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Intensifiers of adoption of improved upland rice agronomic technologies in northern Uganda

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ABSTRACT

Adoption of improved agricultural technologies by smallholder farmers continues to remain relatively low in Uganda. This has resulted into low production of staple crops at both subsistence and large-scale levels. This study examined the intensifiers of adoption of improved upland rice agronomic technologies in northern Uganda. A cross-sectional survey was carried out to collect data from 248 randomly selected respondents through use of semi-structured pretested questionnaires. Descriptive statistics such as frequency counts and percentages were used to characterize rice farmers, whereas a Tobit regression model was fitted to analyze the hypothesized factors influencing farmers' adoption intensity of improved upland rice agronomic technologies. Results revealed that adoption index for majority of the farmers were relatively high for improved varieties (66.0%) and weeding (99.9%), whereas fertilizer application (0.2%) and spacing (4.8%) showed the least adoption levels. Land under rice, access to extension services, access to market, membership in farmers' groups (P≤0.01), education level, and rice farming experience (P≤0.05), showed a positive and significant influence on adoption intensity, whereas, distance to the nearest market (P≤0.01), and years of rice farming (P≤0.05) had a negative but significant influence on adoption intensity of improved rice production technologies. Mean household size (p≤0.1), age (p≤0.01), land size (p≤0.01) and years of farming (p≤0.05) significantly differed among adoption categories. In conclusion, improving farmers' incomes, education, and engagement in extension programs as well as inspiring more youth into farming intensifier improved technology adoption hence more productivity, incomes and food security for various actors in the rice value chain.

Keywords: Adoption categories, adoption intensity, agronomic technologies, rice farming, Uganda

RÉSUMÉ

L'adoption des technologies agricoles améliorées par les petits exploitants agricoles reste relativement faible en Ouganda. Cela a conduit à une faible production des cultures de base aux niveaux de subsistance et à grande échelle. Cette étude a examiné les facteurs intensificateurs de l'adoption des technologies agronomiques améliorées du riz pluvial en Ouganda du Nord. Une enquête transversale a été réalisée pour collecter des données auprès de 248 répondants sélectionnés au hasard à l'aide de questionnaires semi-structurés prétestés. Des statistiques descriptives telles que les décomptes de fréquence et les pourcentages ont été utilisées pour caractériser les riziculteurs, tandis qu'un modèle de régression Tobit a été ajusté pour analyser les facteurs hypothétiques influençant l'intensité d'adoption des technologies agronomiques améliorées du riz pluvial par les agriculteurs. Les résultats ont révélé que l'indice d'adoption pour la majorité des agriculteurs était relativement élevé pour les variétés

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améliorées (66,0%) et le désherbage (99,9%), tandis que l'application d'engrais (0,2%) et l'espacement (4,8%) montraient les niveaux d'adoption les plus bas. La superficie en riz, l'accès aux services de vulgarisation, l'accès au marché, l'appartenance à des groupes d'agriculteurs (P≤0,01), le niveau d'éducation et l'expérience en riziculture (P≤0,05) ont montré une influence positive et significative sur l'intensité d'adoption, tandis que la distance au marché le plus proche (P≤0,01) et les années de riziculture (P≤0,05) ont eu une influence négative mais significative sur l'intensité d'adoption des technologies de production de riz améliorées. La taille moyenne des ménages (p≤0,1), l'âge (p≤0,01), la taille des terres (p≤0,01) et les années de culture (p≤0,05) différaient significativement parmi les catégories d'adoption. En conclusion, l'amélioration des revenus des agriculteurs, de l'éducation et de l'engagement dans les programmes de vulgarisation ainsi que l'inspiration de plus de jeunes à se lancer dans l'agriculture intensifieraient l'adoption des technologies améliorées, entraînant ainsi une augmentation de la productivité, des revenus et de la sécurité alimentaire pour divers acteurs de la chaîne de valeur du riz.

Mots-clés : Catégories d'Adoption, Intensité d'Adoption, Technologies Agronomiques, Riziculture, Ouganda

Introduction

Globally, rice is a source of staple nourishment for over 50% of the population (Zhou *et al*., 2002; Nwanze *et al*., 2006; Akighir and Terfa, 2011). In Sub Saharan Africa (SSA), it is the largest source of energy which has made it to rapidly gain importance (FAOSTAT, 2016; CARD, 2018). Rice production in SSA was estimated at 14.4 million MT and consumption levels at 26 million MT of milled rice (USDA, 2016). According to Nwanze *et al*. (2006), approximately 20 million farmers in Sub-Saharan Africa are involved in rice production, whereas about 100 million people source their livelihoods from rice.

In Uganda, annual demand currently stands at 300,000MT which far outstrips supply standing at 280,000MT (MAAIF, 2012). This, therefore, implies that the country meets most of its rice demand from imports (Hyuha *et al*., 2007; Van Campenhout and Bizimungu, 2018). The increasing demand is largely attributed to the growing population, urbanization and changing life styles (Kijima *et al*., 2006; MAAIF, 2012). Rice production in the country is dominated by smallholder farmers who are mostly in eastern and northern parts of Uganda (ADC, 2001; MAAIF, 2012). The smallholder rice output is inadequate to cover the increasing demand-supply gap for rice in the country (Jagwe *et al*.,2005).

The Government of Uganda has supported NERICA production across the country mainly through demonstrations, trainings and provision of seed credit support to farmers as an incentive for adopting and improving national rice supply (Jagwe *et al*., 2005; Aker, 2011). This was purposed to address the challenges of food insecurity, poverty and unsustainable paddy production (Kijima *et al*., 2006; Kasirye, 2010). Despite the widespread promotion, national rice yields have not changed significantly in the last 10 years and have stagnated at about 1.5 t ha^{-1} (UBOS, 2005a; Muzari *et al*., 2012). According to the national crop survey 2008/09, average rice yield in eastern and northern Uganda was 3.6 and 1.7 t ha^{-1}, respectively (UBOS, 2010), which is far below the potential yield of 5 and 8 t ha^{-1} in upland and lowlands, respectively (Luzi-Kihupi, 2011; Tsuboi, 2011). This could be attributed to the slow uptake and adoption of improved agricultural technologies.

In addition, several attributes of adoption are not understood regardless of its importance in poverty eradication in most countries (Bandiera and Rasul, 2010; Simtowe, 2011). To increase rice yields, there is a need for farmers to adopt and properly use improved agricultural technologies (Parvan, 2011; Donkoh *et al*., 2012; Loevinsohn and Sumberg, 2013). These improved technologies and practices include; proper spacing, use of improved varieties, complementary use of organic and inorganic fertilizers, weed management, and drip irrigation which highly boosts crop output (Lee, 2005; Singh and Varshney, 2010; Challa, 2013). Whereas literature is replete with numerous studies on adoption, most of them have concentrated on dichotomous indicators. This study, therefore, departs from other studies by identifying the intensifiers of adoption of rice production technologies in northern Uganda.

Methodology

Study area. The study was conducted in Amuru (020 50'N 330 05'E) and Nwoya (020 38'N 320 00'E) of Acholi Sub region in Northern Uganda. The region encompasses about 28,500 km^2 (11,000 square miles). Its current population is estimated to be around 3.58 million individuals, which makes 10.25% of the overall national population (UBOS, 2015). Amuru district which covers a total land area of 3626 km^2 is made up of six sub counties, 32 parishes and 67 villages while Nwoya has five sub-counties, 25 parishes, and 63 villages and it covers a total land area of 4736 km^2 (Nassanga *et al*., 2018). The choice of the two districts was guided by the fact that they are among the highest rice producers in the region. The 2014 census results revealed that a total of 5.8 million households engage in agriculture (UBOS, 2014). More than two thirds (69%) of households derive their livelihoods from subsistence farming as the main source of earning. In terms of employment, the majority of the working populations (65%) are subsistence farmers (UBOS, 2014).

Study design. A cross sectional study design that made use of in-depth face to face interviews using a pretested and structured questionnaire as a survey instrument was employed. Sampling of respondents in this study was done in two stages. Firstly, two districts (Amuru and Nwoya) (Figure 1) were purposively selected due to their predominance in upland rice production in northern Uganda. This was followed by purposive selection of two sub-counties per district which are intensively involved in rice production from which rice farmers were selected randomly following simple random sampling technique.

An equal number of 62 respondents was selected per sub county, and the number of participants that were involved in the study were determined according to a formula provided by Yamane (1967)

$$n = \frac{N}{[1 + N(e^2)]} \dots\dots\dots\dots\dots\dots\dots\dots (I)$$

N= 700

Where; n: is the required sample size, N: Population size of rice producers, e: Level of precision.

$$\mathrm{n} = \frac{700}{1+700(0.005)^2} = 248$$

Data collection and analysis. Data were collected using a semi-structured pretested questionnaire. This comprised questions on farmers' socio- economic characteristics (age, education level, land size, marital status, etc.), institutional factors (access to credit, market and extension services) and adoption intensity of selected rice production technologies (spacing rate, fertilizer application rate, frequency of weeding and improved varieties) (Table 1) To measure intensity of adoption of improved rice production technology package, adoption indices of individual farmers were calculated following procedures of Tadasse (2008), and then categorized into low, medium, and high level of adoption.

$$\mathrm{AIi} = \sum_{i-1}^{n} \frac{\left(\frac{AH}{ATi} + \frac{FAi}{FRi} + \frac{WAi}{WRi} + \frac{SRAi}{SRi}\right)}{\mathrm{NP}} \dots\dots\dots.(II)$$

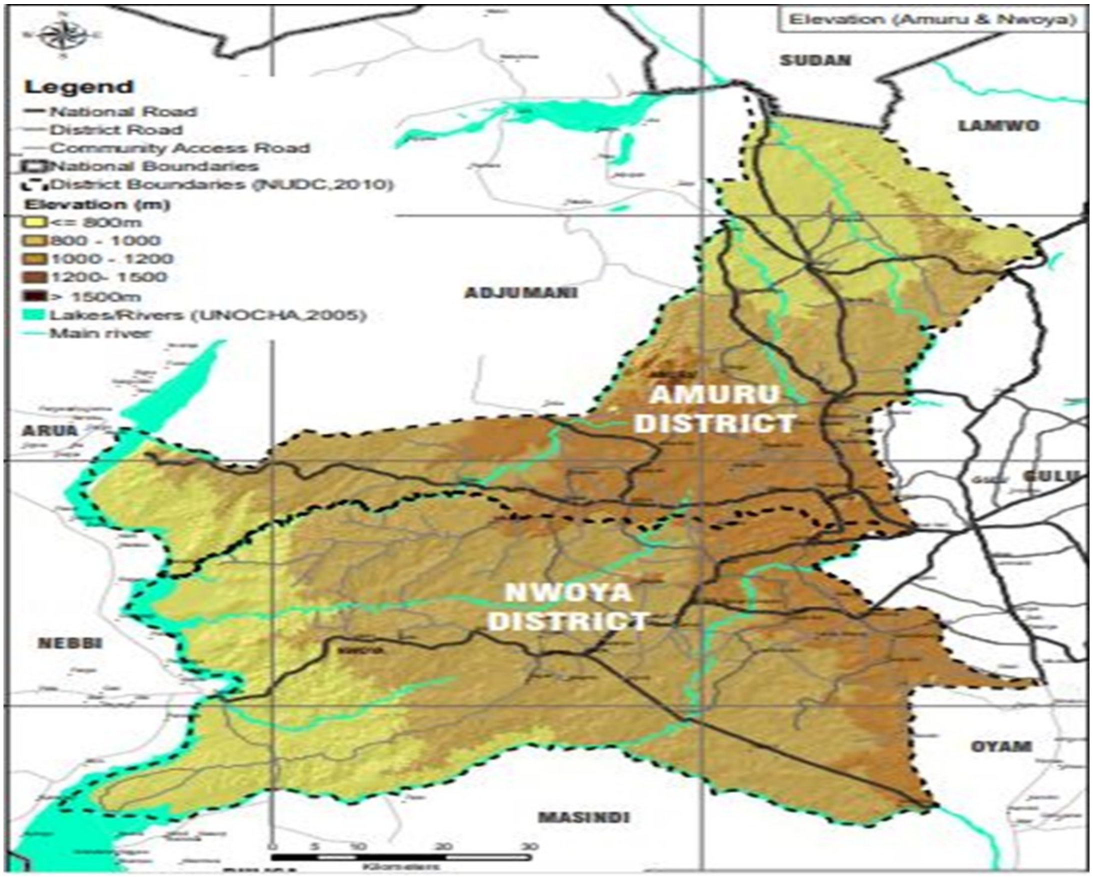

Figure 1. Map showing location of Nwoya and Amuru districts.

Where:

NP: is the number of practices in the technology package,

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NP: is the number of practices in the technology package,

AI_i: is the adoption index of an individual farmer,

Ah_i: is the area under improved variety of rice of the i^{th} farmer,

AT_i: is the total rice production area (improved variety + local, if any) of the i^{th} farmer,

FA_i: is the amount of fertilizer applied per unit of area in the cultivation of improved variety of rice by i^{th} farmer,

FR_i: recommended quantity of fertilizer to be applied per unit of area of improved rice variety produced,

WA_i: Number of times of weeding by i^{th} farmer, WR_i: Recommended number of times of weeding for improved rice production,

SRA_i: Plant spacing rate used by i^{th} farmer,

SR_i: Recommended plant spacing rate to attain the optimum plant population, i: 1, 2, 3………n, and n: is the total number of rice farmers.

Adoption indices obtained from equation (II) varied from 0 to 100% depending on the farmer's adoption intensity of the improved upland rice production technologies specified in the package. Using the calculated adoption indices, a Tobit model was fitted to analyze the hypothesized factors influencing farmers' adoption intensity of improved upland rice production technologies as presented below;

$$\gamma = \beta_o + \beta_1\chi_1 + \beta_2\chi_2 + \beta_3\chi_3 + \beta_4\chi_4 + \beta_5\chi_5 + \beta_6\chi_6 + \beta_7\chi_7 + U \ldots III)$$

Where, Y: Dependent variable (adoption intensity of improved rice production technologies), β_o : Intercept, β_{1-7} : Coefficient of the explanatory variables, χ_{1-7} : Explanatory variables (social, economic and institutional variables), X_1 : Age (continuous; years), X_2 : Gender (Dummy: 1 if male and 0 otherwise), X_3: Membership of association (Dummy: 1 if member and 0 otherwise), X_4 : Educational level (years spent in formal schooling), X_5 : Household size (Number of persons), X_6 : Farm size (continuous; ha), X_7 : Extension contacts (Dummy; 1 if the farmer has contact with extension agents, 0 otherwise) and U: Error term

On the basis of adoption indices calculated using equation (II), farmers were grouped into three adoption categories: Low, medium and high adopters with adoption indices ranging from 0.1-0.33, 0.34-0.66 and 0.67-1.00, respectively. Data were then subjected to analysis using descriptive statistics; T-tests, chi- square tests, ANOVA and Tobit regression were carried out to determine the levels of significance.

Results

Adoption intensity for improved upland Rice agronomic technologies. Farmers were allocated to three adoption categories: Low (24.19%), medium (56.45%) and high (19.35%) adopters with adoption indices ranging from 0.1-0.33, 0.34-0.66 and 0.67-1.00, respectively (Table 2). Results from the analysis of variance indicate that there was a significant difference ($p \leq 0.001$) among the adoption indices of the three adoption categories.

Distribution of respondents based on adoption index of rice agronomic techniques. Results in Table 3 reveal that majority (66%) of the respondents adopted the use of improved rice varieties. Weeding (97.1%) was almost the same as the recommended rates. The adoption indices also revealed that 91.9% farmers had low scale adoption of spacing. This was majorly attributed to its intensive labor requirement. Rate of fertilizer application revealed well above average proportion (99.4%) on a low adoption scale. This implied low level of rate of fertilizer application among rice farmers. This could be attributed to the high cost and low-availability of the fertilizer in their locality as well as inadequate knowledge on fertilizer usage. Tittonell *et al*. (2010) and Andersson and D'Souza (2014) had similar findings.

Descriptive statistics for adopter categories. Farmers were allocated to three adoption categories: Low (24.19%), medium (56.45%) and high (19.35%). adopters with adoption indices ranging from 0.1-0.33, 0.34-0.66 and 0.67-1.00, respectively, as shown in Table 3. Mean household size ($p \leq 0.1$) age ($p \leq 0.01$), and years of Farming ($p \leq 0.05$) significantly differed between the medium and high adopter categories; land size for medium adopters was found to be significantly different ($p \leq 0.01$) from the low adopters of improved rice production technologies (Table 4).

Table 1. Description of explanatory variables used in the Tobit model and their measurement

Variable	Measurement	*A priori*	Literature
Age of household head	Age in years	+/--	Gebrezgabher *et al*., 2015
Access to extension services	1 if the farmer has contact with extension agents, 0 otherwise	+	Mignouna *et al*., 2011; Asfaw *et al.,* 2011
Access to credit	1 if the farmer has access to credit, 0 otherwise	+	Hoop *et al*., 2014
Market distance	Distance to the nearest market in kilometer	-	Milkias and Abdullahi, 2018
Land size	Size of land under cultivation (ha)	+	Kassie et al., 2011; Mariano *et al*., 2012
Farming experience	Number of years of farming	+/-	Ainembabazi *et al*., 2014
Land under rice	Size of land under rice production (ha)	+/-	Akerele, 2014
Years of rice farming	Number of years of rice production	+/-	Kunzekweguta *et al*., 2017
Education	Years spent in formal schooling	+	Tey and Brindah, 2012; Pierpaoli *et al.,* 2013
Household size	Number of members in the household	+	Robertson *et al*., 2012; D'Antoni *et al*., 2012

Note. The *A priori* signs in Table 1 indicate a positive, negative and mixed effect on adoption intensity

Table 2. Adoption intensity for improved upland rice agronomic technologies

Adoption categories	Mean (std. dev)	Mean difference	P value
Low	0.22(0.49)	0.1807[a]	0.00***
Medium	0.51(0.09)	0.3384[b]	0.00***
High	0.83(0.18)	0.1577[c]	0.00***

***, **, * indicates significance at 1%, 5% and 10% respectively; Mean difference Code: a (medium and low), b (high and low), c (medium and high)
Source: Survey 2019

Table 3. Adoption indices for rice production technologies (n=248)

Production technologies	Adoption categories and score range		
	Low (0.01-0.33)	Medium (0.34-0.66)	High (0.67-1.0)
Improved varieties	57(23.0)	28(11.0)	163(66.0)
Fertilizer	247(99.6)	1(0.4)	0(0.0)
Weeding	0(0.0)	7(2.9)	248(97.1)
Spacing	227(91.5)	9(3.6)	12(4.8)

Source: Survey data, 2019.

Table 4. Continuous variables for adopter categories (n=248)

Variable	Adoption categories: Low Mean	Low Std. dev	Medium Mean	Medium Std. dev	High Mean	High Std. dev	Mean difference	P value
Age	36.2	(12.96)	37.13	(11.5)	32.81	(10.31)	0.0608[a]	0.639
							-0.0624[b]	0.934
							-0.1232[c]	0.064*
Farming Experience	17.9	(13.03)	18.44	(12.11)	13.83	(8.81)	2.4840[a]	0.517
							-2.1610[b]	1.000
							-4.645[c]	0.060*
Land size	11.2	(11.75)	10.46	(9.16)	6.94	(5.24)	0.576[a]	0.007***
							0.4149[b]	0.247
							-0.1609[c]	1.000
House hold size	7.15	(3.45)	7.96	(3.90)	7.48	(3.3)1	0.9014[a]	0.341
							-0.4035[b]	1.000
							-1.30496[c]	0.109*
Years of rice farming	19.07	(59.36)	17.29	(32.31)	21.75	(65.01)	1.2039[a]	1.000
							-1.6258[b]	1.000
							-2.8310[c]	0.22

***, **, * indicates significance at 1%, 5% and 10% respectively; Mean difference Code: a (medium and low), b (high and low), c (medium and high) Source: Survey 2019

Categorical variables for adopter categories. To determine the association between categorical variables, chi-square tests were carried out (Table 5). There was a significant difference (p≤0.05) in gender among the three adopter categories with male farmers (63.83%) dominating the high adopter category of improved upland rice production technologies. Results further indicate that low adopters registered the highest percentage of illiterates (18.33%) as compared to the rest of the adoption categories. Membership in a farmers' group was significantly different (p≤0.1) among the three adoption categories. Access to extension services was significantly different (p≤0.1) among the adopter categories in Table 6. A relatively larger percentage of low adopters (75%) could not access extension services.

Factors intensifying adoption of upland rice agronomic technologies. Education level (P≤0.05, land under rice (P≤0.01), access to extension (P≤0.1), Rice farming experience in (P≤0.05) and access to extension services (p≤0.1) showed a positive and significant) influence on adoption intensity (Table 6). However, distance to the nearest market (P≤0.01), and Years of rice farming (P≤0.05) had a negative and significant influence on adoption intensity of improved upland rice production technologies.

Table 5. Categorical variables for adopter categories (n=248)

Variables	Adoption categories (%)			P value
	Low	Medium	High	
Extension services				
Access	25	38.3	25.53	
No access	75	61.7	74.47	0.094*
Gender				
Male	41.67	56.03	63.83	
Female	58.33	21.28	36.17	0.057*
Group membership				
Member	66.67	73.05	57.45	
Non-member	33.33	26.95	42.55	0.128*
Credit				
Access	33.33	38.3	31.91	
No access	66.67	61.7	68.09	0.654
Marital status				
Married	90	91.49	95.74	
Single	5	2.13	4.26	
Divorced	1.67	2.13	0	
Widowed	3.33	4.26	0	0.631
Education				
Formal education	81.67	88.65	91.49	
No formal education	18.33	11.35	8.51	0.256

***, **, * indicates significance at 1%, 5% and 10% respectively
Source: Survey 2019

Table 6. Tobit estimate for factors intensifying adoption of the upland rice technologies

Adoption intensity	Coefficient	Std. Err.	T	P>t
House hold size	0.002303	0.003519	0.65	0.513
Education	0.000461	2.88E-05	15.99	0.000***
Credit	-4.24E-08	4.14E-08	-1.02	0.307
Access to extension services	0.013261	0.007458	1.78	0.077*
Age	-0.00024	0.002378	-0.10	0.919
Land size	-0.00019	0.000233	-0.80	0.426
Land under rice	0.047912	0.00881	5.44	0.000***
Years of farming	0.000279	0.002322	0.12	0.905
Years of rice farming	-0.00401	0.001611	-2.49	0.014***
Distance to the nearest market	-0.00332	0.000783	-4.24	0.000***
Constant	0.470115	0.064509	7.29	0.000***

***, **, * indicates significance at 1%, 5% and 10% respectively Obs. summary: 0 left-censored observations, 240 uncensored observations; 8 right-censored observations at AI>=1; Number of observations = 248; Number of obs = 248; F (10, 238) = 40.91; Prob > F = 0.0000; Log pseudo likelihood = 41.857875; Pseudo R2 = -0.8380

Source: Survey 2019

Discussion

Distribution of respondents based on adoption index of rice agronomic technologies. Rate of fertilizer application revealed well above average proportion (99.4%) on a low adoption scale. This implied low level of fertilizer application among rice farmers. This could be attributed to the high cost and low-availability of the fertilizer in their locality as well as inadequate knowledge on fertilizer usage. Andersson and D'Souza, (2014) and Tittonell *et al*., 2010 had similar findings.

Descriptive statistics for adopter categories. Results showed a significant difference between the ages of the high and medium adopters of improved rice production technologies. High adopters were slightly lower in age (32.81%) as compared to the rest of the categories. This indicated that younger people are likely to adopt improved technological practices than old people (Haji *et al*., 2018). Present findings are in line with those of Kadafur and Oyakhilomen (2017) who reported that the active farmers were within the same age and referred to them as young and energetic. They are always vigilant and active enough to endure the difficulties that come with the technologies (Okunlola *et al*., 2011). High adopters were more experienced in rice farming as compared to other categories. This indicates that as farming experience increases, farmers' involvement in rice production tends to also increase. In addition, the results revealed that low adopters were more experienced in farming than high adopters. This implies that as one gains more experience in farming, they tend to become rigid which makes it hard for them to adopt new farming technologies. An average experience in rice farming is advantageous since it encourages prompt adoption of Improved upland rice agronomic technologies (Mekonnen *et al*., 2010). Farmers with larger pieces of land are more likely to adopt improved technologies compared to counterparts with small land since they can afford to apportion part of their fields to try out the improved technology (Emana *et al.,* 2012). On the contrary, findings in the present study showed that medium and high adopters had less land as compared to the low adopters. This could be attributed to inadequacy to access extension services and high labour costs in the study area.

Categorical variables for adopter categories. Results in Table 5 showed a significant difference ($p \leq 0.05$) between gender among the three adopter categories, with male farmers (63.83%) dominating the high adopter category of improved rice production technologies. Results further indicate that low adopters registered the highest percentage of illiterates (18.33%) as compared to the rest of the adoption categories. Membership in a farmers' group significantly ($p \leq 0.1$) influence the three adoption categories. Also access to extension services was significantly ($p \leq 0.1$) among the adopter categories. A relatively larger percentage of low adopters (75%) could not access extension services. Male farmers dominated the high adopters of Improved upland rice production technologies compared to their female counterparts. This could be attributed that fact that that women are less exposed to technologies (Abdullah and Adila, 2013) and are always asset poor and subsistence oriented than their wealthier male counterparts. This therefore significantly affects their level of technology adoption (Peterman *et al*., 2010) . This is consistent with the findings of Martin *et al*. (2012) and Chekene and Chancellor, (2015) whose results indicated that rice farming was dominated by males.

Factors intensifying adoption of upland rice technologies. Results in Table 6 indicated that rice farming experience had a negative and significant ($P \leq 0.05$) relationship with adoption intensity of the production technologies. This inverse relationship with intensity of adoption, was also reported by Kunzekweguta *et al*. (2017). The present results highlight the point that experienced farmers feel more comfortable and secure with the conventional technologies which they have been practicing over time. Rice farming experience is anticipated to have a positive effect on intensity of adoption of improved upland rice production technologies since experienced farmers are thought to have accumulated technical know-how over time and therefore are in a better position to adopt the technologies. Some empirical studies have found a positive effect of farming experience on adoption of agricultural technologies (Mazvimavi and Twomlow, 2009; Pedzisa *et al*., 2015; Awuni *et al*., 2018). Similar findings were reported by Sheng and Mark, (2012) and Akudugu *et al*. (2014) that experience improves farmers' skill in production which implies that more experienced farmers may experience less uncertainties regarding the performance of an innovation and also have an additional advantage in assessing the benefits of technology in consideration. Access to extension services positively and significantly ($p \leq 0.1$) intensified adoption of improved upland rice agronomic technologies in the study area. This implied that, frequency of extension visits for dissemination of information and advisory services would give the farmers more confidence to sustain the use of production technology package. The influence of extension contacts can counter balance the negative effect of lack of years of formal education in the overall decision to adopt certain technologies, and can create better awareness about the potential gains of improved agricultural innovations. This is in line with Mihiretu, (2008) who observed that the variable for extension contact had a positive coefficient, indicating that adoption of quality rice management practice increases with increase in the extension services offered to farmers. In a similar study in Northern Ghana, Awuni *et al*. (2018) reported extension contacts to have a positive and significant impact on intensity of adoption. Nkegbe and Shankar (2014), in a study carried out in northern Ghana, reported a positive effect of extension contacts on intensity of adoption of soil and water conservation practices. Danso-Abbeam *et al*. (2017) also reported that in northern Ghana, adoption of improved maize variety was significantly influenced by farmers access to extension services. Education level showed a positive and significant ($P \leq 0.05$) influence on adoption intensity. This suggests that as farmers spend more years in school, their understanding of the benefits of applying sustainable techniques in production improves. However, Awuni *et al*. (2018) found that education had an insignificant but a relationship with intensity of adoption of improved upland rice production technologies by rice farmers in northern Ghana. A possible explanation is that educated farmers tend to have better access to research output reports and generally to update on information about the risks associated with improved production technologies (Chekene*et al.* 2015). Literate farmers also often serve as contact farmers for extension agents in disseminating information about agricultural technologies from government agencies (Arslan *et al*. 2014). The results further indicated that distance from market has negative coefficient (-0.0032903) and was significant (P≤0.01). These results conform to a priori expectation of the study. The negative coefficient is an indication that as distance to market decreases it invariably means a close proximity thereby adoption and use intensity of production technologies increases. This implies that short distance to the nearest market centre and the frequency of contact that the farmer maintains with it has contributory influence on adoption of production techniques. The closer they are to the nearest market, the more likely it is that the farmer will receive valuable information (Issa*et al.* 2016). This agrees with Ndagi *et al*. (2016) who opined that adoption of technologies is expected to increase as distance to market decreases.

Access to credit is considered to be very crucial in dealing with the limitations related with adoption of agricultural technologies (Doss, 2003). However, results showed a negative effect of credit on intensity of adoption of improved upland rice production technologies. This denotes that as farmers' access to credit increases, their desire to venture into other non-farm profit making enterprises also increases, and this eventually limits their investment in rice production. This could also be attributed to the unpredicted rainfall and temperature patterns of Northern Uganda which puts farm enterprises at a risk. Furthermore, rice not being a traditional staple food crop in the region, utilization at household level is often low. Therefore, farmers will either invest more of the attained credit in the production of staple crops that boost their food security or other non-farm activities that will elevate their incomes. This observation is consistent with those of Motin et al. (2014) and Hamidi and Sabbaghi (2016) who reported deviation of credit intended to finance farm activities to non-farm activities by farmers in Ghana. The negative effect of credit is contrary to the findings by Mensah Bonsu et al. (2017) and Ullah et al. (2018) on intensity of adoption of land conservation practices in Ghana and improved peach cultivars in Pakistan, respectively.

Land under rice had a positive and significant (P≤0.01) relationship with adoption intensity of improved upland rice production technologies. This implies that larger land under rice production, encourages farmers to adopt more technologies . This is similar to the findings of Bawa and Ani (2014) and Akerele (2014) who reported that farm size had bearing on the capacity of farmers to utilize agricultural innovation and new farm practices. Farmers with larger farm size are more likely to adopt modern technologies (Akudugu *et al*., 2014). However, the results of this study further showed a negative influence of land size on adoption of improved upland rice production technologies. This implies that as land size increases, use of improved upland rice production technologies decreases.

Statement of No-Conflict of Interest

The Authors declare no conflict of interest in the paper.

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