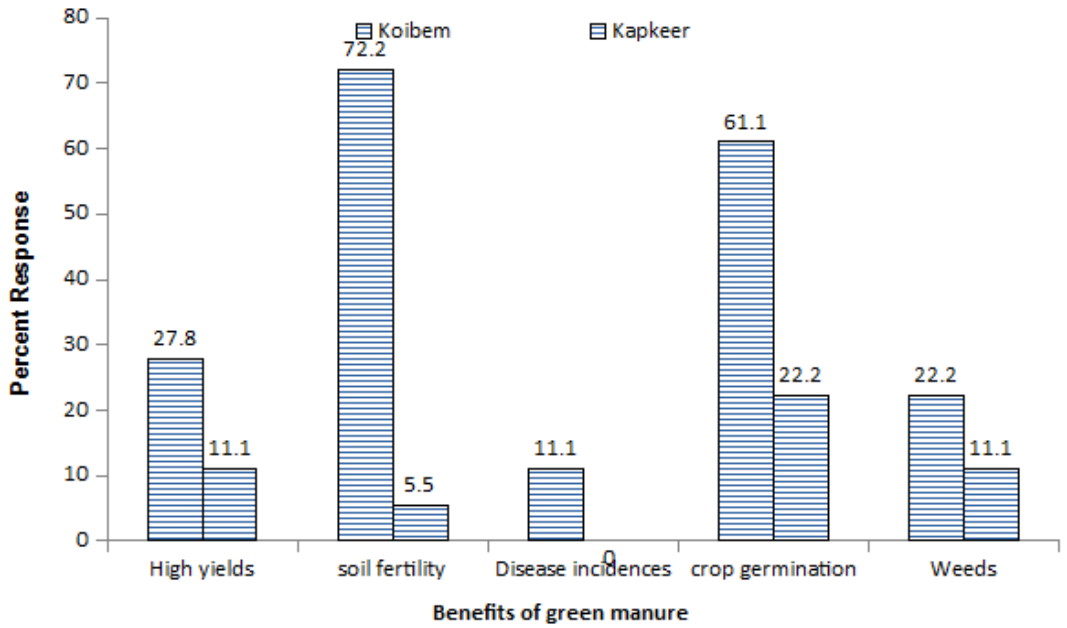

Figure 6: Benefits of green manure

enhanced crop germination (61%). Farmers in Koibem also listed high yields, reduced disease incidences and suppression of weeds as some of other benefits of incorporating green manure. However, the same cannot be reported for Kapkerer as most farmers do not recognize benefits associated with green manure application. Only 22% of the respondents reported that green manure improved crop germination.

When the farmers were asked how they planted their crops after green manure incorporation, all the farmers from Koibem reported that they planted their crop evenly over the incorporated green manure. However, only 57% of the interviewed farmers in Kapkerer evenly planted their crops after green manure application. Others farmers from Kapkerer planted crops on top of green manure applied.

Discussion

The high proportion of farmers growing improved common bean varieties infers that the Multipurpose Legume Project (MLP) has played a major role in enabling farmers to access improved bean varieties with attributes that farmers have been longing for. The observed decline in number of farmers growing local cultivars is a clear indication that the newly introduced improved common bean varieties were replacing some of the local varieties in the area where the project covered. This, however, has a negative effect has it will lead in erosion of genetic diversity of beans (Sanya et al., 2015).

Attributes like disease resistance, high yields, and marketability and consumer consumption preferences directed farmers in choosing which variety of beans to plant. Majority of farmers based their choice of variety on high yields and early maturity. How-

ever, Sanya et al (2015) working on uptake of bean root rot resistant varieties reported that the choice and preferences of a variety could be house specific or location specific. The influence of yields, disease tolerance and resistance and varietal marketability are in consistent with other studies for improved varieties (Mugisha-Mutetika, 1997; Nasirumbi, 2008). High yields play a significant role in adoption of improved variety as it results in satisfactory consumption and surplus being sold to earn income (Sanya et al., 2015).

Majority of the farmers grew crops like maize, tea, sweet potatoes. These crops were identified by asking the farmers to indicate which of the crops they grow a part from beans. These crops were planted on land sections of individual land, family or inherited land as they are the major sources of income for the farmers. Other crops like maize were used or intercropping as majority of the farmers practised intercropping type of farming.

The farmers' main source of seed is retained seed; majority of the farmers selected the best seed after harvest and treated them traditionally for preparation to planting (Ngayu-Wanjau, 2013). These varieties, however, are of superior qualities compared to the local isolates. Other farmers obtained their seed from their neighbours and from the market. A number of local varieties planted significantly reduced since the introduction of improved bean varieties in the project area. Similarly the yield harvestable per unit area of beans improved. The increase in total yield harvested and the reduction in the number of local bean varieties planted can be attributed to better yields and disease resistance abilities of the improved bean varieties. The same has been reported by (Sanya et al., 2015). The results that farmers were saving their own seeds for planting and applying inorganic fertilizers at rates that are not recommended due to high costs and lack of reliable source imply that input costs and availability influenced farmers' choice of variety and fertilizer to apply. Poor soil fertility is one of the major causes of low agricultural productivity in Sub Saharan Africa (Williams 1999). Organic manure increases yield, enhances soil organic matter, raises soil pH and improves nutrient availability and exchange and water holding capacity (Williams 1999). However, despite the beneficial effects of organic manure in crop production and soil fertility management, organic manure is not frequently applied by most farmers (Oyesola et al., 2011).

Sources of information on green manure use are the channels through which farmers obtain information for farming and utilization of green manure as a soil amendment. The information sources were evaluated by asking the individual farmers where they obtained information on green manure use. All the farmers (100%) accessed information on green manure use through the KALRO staff in the MLP project; however, not all the farmers adopted the technology. This shows that the project had some positive outcome and encouraged farmers on the benefits of green manure on soil and crop production in general. The level of adoption of green manure usage amongst the interviewed farmers was average. This contradicts findings by Emu et al., (2011) who found that the extent of adoption by small scale farmers was very low and this required a more extensive approach by the extension agents on this group of farmers. Some of the factors influencing decisions by farmers to adopt organic manure usage may include farming experience, high cost of inorganic fertilizers, level of education and estimated yield from organic manure in the short term.

Majority of the respondents planted crops two to three weeks after incorporation. It would appear that the farmers understood the effects of planting immediately after

incorporation. This they did to avoid the deleterious effects associated with in farms with undecomposed plant residues. Some of the deleterious effects associated with undecomposed plant residues include release of phytotoxic compound products, enhancement of pathogenic organisms and increased competition (Wall, 1984). The effect of plant residues on seedling emergence can be influenced by maturity of the tissues and their carbon to nitrogen ratios and the time elapsed between incorporation and planting. Immediately after incorporation there is usually an explosion of microbial activity that includes germination of propagules of pathogenic fungi that may invade susceptible hosts and this may results in poor crop establishment.

Improved bean varieties gradually replaced local bean cultivars as farmers increasingly appreciated and planted the resistant varieties. The main varieties adopted were KK8, KK15 and Rosecoco. High yields, diseases resistant and palatability were the attributes influencing farmers choice of these varieties. The farmers should be encouraged to consider application of green manures as an alternative to the expensive inorganic fertilizers. This, however, calls for the people involved to train the farmers on the benefits of green manure technology. When applying these green manures farmers should know that a fallow period of several weeks between incorporation time and planting may allow for the drop in pathogen populations and reduction of other deleterious effects associated with decomposing green manure. It is therefore important that farmers allow for time between incorporation and planting to ensure decomposition. To sustain this technology, access to information and extension services are to be improved to increase adoption and use of green manures.

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