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Factors influencing the adoption intensity of improved yam (*Dioscorea spp.*) seed technology in the western highlands and high guinea savannah zones of Cameroon

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ABSTRACT
Objective: Yam (*Dioscorea* spp.) is one of the staple tubers consumed by most households in West and Central African countries. It exists in many varieties and forms and could also be consumed in a number of ways. However, the cultivation of this very important crop is limited by several factors, such as the scarcity of high yielding seedlings resulting in low yield, thereby compromising food security. To address some of these problems, the National Agricultural Extension and Research Programs in Cameroon adopted and disseminated the yam minisett seedling technology to yam farmers in Cameroon to improve productivity. This study evaluated the factors influencing the adoption and use intensity of this innovation.
Methodology and results: Survey data was collected from 76 farmers chosen randomly in the Western Highland (WHL) and High Guinea Savannah (HGS) agro-ecological zones of Cameroon following a quasi experimental research design. Tobit regression method was used as the main analytical tool. Results showed that factors such as age ($P<0.01$), mixed cropping ($P<0.01$), hired labour ($P<0.05$) and membership in farmers' organizations ($P<0.01$) positively and significantly influenced the adoption intensity of minisett technology in areas covered.
Conclusion and recommendation: In order to scale up the level of adoption and intensity of minisett yam seedling technology, stakeholders are called upon to reach out to the younger and energetic farmers (<41 years), consider re-packaging and disseminating the technology to farmers preferably through existing networks such as farmers' groups, encourage wealthy farmers to take up yam seed production as a major source of income while still promoting small-scale farmers. Research should consult and incorporate farmers' inputs in the designing of yam minisett seedling technology, while policy makers and extension services should consider disparities across agro-ecological zones in decision making and outreach strategy.
Key words: Yam, minisett seedling technology, adoption and determinants

INTRODUCTION

Yam minisett seedling technology was developed by the Nigeria Root Crops Research Institute and the International Institute of Tropical Agriculture (IITA) in the 1970s (IITA, 2004). In order to improve on yam production, the government of Cameroon through the National Agricultural

Extension and Research Programs (PNVRA) adopted and introduced the minisett technology to farmers in the eight yam producing regions of the country as far back as the early 1980s. This was jointly done by Cameroon's ministry of agriculture, the then Institute of Agronomic Research (now Institute of Agricultural Research for Development-IRAD), the Dschang University Centre (now Faculty of Agronomy and Agricultural Sciences) in collaboration with IITA and some funding bodies.

The minisett technology consists of using healthy ware yams to produce "clean" seeds within a gestation period of 6-7 months. This technology was adapted to the Cameroonian context as described in technical bulletins by Ajaga et al. (1987) and Ngue et al. (2007). The idea of introducing this technology to yam farmers in Cameroon stems from the argument that large quantities of high quality planting materials could be generated at economically viable rates (Ezeh, 1992). This goes to address the problem of seed scarcity and high seed cost (40-70%) in yam production (Asumugha et al., 2008; RIU[i], 2009). The expected outcome of adopting this technology is not only to increase yield (Arega and Ousmane, 2009) but also to raise additional income and address livelihood problems hence poverty alleviation (Mendola, 2007).

Consequently, in the mid 1980s, MIDEVIV (Seedlings and Foodstuff Development Authority) with funds from the United States Agency for International Development (USAID) produced and distributed improved seeds (including yam seeds) from research to farmers (USAID, 1994). This lasted up to the 1990s and opened the way for PNVRA to pursue the transfer of the minisett technology to farmers in collaboration with the then Institute of Agricultural research (IRA) now known as IRAD.

New agriculture and seed policy in Cameroon were adopted in the early 1990s within the context of the structural adjustment program. This consisted of progressive withdrawal of the state from the agricultural sector, privatisation of production and commercialisation of seed supply systems. Consequently, in 2001 a seed law (*no 2001/014)* was voted by the National Assembly and promulgated that same year.

At the time, the mandate to implement this law, alongside the agricultural policy, was left in the hands of the National Agricultural Extension and Research Program (PNVRA). This was a government body responsible for extension services and implementation of the then agricultural policy in collaboration with research institutions (IRAD and Universities). PNVRA was funded jointly by the Cameroon government, African Development Bank (ADB), International Fund for Agricultural Development (IFAD) and the World Bank. During the implementation phase of the program (1998 to 2004), PNVRA further developed agricultural research by revitalizing the use of improved yam seeds through training in collaboration with IRAD (World Bank, 2004). A total of 2.8 million yam seeds (setts) were produced and distributed to farmers alongside training on techniques of yam seed multiplication (ADB, 2008). Despite the effort of the government, aggregate yam production still remains low especially when compared to other countries in the region. The average national yam yield in Cameroon was estimated at 6.08t /ha (NPRTD, 2006) approximately 50% below the average African yield of 11t/ha in 2006 (FAO, 2009). Yields are even as low as 3.08t/ha in the Western Highlands of Cameroon (NPRTD, 2006).

Since the minisett technology was disseminated to farmers in Cameroon, no evaluation has been done in a bid to improve on the outreach strategy. In fact, the only research done on yam seeds in Cameroon was by Ngeve and Nolte (2001) and they focused on the variation of techniques of seed production across the 5 agro-ecological zones of Cameroon. On the other hand, Acquah and Evange (1991a & 1994b) identified scarcity of yam seeds as one of the major constraints to yam production in the Fako Division of Cameroon. None of these studies assessed the determinants of adoption and use intensity of transferred yam seed technology in Cameroon. This study, therefore, aimed at evaluating some of the factors that are influencing the adoption intensity of improved yam seed (minisett) technology by yam farmers in the Western Highlands (WHL) and High Guinea Savannah (HGS) agro-ecological zones of Cameroon.

The findings of this study will provide policy guidelines geared at promoting the adoption and intensification of minisett technology that has been proven to have the potential of tripling yam yields (Manyong et al., 2008), reduce cost of planting materials (Acquah and Evange, 1991a), address problems of food security and improve livelihoods (Douglas and Mackay, 2003 and Ian, 2009). Furthermore, it will permit breeders to improve (if necessary) on the yam seed technology (Lynne et al., 1988 and Sall et al., 2000) and learning from the constraints and challenges as claimed by Alene and Hassan (2006).

Arega and Ousmane (2009), Bart and Barrett (2008), Mendola (2007) and Campell (1995) showed that adoption of improved technology increases agricultural yield, and argued that yields are a very important determinant of minisett technology adoption. Similarly, Arega and Ousmane (2009) argued that at the aggregate level, the use of improved agricultural technologies developed through research reduces poverty by 0.8% annually through out the world.

Empirical evidence provided by Lawal et al. (2005) indicated that improved maize *varietal attributes* (low production risk and good market value) in the Southwest of Nigeria influenced adoption as yellow-grain and early maturing varieties were preferred by farmers. The direction of influence may be positive or negative depending on the factor in question. As an example, *poor initial impression* about rice variety was inhibiting adoption (Sall et al., 2000). However, a better initial impression resulting from peers or extension service units would influence adoption especially in this era where farmers' participation in innovation transfer is encouraged.

Some of the interactive characteristics shown to positively influence adoption and use intensity of maize seed, rice technology and farming systems were membership to farmer organisation, access to information, farm size, and fertilizer use in addition to education, age, sex and household size (Nkonya et al., 1997; Sall et al., 2000; Lawal et al., 2005; Faturoti et al., 2008 and Mazvimavi and Twomlow, 2009). In addition to education and fertilizer use, Oyekale and Idjesa (2009) empirically showed that farming experience significantly and positively influenced adoption of improved maize seeds in the River State, Nigeria. Though age and farming experience significantly influence adoption positively, they may not go together in empirical analysis if a high correlation is established between the two. One may be used as a proxy for the other. Furthermore, exposure or interaction with information sources (other farmers, groups, radio, extension workers) influence farmers decision to adopt an improved technology. This was the case with radio programs in Enugu, Nigeria according to Agwu et al. (2008).

The absence of visits from the extension service in the River State of Nigeria highly influenced the adoption of maize seeds negatively [$P<0.001$] (Oyekale and Idjesa, 2009). On the contrary and as often expected, contacts with the extension service and access to information through social networks have a positive and significant influence on adoption and intensity of use of technology (Nkonya et al., 1997 and Floyd et al., 2003). Also, where farmers' access to credit is possible, it has proven to significantly and positively influence the adoption of agricultural technology (Sodiya, et al., 2007). Access to credit permits farmers to invest in a new technology or acquire related inputs (e.g. labour, fertilizer). For instance, in an adoption study in Zimbabwe, Mazvimavi and Twomlow (2009) and Oyekale and Idjesa (2009) concluded that access to fertilizers and seeds increased the intensity of adoption of conservation farming. Accumulated savings allow farmers to access more credit required for investment in the new technology hence positively influencing adoption. Labour may be hired locally, provided by local labour exchange groups or provided by the households hence influence technology adoption (Doss, 2006; Oyekale and Idjesa, 2009)..

Agro-ecological zone was shown to influence the productivity of improved cowpea in Nigeria, and hence adoption (Alene and Manyong, 2007). Agro-ecological zones are often associated to cultural practices and soil fertility and this determines yield and adoption. Bart and Barrett (2008) add that the adoption of yield increasing technologies depends on how well the geographical and physical characteristics are managed. Oyekale and Idjesa (2009) showed empirically that mono-cropping significantly and positively influenced adoption of improved maize seeds in River state, Nigeria. Similarly, the use of fertilizers due to poor soil characteristics significantly and positively influenced the adoption and use intensity of improved maize seeds in Northern Tanzania (Nkonya et al., 1997; Oyekale and Idjesa, 2009). Markets, extension services, social networks, farmlands, the people and their traditions exist in particular space and context. Access to these facilities influence adoption. For instance, the distances covered to the nearest market and related institutions influence adoption (Kristjanson et al., 2005 and Adeogun et al., 2008).

Empirical approach to technology adoption and intensity studies:

Factors determining farmers' behaviour vis-à-vis the adoption of agricultural technologies and intensity of use have been determined using various theoretical models. The determination of factors influencing the adoption of agricultural technology using logit and probit is appropriate but not indicated with Ordinary Least Square (OLS) regression as the estimates may be biased (Feder et al., 1985). More over, the use of a probit model is not suitable for the determination of technology adoption intensity even though it is adapted for dichotomous dependent variables. The intensity of adoption is a continuous dependent variable. This is why some authors combine *probit* and *Tobit* in determining adoption behaviour and intensity based on a two stage decision argument. Fufa and Hassan (2006) used *probit* to determine the factors influencing adoption probability and Tobit for determinants of adoption intensity. Others argue that the decision to adopt a technology and extent may be taken at the same time or separately (Berhanu and Swinton, 2003). Categorically, Sall et al. (2000) argues that this takes place in two stages: firstly, the decision to adopt and secondly the intensity of adoption. This is indicated in a situation where problems of *selection bias* and *endogeneity* must be addressed (Nkonya et al., 1997).

The literature above shows that if adoption and intensity decisions are assumed to be taken at the same time, the one stage *Tobit* model can be used based on the assumption that there is no selection bias. In fact, the *Tobit* model originally developed by Tobin (1958) also has the advantage that when used, it provides both the influence of exogenous factors on the probability of adoption and the intensity of adoption in addition to estimating the marginal effects of the factors (Chukwuji and Ogisi, 2006). These authors further argue that farmers adopt a given technology based on the utility (U_{ij}) maximization assumption. Farmer (*i*) adopts a technology j=1 if $U_i1 > U_i0$ where *j=0* is the non-adoption of the technology. In other words, a farmer would only adopt a given technology if his marginal utility of adopting and consuming that technology is greater than that of not adopting the technology at all. The utility for a farmer (i) that adopts the technology j=1 is not observed and depends on a set of observed exogenous factors.

An adoption decision is a dichotomous choice where a farmer adopts the technology if there is a positive marginal net benefit compared to that of not adopting it. Alene and Manyong (2007) proposed the *probit* model in equation (1) for the adoption of new technology. The net benefit or *latent variable* (y_i^*) is such that $y_i^*>0$ for adoption and $y_i^* \leq 0$ for non-adoption. The *latent variable* is the non observed factor that could influence adoption or non-adoption. What is observed about the adoption behaviour of farmers is y_i as presented in equation (2).

$$y_i^* = \beta_i X_i + \varepsilon_i \quad (1)$$

$$y_i = \beta_i X_i + \varepsilon_i \quad (2)$$

Where:

The latent variable $y_i = 1$ if $y_i^*>0$ and $y_i=0$ if $y_i^* \leq 0$; $\varepsilon_i \sim N(0, \sigma^2)$

β_i are the unknown parameters to be determined and ε the independent error term with *zero mean* and *constant variance*. X_i is a vector of independent variables specifying the characteristics of the innovation, innovators and the environmental context as the case may be.

The arguments and specification of the *probit* model (Alene and Manyong, 2007) are similar to the second option which is *Tobit* (Chukwuji and Ogisi, 2006) except for the fact that the dependent variable in the former is continuous and censored. The dependent variable in the case of tobit is the intensity of adoption that may be censored at the lower limit (0) and/or the right as it was the case with the work of the previous authors and Nkonya et al. (1997). This was equally recommended by Feder et al. (1985). Unlike *probit*, the *Tobit* regression model provides both the influence of exogenous factors on the probability of adoption and the intensity of technology use for current and new adopters. The interpretation given to tobit coefficients is not the same as it is with OLS regression coefficients. The coefficients of tobit models are tricky to interpret and have often been interpreted differently or incorrectly by researchers. Kang (2007) re-emphasizes this misinterpretation and further illustrates how generalizations are wrongly made on coefficients determined at one point (e.g. mean). He further claims that this coefficient differ and depend at what point they are determined. As an example, the tobit regression coefficients determined at the mean values of the explanatory variables would not be the same as the ones determined at the median or mode of these factors.

RESEARCH METHODOLOGY

Selection and description of study area: The study was carried out in the High Guinea savannah and Western Highlands agro-ecological zones where two of the five main yam varieties (*D. rotundata* and *D. cayenensis*) are cultivated. These zones are also areas where improved or rapid yam seed multiplication techniques were disseminated. The choice of different zones permits the capturing of differences resulting from disparity in cropping systems and cultural practices as recommended by Campell (1995).

Description of data and hypotheses: Data for this study was collected in June and July 2007 within the framework of an IITA/IRAD/IFAD 704 project. The data were collected using questionnaires and a focus group. The ex-post cross-sectional data were collected from adopters (treated) and non-adopters or control groups (Feder and Umali, 1993) of minisett technology following a quasi-experimental research design (Bamberger and White, 2007). The data collected include age, yam/seed farm sizes, expenditure on inputs, use of hired labour, membership in community farmers' organization, yam cropping system and experience in yam production. Table 1 includes the description of variables used in the empirical modelling as well as related hypotheses.

The variables are carefully selected (Feder et al., 1985) for various reasons. The choice of age is stimulated by the fact that young energetic farmers (<=41 years) are more likely to adopt a technology that demands a lot of physical input than elderly farmers (41 years and above). However, younger farmers may have limited resources or assets that permit them to adopt a technology. Also, availability of labour and packaging of agricultural technology to suite the cultural practices of farmers may positively influence the adoption of yam minisett technology. Sources of information are other important factors in technology adoption. This is why membership in community farmers' organisations is used as a proxy for farmer-to-farmer sharing of information and access to extension service packages. Resources are also necessary for the adoption of an innovation. The farmers will tend to adopt a technology if they could afford the cost of adoption as well as have access to the farm land on which the innovation will be placed.

Sources of secondary data: The workshop and activity reports of the ministry of agriculture, the National Extension and Research Program (PNVRA), IRAD and NPRTD were exploited. The extension workers and the authorities of the competent ministry were also consulted as key informants especially given the fact that they were future users of the findings. The information collected from focus group discussions was used to enrich the interpretation of the established empirical evidence and analysis as advised by Howard (2008).

Sampling of respondents: A total of 150 respondents were administered randomly to yam farmers in the study zone. Fifty questionnaires were administered in the High Guinea Savannah Highlands and 100 in the Western highlands. In the Western Highlands, 49 questionnaires were administered in Mezam Division and 51 in Momo Division respectively. Furthermore, 36 adopters and 40 non-adopters of minisett technology were interviewed. The other 74 respondents to whom questionnaires were administered had no knowledge about the minisett technology and were therefore not used in the analysis

Table 1: Description of variables used in the empirical model and hypotheses

Variable	Definition and measurement of variables	Hypotheses
Dependent		
INTENSI0	Proportion (%) of land under adopted yam seed technology cultivation as a percentage of yam farm area cultivated (censored at zero)	
Independent		
Age in years (AGE)	Age. '1' if less than forty one years and '0' otherwise	+
Farm size (SQRT_FARMSIZE) in ha	Farm size allocated for yam cultivation (ha)	+
Input expenditure (SQRT_CSTINPUT)	Average annual input expenditure for seed production in FCFA (proxy for viability of respondents to afford cost of technology adoption)	+
Hired labour (HIRELAB)	Use of hired labour in yam/seed cultivation. '1' if yes and '0' otherwise	+
Membership in association (MEMBASSO)	Respondents that are members of community farmers' organisation. '1' if yes and '0' otherwise	+
Yam cropping system (YAMASS)	Yam cropping system. '1' if yam is grown in association with other crops and '0' otherwise	+

NB*:* Hypothesized to positively (+) influence the adoption and intensity of technology.

Model specification and analysis: This section is built on the empirical approach earlier discussed. The variables hypothesized to influence the adoption intensity of minisett technology (table 1) are presented in the form of a model as below. The empirical specification was used to examine the influence of explanatory variables on the adoption and intensity (Y) of minisett technology in the surveyed area. This is based on the assumption that the two decisions (adoption and intensity) were taken at the same time (Nkonya et al., 1997; Akinola et al., 2007; Chukwuji and Ogisi, 2006;).

$$Y = \beta 0 + \beta_1 AGE + \beta_2 FARMSIZE + \beta_3 YAMASS + \beta_4 HIRELAB + \beta_5 MEMBASSO + \varepsilon_i$$

Where;

βi , i = 1, 2 … and 5 are parameters associated to dependent variables to be estimated.

ε is the error or disturbance term with zero mean and constant variance (0, σ^2).

B_0 is a constant. Y =adoption intensity (area under improved yam seed cultivation as a percentage of yam farm size).

The latent variable Y= 1 if $Y^*>0$ and Y=0 if $Y^* \leq 0$.

The independent variables are as defined in table 1.

The data were analysed using STATA 10.1. T-test statistics were used to test differences in means of values of the characteristics of adopters and non-adopters and across the two agro-ecological zones. The hypotheses were verified after running the tobit regression censored at the lower limit (zero) based on the assumption that technology adoption and intensity decisions took place at the same time. An attempt was made to control for agro-ecological disparities.

Limitations of the study: The dynamic process of technology adoption over the years could not be captured with cross-sectional data. All the processes and changes that took place before the time of the study were not fully considered and may be a source of bias (Feder et al., 1985 and Cheryl, 2006). Though Cameron (1999) empirically concluded that cross-sectional estimates of technology adoption coefficients are biased, he concluded that the extent was small and not significant. The study did not take into consideration the issue of selection bias resulting from the technology dissemination process on the side of extension service and even the decision to adopt on the side of the farmers. It was assumed that the adoption and intensity decisions took place at the same time whereas it could have been at different instances thereby requiring the use of a switching method to account for the bias. These limitations are common and extensively discussed by Cheryl (2006) and Feder et al. (1985). However, a substantial description of differences across the two zones was done and used in discussing the results. On the other side, the *tobit* modelling used could be biased as it assumes that the error term is independent and normally distributed with zero mean and constant variance. A violation of this assumption may produce biased coefficients and errors carried along in the analysis process. Nevertheless, the coefficients were tested and proven to be different from zero at P < 0.01.

RESULTS AND DISCUSSIONS

Descriptive statistics of non-adopters of minisett technology: The analysis of the data (table 2) shows that there is a significant (P<0.01) mean difference between sex of adopters and non-adopters. Most (74%) of the adopters of minisett technology were women. The age of adopters was significantly (P<0.01) different from that of non-adopters. The adopters were mostly younger than forty one years as opposed to the non-adopters that are forty one years and above. The mean experience in yam production for adopters (11 years) was also significantly (P<0.01) different and smaller than that of non-adopters (17 years).

Table 2: Mean difference t-test statistics for 76 adopters and non-adopters of yam minisett technology in the Western High Lands and High Guinea Savannah zones of Cameroon (2007).

Variable	Adopters (n=36)			Non-adopters (n=40)			Difference
	Mean (b)	**Std. Err.**	**Std. Dev.**	**Mean** (a)	**Std. Err.**	**Std. Dev.**	**(a-b)**
Sex	0.74	0.07	0.44	0.45	0.08	0.50	-0.29***
Age (AGE) in years	0.71	0.08	0.08	0.46	0.08	0.50	-0.28**
Hired labour (HIRELAB)	0.66	0.08	0.48	0.22	0.07	0.42	-0.44***
Input expenditure (SQRT_CSTINPUT) in Fcfa	158.82	13.15	68.32	133.04	9.78	54.43	-25.78*
♠♠ Farm size (SQRT_FARMSIZE)	0.89	0.04	0.24	0.80	0.05	0.31	-0.09*
Yam cropping system (YAMASS)	0.86	0.06	0.36	0.41	0.08	0.50	-0.44***
Membership in association (MEMBASSO)	0.86	0.06	0.36	0.71	0.07	0.46	-0.15
Others factors							
Experience (EXPYAMPT) in years	10.91	1.14	6.76	16.88	1.42	9.18	5.97***
Contacts with other farmers (ORIGFARM)	0.53	0.06	0.51	0.08	0.09	0.28	-0.45***
Family labour (FAMILAB)	0.62	0.08		0.40	0.08	0.50	-0.21**

Values in square root (♠♠); ***, **, and * represent 1%, 5% and 10% significance levels respectively.

The average annual expenditure (SQRT_CSTINPUT) incurred by adopters (Fcfa 25,224 ±4,668)[ii] in the purchase of inputs (fertilizer, stakes) and transport to the nearest market for seed yam production/marketing related activities is significantly (P<0.1) different from that of non-adopters (Fcfa 17,700 ±2,963). On the other hand, the average surface area allocated for yam production is significantly (P<0.1) different and higher among adopters (0.79±0.06ha) than non-adopters (0.64±0.10ha) who mostly cultivate yam in association with other crops. The yam cropping system is also significantly different among adopters and non-adopters at P<0.01. Adopters cultivate yam/seeds mostly in association with other food crops such as maize, beans and groundnuts.

However, no significant difference exists as concerns their affiliation to community farmers' organisations (MEMBASSO). Rather, a significant difference (P<0.01) was recorded as concerns farmer-to-farmer contacts and access to information. This follows from the fact that adopters had more contacts and information on the technology (ORIGFARM) from other fellow farmers than it was the case with non-adopters.

Descriptive statistics of non-adopters across agro-ecological zones: Table 3 provides the mean t-test statistics of the characteristics of the respondents across the two agro-ecological zones covered by the research. As far as the descriptive statistics are concerned, no significant differences exist for family labour (FAMILAB). Nevertheless, a significant difference (P<0.05) exist in yam cultivation experience (EXPYAMPT) between the HGS (18 years) and WHL (13 years). Meanwhile, the result for sex (SEX) showed highly significant difference (P<0.01) between the two zones. Yam is mostly cultivated by women in the WHL and by men in the HGS zones of Cameroon.

The information gathered from the groups, authorities of the ministry of agriculture confirmed this gender differences in yam cultivation. In fact, this gender disparity characterizes some of the complexities in the adoption of minisett technology in the areas reached. In the WHL, and until recently, the cultivation of food crops and particularly yam was mostly (but not exclusively) done by women. In the HGS where yam is the main *"cash crop",* it is an activity carried out by men. It is also perceived by women as an energy demanding activity in the HGS zone, as indicated by some of the women during focus group discussions in that area.

Table 3: Mean t-test statistics of 76 respondents across HGS and WHL zones of Cameroon (2007).

Variable	HGS			WHL			Difference
	Mean	Std. Err.	Std. Dev.	Mean	Std. Err.	Std. Dev.	
Age (AGE) in years	0.47	0.12	0.51	0.61	0.06	0.49	-0.14
♠♠ Input expenditure (SQRT_CSTINPUT) in Fcfa	166.29	18.60	64.44	137.32	9.22	62.55	28.97*
♠♠ Farm size (SQRT_FARMSIZE)	0.72	0.05	0.21	0.89	0.04	0.29	-0.17**
Yam cropping system (YAMASS)	0.12	0.08	0.33	0.80	0.05	0.41	-0.68***
Membership in association (MEMBASSO)	0.81	0.10	0.40	0.78	0.05	0.42	0.60
Others							
SEX	0.06	0.06	0.24	0.77	0.06	0.43	-0.71***
Experience (EXPYAMPT) in years	17.65	2.13	8.79	12.97	1.09	8.40	4.68**
Contacts with other farmers (ORIGFARM)	0.40	0.07	0.50	0.34	0.07	0.48	0.40***
Family labour (FAMILAB)	0.41	0.12	0.51	0.53	0.07	0.50	-0.11

Mean values in square roots (♠♠). ***, **, and * represent 1%, 5% and 10% significance levels respectively.

However, a highly significant difference (P<0.01) exists across the zones as concerns farmer-to-farmer dissemination of knowledge (ORIGFARM) on yam minisett technology, expenditure on inputs for yam/seed production (SQRT_CSTINPUT), yam production system (YAMASS) and membership in community farmers' organizations (MEMBASSO). Farmer-to-farmer access to information on minisett technology is significantly high (P<0.05) in WHL than the HGS zone despite the fact that no marked difference was recorded in the associative live (MEMBASSO) among the respondents. The yam growing systems (YAMASS) are equally significantly different (P<0.001) across these two agro-ecological zones. Information from group discussions and our observations confirmed this result. Mixed cropping of yam is common in the WHL as opposed to mono-cropping in the HGS zone. Similarly, the farm sizes (SQRT_FARMSIZE) are also significantly different (P<0.05) between HGS (0.53 ha) and WHL (0.79 ha).

Determinants of adoption and intensity of minisett technology: Table 4 provides the overall results (all zones included) of the tobit model of adoption intensity (outcome) regressed on the explanatory variables. Goodness-of-fit measures indicate that the model is highly significant at P<0.01 with a likelihood ratio chi^2 of 39.50, Log likelihood value of -154.72 and a Pseudo R^2 of 0.1132. The standard error of the model is 11.1051. The model correctly explains 55.40% of the sample cases with a Maximum Likelihood (Cox-Snell) correlation coefficient (R^2) of 0.42.

The tobit regression coefficients in table 4 only show the direction of influence of the variables hypothesized to influence the adoption and use intensity of the minisett technology (Amemiya, 1984 and Sall, 2000). All the variables hypothesized to positively influence minisett adoption intensity in the model presented were positive and significant as expected at various levels except farm size (SQRT_FARMSIZE) and expenditure on inputs (SQRT_CSTINPUT).

Table 4: Tobit model for adoption and use intensity of minisett technology for 72 farmers in the Western High Land and High Guinea Savannah zones of Cameroon (2007).

Adoption intensity (INTENSI0)	Coef.	Std. Err.	t-values	Sign. level
Age (AGE)	9.9633	3.6240	2.75	0.0080
Farm size (SQRT_FARMSIZE)	2.6224	5.8875	0.45	0.6570
Yam association (YAMASS)	17.6248	4.4713	3.94	0.0000
Use of hired labour (HIRELAB)	6.9462	3.3207	2.09	0.0400
Membership in farmer's organization (MEMBASSO)	13.2353	4.6109	2.87	0.0050
Constant	-35.8874	9.0690	-3.96	0.0000
/sigma	11.1051	1.3294		

LR $chi^2(5)$ =, 39.50, Prob > chi^2= 0.0000, Log likelihood 154.7182, Pseudo R^2= 0.1132
35 left-censored observations at intensity 0<=0, 37 uncensored observations, 0 right-censored observations.

As concerns the positive, non-significant coefficient of farm size, it signifies that a unit (ha) increase in farm size will not have any significant influence on the adoption and use intensity of minisett technology. On the other hand, the coefficient of age (AGE) was significantly positive at P<0.01. It was hypothesized that reaching out to farmers less than forty one years of age would positively influence the adoption and intensity of minisett technology. The significance of this coefficient allows us to accept this hypothesis. In order words, reaching out to farmers below forty one years that are a year younger would increase the chance of adoption and intensity of the technology studied. In fact, when experience in yam production (EXPYAMPT) was fitted in the place of age in this model, same results were obtained as the coefficient was negative showing that experience would rather have a negative influence on adoption intensity.

The use of hired labour (HIRELAB) is significant at P<0.05 thereby indicating that labour availability and resource endowment of farmers may positively influence the adoption of minisett technology. Respondent's membership to farmers' organization (MEMBASSO) and yam cropping system (YAMASS) are all highly and positively significant at P<0.01 as expected. The significant and positive coefficient of yam cropping system (mixed) is a sign that aligning yam growing system to that practiced by the farmers would increase the likelihood of adoption and intensification of minisett technology. This finding differ from the findings of Oyekale and Idjesa (2009) who showed empirically that mono-cropping significantly and positively influenced the adoption of improved maize seeds in River State Nigeria. The association of crops observed in the WHL of Cameroon is partly explained by a high population density hence limited access to farmland. Farmers prefer adopting minisett technology under mixed cropping system as a way of managing possible risks and optimizing the use of land.

Furthermore, one of such cultural practices identified during the study in the WHL was the use of *"mini-tubers"* instead of minisetts for setts production hence a modification on the technology. The use of *"minitubers"* is a way for farmers to make use of "rejected" small tubers. This modification or partial adoption of the technology was also noted by Mazvimavi and Twomlow (2009) whereby parts of conservation farming technology were dropped. Similarly, Joshi and Bantilan (1998), after an impact assessment of disseminated groundnut production technology found that 84% of the components of the technology were adopted, hence not the full package. There is need to explore this modification for possible adaptation or improvement. This was previously recommended by Lado (1998) who asked for consideration to be given to the cropping system and cultural practices of farmers in the design of agricultural technology. A unit increase in the number of yam farmers who are members of community-based farmers' organizations positively and significantly (P<0.01) influence the adoption and intensity of the minisett technology as expected (all other factors held constant).

However, when we substituted membership in farmers' groups by a proxy for contacts with extension service (ORIGEXTE) we found out that the coefficient was negative and significant (P<0.05). Oladele (2005), like in our case, unexpectedly observed similar negative influence and attributed it to the correlation of farmers' participation in technology evaluation carried out by the extension service. This might possibly be the case with this study as the technology was disseminated by the extension service through group participation and contact farmers. The use of an additional unit of hired labour in yam seed production would also increase the probability of adoption and intensity of the technology as the coefficient was significant at P<0.05. Similar positive results were obtained by Oyekale and Idjesa (2009). The coefficient of hired labour was also positive in the second model just as the other explanatory variables maintained their signs. In fact, yam/seed cultivation is tedious and labour intensive. Hired labour is required to complement family labour in fetching stakes/staking, ploughing, mulching and even harvesting.

However, after controlling for agro-ecological zones, we found out that all the hypothesized factors were still positive and significant at the same levels of significance as expected except farm size that witnessed a change in sign from positive to negative (table 5) though it still remained insignificant in the WHL[iii]. The change in the sign of the coefficient of farm size is a signal that a unit increase in farm size would negatively but not significantly affect the prospects for adoption and intensification of minisett technology. This change in sign may be attributed to the limitation of farm land and population pressure witnessed in the western highlands. In fact, our estimates of population density of 2006 based on the 1976 and 1985 population census results show this disparity on land pressure in the two agro-ecological zones. The population density in the WHL (144 inhabitants/Km^2) is 11 times higher than that of HGS that is just 13 inhabitants/Km^2.

Any additional unit of farm land without accompanying incentives (e.g. inputs) for technology adoption will give farmers the opportunity to go in for more productive and less risky activities like growing of beans and maize. Insufficient access to land limits the intensity of technology use as farmers may not be willing to forgo food crop land for technology uptake. Access to land is a limiting factor to adoption of technology in the WHL where population density is very high. This was not an issue in the HGS zone. Though the coefficient of farm size is not significant, it is an indicator of dire outcomes in the future as far as farm land is concerned. The non-significance and negative influence of farm size is not surprising, since Sall et al. (2000) also concluded that farm size has a negative but not significant influence on the adoption of improved rice variety in Senegal. The negative and non-significance of the coefficient of farm size as well as the non-significance of the coefficient of input expenditure means the farmers could afford for the relatively cheap cost of adopting the minisett technology (Sall et al., 2000).

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Table 5: Tobit model for adoption and intensity of yam minisett technology for 56 farmers in the Western High Lands zone of Cameroon (2007)

intensi0	Coef.	Std. Err.	t	P>|t|
Age (AGE)	10.8723	3.7066	2.93	0.005
Farm size (SQRT_FARMSIZE)	-1.6058	5.9295	-0.27	0.788
Yam association (YAMASS)	14.7055	4.7659	3.09	0.003
Use of hired labour (HIRELAB)	3.7011	3.4824	1.06	0.293
Membership in farmer's organization (MEMBASSO)	14.0839	4.7011	3.00	0.004
Constant	-27.9514	9.3260	-3.00	0.004
/sigma	10.8920	1.2985		

Obs. summary: 19 left-censored observations at intensi0 <=0. 37 uncensored observations; 0 right-censored observations. LR chi2(5) =23.2, Prob > chi2= 0.0003 Log likelihood -151.1007, Pseudo R2= 0.0713

Furthermore, after controlling for agro-ecological zone, a good-fit model could not be established for the HGS zone because the level of adoption in the area is practically zero as this was confirmed by the information from focus group discussions and the extension service of the locality. Another important change after controlling for agro-ecological zone was the non-significance of the hired labour which was earlier shown to be a factor significantly and positively influencing the adoption of the minisett technology (table 4). Household labour was also not significant (for WHL) when fitted in the place of hired labour neither was the combination of the two. Consequently, the use of additional hired agricultural labour is not a factor explaining the adoption and intensity of minisett even though a significant difference in use of hired labour was found between adopters and non-adopters (table 2).

CONCLUSIONS AND RECOMMENDATIONS

This paper empirically examined evidence of factors influencing the adoption and use intensity of improved yam seed technology by yam farmers in the Western Highlands (WHL) and High Guinea Savannah (HGS) agro-ecological zones of Cameroon. The aggregate results after performing a tobit regression revealed that age (P<0.01), cropping system (P<0.01), use of hired labour (P<0.05) and affiliation to community-based farmers' organizations (P<0.01) positively and significantly influence the adoption and intensity decision of minisett technology. However, after controlling for agro-ecological differences, the coefficient of hired labour was not significant. The coefficient of farm size was also not significant in either case though the sign changed from positive to negative after controlling for agro-ecological zone. Hence, hired labour and farm size are not determinants of the adoption and intensity of minisett technology in the WHL of Cameroon. Agro-ecological differences should be taken into consideration when making strategic decisions in the dissemination of minisett technology.

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