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Willingness of farmers to adopt rice intercrops in the Lake Victoria Crescent Agro-ecological Zone of Uganda

Ruth Kabanyoro, Stella Kabiri, Immaculate Mugisa, Winfred Nakyagaba, Losira Nasirumbi, George Kituuka, Barbara Kyampeire, Maria Nampera, Teopista, Namirimu and Bernard Fungo*
Mukono Zonal Agricultural Research and Development Institute (MuZARDI), National Agricultural Research Organization (NARO), P. O. Box 164, Mukono, Uganda
Correspondence: bfungo1@yahoo.com; Tel: +256 772 380 592

Abstract
Intercropping, particularly with legumes, is a food security and soil fertility management strategy of small-holder, resource-poor farmers in sub Saharan Africa. Understanding the extent of and factors affecting farmers' willingness to adopt intercropping practices is central to decisions to promote this practice. We assessed the socio-economic factors affecting the farmers' choice to adopt an emerging rice intercrop technology in the Lake Victoria Crescent Agro-ecological Zone (LVCAZ) of Uganda. A household survey was conducted with 171 rice farmers in Kiboga, Kayunga and Luwero districts. Logistic regression analysis was used to model the willingness of farmers to adopt the rice intercrops. Results show that approximately 60% of the farmers are willing to adopt the practice. The willingness to adopt is higher with higher level of education of household heads, contact with extension agents and training, ease of access to rice seed and membership to farmer groups. On the other hand, farmer experience with rice cultivation negatively affects willingness to adopt the technology. The implication of our findings is that extension agents, especially the National Agricultural Advisory Services, should work with farmer groups to create awareness of the benefits of rice intercrops, link them with research institutions such as the National Agricultural Research Organization to enable them access seed. The Participatory Market Chain Approaches that have already shown success in potato value chains should be promoted so that commercial rice farmers have alternative markets for secondary crops from the intercrops. Further studies into the economic and social and environmental benefits of these practices are required to shed light on their sustainability.
Keywords: *Rice intercrops, adoption, willingness, Lake Victoria Crescent Zone, Uganda*

Introduction

Soil fertility decline as a contributor to food insecurity and household poverty in Sub Saharan Africa (SSA) cannot be overemphasized. According to Bekunda *et al*. (2010), failure by smallholder farmers to intensify agricultural production in a manner that maintains soil productivity is the main cause of land degradation in SSA. Improved soil nutrient management is important for maintaining and improving soil productivity in Uganda, and strategies are required that more closely address farmer requirements and priorities (Deugd *et al*., 1998; Esilaba *et al*., 2005, Fungo *et al*., 2011a).

Field tests reveal that the most limiting nutrients in SSA are Nitrogen (N) and Phosphorus (P) (Bekunda *et al*., 1997; Woomer and Muchena, 1996, Fungo *et al*., 2011b). For example, in a series of fertilizer trials conducted throughout the Kenyan highlands, N and P deficiencies were reported in 57% and 26% of the cases, respectively (KARI, 1994). Biological Nitrogen Fixation (BNF) in Africa accounts for approximately 80% of the total N supplied to the soils, amounting to 28 Tg (Galloway *et al*., 2004). The use of dual purpose legumes that are grown in intercrop or rotation with cereals both for production of grain and provision of BNF benefits is one of the promising farming systems for soil fertility management (Bekunda *et al*., 2010).

Studies show that in Uganda, between 50 – 80% maize yield increase is possible with nitrogen addition from legumes (Bationo *et al*., 2007). In many African farming systems, less than 5% of the farm area is planted with legumes (Giller *et al*., 2006; Ojiem, 2006; Ojiem *et al*., 2006). This paucity is largely the result of weak marketing infrastructure and low market prices for legumes, conditions that are being addressed through numerous rural development initiatives. Fortunately, the recent increase in food prices will most likely encourage rice farmers to adopt farming practices that maximize yield as well as sustain productivity of commercially important crops, especially the grains (Minten *et al*., 2010; Huang *et al*., 2011).

Intercropping is a practice that some farmers undertake to ensure food security as well as supplement soil nutrient sources, especially biological nitrogen fixation and soil organic matter. Despite these benefits, use of adoption of these practices remains low. There is need to explore the factors that limit the use of these practice in

order identify intervention strategies. Social-economic factors are critical to adoption and retention of farming practices and an in depth understanding of these factors is paramount to design of the intervention strategies. This study is part of a wider project aiming at productivity improvement in rice-based intercropping systems of the LVCAZ.

The socio-economic factors that affect the adoption of technologies may be classified as those that determine feasibility, accessibility and profitability of the technology (Swinkels and Franzel, 1997; Nkonya *et al*., 2008). Feasibility refers to farmers' financial resources, knowledge and experience to buy and manage the technology. Feasibility would also include institutional support like extension services, credit and marketing services. Profitability refers to returns, as perceived by the farmer, of the new technology when compared with the technology that the farmer uses and other alternative new technologies. Profitability of a technology is influenced by the opportunity cost of labor, land and other factors of production, and the output. Acceptability concerns the suitability of the technology, its riskiness, cultural acceptance and compatibility with other farm enterprises (Nkonya *et al.*, 2002).

Some of the widely investigated variables include sex of household head, contact with extension/training, income sources, land size, location, quality and accessibility, access to farm inputs such as seed, exposure to the technologies, access to credit and and membership to farmer groups (Nowak and Korsching, 1983; Wiersum,. 1994; Calatrava-Leyva *et al*., 2005; Mendola, 2005). Results from these studies do not show consistent trends even of the same test variables, implying that the effect of the variable may have technology- and site-specificity. Thus, understanding diffusion and adoption of technologies requires closer focus on the technology as well as the socio-economic setting in which it is being promoted.

Despite the promising nature of the rice-legume intercrops, intercropping rice is not common practice among rice farmers in many parts of the world, including those in the LVCZ of Uganda. Several studies have investigated the socio-economic factors affecting willingness to adopt new technologies among rural farmers. Recommendations from these studies have always been constrained by the fact that farmers' adoption behavior, especially in low income countries, is highly diverse and influenced by a complex set of technology and site-specific socio-economic variables (Buyinza *et al*., 2008). The aim of this study was to determine the willingness of farmers to adopt the rice-legume intercrops in the LVCZ of Uganda.

Study area and methods

The study was conducted in three major rice producing districts (Kiboga, Kayunga and Luwero) in the Lake Victoria Crescent Agro-ecological Zone of Uganda (Figure 1). The contemporary climate in this area is wet tropical with a mean annual precipitation of 1200 mm (distinctly bimodal distribution), and a mean annual temperature of 23^0C at an elevation over 1 km above sea level.

Due to the range in K-feldspar content and variable texture contrast, the soils are classified as a mixture of Oxisols, Ultisols and Inceptisols. Black and grey clays are also found in the flat, poorly drained, bambos (flat, channel-less, poorly drained valley bottoms), with yellow sands on the sloping bambo margins. The topography is characterized by hills and ridges that are highly dissected by streams and drainage ways. The main economic activity of the people in the sampled districts is subsistence farming of bananas, beans, maize, rice, potatoes, and cassava among other crops. Land use types include annual crops, plantation forestry, perennial cropping such as bananas, coffee, and agro forestry. Large expanses of grazing lands are common in Luwero and Kayunga districts.

The districts of Kayunga, Kiboga and Luwero were selected for this study because they ranked highest among the rice growing districts in the LVCAZ. From each of these districts, two sub counties ranked highest in rice production were selected using key informants. The sampling frame consisting of rice farmers was generated using the local councils of the villages in the selected sub counties. Using a list of random numbers, 60 farmers were selected from each district. Household interviews were held with the selected households using a structured questionnaire.

Analytical model

The probability of adopting choice, $Pr(\text{Ti} = 1)$, is cumulative density function F evaluated at χ_i , where χ_i is a vector of explanatory variables and is a vector of unknown parameter (Maddala, 1983). This kind of cumulative density function can be modeled using binary logit probability function, which has the following form:

$$\text{Choice to adopt rice intercrop, Pr(Ri} = 1) = \frac{\exp(\chi_i \beta)}{1 + \exp(\chi_i \beta)}$$

$Pr(\text{Ti} = 1)$ = Probability of adopting choice,
χ_i = Vector of explanatory variables and
is a vector of unknown parameter

The factors thought to influence farmers' choice to adopt rice intercrops include the following (Table 1).

Results

Characteristics of the respondents

The average age of the household heads sampled in this study was 39 years and their level of education is approximately 8 years of schooling (Table 2). The number of years they have been cultivating rice ranges from 1 to 20 with an average of five years. Majority of the households sampled were male-headed (Table 3). Approximately 78% of the respondents have had contacts with extension agents and or received some training on rice cultivation. Rice is the major income crop of approximately 70% of the respondents. The number of farmers having rice in paddy is just 10% above the number in uplands. Close to 40% of the farmers have a problem accessing good quality seed for the rice they want to plant. About 64% of the respondents belong to rice farmer groups in which they access credit, jointly sell and procure rice seed.

Constraints faced in rice production

Farmers reported several problems faced in the production of rice (Table 4). The most frequent problems include damage by birds, rapid weed infestation, pests and diseases and unreliable weather. Other problems include high input costs, especially fertilizers and seed, high labour requirements during weeding, guarding and harvesting, low soil fertility, seed scarcity, and damage from rodents and long distances to markets.

The nature of problems farmers face in accessing good quality seed vary widely. The major problem with seed is its unavailability in addition the high cost if available (Figure 2). Some farmers also pointed out that poor quality seed is often the major constraint as well as its late delivery.

Rice-based intercropping practices

The various crops used as intercrops with rice are presented in Figure 3. Maize is the major crop used by approximately 80% of the respondents. This is followed by beans and finger millet. Other crops which farmers use to intercrop rice include ground nuts, sorghum, cassava and simsim.

Table 5 shows the various reasons given for practicing intercrops with rice. The reasons were given for intercropping rice with these crops include (i) ensure food and income security, (ii) reduce damage of rice by birds, (iii) optimize utilization of land, reduce damage to birds and (iv) improve soil fertility. According to the respondents, adoption of rice intercrops is hindered by several factors such as the high labour requirements at planting, weeding and selective harvesting to reduce damage by pests, particularly birds.

Determinants of willingness to adopt rice intercrops

The factors that significantly explain farmers' willingness to adopt rice intercropping are experience in rice growing, access to extension services, membership to farmer organizations, land size under rice cultivation, whether the farmer grows paddy or upland rice and problems accessing good quality rice seed (Table 6). As indicated by the negative coefficients, farmers with more experience with rice growing are less willing to adopt rice intercrops. Similarly, farmers growing rice in paddy are more willing to adopt intercrops compared to if they had their rice fields cropped in upland rice. Ironically, contact with extension agents, membership to farmer groups, acreage under rice and access to good quality rice seed increases the likelihood of farmers adopting rice intercrops, as indicted by the positive coefficient.

Discussion

Intercropping rice with maize, as done by most farmers in this study, is not a technically appropriate practice in terms of soil fertility and pest management. Being similar in nutrient demands, both crops would result in rapid nutrient mining and possibly increase in pest infestation. Additionally, the respondents seem to pay little attention to the inherent and potential soil fertility problem. Those that intercrop with legumes that can add nitrogen are a meager fraction. Sensitization of the selection and use of appropriate intercrops should be at the

forefront of the planned multi-stakeholder platform for improving soil fertility through rice-based intercrops.

In many parts of Uganda where employment is lacking, the youth usually prefer to migrate to nearby towns to engage in motorcycle transport as the source of livelihood. The average age of 39 years indicates a young and energetic community of farmers who can take on the highly labour requiring rice growing practice. The retention of this youthful labour force could be driven by the relatively high commercial value of rice compared to other crops such as maize. An education level of eight years in school is also relatively high for many parts in sub Saharan Africa. This could be explained by the introduction of Universal Primary Education (UPE) by government of Uganda about 13 years ago. The average of five years in rice experience in this study coincides with the recent advances in the promotion of upland rice by the government of Uganda and this is further supported by the relatively larger number of farmers growing upland rice compared to those with paddy rice.

Reasons for gender difference in the choice to adopt or not to adopt are diverse. For example, it is more likely that females will be more willing to adopt rice intercrops because they focus mainly on food security rather than commercial goals when choosing which crop to grow in their farms (Dos, 2001, Buyinza and Naagula, 2009). Our study showed that women are more willing compared to men but was not significant. However, available literature shows that men and women may have different agricultural production functions, possibly because crop choice differs by gender as a function of cultural norms (Doss, 2002) or by other considerations such as the lack of resources to cultivate specific crops and the culturally appropriate division of labor. Frank (1999), for example, noted that cultural norms in Ethiopia forbid women from using the plow because such work is perceived to be too physically strenuous. Furthermore, Peterman *et al*. (2010), using Ugandan data, showed that a range of household-level gender indicators obscure and underestimate gender differences in productivity. That notwithstanding, the number of female rice farmers was generally small to provide empirical conclusion.

Age of household head is thought to have positive influence on adoption because we assume that older farmers have more general experience and knowledge to easily appreciate the benefits of improved technologies. Because of the mixed findings, it can be difficult at the moment to conclude on the direction that gender has on willingness to adopt agricultural technologies. In the Phillipines, Lapar and Pandey (1999) reported both positive and negative influence of hedgerow intercrops in two sites. Baidu-Forson (1999) reported that age negatively influenced the adoption of land enhancing technology in the Sahel. In Zimbabwe reported positive effect on adoption of conservation farming and attributed it to changing life cycle of the farmer with time, and the effect on adoption of CF practices. The authors observe that as farmers grow older, they become more skillful, through learning by doing. But this trend attenuates as they reach middle age and their physical strength begins to decline. Also, with age farmers become more risk averse and less willing to adopt new farming technologies. Mazvimavi (2004) proposed to include a quadratic function to the age variable in order to capture the effect of changing life cycle of the farmer through time.

It is expected that farmer education will positively influence decision to adopt rice intercrops. The accumulation of farmer knowledge through formal and informal learning media helps them in developing a favorable attitude towards new technologies. Our results are consistent with those of Maziwimani and Twomlow (2009). The implication of our findings is that contacts with extension and other forms of trailing are important to technology adoption. Increased collaboration of private initiatives with local institutions such as extension service could improve the reach of the technology to farmers.

Although it was envisaged that farmers with large experience will tend to adopt more because they are aware of the benefits, our results suggest otherwise. Experienced farmers may be those that have strictly commercial goals outside of which they are not prepared to take risk. Secondly, the partitioning of the land into two crops reduces the total yield of rice. It implies that farmers have to identify other value chains other than the ones they are already familiar with, something many may not wish to venture into intercropping may be perceived to reduce total yield of rice. There could be other constraints that hinder them from practicing the intercropping technologies. If rice is the major income crop of the farmer, it may be even more unlikely that they will adopt the intercrops.

It is expected that farmers with larger areas will more likely adopt intercrops because they have higher “buffer” to maintain profitable quantities if the second crop reduced the plant population of the rice fields. Paradoxically, farmers with smaller plot may be more willing to intercrop so that they obtain diverse benefit and not rely on a single crop. This practice is common with maize-bean intercrop where farmers harvest beans first and later follow with maize. This ensures household food security and diversified production (Buyinza and Naagula, 2009.

Our findings suggest that if farmers have means of easily accessing rice seed, more will be willing to adopt the rice intercrops. Upland rice seed is relatively new on the Ugandan market and many farmers have not adequately devised means to store seed from the previous harvests. One of the benefits of membership to farmer groups is

making access to inputs such as seed easier for farmers. Farmer groups should give due priority to seed acquisition in order to increase the number of farmers that will adopt rice growing and subsequently intercrops. Farmers that join farmer associations may be those generally more receptive to new innovations or interventions in the community which may affect their attitude to the adoption of new technologies.

Conclusions and recommendations

Our study has been able to determine the factors that affect adoption of rice intercrops in the LVCAZ of Uganda. The level of education of household heads, contact with extension and training and ease of access to rice seed and membership to farmer groups are the factors that positively influence the willingness to adopt rice intercrops. On the other hand, farmer experience with rice cultivation negatively affects willingness to adopt the technologies. The implication of our findings is that extension agents, especially the National Agricultural Advisory Services, should work with farmer groups to create awareness of the benefits of rice intercrops, link them with research institutions such as the National Agricultural Research Organization to enable them access seed. The Participatory Market Chain Approaches (PMCA) that have already shown success in different value chains for instance potato, sweet potato and pine apples should be promoted so that commercial rice farmers have alternative markets for rice as well as the secondary crops from the rice intercrops.

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Tables

Table 1: Description of parameters used to estimate the binary logit model of determinants of willingness to adopt rice-based intercrops in Central Uganda

Name of Variable	Description of variable	Type of variable	Responses
Sex	Indicates whether the household head is a male or female	Binary	Yes = 1 No = 0
Age	Provides the age of household head. Age of household head is thought to have positive influence on adoption because it is assumed that knowledgeable farmers are likely to quickly understand the benefits of improved technologies.	Scale	Years
Education	Gives the education level of household head as the number of years in formal school years. Farmer education measures the cumulative number of years that a farmer has been to school. Education thus is expected to have a positive effect on the decision to adopt woodlot technology.	Scale	Years
Experience	Experience in rice farming as the number of years that the farmer has been cultivating rice. It is envisaged that farmers with large experience will tend to adopt more because they are aware of the benefits. It is other constraints that hinder them from practicing the intercropping technologies.	Scale	Years
Extension	Contact with training and extension services measured the contact of farmers with research and development or extension agencies that work on woodlot technology.	Binary	Yes = 1 No = 0
Exposed	Ever exposed to rice-based intercrop indicates if a farmers has ever heard of or seen rice intercrop from somewhere other than his own field.	Binary	Yes = 1 No = 0
Intercrop	Ever intercropped rice. Establishes whether farmer practices rice-based intercrops.	Binary	Yes = 1 No = 0
Major crop	Rice as major income crop grown measures the dominance of rice as a major crop of the household. If rice is the major crop, it might be easier for the household to adopt with the aim of diversifying production.	Binary	Yes = 1 No = 0
Location	Locations of the plots are distinguished in two categories upland and swamps/paddy.	Binary	Upland = 1 Paddy = 0
Acreage	Describes lands that are under rice intercrop for the last one year. Scale variable.	Scale	Acres
Seed	Access to seed determined whether farmers had or did not have easy access to seed.	Binary	Yes = 1 No = 0
Groups	Membership to farmer organization indicates if the farmer is a member of farmers' association. Membership to farmers' organization was hypothesized to positively influence the technology adoption of.	Binary	Yes = 1 No = 0
Willingness	Indicates whether the farmer would be willing to adopt rice intercrops	Binary	Yes = 1 No = 0

Table 2: Characteristics of respondents

Variable	Mean	Std. Dev.	Min	Max
Age of household age	39.0	12.5	19	89
Education level of household head	7.6	4.0	0	15
Experience with rice farming	5.1	3.8	1	20
Acreage under rice	2.3	2.5	0.1	25

Table 3: Characteristics of respondents continued

Variable	**Response**	**Frequency**	**Percentage**
Sex of household head	Female	13	7.6
	Male	158	92.4
Contact with Extension/training	No	37	21.64
	Yes	134	78.36
Rice as main income crop	No	52	30.41
	Yes	119	69.59
Plot location (upland or paddy)	Upland	97	56.73
	Paddy	74	43.27
Any problem accessing seed	No	66	38.6
	Yes	105	61.4
Membership to farmer groups	No	109	63.74
	Yes	62	36.26
Willingness to adopt rice intercrops	No	70	40.94
	Yes	101	59.06

Table 4: Constraints faced by rice farmers in Kayunga, Kiboga, Luwero districts of the LVCAZ of Uganda

Constraints faced	Sex of HH head		Total	% of N
	Male	Female		
Birds	99	8	107	62.6
Weeds	95	9	104	60.8
Pests and diseases	54	6	60	35.1
Unreliable weather	53	2	55	32.2
High input costs	16	1	17	9.9
labour intensive	14	2	16	9.4
low prices at outlets	14	1	15	8.8
Poor soil fertility	12	1	13	7.6
seed scarcity	13	0	13	7.6
Rodents/rats	5	2	7	4.1
long distance to market	3	0	3	1.8

Table 5: Reason for intercropping rice in the LVCAZ of Uganda

Reasons for intercropping	Frequency (N=77)	Percentage
Food security	56	72.7
Income security	14	18.2
Land utilization	5	6.5
Reduce damage by birds	1	1.3
Improve on soil fertility	1	1.3

Table 6: Determinants of farmers' willingness to adopt rice intercrops in the LVCAZ of Uganda

Factor	B	S.E.	Wald	df	Sig.	Exp(B)	95.0% C.I.for EXP(B)	
							Lower	Upper
Sex of HH	-0.941	0.680	1.916	1	0.166	0.390	0.103	1.479
Age of HH	-0.006	0.013	0.170	1	0.680	0.994	0.969	1.021
Education level of HH	0.060	0.046	1.679	1	0.195	1.062	0.970	1.163
Years of rice growing	-0.219	0.062	12.495	1	0.000***	0.803	0.711	0.907
Ever received extension advice	1.301	0.475	7.512	1	0.006***	3.674	1.449	9.317
Ever seen rice intercrop	-0.439	0.408	1.162	1	0.281	0.644	0.290	1.433
Ever intercropped rice	0.247	0.416	0.351	1	0.553	1.280	0.566	2.895
Membership to farmer groups	1.022	0.427	5.711	1	0.017***	2.777	1.202	6.419
Rice as major income crop	-0.162	0.417	0.150	1	0.698	0.851	0.376	1.926
Acreage under rice	0.214	0.131	2.669	1	0. 012**	1.239	0.958	1.603
Paddy or upland rice	-1.375	0.625	4.836	1	0.028**	0.253	0.074	0.861
Problem accessing seed	2.029	0.619	10.759	1	0.001***	7.605	2.263	25.560

, **, and * = Significant at 0.1, 0.05, and 0.001, respectively. N= 171, Log likelihood = -83.37044, LR Chi^2 (9) = 64.66, Prob. > Chi^2 = 0.0000, Pseudo R^2 = 0.4794*

Figures

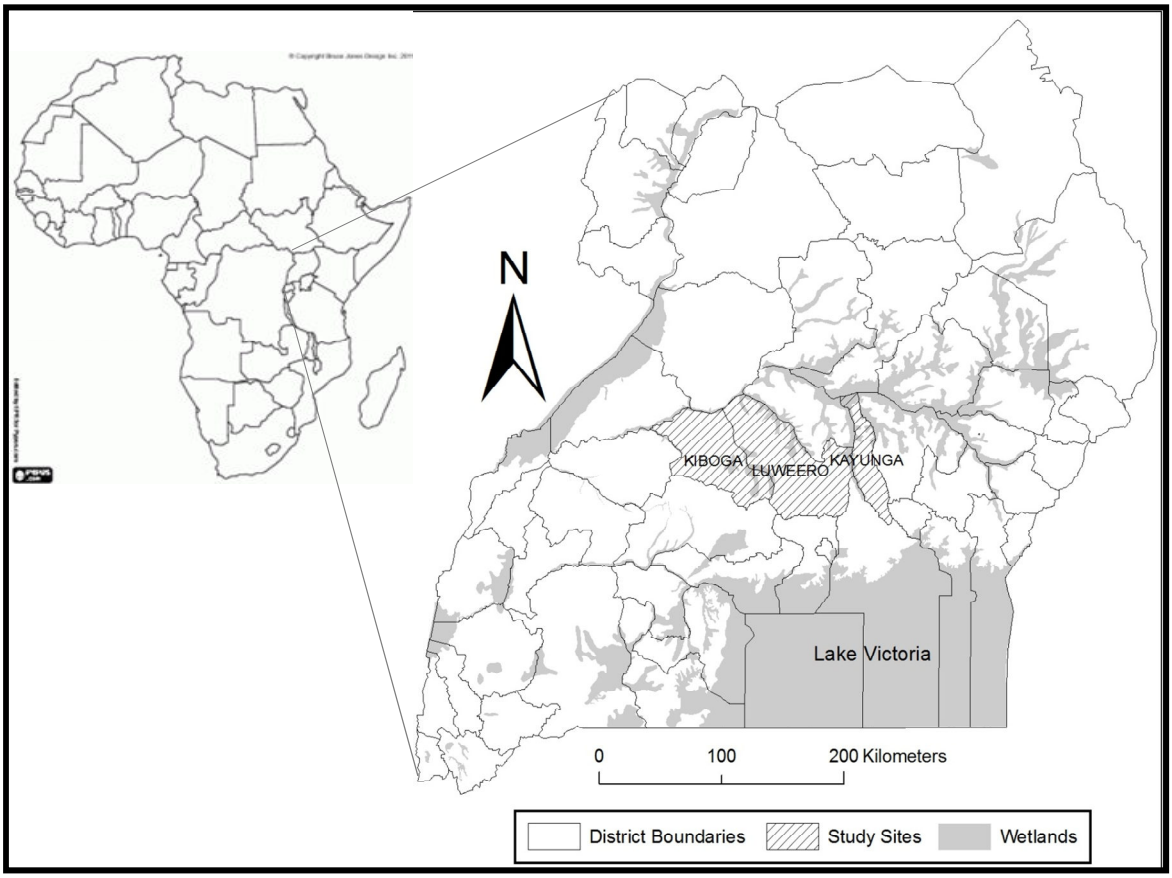

Figure 1: Location of study districts in the LVCAZ of Uganda

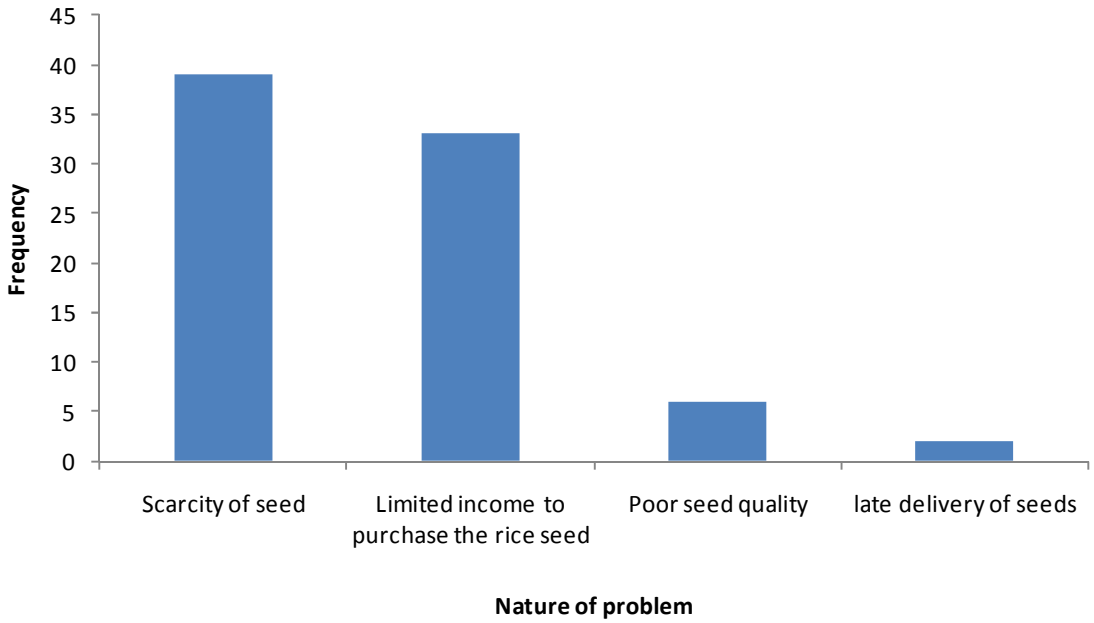

Figure 2: Nature of constraints to good quality seed by rice farmers in the LVCAZ of Uganda

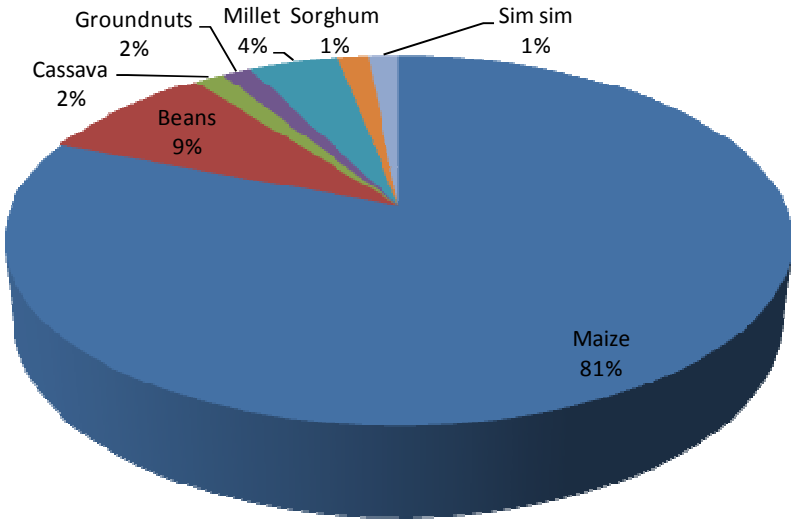

Figure 3 : Various crops used as intercrops with rice in the LVCAZ of Uganda