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Farmer perceptions of legumes and their functions in smallholder farming systems in east Africa

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ABSTRACT

Legumes play an important role in sub-Saharan Africa (SSA) farming systems through the provision of food, feed, fuel, income and a range of biophysical benefits, such as soil fertility enhancement and erosion control. However, their full potential is not being realized. The purpose of this study was to assess farmers' perceptions and knowledge towards legumes and the rationale of farmers for current legume production practices using a survey of 268 farmers in the Democratic Republic of Congo and Kenya. Most of the farmers had some knowledge of legumes and their characteristics. However, they had little knowledge of some key functions, including soil erosion control and soil fertility improvement. Most farmers relied on radio and other farmers for legume-related information. Farmers with relatively large livestock holdings ranked provision of livestock feed as an important legume function. We conclude that farmers put more value on short-term benefits of legumes including food and income than long-term benefits such as natural resource management and thus grain legumes are more readily identified by farmers than forage species. Also, we conclude that farmers require more than just information about legumes to increase uptake, they also require improved market access to procure inputs and sell products to realize other benefits that are associated with growing legumes.

1. Introduction

To feed the growing population of sub-Saharan Africa (SSA), agricultural production and productivity needs to increase significantly. The crop yield increase per unit area in SSA is projected to decrease from 3.3% per annum (1987–2007) to 2.4% and 1.9% per annum during 2007–2030 and 2030–2050, respectively (Alexandratos & Bruinsma, 2012), against an estimated increase in demand for cereals of 335% between 2010 and 2050 (van Ittersum et al., 2016). Similarly, the demand for legumes is also expected to increase as consumers' income increases with a likely shift in preferences from cereal grains to more nutrient-dense foods (Syngenta, 2017). This growing gap between demand and supply of food in SSA will require improved agricultural practices that overcome current crop production constraints which include erratic rainfall patterns, poor soil fertility status, and limited access to adequate inputs (Fermont, van Asten, & Giller, 2008). In east Africa, including DRC and Kenya, increasing agriculture production is linked to land expansion which results in the encroachment of forest and grazing land, and use of marginal lands which increases erosion. This is further worsened by high population density which increases pressure on land and hence, the decline of

Figure 1. Maize (*Zea Mays*) intercropped with common bean (*Phaseolus vulgaris*) is a common practice among smallholder farmers in the Kenyan and DRC study sites. The photo is from Rongo, Kenya.

crop yields. A promising solution for farmers is to intensify their cropping systems by incorporating annual and perennial legumes, e.g. through intercropping (Figure 1), but also in rotations with other staple crops (Odendo, Bationo, & Kimani, 2011) and as hedgerows along contour lines and living fences (Graham, 2003). Although there is high diversity in the livelihoods of smallholder farmers in DRC and Kenya, both countries have some experience with legumes in their cropping systems. Hence, legumes already have an entry point in these countries.

Most legumes produce several products, or serve various functions, during their growth or after harvest and are often referred to as being multipurpose. These functions include generation of income, provision of food, fuel and livestock feed, soil fertility improvement through biological nitrogen fixation (BNF), soil erosion control, and a range of other benefits (Giller & Cadisch, 1995). Most farmers prefer to include legumes as intercrops with carbohydrate rich staple food crops such as maize (*Zea mays* L) and cassava (*Manihot esculenta* Crantz. Inst.). The most common legumes used as intercrops are cowpea (*Vigna unguiculata* (L.) Walp.) and common bean (*Phaseolus vulgaris* L.) (Brooker et al., 2015). Herbaceous and tree/shrub legumes may also be intercropped with staple food crops as hedgerows along contour lines

or along the field edges, for provision of livestock feed, soil fertility improvement and soil erosion control in smallholder farms (Hassen, Talore, Tesfamariam, Friend, & Mpanza, 2017). Such practices have been tried in Malawi, Tanzania and Zambia where Gliricidia (*Gliricidia sepium* (Jacq.) Kunth ex Walp), Tephrosia (*Tephrosia vogelli* Hook.f.) and Sesbania (*Sesbania sesban* L.) were intercropped with maize increasing maize yield by 56%–583% (Akinnifesi, Ajayi, Sileshi, Chirwa, & Chianu, 2011). Tree/shrub legumes can also contribute to the provision of fuel. Various legume types (grain, herbaceous and tree legumes) have the potential to yield well in climatic conditions that are common in sub-Saharan Africa. These include grain legumes such as chickpea (*Cicer arietinum* L.), cowpea, groundnut (*Arachis hypogaea* L.) and pigeon pea (*Cajanus cajan* L.) (Abate et al., 2012), herbaceous legumes such as lucerne (*Medicago sativa*), velvet bean (*Mucuna pruriens* L.), lablab (*Lablab purpureus* L.), and tree legumes such as calliandra (*Calliandra calothyrsus* Meisn), sesbania and gliricidia (Sileshi, Akinnifesi, Ajayi, & Place, 2008). However, despite the wide range of benefits provided by legumes their full utilization and the adoption of legumes is still relatively low in SSA (Hassen et al., 2017).

There are various reasons for the generally low uptake of legumes in SSA. Firstly, farmers, breeders

and development agencies hold different views on what constitutes desirable legume characteristics (Waldman, Ortega, Richardson, Clay, & Snapp, 2016). This results in failure to establish effective partnerships between farmers and key stakeholders towards common goals (Shelton, Franzel, & Peters, 2015). Secondly, several studies on the adoption of legumes have indicated that lack of reliable seed production and supply of high quality seeds reduces the uptake of legumes (Shelton et al., 2015). In some areas, farmers do not grow legumes due to poor market structures that limit financial returns (Yap, de Neergaard, & Bruun, 2017). Thirdly, insecurity of land tenure, farmers' lack of interest in testing legume species that are new to them and lack of extension information, (Shelton et al., 2015) all act as barriers to uptake. Other constraints which reduce legume adoption include unsuitable rainfall pattern, soil nutrient depletion, pests and disease (Ojiem, De Ridder, Vanlauwe, & Giller, 2006). Waldman et al. (2016) and (Pircher, Almekinders, & Kamanga, 2013) reported that use of legumes in smallholder farms in Malawi is driven by socioeconomic factors including gender and income, and various legume attributes including grain yield, taste, adaptability and capacity for soil fertility improvement. However, working with farmers on new and existing legume species through participatory research and extension may help improve legume uptake in smallholder farming systems (Mhango, Snapp, & Phiri, 2013).

Several studies have assessed farmers' perceptions and knowledge of different issues around agriculture and they argued for the importance of sharing information between farmers and researchers (Waldman et al., 2016). Sharing information can be achieved through group extension approaches and farmer field schools among other methods (Prager & Creaney, 2017). Assessing farmers' perceptions and knowledge on various subjects can help to explain farmers' attitudes and behaviour towards innovations. Thus, the research questions of this study were: (a) what are smallholder farmers' perceptions and knowledge levels of different legume types and the functions they serve in support of their livelihoods, and (b) what is the rationale for current use of legumes in smallholder farms in east and central Africa, and (c) are there differences in preferences for functions depending on farmers' context? In order to explore these questions, a detailed survey of farmers in western Kenya and eastern Democratic Republic of Congo (DRC) was conducted. These two

countries have similar biophysical conditions for farming but with differences in enabling environment such as institutional arrangements and market access.

2. Materials and methods

2.1. Site description

The study was conducted in Kenya and DRC (Figure 2), from September 2016 to February 2017. In Kenya data was collected in four sub-counties namely Rongo Suna West, Kitutu Chache and Nyaribari Chache. Rongo and Suna West are located in Migori County while Nyaribari Chache and Kitutu Chache are located in Kisii County. These sites have a sub-humid climate and receive rainfall in a bimodal pattern (1000–1600 mm per annum), average precipitation 550 mm during short rains and 800 mm during the long rains. The average maximum temperature is 28°C during the short rains and 27°C during the long rains seasons in Kenya. The average minimum temperature is 12°C and 14°C during short and long rains respectively. All the sites in Kenya have weekly market days where farmers sell their produce among each other or people from nearby cities. The average size of land hold by the interviewed farmers was 1.2 ha (Table 1). Maize and common bean are common across sites and are usually grown in all cropping seasons. Other major crops include sugarcane (*Saccharum officinarum*) in Rongo; tea (*Camellia sinensis*) in Kitutu Chache and Nyaribari Chache; and cassava in Suna West. Cattle (*Bos Taurus*), goats (*Capra aegagrus hircus*), sheep (*Ovis aries*) and chickens (*Gallus domesticus*) are among the livestock kept in Kenya sites. Soils at Suna West are classified as *Planosols* while at the other three sites they are dominated by *Acrisols*, according to FAO classification (Jones et al., 2013).

In DRC, data was collected from four sites in South Kivu Province (humid climatic conditions) namely Luduha, Madaka, Bushumba Centre and Mulengeza. All sites receive rainfall in a bimodal pattern ranging 1100–2700 mm per annum (long rains last from March to July (approximately 600 mm) and short rains last from September to December (approximately 530 mm)). The altitude at all sites ranges between 1300 and 2000 m above sea level and the annual average temperature in all sites ranges between 18°C and 21°C. The average maximum and minimum temperature during the short and long rains is approximately 23°C and 8°C at the DRC sites.
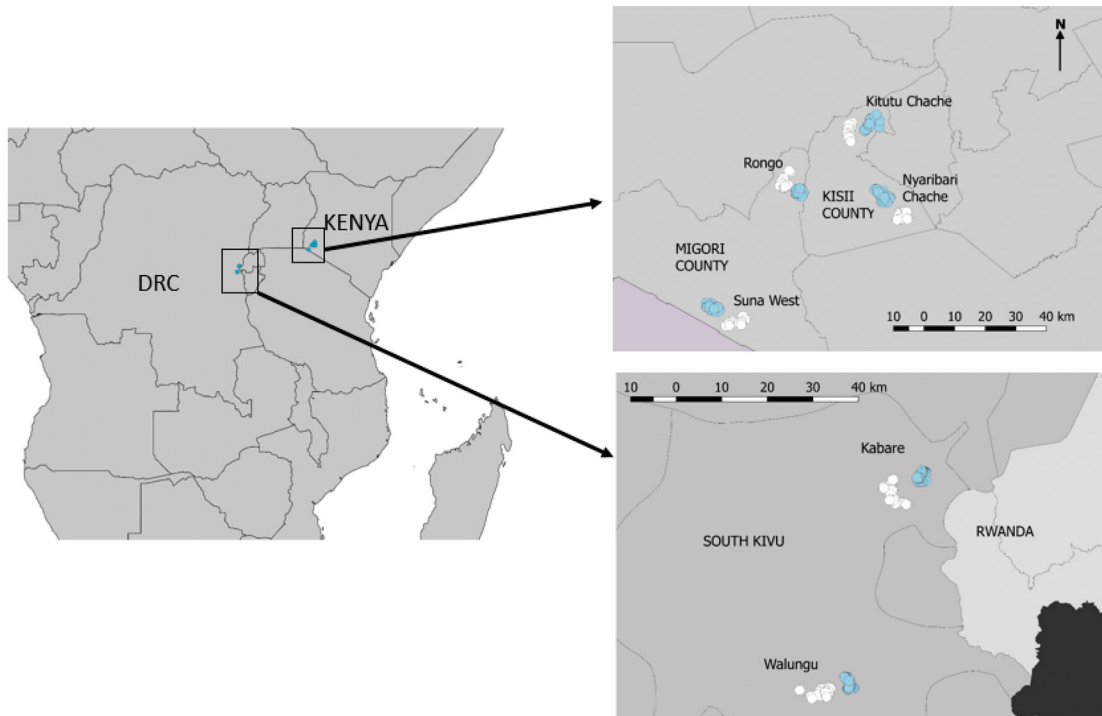
Figure 2. The sites where the survey was conducted in Kenya and DRC. White circles in each country indicate non-legumeCHOICE farmers, while the blue circles are for legumeCHOICE farmers.

Table 1. Smallholder farmers' characteristics in DRC and Kenya sites.

	Mean	Standard deviation	Mean	Standard deviation	t-test[†]
	Kenya		DRC		
Age	48.1	14.9	44.4	13.6	0.038
Land size (ha)	1.2	1.6	1.0	3.1	NS
Livestock units (TLU)	1.9	1.7	0.5	1.1	<0.001
Livestock: cattle	2.4	2.2	0.6	1.5	<0.001
Livestock: goats	0.9	1.7	1.0	1.4	NS
Livestock: sheep	0.4	1.5	0.2	1.0	NS
Livestock: chicken	9.7	8.5	1.6	3.1	<0.001

[†]Significance test between farmers in Kenya and DRC using a chi-square test for knowledge of legumes.

Average land size of the interviewed farmers in DRC sites was 1 ha (Table 1). Maize, common bean and cassava are the most common crops across the sites. Cattle, goats, sheep and chickens are among the livestock kept in DRC sites. The soils in the study areas are characterized as *Acrisols*, according to FAO classification (Jones et al., 2013).

We consider crop and livestock farming systems being predominant in the investigated areas to be representative of smallholder farming systems within densely populated areas of Kenya and DRC. Crop and livestock farming is practiced by approximately 70% of the farmers in SSA (Garrity, Dixon, & Boffa, 2012). Farms in Kenya have higher tropical livestock units (1.9) than in DRC (0.5) (Table 1). Farmers in both countries rely largely on agriculture to sustain their livelihoods.

2.2. Identification of participants

The survey involved a mix of farmers who participated in the 'LegumeCHOICE (LC) project[1]' which ran from 2014 to 2017 and those who were not involved in the LC project. The goal of LC was to improve food and nutrition security and enhance the production environment at smallholder farms through the integration of multipurpose legumes in crop-livestock systems in east and central Africa. This study selected some of the farmers from the LC project and preference was given to those farmers who had been in the project since the beginning. In addition, farmers

who lived approximately 5 km away from the LC farmers were interviewed and served as the reference group. Farmers in the latter group were randomly selected mainly on their willingness to participate in the survey, lack of awareness of the LC project, distance from the LC farmers and being household heads. The sample frame was designed so that there was an equal split between LC farmers and those who had not participated in the project. A total of 162 farmers in Kenya and 106 farmers in DRC were interviewed. Of the 268 farmers interviewed 119 were LC farmers and 149 were non-LC farmers. The average age of the interviewed farmers was 48 in Kenya and 44 in DRC (Table 1).

2.3. Survey instrument

A structured questionnaire was used for the interviews (supplement 1). The questionnaire was divided into two sections that assessed:

(i) Household characteristics
(ii) Farmers' knowledge and perceptions of legumes and their functions, as well as the rationale for their use.

The first section was used to collect farmers' basic background information which included land size, livestock holdings, family size, age of the household head, family monthly expenditure and income and the main crops grown. Contact details and the location (Global Position System, GPS) were recorded.

The second section was used to evaluate farmers' knowledge of legumes and their functions. Farmers' knowledge of legumes was categorized into 'no knowledge', 'weak knowledge', and 'strong knowledge'. 'No knowledge' was allocated to farmers could not mention any legume while 'weak knowledge' was when farmers could mention at least one legume example or one legume characteristic. 'Strong knowledge' indicated farmers could mention at least two legumes species and two characteristics. Farmers were also asked about legume functions without hints from the enumerators. After documenting the response of the farmers regarding their knowledge of legumes, they were shown 12 photos of different legume types (grain, herbaceous and tree legumes) and asked to identify them by common or local name without the enumerator providing hints. The included species were common bean, lablab, cowpea, groundnut, soybean (*Glycine max*), pigeon

pea, velvet bean, silver leaf desmodium (*Desmodium uncinatum*), Calliandra, sesbania, Acacia (*Acacia angustissima*), and gliricidia. These species included commonly grown legumes which were expected to be easily identified by farmers and some which were less common but have potential to improve productivity in smallholder farming systems. Farmers could use local, English or French names of the legume species and consult with other family members who were present during the interviews. The level of consultation was recorded as part of the data collection exercise.

The last section involved scoring of the key legume functions incorporated in the LC tool (Duncan et al., 2016). These were the provision of food, fuel, and livestock feed, control of soil erosion, generation of income and improvement of soil fertility. These functions were explained to farmers by enumerators in detail before the scoring exercise. Scoring was conducted using counters; each farmer was given 30 counters to distribute among the 6 functions in priority of their importance. After the scoring exercise, farmers' source of legume knowledge was assessed. The level of access of legume knowledge using the different sources was categorized using a likert scale (yes frequently, yes occasionally and never).

2.4. Data collection and analysis

The questionnaire was piloted at three field sites in Kenya (Rongo, Kitutu Chache and Nyaribari Chache) with 15 farmers. The main issue that emerged was the length of time taken to complete the survey and the questionnaire was therefore reduced to the presently described protocol to allow more efficient data collection. Enumerators were then trained on how to use the survey instrument before interviews commenced. All enumerators were either research technicians at IITA in DRC, KALRO in Kenya or University students doing internships at these two organizations. In each country, the same enumerators participated at all sites. Data were recorded on paper survey forms by enumerators and these were checked and cleaned and then entered into the Statistical Package for Social Sciences (SPSS). The interviews were carried out by trained enumerators in Luo, Kisii, Swahili, Mashi and French languages and the results were translated into English.

The data for farmers' background information, which were continuous were analysed using descriptive statistics such as mean and standard deviations.

Simple T-tests were used to assess the differences between DRC and Kenyan farmers and LC farmers and non-LC farmers. For farmers' knowledge and perceptions, the variables used included ability to define legumes, priority legume functions and ranking of legume functions. These data, which were categorical, were subjected to chi-square tests to assess the differences between the two countries using Statistical Package for Social Sciences (SPSS). Farmers who had 'no' knowledge about legumes were excluded in the analysis of the question regarding legume functions without hints from enumerators. The generalized linear model (binomial probability distribution using the Logit link function) in SAS 9.4 of the SAS System for Windows © 2002–2012 was used to assess the relationship between farmers' livestock ownership and farmers prioritization of key provision of feed function.

3. Results and discussion

3.1. Farmers' knowledge of legumes in Kenya and DRC

Farmers' knowledge of legumes differed between Kenya and DRC. More than 50% of the interviewed farmers in both countries could at least give a weak definition of legumes (Table 2). This suggests that farmers have some knowledge levels about legumes. Farmers in DRC had less knowledge about legumes than in Kenya. Agricultural productivity is low in DRC due to civil wars which have affected economic development, and both market and transportation are still

poor (Ochieng, Knerr, Owuor, & Ouma, 2016). Poor markets access limits farmers' choice on which crops to grow on their farms and also reduces income from selling food due to the high transaction costs including packing material, labour for harvesting and hiring lorries for transporting their produce. Most farmers therefore focus on carbohydrate rich crops such as cassava, yams (*Ipomoea batatas*), maize and rice (*Oryza sativa*) for subsistence. In Kenya, there is a strong link between the large urban areas and the rural economies that helps increase the diversity of crops grown in rural areas. Also at all sites in Kenya, there are weekly market days where farmers sell their products, and this improves the marketing situation. On the other hand, (Olwande, Smale, Mathenge, Place, & Mithöfer, 2015) identified that some farmers in Kenya prefer to buy staple crops such as maize using income they generate from growing cash crops including tea, vegetables, sugarcane and banana (*Musa* sp.). When farmers have the opportunity to purchase food crops they no longer need to produce for subsistence. This increases their options to grow crops based on market demand which improves agricultural activities and productivity in Kenya and could help explain why farmers in Kenya seemed to know more about legumes than in DRC. The results also indicate that more farmers within the LC project could give at least one legume example and characteristic (78%) than farmers outside the project (62%) (Table 2). The farmers that were included in the LC project seem to have better knowledge than non-project farmers showing that interaction of farmers with researchers through participation in focus group discussions and on-farm trials of legume interventions helped farmers gather more knowledge on the different legume types that have potential in their areas. It has been shown in previous studies that farmers' knowledge improves after being engaged in the implementation of various projects/research that led to higher adoption rates of a recommended technology, e.g. (Kangmennaang et al., 2017). Thus, farmers in both countries have some knowledge about legumes but this knowledge has gaps, and the various functions of legumes are not fully known. Many of the farmers traditionally grow legumes, in particular intercropping of common bean with maize, but their knowledge of legume functions (at least as defined by scientists) remains relatively limited.

The majority of the interviewed farmers could identify 3 - 4 legumes species out of the 12 species

Table 2. Farmers knowledge of legumes and their functions without hints from the enumerators in Kenya and DRC.

	Kenya (%)	DRC (%)	χ^2 significance[†]
Legume knowledge			0.001
Strong	38	14	
Weak	40	41	
No	22	44	
	LC farmer (%)	Non-LC farmers (%)	χ^2 significance[‡]
Legume knowledge			0.012
Strong	35	24	
Weak	43	38	
No	22	38	

[†]Significance test between farmers in Kenya and DRC using a chi-square test for knowledge of legumes.
[‡]Significance test between LegumeCHOICE farmers and non-Legume-CHOICE farmers using a chi-square test.
Note: The number of farmer participating was 105 in Kenya sites and 161 in DRC sites.

Table 3. Identification of legumes shown in provided pictures during the interviews in Kenya and DRC sites.

Legume species	Legume type	Country	Identified, local name (%)	Identified, English/French name (%)	Consulted family member (%)	Could not name (%)	χ^2 significance[a]
Common bean (*Phaseolus vulgaris*)	Grain legume						NS
		Kenya	70	22	1	7	
		DRC	68	25	0	7	
Cowpea (*Vigna Unguiculata*)	Grain legume						<0.001
		Kenya	20	6	1	74	
		DRC	4	1	0	95	
Groundnut (*Arachis hypogea*)	Grain legume						NS
		Kenya	61	15	1	23	
		DRC	56	25	0	19	
Soybean (*Glycine max*)	Grain legume						<0.001
		Kenya	21	37	0	42	
		DRC	48	24	0	28	
Pigeon pea (*Cajanus cajan*)	Grain legume						NS
		Kenya	1	2	0	97	
		DRC	3	1	1	95	
Lablab (*Lablab purpureus*)	Herbaceous legume						0.004
		Kenya	1	1	0	98	
		DRC	8	3	0	90	
Velvet bean (*Mucuna pruriens*)	Herbaceous legume						NS
		Kenya	1	1	0	99	
		DRC	2	2	0	96	
Silver leaf desmodium (*Desmodium uncinatum*)	Herbaceous legume						NS
		Kenya	7	3	0	90	
		DRC	4	2	0	94	
Calliandra (*Calliandra calothyrsus*)	Tree legume						<0.001
		Kenya	16	23	0	60	
		DRC	42	21	0	37	
Sesbania (*Sesbania sesban*)	Tree legume						NS
		Kenya	20	3	0	77	
		DRC	13	4	0	83	
Acacia (*Acacia angustissima*)	Tree legume						NS
		Kenya	2	2	0	96	
		DRC	2	0	0	98	
Gliricidia (*Gliricidia sepium*)	Tree legume						NS
		Kenya	2	2	0	96	
		DRC	4	0	0	96	

[a]Significance test between farmers in Kenya and DRC sites using a chi-square test.

shown on pictures. Grain legumes including common bean, groundnut and soybean were the most readily identified legumes using local, English or French names (Table 3). This could be related to the fact that 98% of the interviewed farmers in both countries mentioned the provision of food as a key legume function without hints from the enumerator. Soybean is a relatively new crop in most parts of SSA that was highly promoted between 2000 and 2012 (Mutegi & Zingore, 2014), which may have resulted in approximately 60% and 70% of the farmers in Kenya and DRC, respectively, being able to identify it. According to Abate et al. (2012), most farmers in SSA grow legumes for food security, income generation and soil fertility maintenance. Many farmers in both countries could not recognize pigeon pea or cowpea although these species are suitable in areas which receive low rainfall per annum. The majority of the

participating farmers could not identify the herbaceous and tree legumes shown (except for calliandra, in DRC) (Table 3). This could be because farmers are interested in crops that they can either directly consume or readily sell in the markets and these species do not meet these criteria.

Farmers in DRC generally mentioned more legume functions than farmers in Kenya. Significantly more farmers mentioned that legumes provide livestock feed in DRC (62%) than in Kenya (19%) (Figure 3). Gliricidia was more often perceived as a source of livestock feed in DRC (51% of the interviewed farmers) than in Kenya (33% of the farmers) while calliandra was more often perceived as livestock feed in Kenya (51%) than DRC (33%). For other species, less than 20% of the interviewed farmers in both countries recognized them as a source of livestock feed. Grain legume crop residues can be used as livestock feed,
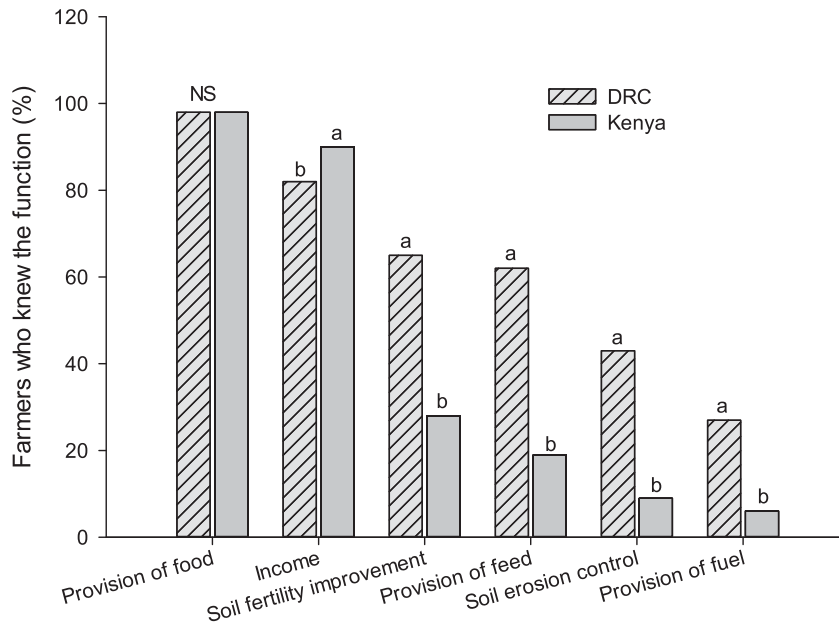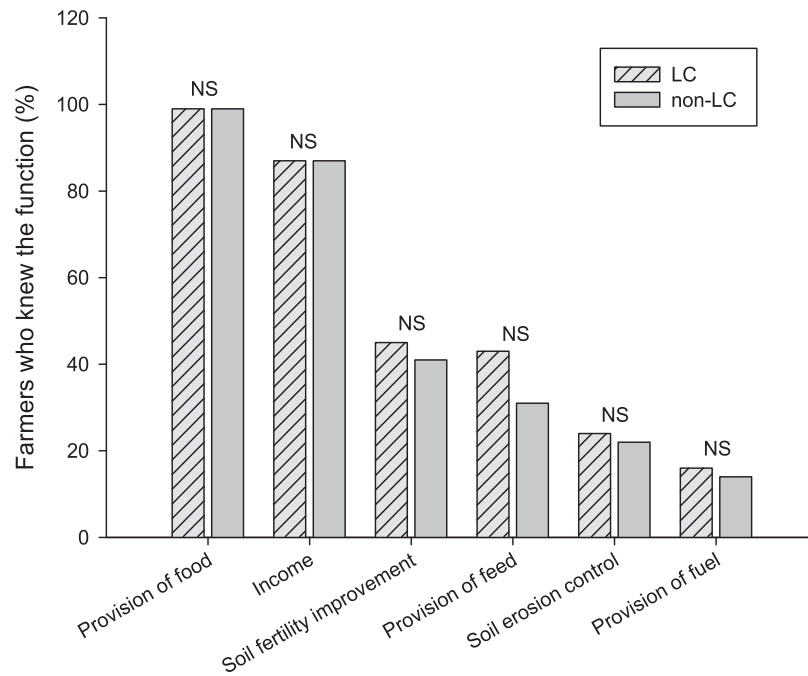
Figure 3. Farmers knowledge on legume functions in DRC and Kenya sites, and in LC and non-LC farmers. Bar with different letters are significantly different from each other.

Table 4. Source of legume related information in smallholder farming in Kenya and DRC.

Source of information	Category	Kenya (%)	DRC (%)	χ^2 significance[a]
National radio				0.024
	Yes, frequently	46	39	
	Yes, occasionally	27	18	
	Never	27	43	
National television				<0.001
	Yes, frequently	8	1	
	Yes, occasionally	12	1	
	Never	80	98	
Newspapers/magazines				0.001
	Yes, frequently	4	1	
	Yes, occasionally	14	1	
	Never	82	98	
Extension officers				<0.001
	Yes, frequently	11	32	
	Yes, occasionally	24	10	
	Never	65	58	
Research institutes				0.014
	Yes, frequently	29	25	
	Yes, occasionally	27	14	
	Never	44	61	
Farmers to farmer				NS
	Yes, frequently	57	68	
	Yes, occasionally	17	9	
	Never	26	23	

[a]Significance test between farmers source of legume information in Kenya and DRC using a chi-square test.
Note: The number of farmers participating in the survey was 162 in Kenya and 106 in DRC.

but herbaceous legumes and tree legumes offer direct provision of feed for livestock. They have high energy and protein content and the introduction of such crops could result in improved livestock productivity and potentially improved farmer livelihoods (Pugalenthi, Vadivel, & Siddhuraju, 2005). More than 80% of the interviewed farmers in both countries identified generation of income as a function of legumes, and the proportion was significantly higher in Kenya than in DRC. Only 9% of farmers in Kenya associated erosion control with legumes compared to 45% in DRC (Figure 3). The same trend was observed for soil fertility improvement and provision of fuel functions where more farmers in DRC identified soil fertility improvement (65%) and provision of fuel functions (27%) than in Kenya where the figures were 28, and 6%, respectively (Figure 3). This could be due to more limited resources for farmers in DRC and therefore a greater focus on multiple benefits of legumes. Previous work has shown that farmers' limited knowledge on various legume functions, which are seen to have potential on improving productivity in their farms, may result in underutilization and low adoption of various legumes in smallholder farms. For farmers to use underutilized legumes they need to know about them and their functions. LC has increased this knowledge slightly, but not substantially. Thus, it

is essential to build the knowledge base of smallholder farmers and enable access to input and output markets as well as extension and decision support, so that they have a wide range of legumes to choose from that could potentially meet their food, feed, fuel, erosion control and soil fertility improvement demands as well as contribute to income.

Interviewed farmers mainly rely on each other for information exchange about legumes (Table 4). Similar proportions of farmers in Kenya and DRC relied on frequent or occasional exchanges with other farmers for legume related information. These findings concur with Mashavave, Mapfumo, Mtambanengwe, Gwandu, and Siziba (2013) who reported that farmers in Zimbabwe rely on intergenerational and indigenous knowledge, on what works and what does not work for them. Hence the majority of smallholder farmers in SSA use indigenous knowledge to make agricultural decisions that help them withstand risks associated with market volatility and climate variability among others (Mapfumo, Mtambanengwe, & Chikowo, 2016). Such a knowledge base works within existing farmers' circumstances, however, there is need to integrate it with scientific knowledge to introduce new species and technologies to improve the agricultural production and productivity in the face of increased pressure on resources.

Farmer groups and their advisory services, producer or innovation platforms and participatory decision support tools (Duncan et al., 2016) are examples of initiatives that could be utilized to combine local and scientific knowledge to facilitate the spread of knowledge on the benefits of various legumes in smallholder agriculture in SSA. Producer or innovation platforms, learning space for people with different backgrounds aimed at addressing common goals, are formed by bringing farmers, researchers, input suppliers and food processors together, often facilitated by development or market actors (Dror, Cadilhon, Schut, Misiko, & Maheshwari, 2016). Results indicate that more farmers in Kenya had access to legume information from the radio than in DRC, very few farmers in Kenya or DRC sourced information about legumes from television. Very few farmers in either country sourced information about legumes from newspapers or farming magazines.

Most of the farmers in DRC and Kenya had no access to extension services or research institutes. These findings concur with Muyanga and Jayne (2006) who reported that most of the farmers who produce low-value crops in remote areas are poorly served by the extension services in Kenya. Agricultural advisory services are provided by different actors including NGOs, development actors, community-based organizations. The public extension services in both countries are managed by the Ministry of Agriculture and in DRC this ministry relies on funding from the government, at national level, which often is too low (Ragasa, Ulimwengu, Randriamamonjy, & Badibanga, 2016). This results in extension officers failing to deliver their services to smallholder farms. In Kenya, the public agricultural extension service is devolved to the Counties under the Ministry of Agriculture which gets support from the Kenyan government and rural development programmes supported by different organizations and countries (Muyanga & Jayne, 2006). Research organizations target smallholder farmers, but their reach is limited. In DRC there is a lack of coordination, clear policies, mandates and funding and low competencies in the extension system that limits its effectiveness (Ragasa et al., 2016).

### 3.2. Farmer perceived functions of legumes

Farmers in DRC and Kenya scored provision of food as the most preferred function of the legumes followed by income generation (Figure 4). These results concur with other studies which reported that

farmers are more concerned about food availability and income opportunities than other functions, e.g. (Schmidt, Kolodinsky, DeSisto, & Conte, 2011). This could explain why smallholder farmers grow more grain legumes than tree and herbaceous legumes. Thus, grain legumes with high grain yield are preferred options on their farms, as they provide food and potentially income. However, when farmers are concerned about soil fertility improvement, herbaceous and tree legumes have more potential, since most of the nitrogen fixed in grain legumes is removed from the field as grains. Provision of fuel had the lowest score in both countries, although it was ranked higher in DRC than in Kenya (Figure 4). There were no significant differences between Kenya and DRC in scoring of the other four legume functions. Scoring of provision of livestock feed legume was influenced by livestock ownership. The results from combined analysis indicate that there was a significant relationship between livestock ownership, expressed as tropical livestock unit – TLU (Njuki et al., 2011), and scoring for provision of livestock feed. The regression line equation ($P = 0.02$ and $R^2 = 0.05$):

$$y = 0.0243x + 0.1018 \qquad (1)$$

where y is the scoring of provision of livestock feed function and x is TLU.

Farmers with low numbers of TLU scored provision of livestock feed function lower than farmers with high numbers of TLU presumably due to increased demand for livestock feed. Most of the former grazing lands in all sites are used for cropping and most animals are kept in zero grazing systems, hence, farmers require other sources for livestock feed and legumes are a viable option for them. Furthermore, soil erosion control and provision of fuel were not highly ranked as important legume functions for the interviewed farmers in Kenya and DRC. This indicates that farmers do not prioritize these two legume functions in their farming systems. However, soil erosion and deforestation are some of the major problems faced by smallholder farmers in SSA. Legumes, in particular herbaceous legumes and shrub/tree legumes, contribute to soil erosion control through increased ground-cover that reduces rainfall runoff and conserves soil (Beyers, 2004). Provision of fuel is a characteristic of tree legumes including *Calliandra calothyrsus*, *Leucaena* sp. and *Gliricidia sepium* as examples. These tree legumes have been promoted in SSA by various research and development organizations and they
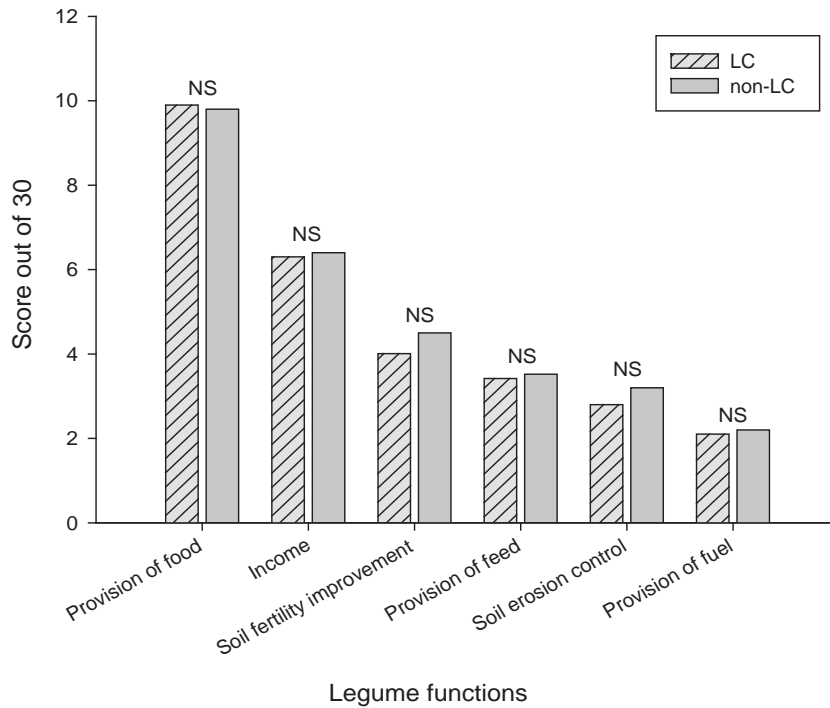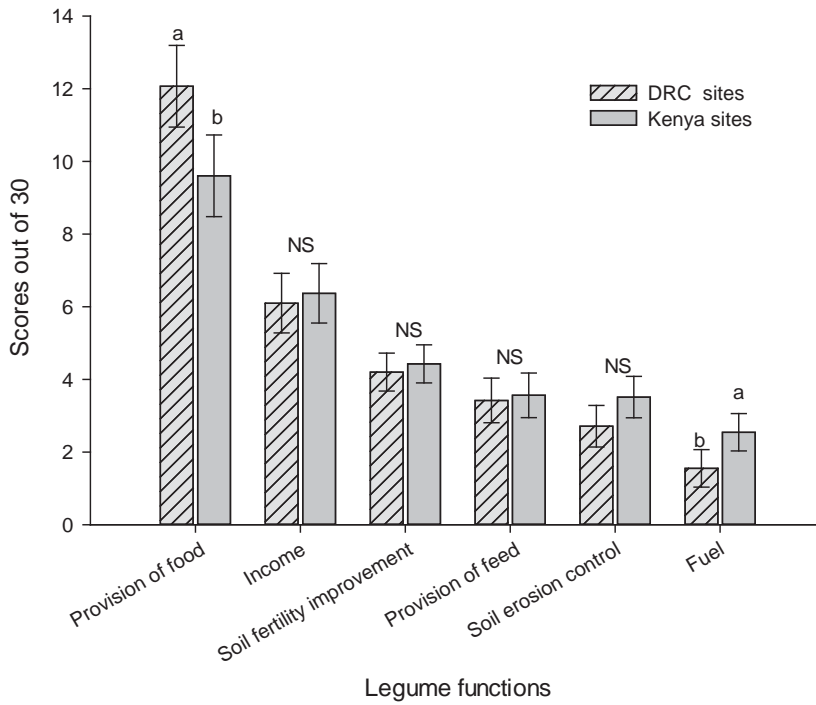
Figure 4. Ranking of different legume functions by farmers in DRC and Kenya. Bars with different letters are significantly different from each other. Bars with strips are for DRC sites while bars without strips are for Kenya.

show fast growth rates and high yields of wood that can be used for fuel. Also, they contribute to soil fertility improvement through BNF and provide livestock feed. Low scores for livestock feed, soil erosion control and fuel suggest that farmers place a higher value in short term benefits including feeding their families and securing income than long term benefits such as natural resource management. Thus, there is an untapped potential for legume intensification and diversification to improve farm productivity and sustainability of smallholdings.

4. Conclusions

Farmers in DRC and Kenya have a diverse knowledge around legumes and their functions, and the most known were provision of food and income. Also, farmers could identify grain legumes more readily than other legume types. They scored provision of food and income higher than provision of livestock feed and fuel, soil fertility improvement and soil erosion control. Based on our results, we conclude the following

- Grain legumes were more readily identified by interviewed farmers because farmers put more value on short term benefits of legumes including food and income than long term benefits such as natural resource management. Accordingly, the multifunctional nature of legumes, promoted by aid agencies and national governments do not fully align with the goals of small holder farmers. Ultimately, if farmers perceive legumes as a means to generate income and promote nutrition this may be the main mechanisms for framing transfer programmes to these farmers and, hence, reduce emphasis on long term goals.
- Farmers' knowledge of the BNF characteristic of legumes, associated with soil fertility improvement, and other functions including provision of livestock feed and fuel are not well articulated, making it difficult for them to see the diverse plants we are asking about as a single group with common characteristic (legumes).
- Although the key functions of legumes were discussed with farmers before scoring exercise, food and income remained the key functions farmers are interested in. Thus, farmers require more than just information but also improved market access to purchase inputs and sell products to realize the other benefits that are associated with growing legumes.

Disclosure statement

No potential conflict of interest was reported by the authors.

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