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Journal of Development and Agricultural Economics

Full Length Research Paper

Food and income diversification decisions as climate change adaptation strategies: Evidence from Kalfou and Tabalak local governments, Tahoua State, Niger Republic

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The purpose of this study is to evaluate rural household's food and income diversification decisions in face of climate change adaptation strategies using advances in choice-based experiment. Several studies have focused on general and specific food values using the balanced incomplete block design; but fewer studies have been devoted to study rural household food and income diversification decisions via the lens of balanced incomplete Latin square design (BILSD). The BILSD was used to design questionnaire served in data collection. For each question, respondents were asked to choose his best and worst coping strategies. Mixed logit model was used to data. Results reveal that agricultural production, livestock products and remaining stock from previous harvest were the most important sources of food; while the sale of agricultural product followed by the sale of garden product, picking and the sale wild fruits and leafy vegetables, small business, crafting, project transfer, the sale of firewood and straw and the sale of livestock product were the most important sources of income. Results suggest that agricultural production, livestock production and stock from previous harvest and as well as the sale of agricultural product, the sale of garden product, picking and the sale wild fruits and leafy vegetables, small business, crafting, project transfer, the sale of firewood and straw and the sale livestock product are the optimal combination food and income diversification decisions to enhance rural household resilience building capacity. Results finally suggest that collective decision made about food and income diversification decisions is more welfare enhancing that individual decision.

Key words: Food and income diversification decisions, rural household, choice experiment, climate change adaptation strategies.

INTRODUCTION

Rural households have developed and continue to develop various food security and income diversification strategies to cope with the negative externalities of climate change. Food and income diversification

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strategies have been argued to provide the most promising ways to enhance vulnerable rural households' resilience building capacity. Family farming is also important to improve rural households' food security by reducing dependence on market purchases and generating diverse opportunities to increase and stabilize their incomes. However, few studies have focused on how food and income diversification decisions as climate change adaptation strategies affect rural households' welfare. Scientific data are needed to determine the most important food and income combinations capable of guiding policy-makers on how to efficiently assist rural household to maintain their livelihoods when climate change hit. Choice experiment consistent with random utility theory well-rooted in consumer theory will provide a useful insight for the modeling. Behavioral economists hypothesized that our values and well-being are often reflected by our choices. The economic value of these choices is determined by the rate a person is willing to exchange one good for another. This rate is captured in a person's maximum willingness-to-pay to purchase a good or their minimum willingness to accept to sell a good (Lusk and Shogren, 2007). Understanding rural household food and income diversification strategies are keys to evaluate not only the degree of vulnerability, but also to determine which types of assistance rural households generally need to maintain its livelihoods when crises such flood, food shortage, drought and climate change hit.

The value rural household place on food and income diversification is often unknown and subjected to speculation. In addition, simply frequency distributions are used to rank preferences. However, little research is relatively geared towards best-worst scaling in the balanced incomplete Latin square design framework to evaluate and rank these food and income diversification strategies. Although food and agricultural policies produce winners and losers, agricultural economists should take the leadership to assist the policy community with modeling and the computation of the welfare gains and losses as tools in solving conflicts between gainers and losers. In Niger, from 1960 to date, several agricultural policies have been implemented to achieve food security, reduce poverty and increase income. From direct intervention government to boost agricultural productivity via research to self-sufficiency, to food security and as well as poverty reduction, agricultural policies have failed to address primary problems facing rural communities. These policies were unsuccessful because they emphasized on top down approach and little effort is geared towards educating and training rural communities. Therefore, keeping food production and population growth is still a challenge for most developing nations (Mousa, 2000).

Rapid intervention to assess rural households' food, income and expenditure diversification strategies using focus group discussions also called household economy approach (HEA) has been well-studied. In addition, food and income diversification strategies as risk management have been well-documented. However, little research is devoted to study and document the merit of choice-based experiment in developing country setting. Although the balanced incomplete block design (BIBD) has gained popularity as tool to collect best-worst scaling data, its merit is still in its infancy for modeling discrete choice. Furthermore, several studies have focused on general and specific food values for consumers, but fewer studies have investigated disaggregated preference of food, income and expenditure diversification strategies among rural household. This type of information is important in understanding and how to timely channel humanitarian aid to vulnerable rural household and to help maintaining its livelihoods when food crisis resulting from flood, food shortage and climate change hit. The overall purpose of this study is to evaluate rural households' food and income diversification decisions as climate change resilience capacity. Specific objectives include to determine the relative importance of food, income and expenditure diversification strategies and to evaluate whether collective decisions about food, income and expenditure diversification strategies are more welfare enhancing than individual decisions within a given household.

Background on best worst scaling (BWS) method

The use of experimental design in agriculture both in laboratory and field settings to elicit consumers' values and preferences for private and public goods and services has been recently exploded. Thus, economists have argued that demand for goods is affected not only by price of substitutes, complements and income, but also by demographic and climate change. Rural household sources of food, income and expenditure are complex and subjected to fluctuation over time and the modeling of these sources requires knowledge both in experimental design and economic theory. Also, many agricultural economists have recently used the best-worst scaling method to determine the most important strategies developed by rural farmers to increase their resilience against the negative externalities of climate change (Tabbo et al., 2016), which livestock production methods matter most to consumers (Ellison et al., 2017), consumers general and specific food values (Lister et al., 2017; Lusk and Briggeman, 2009), preferences for sustainable agricultural production (Sackett et al., 2013) and eliciting the most important domains of health for health-related quality of life in Singapore (Judy et al., 2018) and introduction to the application of best worst scaling in marketing research (Louviere et al., 2013) and evaluation of improved cowpea variety attributes (Moctar et al., 2018).

The BWS provides better information with fewer

respondents, works better than traditional likert scale and permits to achieve better discrimination among items (Louvriere et al., 2013).

Additionally, household economy approach has been increasingly used to study rural household's livelihoods by classifying household based on wealth groups (very poor, poor, middle and higher income). The first research using HEA is credited to an international organization called Save the Children UK (2009). It has conducted a study aims at understanding household economy in rural Niger (Eijkenaar, 2009).

The main objective of its study is to understand how rural households earn their livelihoods and how they have access to food. To achieve this objective, HEA profiles were conducted in five zones (Dosso district, Tessaoua district 1, Tessaoua district 2, Dakoro district1 and Dakoro district 2). Many researchers hypothesized that the well-being of rural households largely depend on what they buy and sell, what they earn and what they spend and how they cope with bad years. Results from this study revealed that wealth gap did really exist between people in the same communities and this tends to increase with time as resources getting rare and as result of population increase. Results also indicated that cash economy is very important for rural household because this will determine their food security which largely depends on their capacity to buy food on markets on daily or weekly basis. This study is different from our own because simple frequency distribution was used to classify sources of food, income and expenditure across wealth groups and little attention is given to how household preference share for sources of food, income and expenditure change when tradeoffs among these sources are assumed. In addition, Oni and Fashogbon (2013) have used the livelihood approach due to its holistic view and ability to generate disaggregated information in analyzing food insecurity and poverty. Results from ordered probit showed that farming was the predominant livelihood activity of rural households of Nigeria. Results also indicated that female headed households diversify their income and they are more food secure than their male counterparts. They finally concluded that poverty could be reduced when via human capacity building, accessibility to credit facilities and promotion of farming activities are implemented. This study used ordered logit to assess factors influencing rural household poverty level while our study used mixed logit method to evaluate rural households' preferences for sources of food, income and expenditure as climate change adaptations.

Previous studies have frequently used experimentation to study growth parameters of crop and animal in various trials. However, the use of experiments in agricultural development, natural resource economics, health economics, and environmental economics as a tool to not only measure and evaluate preference, but also as a method to separate cause and effect is still in its infancy (Voors et al., 2016). Their study also concluded that experimental studies are not only focusing on empirical testing, but also testing theoretical predictions, assessing impact both at local and community levels and analyzing how advances in technology offering new opportunities to elicit preferences and behavior of agents involved in the field of agriculture. Others studies conducted by Narloch et al. (2013) to investigate at payments for ecosystem services, by Prediger et al. (2014) and Pfaff et al. (2015) to study water scarcity and collective decision using a framed field experiments known as experimental auctions. Furthermore, Akoa Etoa et al. (2016) conducted a study to understand consumer demand for technology upgrading in rice parboiling in Cameroon using a framed field experiment and results revealed that perfections influenced consumer demand; Torero and Viceisza (2016) sought to analyze the degree of trust and the impact of auditing and to determine a potential collusion between firms and third-party auditors using a within-subject study design and they concluded that the presence of a third party significantly increased trust; Iskandar et al. (2016) conducted a laboratory experiments to study compliance with environmental taxes in Indonesia and results indicated that compliance increases with financial rewards, but is diminished by the presence of bribes; Holden and Bruvik Westberg (2016) employed a series of risk experiments to study whether fertilizer use is associated with risk aversion, rainfall levels and variation among agricultural smallholders in Ethiopia and they found that price level, average rainfall and variability influenced demand for fertilizer. Finally, Thunström et al. (2016) studied the impact of the composition of restaurant menus on the demand for meals using a randomized control trial and they found that introducing a healthy food label has no influence on restaurant sales. These studies have revealed that various survey techniques ranging from laboratory to field experiments can be used to elicit preferences and behavior in agriculture, but the contribution of balanced incomplete Latin square design as data collection tool as well as modeling choice experiment data in random utility framework has not been well assessed in agriculture. This study contributes to enrich literature related to choice experiments and climate change.

METHODOLOGY

Data collection method

Data used in this study were obtained from questionnaire designed via the balanced incomplete Latin square design (BILSD). Based on previous studies and direct interview with rural households, 11 food diversification decisions, 13 income diversification decisions and 13 expenditure diversification decisions were compiled and included in this study. The BILSD method was used to create eleven blocks or questions having five food diversification decisions randomly assigned to each. Similarly, the same procedure was used to generate thirteen blocks or questions for income and expenditure diversification decisions, each having four decisions randomly assigned to each. The questionnaire having 11 questions or 11

Table 1. Food, income and expenditure diversification decisions most and least important as climate change adaptation strategies?

Most important	Food diversification decisions	Least important
○	Cash for work	○
○	Donations	○
○	Food aid	○
○	Agricultural production	○
○	Fishing and wild fruits and vegetable harvesting	○
Most important	**Income diversification decisions**	**Least important**
○	Livestock selling	○
○	Livestock product selling	○
○	Agricultural product selling	○
○	Firewood and straw selling	○
Most important	**Expenditure diversification decisions**	**Least important**
○	Taxes	○
○	Clothing	○
○	Production inputs	○
○	Transportation	○

A sample of Best-Worst Scaling format used in the study.

food diversification decisions, 13 questions or income diversification strategies and 13 questions or expenditure diversification strategies was used to collect data from randomly selected rural households. This design is also a form of choice experiment popularly called the best-worst scaling (BWS) first developed by Louvriere and Woodworth (1990). The BWS is used when researchers seek to understand and measure the relative important of each element within a given set. For each question, household head and his family members were asked to choose their most and least important food, income and expenditure diversification decisions. Thus, the household head was individually interviewed while his family members were collectively interviewed.

Study area and sampling method

The study was conducted in three rural counties namely Kalfou, Kehehe and Tabalak, all located in Tahoua Region, Niger Republic. Before starting the data collection exercise from 22 to 26 March, 2016; students in the Faculty of Agricultural Sciences, University of Tahoua, have received training on how to administer, to code and to analyze data from a well-designed questionnaire. The author also explained in detail that the survey is voluntary and that household should be randomly selected to participate in the survey. Our target population includes household head and family members that are randomly selected and interviewed separately. Overall , 196 rural households were randomly selected and interviewed using face to face interview. Table 1 summarizes a sample of questionnaire format included in this study:

Econometric methods

The author analyzed the choice experiment data using the random utility model (McFadden, 1973). In the best worst framework, if there are j options for food diversification decisions, l options for income diversification decisions and m options for expenditure diversification decisions in a questionnaire, then $j(j-1)$, $n(n-1)$ and $r(r-1)$ best worst combinations' possible exist that an individual rural household could select. The author also assumed that each individual rural household is maximizing his utility/welfare by choosing the most and least important sources of food, income and expenditure. Thus, the difference between the two extremes (most and least) consistent with random utility was used for the modeling.

By following Lusk and Briggeman (2009), let β_j, γ_n and α_r represent respectively locations of food j, of income n and expenditure r on specific scale of importance. Thus, the true importance of each individual rural household can be mathematically expressed as follows:

$F_{ij} = \beta_j + \varepsilon_{ij}$ (1) For food diversification decisions
$I_{in} = \gamma_n + \varepsilon_{in}$ (2) For income diversification decisions
$E_{ir} = \alpha_r + \varepsilon_{ir}$ (3) For expenditure diversification decisions

Where, ε_{ij} , ε_{in} and ε_{ir} are respectively random terms for food, income and expenditure and they are independently identically distributed (i.i.d) type extreme values. The probabilities that an individual rural household chooses a given food j, income n and expenditure r as most important and k, o and s as least important in choice for each source are the probabilities that $F_{ij} - F_{ik}$ for food, $I_{in} - I_{io}$ for income and $E_{ir} - E_{is}$ for expenditure are respectively greater than all $J(J-1)-1$, $N(N-1)-1$ and $R(R-1)-1$ differences in choice set (Lusk and Briggeman, 2009). Thus, these probabilities taking on the popular multinomial logit (MNL) form for sources of food, income and expenditure can be expressed as follows:

$$\text{Prob(}\ \text{j choosen as best and k as worst in food set}\ \text{)} = \frac{e^{\beta_j - \beta_k}}{\sum_{l=1}^{J}\sum_{m=1}^{J} e^{\beta_l - \beta_{m\ 1c}}} \quad (4)$$

$$\text{Prob(}\ \text{n choosen as best and o as worst in income set}\ \text{)} = \frac{e^{\gamma_n - \gamma_o}}{\sum_{p=1}^{N}\sum_{q=1}^{N} e^{\gamma_p - \gamma_{q=1}}} \quad (5)$$

$$\text{Prob}(\text{ r choosen as best and s as worst in expenditure set}) = \frac{e^{\alpha_r - \alpha_s}}{\sum_{t=1}^{R}\sum_{u=1}^{R} e^{\gamma_t - \alpha_{m\ 1c}}} \quad (6)$$

The values of β_j, γ_l and α_m parameters can be estimated through maximizing the log-likelihood functions based on probabilities highlighted in equations 4, 5 and 6. Additionally, these estimates can be used to calculate a preference share for each food, income and expenditure. Thus, the preference share for food diversification decisions can be calculated as follows:

$$\text{Share preference for sources of food j} = \frac{e^{\widetilde{\beta_J}}}{\sum_{k=1}^{J} e^{\widetilde{\beta_k}}} \quad (7)$$

Similarly, the same procedure as shown in equation 7 was used to calculate the preference share of income and expenditure diversification decisions. However, due to the main weakness of the MNL model assuming that all individuals place equal weight of importance on each value. In addition, a random parameters logit (RPL) model was estimated because it is capable to accurately approximate any behavior model by relaxing the assumption the independence of irrelevant alternatives and modeling preference heterogeneity (McFadden and Train, 2000). Thus, the RPL model can be generally specified as follows: $\widetilde{F_{ij}} = \overline{\beta_j} + \phi_j \nu_{ij}$,

Where, $\overline{\beta_j}$ and ϕ_j are respectively the mean and standard deviations of β_j in the population, and ν_i is a random term normally distributed with mean zero and unit standard deviation. If the estimated standard deviation $\widetilde{\phi_j}$ is significant, then we conclude that it is random in the survey population. Furthermore, Likelihood ratio tests (LRT) were used to determine whether individual decision and collective decision can be pooled and whether mixed multinomial logit also called random parameter (RPL) model performed better than multinomial logit model (MNL).

Finally, the impact between decisions made by individual household head and those made by others members on rural household welfare was also computed for each food, income and expenditure diversification decision. Thus, the difference in preference share scores under individual decisions and those under collective decisions divided by preference share scores under collective decisions for each source was used to estimate the welfare impact.

RESULTS AND DISCUSSION

This section summarizes results and interpretation from data analysis. Table 2 reports the socio-economic characteristics of our sample respondents. As indicated in Table 2, the majority of the respondents had an average of 43 years with an average income of 39420 FCFA. Most of the respondents were men (85.3%), married (82.3%) and educated (22%). Seventy five percent of respondents reported having climate change information and majority of them had a large family size (61.6%) and a small farm size (68.9%). Table 2 also showed that a significant difference exists for average age ($p<0.001$), gender category ($p<0.001$), marital status ($p<0.001$) and household size ($p<0.001$) between individual and collective decisions for rural household. Additionally, further analyses revealed that these differences did not influence final results and therefore aggregate socioeconomic profiles were presented.

Results from LRT revealed that individual decision and collective decision in a given household could not be pooled across MNL and RPL models. Tables 3, 4 and 5 present respectively results from random parameter logit models for food, income and expenditure diversification strategies. Results from Likelihood ratio tests (LRT) showed that mixed multinomial logit model outperformed multinomial logit model, implying that only estimates from mixed multinomial logit (RPL) were reported in this study.

Lusk and Tonsor (2016) have drawn similar conclusion by studying different models related to how meat demand elastcities vary with price, income and product category. Table 3 presents coefficients for food diversification strategies for both individual and collective decisions made at the household level from RPL model. Coefficients with positive sign were preferred while coefficients with negative sign were discounted. As can be seen in Table 3, regardless of who made decision at the household level (household head or his family member), agricultural production, followed by livestock product and remaining stock from previous harvest were the most important food diversification strategies; while food aid followed by food for work, payment in cash, donation and agricultural loan were the least important food diversification strategies relative to cash for work. Table 3 also presents preference share for each food diversification strategy. Results generally showed that the combination of agricultural product and livestock products and remaining stock from previous harvest captured 87.70 and 93.73% for individual decision and collective decision respectively; indicating that collective decision about food diversification strategies is more welfare enhancing that individual decision. Furthermore, Table 3 reports comparison between individual and collective decisions on rural household welfare. Specific results showed that for agricultural production, collective decision (88.9%) is more welfare enhancing than individual decision (79.83%). Conversely, for livestock products (52.63%) and remaining stock from previous harvest (83.75%), individual decision is more welfare enhancing than collective decision. Our results indicate that agricultural and livestock products as food diversification strategy are more welfare enhancing. These findings are consistent with a recent study reporting that crop production furnishes a basic food source and improve capable to improve farmers living conditions (Wan et al., 2016).

Table 4 reports coefficients, preference share and comparison between individual and collective decisions for income diversification strategies. Table 4 shows that the sale of agricultural product (15.25%) followed by the sale of garden product (11.72%), picking and the sale wild fruits and vegetables (9.57%), small business (8.57%), crafting (7.88%), begging(7.86%), project transfer (7.32%), the sale of firewood and straw (7.35%) and livestock product selling were the most important income diversification strategies in face of changing

Table 2. Summary statistics of surveyed respondents.

Variable	Definition	Mean for individual decision	Mean for collective decision	Mean Aggregate	Individual vs. collective
Age	Age in years	49.443(13.629)	34.426(17.173)	42.013(17.194)	p<0.001
Gender	1 if male, 0 if female	0.929(0.328)	0.776(0.418)	0.853(0.383)	p<0.001
Marital status	1 if married, 0 otherwise	0.903(0.297)	0.741(0.439)	0.823(0.382)	p<0.001
Education	1 if uneducated, 0 if educated	0.796(0.404)	0.763(0.426)	0.780(0.415)	p=0.439
Income	Monthly income in 1000	39.180(23.910)	39.420(36.360)	39.300(30.630)	p=0.940
Household size	1 if size ≤5, 0 otherwise	0.163(0.371)	0.615(0.488)	0.384(0.487)	p<0.001
Farm size	1 if size ≥5, 0 otherwise	0.296(0.458)	0.326(0.470)	0.311(0.463)	p=0.520
Climate change information	1 if yes, 0 otherwise	0.719(0.494)	0.750(0.530)	0.735(0.512)	p=0.554
Sample size	N	196	196	392	

Numbers in parentheses are standard deviations. Income reported in FCFA ($1=500FCFA).

Table 3. Rural household food diversification strategies coefficients based on random parameter logit model (RPL Estimates).

Food diversification	Individual decision		Collective decision		Aggregate decision		Individual share vs collective (%change)
	Estimates	Share (%)	Estimate	Share	Estimate	Share	
Agricultural production	3.564(0.272)**	79.83	4.340(0.355)**	88.9	3.826(0.211)**	83.33	-10.20
Livestock products (milk, meat)	0.780(0.110)**	4.93	1.025(0.122)**	3.23	0.882(0.080)**	4.39	52.63
Remaining stock from previous harvest	0.264(0.109)**	2.94	0.323(0.107)**	1.6	0.286(0.075)**	2.42	83.75
Fish farming and wild fruit harvesting	0.033(0.113)	2.34	0.032(0.117)	1.2	0.024(0.080)**	1.86	95.00
Purchasing	-0.060(0.098)	2.13	-0.033(0.097)	1.12	-0.042(0.068)	1.74	90.18
Food aid	-0.317(0.099)	1.65	-0.312(0.095)**	0.85	-0.383(0.068)**	1.25	94.12
Food for work	-0.438(0.095)**	1.46	-0.453(0.096)**	0.74	-0.373(0.067)**	1.24	97.30
Payment in cash	-0.821(0.104)**	1.00	-0.774(0.106)**	0.53	-0.796(0.073)**	0.82	88.68
Donation	-0.842(0.101)	0.97	-0.973(0.101)**	0.44	-0.899(0.069)**	0.74	120.45
Agricultural loan	-1.522(0.120)**	0.49	-1.604(0.123)**	0.23	-1.538(0.082)**	0.39	113.04
Cash for work	0.00	2.26	0.00	1.16	0.00	1.82	94.83
Number of individuals	196		196		392		
Log-Likelihood	-5441		-5243		-10666		

*, ** denote mean importance level significantly different from cash for work option at 5 and 1% respectively. Numbers in parentheses are standard errors.

climate; while remittances from migrants (3.55%) and the sale of livestock (2.98%) were the least important income diversification strategies relative to income such as hired labor. While results are similar for both individual and collective decisions with regard to income diversification, results from

Table 4. Rural household income diversification strategies' coefficients based on random parameter logit model (RPL Estimates).

income diversification	Individual decision		Collective decision		Aggregate decision		Individual share vs collective share (% change)
	Estimate	Share (%)	Estimate	Share (%)	Estimate	Share (%)	
The sale of Agricultural product	0.994(0.112)**	15.25	0.976(0.109)**	15.31	1.010(0.079)**	15.25	-0.39
The sale of garden product	0.823(0.086)**	11.72	0.650(0.085)**	11.05	0.747(0.061)**	11.72	6.06
Picking and sale wild fruits	0.544(0.076)**	9.57	0.497(0.105)**	9.48	0.544(0.076)**	9.57	0.95
Small business	0.581(0.108)**	8.57	0.408(0.086)**	8.67	0.434(0.065)**	8.57	-1.15
Crafting	0.350(0.055)**	7.88	0.287(0.077)**	8.40	0.350(0.055)**	7.88	-6.19
Begging	0.348(0.058)**	7.86	0.376(0.083)**	7.68	0.348(0.055)**	7.86	2.34
Project transfer	0.276(0.054)**	7.32	0.216(0.075)**	7.46	0.277(0.054)**	7.32	-1.88
The sale of firewood and straw	0.266(0.051)**	7.25	0.258(0.073)**	7.16	0.267(0.051)**	7.25	1.26
The sale of livestock product	0.180(0.058)**	6.65	0.126(0.082)**	6.54	0.181(0.058)**	6.65	1.68
Borrowing	0.051(0.058)	5.85	0.055(0.080)	6.09	0.052(0.058)	5.85	-3.94
Remittances from migrants	-0.448(0.059)**	3.55	-0.504(0.076)**	3.49	-0.448(0.058)**	3.55	1.72
The sale of livestock	-0.622(0.068)**	2.98	-0.692(0.095)**	2.89	-0.623(0.068)**	2.98	3.11
Wages from hired Labor	0.00	5.55	0.00	5.77	0.00	5.55	-3.81
Numbers of individuals	196		196		392		
log Likelihood	-6004		-5972		-11940		

*, ** denote mean importance level significantly different from wages from hired labor option at 5 and 1% respectively. Numbers in parentheses are standard errors.

difference between preference share for individual decision and that of collective decision reveal more information about welfare. Thus, for the sale of agricultural product (-0.39%), crafting (-6.19%), small business (-1.15%) and project transfer (-1.88%), decisions made collectively are more welfare enhancing than decisions made individually. Conversely, the sale of garden product (6.6%), picking and the sale of wild fruits and vegetables (0.95%), begging (2.34%), the sale of firewood and straw (1.26%) and the sale of livestock product (1.68%), decisions made individually are more welfare enhancing than those made collectively. Key results show that agricultural product and garden products selling as income diversification strategies are more welfare enhancing.

These results are consistent with recent studies by Tithy et al. (2017) stating that income diversification has been identified as the most important strategy to raise income and reduce rural poverty. They also added that the level and type of income diversification depends on the accessibility and availability of different income sources. Furthermore, a recent study by Wan et al. (2016) have confirmed that income diversification could assist rural households to reduce the adverse impact of drought, enhance their resistance and resilience to drought, and make their livelihood system more stable. They have reported that income diversification not only is a useful strategy in terms of managing disaster risk and improving social welfare, but also may offer a new perspective for the research of vulnerability, resilience, and adaptive ability of rural social-ecosystem.

Finally, another research by Fentahun et al. (2018) stated nonfarm and off farm activites are the main income diversification strategies in most developing countries. They also show that income diversification such as crop income has the highest share followed by livestock income.

Table 5 presents individual and collective decisions, their preference share and a comparison between these preference shares. As can be seen in Table 5, regardless of individual or collective decisions about expenditure diversification strategies, household equipment (12.16%) followed by clothing (10.57%) and donation (9.76%) were the most important expenditure diversification strategies, while staple

Table 5. Rural household expenditure diversification strategies coefficients based on random parameter logit model (RPL Estimates).

Expenditure diversification	Individual decision		Collective decision		Aggregate decision		Individual share vs collective share (% change)
	Estimates	Share (%)	Estimates	Share (%)	Estimates	Share (%)	
Household equipment	0.435(0.080)**	13.27	0.325(0.082)**	12.31	0.387(0.058)**	12.16	7.80
Clothing	0.293(0.097)**	11.52	0.195(0.083)**	10.81	0.247(0.057)**	10.57	6.57
Donations/gifts	0.108(0.080)**	9.57	0.231(0.087)**	11.20	0.160(0.059)**	9.76	-14.55
Non staple food	-0.001(0.071)	8.58	-0.175(0.076)	7.46	-0.085(0.052)	7.58	15.01
Community commitment	-0.011(0.072)	8.5	-0.110(0.072)	7.96	-0.055(0.051)	7.81	6.78
Communication	-0.057(0.075)	8.12	-0.052(0.073)	8.44	-0.049(0.052)	7.86	-3.79
Staple food	-0.172(0.086)*	7.23	-0.192(0.093)**	7.34	-0.189(0.063)**	6.84	-1.50
Social services	-0.334(0.076)**	6.09	-0.466(0.078)**	5.58	-0.395(0.053)**	5.56	9.14
Transportation	-0.380(0.084)**	5.88	-0.316(0.088)**	6.48	-0.384(0.060)**	5.85	-9.26
Taxes	-0.552(0.078)**	4.95	-0.415(0.077)**	5.87	-0.483(0.055)**	5.09	-15.67
Water	-0.602(0.077)**	4.71	-0.593(0.079)**	4.91	-0.592(0.054)**	4.57	-4.07
Production inputs	-1.050(0.097)**	3.01	-1.184(0.099)**	2.72	-1.104(0.067)**	2.89	10.66
Ceremonies/funerals/festivity	0.00	8.59	0.00	8.89	0.00	8.72	-3.37
Numbers of individuals	196		196		392		
log Likelihood	-6084		-6085		-12147		

*, ** denote mean importance level significantly different from wages from hired labor option at 5 and 1% respectively. Numbers in parentheses are standard errors.

food (6.84%) followed by social services (5.56%), transportation (5.85%), taxes (5.09%), water (4.57%) and production inputs (2.89%) were the least important expenditure diversification strategies.

CONCLUSION AND RECOMMENDATION

Numerous studies have well documented that food and income diversification strategies as climate change adaptation strategies have produced successful stories in changing climate**.** The use of experiments to determine rural households' food, income and expenditure diversification strategies is increasingly gained interest in agriculture. However, there are relatively few studies focused on evaluating rural households' food and income diversification strategies as climate change adaptation strategies. Household economy approach has been widely used to classify household based on degree of vulnerability. It also employs to efficiently target household that could not maintain their livelihoods after crises such flood, climate change, food shortage and drought occurred. However, little research has been conducted to determine rural household food and income diversification strategies as climate change adaptation strategies. The purpose of this study is to determine value rural household on various food, income diversification decisions as climate change hit. Specific objectives are to determine the optimal food, income and expenditure combinations capable of building and maintaining rural household resilience building capacity in face of changing climate and to determine whether decision made individually by rural household is more welfare enhancing than decision made collectively. Based on previous studies related to food and income diversification as well as direct interview with farmers, 11 food diversification decisions, 13 income diversification decisions and 13 expenditure diversification decisions were identified and included in this study. The balance incomplete Latin square design consistent with best-worst scaling approach was used to design questionnaire utilized in data collection, while random parameter model was used to model the choice data.

Results showed that agricultural production

followed by livestock products and remaining from previous harvest were the most important food diversification strategies for respondents surveyed in the study area, suggesting that projects aim at improving agricultural production and livestock products (milk and meat) as food diversification decisions would be more beneficial for farmers. Results also indicated that agricultural product selling followed by garden product selling, picking and selling wild fruits and leafy vegetables, small business, crafting, project transfer, firewood and straw selling and livestock product selling were the most important income diversification strategies in the study area, indicating that welfare of rural household could be considerably improved when projects have been developed and implemented based on these identified most important income diversification strategies. Moreover, results from this study revealed that household equipment followed by clothing and donations were the most important expenditure diversification strategies, implying that most rural household spent a large proportion of their income on household appliances, clothing and donation or gifts. Finally, results suggested that decisions made collectively for food and income diversification strategies are more welfare enhancing than those made individually, while decisions made individually for expenditure diversification strategies are more welfare enhancing those made collectively.

This study suggests that rural household welfare could be improved when the combination of these most important food and income diversification strategies is considered by policy-makers. These results also help to guide decision-makers on how to act faster, more efficiently and effectively in time of crises as well as to plan rural development in the study area. Limitations of this study include considering only one region and failure to stratify respondents based on wealth groups and as well as hypothetical bias associated with choice experiment. Future direction for research is to study the stability of rural household preference for food, income and expenditure diversification strategies over time and across different experimental designs (balanced incomplete block versus balanced incomplete Latin square designs).

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CONFLICTS OF INTEREST

The authors have not declared any conflict of interests.

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Determinants of the choice of multi-governance structures by producers and processors of paddy in Benin

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This study aims to analyse the factors that influence the selection of governance structures by rice producers and processors in Benin. Unlike previous studies, the factors that influence the selection of governance structures are identified simultaneously for both producers and processors of paddy. Data were collected in Benin from about 300 producers and 140 processors of paddy randomly selected. The results indicate that 78% of producers and 92% of the processors use spot market for paddy transaction. Around a quarter of producers use at least two governance structures to sell paddy. Producers and processors belonging to an innovation platform are more likely to use formal contracts in their transactions. Also, producers and processors are more likely to use credit payment mechanism with formal contract. The findings suggest that innovation platforms can be used to facilitate contractual relationships between paddy producers and processors.

Key words: Multivariate probit, market dynamics, African rice value chains, governance mechanisms.

INTRODUCTION

Global agri-food systems are undergoing significant changes due to the globalization of supply and marketing, the use of quality standards, and product differentiation (Reardon et al., 2009). These responses to liberalization have led to the opening of domestic markets to imported products. As a result, actors of domestic value chains, especially those in developing countries, need to organize their activities to effectively cope with the competition from imported products. In this sense, buyers in domestic value chains often look for suppliers that can abide by the requirements of quality, quantity, and delivery time in order to cope with market demand (Weatherspoon and Reardon, 2003; Poulton and Lyne, 2009). However, small-scale producers in developing countries face many

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constraints that limit their ability to abide by the requirements set by buyers. These constraints include a limited access to credit and production inputs (e.g. seeds and fertilizers) as well as a lack of information on production technologies (Bijman, 2008; Reardon et al., 2009; Barrett et al., 2012).

The negative impacts of these problems on farmers can potentially be addressed through improved market coordination among farmers and other value chain actors (Vroegindewey, 2015). A strategy commonly used to improve market coordination is to adopt buyer-supplier governance structures, such as contracts and long-term partnerships (Prowse, 2013; Reardon et al., 2009). Governments and development actors are increasingly considering using these governance structures as tools to reduce poverty and stimulate agricultural growth (Jia and Bijman, 2014). The key challenge to the development of African rice value chains is the need to improve the governance of quality (Rizzoto and Demont, 2011; Demont and Rizzoto, 2012). However, the force of only spot market is not enough to face the challenge of quality. Accordingly, other governance mechanisms, such as contracts, alliances and vertical integration, are needed to ensure that producers and processors cope with the changing demands of consumers (Swinnen et al., 2010).

A governance structure is an organizational option used by an economic agent to carry out a transaction. Economic agents, when coordinating their activities, adopt governance structures which, according to Williamson (1975), allow them to minimize transaction costs. The governance structures include the spot market, the hybrid or contractual forms, and the hierarchy. The choice of a governance structure or their combination is mainly influenced by the attributes of the transaction. A thorough understanding of the factors that influence the choice of the governance structures is pivotal to design policies that promote a better coordination of activities along rice value chain. As a result of a better value chain coordination, actors can provide consumers with rice that meet their preference.

Theoretically, the choice of a governance structure depends on the importance of the transaction costs related to each governance structure (Renkow et al., 2004; Vakis et al., 2003; Williamson, 1975). However, these transaction costs are difficult to quantify. Thus, this research follows Kpenavoun (2009) and Arinloyé (2013) and focuses on the factors that determine these costs, which are socioeconomic factors, the attributes of the transaction, and the institutional environment. The socioeconomic factors that influence the selection of a governance structure may include the farm size, the age of head of household, the gender, and the level of education of the farm manager (Arinloyé, 2013; Kpenavoun, 2009; Polson and Spencer, 1991). In terms of transaction attributes, Williamson (1979) explains that economic transactions have three main attributes: Asset specificity, uncertainty, and frequency of the transaction. These determine the extent and nature of transaction costs and are pivotal in the decision of governance structures selection.

Asset specificity is the difficulty of using assets for alternative transactions, or their non-redeployability (Moustier, 2012). When the assets involved in a transaction are generic and non-specific, the most effective governance structure is to use the market. However, when asset specificity is average, the company will use a hybrid form if the level of uncertainty is not too high (Williamson, 1996; Bensalk, 2013). Uncertainty includes internal and external disturbances to which transactions are subject (Williamson, 1979). In the presence of uncertainty, agents can be tempted or may attempt to renegotiate the terms of the original agreement. However, a negotiation can increase the cost of contracting and thus the effectiveness of the agreement. A high level of uncertainty will discourage the supplier from investing in specialized assets if appropriate safeguards are absent (Lu, 2007).

The frequency of the transaction affects transaction costs and has an ambiguous effect on the mode of organization (Crocker and Masten, 1996). However, the more the transaction is repeated, the better the partner is known and the harder it becomes to a partner to be opportunistic (Williamson, 1985; Bensalk, 2013). Accordingly, it is advisable to use a governance structure that minimizes opportunistic behaviour (Royer, 2009; Bensalk, 2013). Several recent researches in the rice sector in Benin have examined the issue of competitiveness of rice production (Codjo et al., 2016; Adegbola et al., 2003). However, few studies have addressed the organizational facet of rice value chain. Unlike previous studies addressing the issue of governance structures selection (Arinloyé, 2013, Kpenavoun, 2009), this paper considers both producers and processors. Producers sell paddy to processors through various governance structures. Processors of paddy; however, are the buyer of paddy, which one is processed to obtain the milled rice. Accordingly, looking at jointly the factors that influence the selection of governance structures by the buyers and sellers of paddy may be important to guide the design of policies to promote the selection of suitable governance structures.

METHODS

Description of study area

This study was conducted in the rice development hub of lowland rice and strict rainfed rice of Benin. This rice development hub is in the central part of Benin and known as Glazoué rice development hub. This hub includes the districts of Glazoué, Dassa, Savalou and Bantè. A rice development hub is a part of an agro-ecological zone of a country with a strong concentration of integrated research and extension work along the rice value chain for more impacts (AfricaRice, 2015). It is also a multi-stakeholder partnership operating

Table 1. Number of villages and respondents per district.

District	Producers		Processors	
	Number of villages	Number of respondents	Number of villages	Number of respondents
Dassa	10	70	5	41
Glazoué	12	78	6	52
Savalou	9	66	4	21
Bantè	10	86	5	26
Total	41	300	20	140

Table 2. Description of variables included in the regression model.

Variable	Description	Level
Socioeconomic characteristics		
Belonging to an innovation platform	Binary variable indicating if actor i belongs to an innovation platform	0 = No, 1 = Yes
Agricultural training	Binary variable indicating if actor i received agricultural training	0 = No, 1 = Yes
Sex	Binary variable indicating the sex of actor i	0 = Women, 1 = Men
Actor	Binary variable indicating the type of actor i	0 = Processor, 1 = Producer
Information, search, and bargaining costs		
Location of the transaction partners	Binary variable indicating if the transaction partners are in the same village	0 = Not the same village, 1 = Same village
Existing of middleman for the negotiation	Binary variable indicating if the negotiation is made by a middleman or not	0 = No, 1 = Yes
Mechanism of payment	Binary variable indicating if the producer is paid at the delivery or not	0 = No, 1 = Yes

in synergy on value chains (processing, marketing, etc.) to promote rice in a given area.

Source of data and sampling method

Producers and processors were randomly selected. At the producer level, a list of villages active in rice production was established in each of the districts forming the rice development hub of Glazoué, with the assistance of members of the rice producers' associations. Thus, 15 villages were identified as being active in the district of Bantè, 14 in the district of Savalou, 16 in the district of Dassa, and 19 in the district of Glazoué. Forty-one (41) villages were selected randomly from the pool of villages (Table 1). At the level of each selected village, the list of rice-producing households is set with the assistance of producer associations' leaders. This list is supplemented by a census of the other producers of the village. A total of 300 producers randomly selected from forty-one (41) villages were surveyed. As in the case of producers, rice-processing villages were randomly selected in each district. In each village, a list of processing units was established with the assistance of the leaders of associations of processors. Rice processors considered in this study are those who purchase paddy, parboil it or not, and sell the milled rice after the milling of paddy. The millers that provide just a milling service and do not purchase paddy to mill and sell the final product as a milled rice are not included in this study. Then the processors were randomly selected in each selected village. Thus, a total of 140 processors were surveyed in 20 villages.

Empirical model

A governance structure defines the type of agreement that exists between the producer and the processor of paddy. This research focuses on four governance structures: The spot market, formal contracts (written), informal or relational contracts, and producer associations. This study focused on the socioeconomics characteristics and information, search, and bargaining cost to explain the choice of governance structures. In line with Arinloyé (2013) and Getachew (2009), the choice of governance structure made by an actor may be explained by the socioeconomic characteristics of the household (HH_i^k) and the information, search and bargaining costs (ISB_i^p). The socioeconomic characteristics of the household are included in the model to account for the effect of individual characteristics on the choice of governance. Table 2 presents the explanatory variables included in the model together with their descriptions and levels.

The empirical model is as follows:

$$\begin{cases} SM_i = \alpha_0 + \sum_{K=1}^{4} \alpha_{1i} HH_i^k + \sum_{p=1}^{3} \alpha_{3i} ISB_i^p + \varepsilon_a \\ FC_i = \beta_0 + \sum_{K=1}^{4} \alpha_{1i} HH_i^k + \sum_{p=1}^{3} \beta_{3i} ISB_i^p + \varepsilon_b \\ IC_i = \gamma + \sum_{K=1}^{4} \gamma_{1i} HH_i^k + \sum_{p=1}^{3} \gamma_{3i} ISB_i^p + \varepsilon_c \\ AP_i = \delta_0 + \sum_{K=1}^{4} \delta_{1i} HH_i^k + \sum_{p=1}^{3} \delta_{3i} ISB_i^p + \varepsilon_d \end{cases}$$

with SM_i, FC_i, IC_i, AP_i, binary variables, taking the value 1 if actor i (producer or processor) chose respectively the spot market, formal contracts, informal agreements and producer association and 0 if not. HH_i^k, a vector of variable representing the socioeconomic characteristics of actor i, ISB_i^p, a vector of variable representing the information, search and bargaining costs of the actor I, and ε the error term.

A multivariate probit model (MVP) or seemingly unrelated regression (SUR) can be used to estimate the model. The SUR model is used in the case where the dependent variables are continuous. As part of this research, the dependent variables are dichotomous. Therefore, the right model for the estimate is MVP (Cappelari and Jenkins, 2003). This model allows the analysis of the relationship between the dependent variables considered (Arinloyé, 2013; N'cho, 2014). It also allows us to consider the multiple choices of governance structures by the actors.

RESULTS AND DISCUSSION

Socio-economic characteristics of producers and processors

Table 3 presents the socio-economic characteristics of the paddy producers and processors that were surveyed. On average, producers were older than processors. The t-test suggests that there is significant difference in the mean of age and cultivated area across producers and processors. Rice production was dominated by men (62.82%). Processing activities were dominantly performed by women (94.70%), who use traditional or modern equipment to parboil the paddy. Processing of white paddy rice is sometimes performed by the men who own the processing units. More than half of the producers and processors have received no formal education, although more than 80% have undergone agricultural training. A chi square test of independence suggests that agricultural training is not related to the type of actors. Accordingly, there is independence between the type of actor and agricultural training. However, the chi square test of independence revealed that participation in innovation platforms activities is related to the type of actor. Around 30% of producers and 56% of processors belong to an innovation platform. Innovation platforms were created in response to rice producers and processors unequal access to information and resources that are necessary for the development for rice value chain (Hinnou et al, 2018). While reducing disparity about access to information, innovation platforms bring together actors including, producers, processors, seed providers, retailers, middlemen, financial institutions and others. Innovation platforms are used to facilitate the access of actors to production resources and marketing relationship.

Types of governance structure used

Based on the exploratory phase, there are four governance structures used by producers and processors: (i) spot market; (ii) formal contract (written contract that gives details about rice transaction between a producer and a processor); (iii) informal contract (oral contract between a producer and a processor); and (iv) association of producers (only producers belonging to the association can sell their product to the association).

Figure 1 shows the distribution of producers and processors by governance structures used to exchange the paddy. These actors mainly use the spot market for their transactions. In all, 78.04% of the producers and 92.59% of the processors use the spot market. This result is consistent with that of Arinloyé (2013), which found that more than 90% of the pineapple farmers in Benin use the spot market to sell their products. These results are also supported by those of Ji et al. (2012), who found that the spot market represents 81% of pork transactions in Ethiopia. However, few actors are engaged in informal contracts and producers' associations for marketing their paddy. This contrasts with the results of Arinloyé (2013), which found that 58% of pineapple producers sell through relational contracts and 41% through producer associations. In this study, only 13% of rice producers and 11% of processors use relational contracts. About 14% of paddy producers sell their rice through producer associations.

Number of governance structures used

Table 4 shows the distribution of producers and processors by the number of governance structures used. Actors using more than one governance structure combine one or more of the alternatives available to them. It appears that almost 68% of producers use only one governance structure to market their paddy, while about 32% use at least two governance structures. Concerning processors, 74% use a single governance structure to procure paddy, with 25% using at least two governance structures. This contrasts with the results of Arinloyé (2013), which found that 80% of pineapple producers in Benin uses at least two governance structures. Using multiple governance structures is a strategy to level off the revenue.

Table 3. Socio-economic characteristics of the sample.

Characteristic	All	Producers	Processors	P-value
Age (mean)	44.82(10.38)	46.75(10.23)	40.78(9.52)	0.000[a]
Sex (%)				0.000[b]
Men	44.25	62.82	5.30	
Women	55.75	37.18	94.70	
Formal education (%)				0.005[b]
No	56.48	51.62	66.67	
Yes	43.52	48.38	33.33	
Agricultural training (%)				0.145[b]
No	14.18	15.88	10.61	
Yes	85.82	84.12	89.39	
Cultivated rice area (ha)	1.07(1.95)	1.33(2.29)	0.53(0.62)	0.000[a]
Belonging to an innovation platform (%)				0.000[b]
No	62.1	70.76	43.94	
Yes	37.90	29.24	56.06	
Number of respondents	440	300	140	-

Standard errors in parenthesis; a: t-test is used to analyse the mean difference significance; b: Chi square test of independence is used to analyse the association between variables.

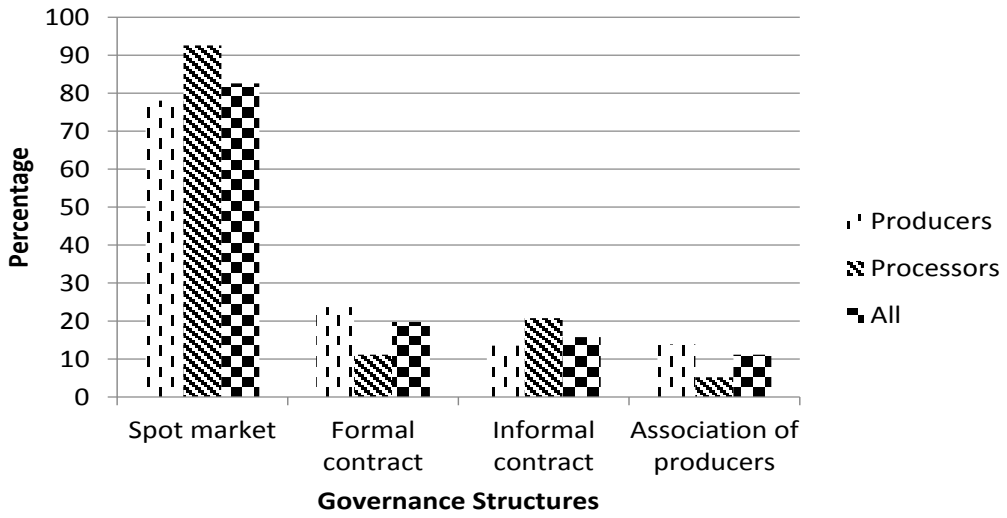

Figure 1. Distribution of producers and processors by governance structures.

Table 4. Number of governance structures in which actors are involved.

Number of governance structures*	Producers		Processors		All	
	Obs*	Percent (%)	Obs	Percent (%)	Obs	Percent (%)
1	188	67.87	99	74.43	287	70
2	73	26.35	27	20.03	100	24.39
3	16	5.78	6	4.5	22	5.36
4	0	0	1	0.75	1	0.24
Total	277		133		410	100

*Obs=Observation.

Table 5. Results of multivariate probit estimation for governance structure choice.

Socioeconomic characteristics	Governance structures			
	Spot market (SM)	Formal contract (FC)	Informal contract (IC)	Association of producers (AP)
Belonging to an innovation platform	-0.54***(0.19)	0.82***(0.17)	-0.01(0.17)	0.14(0.18)
Type of actor	-0.77***(0.25)	0.63***(0.22)	-0.49**(0.21)	0.48*(0.26)
Sex	0.02 (0.019)	-0.22(0.18)	-0.37**(0.19)	-0.24(0.19)
Agricultural training	-0.37(0.33)	0.38(0.28)	0.21(0.24)	0.65*(0.34)
Information, search and bargaining costs				
Location of the transaction partners	0.92***(0.23)	-0.79***(0.17)	–0.27*(0.15)	-0.26(0.19)
Existing of middleman for the negotiation	-0.04(0.20)	0.24(0.18)	0.11(0.17)	0.25(0.20)
Mechanism of payment	0.39(0.24)	-0.87***(0.23)	-0.20(0.22)	–0.24(0.26)
$\rho FC * SM$	0.80***			
$\rho IC * SM$	-0.27***			
$\rho AP * SM$	-0.06			
$\rho IC * FC$	0.26***			
$\rho AP * FC$	-0.09			
$\rho AP * IC$	0.18*			
Number of observations	410 (277 producers and 133 processors)			
Wald chi^2(df)	125 (77)***			
Likelihood ratio test, H_0: ρ21= ρ31= ρ41= ρ32= ρ42= ρ43=0; chi^2(6)=101.21* **				

*Significant at 10%; **significant at 5%; ***significant at 1%; standard errors in parenthesis.

The choice of governance structures

The results of the MVP model are presented in Table 5. The Wald test was used to examine whether any of the parameters of the model that currently have non-zero values could be set to zero without any statistically significant loss in the model's overall fit to the data. This test the overall significance of the variables included in the econometric model (McGeorge et al., 1997; Ryan and Watson, 2009). The results show that the Wald Chi^2 is statistically significant at 1% level, indicating that the subset of coefficients of the model are jointly significant and that the explanatory power of the factors included in the model is satisfactory. The factors included in the model explain the choice of different governance structures by rice producers and processors.

The likelihood ratio of the null hypothesis of independence (ρFC*SM = ρIC*SM = ρAP*SM = ρIC*FC = ρAP*FC = ρAP*IC) between the decisions of choice of different governance structures is significant at 1%. Thus, the null hypothesis of independence between the decisions of choice of governance structures is rejected. The values of rho (ρij) indicate the degree of correlation between governance structures taken in pairs. The values of rho ρFC*SM, ρIC*FC, and ρAP*IC are significant at the 10% level with associated positive values. From these results it can be concluded that the actors who use the spot market to exchange paddy are more likely to use formal contracts.

Belonging to an innovation platform is an important factor that influences the choice of governance structures. This variable is positively and significantly correlated with formal contracts. Therefore, actors who use formal contracts to exchange paddy are more likely those who belong to an innovation platform. Indeed, the platform is a tool used to facilitate the connection between actors. It allows them to meet, share knowledges and build business relationship. Therefore, the processors belonging to an innovation the platform sign contracts with producers to ensure a reliable supply of the raw material (paddy).

Participation in agricultural training has a significant and positive influence on the use of producer associations. This influence could be justified by the fact that most trainings initiated for the stakeholders in rice value chain are carried out through producer associations. These results confirm those of Arinloyé (2013), which explains that the institutional support received by producers influences the choice of governance structures.

The type of actor negatively and significantly (5%) influences the choice of spot market and informal contract. Thus, the processors are more likely to use these governance structures than producers. This can be justified by the fact that processor generally combine the other governance structures to spot market. Indeed, even

Table 6. Predictions of probabilities of participation in different governance structures.

Mode of governance	Minimum	Mean	Maximum
Spot market	0.50	0.87	0.99
Formal contract	0.01	0.21	0.86
Informal contract	0.004	0.17	0.38
Association of producers	0.003	0.11	0.34
All four governance structures	0.0001	0.004	0.035
Zero mode of governance	0.0003	0.013	0.067

though the processors use formal contracts and farmers associations for their procurement, they can request additional quantities on spot market. Processors may receive an order of milled rice at any time throughout the year and they may not have enough paddy to meet such demand. Accordingly, processors may refer to spot market anytime to request paddy.

The location of transaction partners positively and significantly (1%) influence the choice of spot market and negatively and significantly (1%) the choice of formal contract. Therefore, when the producer and the processor are in the same village, they use more spot market. In contrast, when the transaction partners are in the different village, they conclude the exchange through a formal contract. The mechanism of payment negatively and significantly (1%) influences the choice of formal contract. Thus, the cash payment at the delivery of paddy is more use on spot market and less with formal contract. This suggests that actors that use formal contracts are more likely to use credit payment mechanism.

Predictions of probabilities of participation in different governance structures

After estimating the MVP model, it is possible to predict the probability of the participation of actors in different governance structures, the probability of simultaneously participating in all the governance structures, and the probability of participating in any single mode of governance. Table 6 presents estimates of these predictions. The spot market has the highest predictive probability of participation. Therefore, the current situation favours the involvement of actors in the spot market. The probability of actors participating in formal contracts is 0.21 and that of them participating in informal contracts is 0.17. The probability of actors failing to adopt any form of governance is very low. Thus, different actors are more likely to participate in the spot market.

Conclusion

This study analysed the determinants of the choice of governance structures selected by producers and processors of paddy in Benin. Four governance structures were selected; namely the spot market, the formal contract, the informal contract, and producer associations. To identify the factors influencing the choice of these governance structures, the analyses focused on the socioeconomic characteristics of respondents and the information, search and bargaining costs. The results showed that 78% of producers and 92% of the processors mainly use spot market for transactions of paddy. In addition, 67% of producers and 74% of processors use mostly a single governance structure for the transactions of paddy. The use of formal contracts is positively correlated by the participation in an innovation platform. Participation in agricultural training positively influences the use of producer associations. The results suggest that efforts to promote contractual governance structures should focus on innovation platforms by making existing platforms more dynamic and encouraging additional actors to engage. This will facilitate interactions among producers or suppliers and processors or buyers. Greater engagement in innovation platforms should also have the effect of increasing the quantity and quality of paddy produced and traded. Building on this study, future research could explore the factors that explain actors' adoption of contracts. These studies could focus on the identification of attributes of contracts that are conducive to actors' participation in contracts.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Determinants of adoption of improved Jalenea potato variety: The case of Chencha Woreda, Southern Ethiopia

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This study was to examine factors affecting adoption of improved Jalenea potato variety in the study area in the year 2017. Primary data for the study were collected from respondents using structured interview schedule. Focus group discussions were conducted with farmer and stakeholders. The data were analyzed using mean, percentage, frequency, chi-square test, and T-test. Binary logistic regression analysis was employed to identify factors affecting adoption of the variety. Age of the household negatively and significantly affected adoption whereas sex of the household head positively and significantly affected the adoption. Non-farm activity and farm income had positive and significant effect on adoption. Advisory service from extension agents, attending training and field day, and membership of seed multiplication cooperative had also positively and significantly affected adoption of improved Jalenea potato variety. The finding highlighted the importance of institutional support in the area of extension; training and farmers' cooperatives. Therefore, policy and development interventions should give emphasis to improving institutional support system.

Key words: potato, binary loggit, determinants, odds ratio, management practices.

INTRODUCTION

In many developing countries including Ethiopia, agriculture plays a vibrant role in promoting economic growth and development. The importance of agriculture in Ethiopia is evidenced by its share in GDP (43%), its employment generation (80%), share of export (70%) and providing about 70% raw material for the industries in the country in 2012/2013 (UNDP, 2013). Furthermore, 90% of the poor earn their livelihood from this sector (Yu and Nin, 2011). Thus, it is not surprising that policy action in Ethiopia is largely based on influencing the dynamism of the agricultural sector. Agricultural productivity in general and crop production in particular has been given heavy emphasis over the last two decades in almost all development policies and strategies of the country. The Agricultural Development Led Industrialization (ADLI) places very high priority on accelerating agricultural growth in order to achieve food security of the nation (Byerlee et al., 2007). Agriculture was also the main focus of the 2002 Sustainable Development and Poverty Reduction Plan (SDPRP), and the 2004 Food Security

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Strategy, and also the 2006 Plan for Accelerated and Sustainable Development to End Poverty (PASDEP) (MoFED, 2002; 2005; 2006). More recently, the first Growth and Transformation Plan (GTP) of Ethiopia also gave special emphasis to agricultural growth to achieve food security and poverty alleviation (2010-2015). One of the core goals of GTP is agricultural growth program which aims at increasing productivity to bring agricultural growth at the national level and maintain agriculture as a source of economic growth (MoFED, 2010).

Despite such policies focus on the sector over the last two decades, its productivity is constrained by lack of appropriate and affordable agricultural technologies, inefficiency in production, poor infrastructure, inefficient marketing systems, land degradation, rapidly expanding population, and inaccessibility to agricultural inputs such as improved/hybrid seeds, fertilizers and agrochemicals (Arega and Rashid, 2005; Yu and Nin, 2014). In addition, climate change, which is the principal causes for erratic rainfall and recurrent drought, is also another aggravating factor in the prevalence of low production and productivity of the sector. Besides, the sector mostly depends on rain-fed production system that is dominated by smallholders.

As a result, the growth in agricultural output has failed to provide food for the fast growing population and thus aggravated the food insecurity situation in the country. Thus, the goal of self-sufficiency in food production remains a long-term target and the question of making Ethiopia food self-sufficient continues to be a policy concern. Improvement of agricultural productivity provides an important solution in addressing the problems of food insecurity and poverty, and enhancing the development of agriculture in Ethiopia. Consequently, attempts are being channeled in ways by which increased agricultural productivity can be achieved through promoting the use of improved agricultural technologies and improving the efficiency of production of crops in Ethiopia (Yu and Nin, 2014). Potato (*Solanum tuberosum*) provides an opportunity for food security and value chain development. It is one of the most productive food crops in terms of yields of edible energy and good quality protein per unit area and per unit of time fitting into intensive cropping systems. Nutritionally, the crop is considered to be a well-balanced major plant food with a good ratio between protein and calories, and has substantial amount of vitamin, especially vitamin C, minerals, and trace element. Due to its correct balance between protein and calories, it is considered a good weaning food. Ethiopia has good climate and edaphic conditions for higher production and productivity.

Studies show that the average productivity of potato in Indonesia, Jordan, and Ecuador is 45 ton/ hectare even in Africa like Egypt the average productivity is 20- 25 tons/ hectare; but in Ethiopia where there is a suitable edaphic and climate condition for the production of high quality seed and ware potato, as the study by Tesfaye et al. (2012) on production and marketing of potato in Ethiopia indicates that the total acreage of potato in Ethiopia exceeds 160,000 ha with an annual production of 1.28 million tons. The average yield of potato in Ethiopia is estimated to be 8 t/ha (Tesfaye et al., 2012). Indeed a recent study put the national average yield of potato at 10.5 t/ha which is very much low compared to the potential 50 t/ha elsewhere in the world.

Potato originated from South America, most probably from the central Andes in Peru. Potato has been grown by indigenous farming communities since its demonstration over 4,000 years ago. Introduced into Europe in the sixteenth century, the crop subsequently was distributed throughout the world, including Asia. It was introduced to most parts of SSA in the 19 century. Worldwide, potato comes forth in terms of production after wheat, maize, and rice. In many countries potato serves as a stable food because of its excellent nutritional content. Main potato production zones in the world are Indonesia 10125, Jordan 3400, Cheil 2149, Ecuador 2066, Uruguay 1700, Bolivia 1694, and Egypt 977. Generally total world production is 284,471 thousand tons per year. Potato production trend has shown that it is one of the fastest growing crops in SSA in relation to area coverage, but without a corresponding increase in productivity. Average yield in SSA is only about 8 t/ha, compared to a yield potential of about 40-50 t/ha. Potato arrived late in Africa, around the 20th century. Potato (*S. tuberosum*) has been grown in Ethiopia since the year 1859 (in the mid 19thcentury) and it was introduced by missionaries. Seventy percent of the arable land of Ethiopia is suitable for potato production.

In Bhutan, it is reported that the potential yield of potato can reach up to 50 t/ha (Joshi et al., 2012). In Ethiopia, the productivity of potato was very low, an average tuber yield of potato was almost between 6-8 t/ha in the last 20-30 years while the area planted with potato increased from 30,000 ha to about 160,000 ha in 2012. The development and dissemination of many improved varieties of potato contributed to the improvement and expansion of potato production in Ethiopia. Despite the production potentials and importance of potato crop for the country as well as the study area, there has been limited performance of farmers in potato farming.

Genetically improved varieties of staple crops can play an important role in ensuring the availability of sufficient food for a growing population (Rizvi et al., 2012; Serageldin, 1999). Potato is considered to be one of the main staple crops for ensuring food security (Knapp, 2008), providing more calories, vitamins and nutrients per unit area than any other staple crop (Sen et al., 2010). Improved varieties (IVs) have better yields (Chakraborty et al., 2000) and are more resistant to late blight (Song et al., 2003), virus and bacterial wilt (Thiele, 1999).

Potato (*S. tuberosum*) can play a significant role in ensuring access to food at the household level and can also generate income for smallholders, thereby contributing to the economic sustainability of agricultural

systems in developing countries (Thompson and Scoones, 2009). In Ethiopia, potato has increasingly become a source of cash income for farmers, and retains its importance for household consumption (Gildemacher et al., 2009a, b; Mulatu et al., 2005). Despite the benefits of improved potato varieties (enhanced yield and disease resistance), Ethiopian farmers are often reluctant to grow them. This is despite the efforts of the Ethiopian Institute of Agricultural Research (EIAR) which, with support from the International Potato Center (CIP), has distributed 18 improved potato varieties in the last two decades in an attempt to improve the performance of the potato sector (Gebremedhin et al., 2008). However, the rate of adoption of these improved potato varieties by ware potato farmers (farmers who grow potato for consumption rather than for seed) has been very low. Out of the total land allotted to potato production, only 0.5% of the land was covered by improved varieties in the 2013 main season (CSA, 2014a).

The Ethiopian Institute of Agricultural Research recognizes the problem with low adoption rates by ware potato farmers, although the causes have not been fully investigated. For example, the EIAR mentions shortage of improved seeds and poor supply systems as the main limiting factors (Gebremedhin et al., 2008). This assumes that adoption is low because of supply problems and potential adopters do not have access to IPVs. However, this view is not supported by empirical evidence.

Statement of problem

Adoption is a mental process through which an individual passes from hearing about an innovation to its adoption that follows awareness, interest, evaluation, trial, and adoption stages. It can be considered a variable representing behavioral changes that farmers undergo in accepting new ideas and innovations in agriculture anticipating some positive impacts of those ideas and innovations. The adoption of an innovation within a social system takes place through its adoption by individuals or groups. According to Feder et al. (1985), adoption may be defined as the integration of an innovation into farmers' normal farming activities over an extended period of time. It is also noted that adoption, however, is not a permanent behavior. This implies that an individual may decide to discontinue the use of an innovation for a variety of personal, institutional, and social reasons one of which might be the availability of another practice that is better in satisfying farmers' needs.

Dixon et al. (2006) posit that adoption of improved varieties can have impacts at different levels. First, improved varieties can generate significant field-level impact on yield and stability. Second, intensification of food crops often leads to the release of land, water and labor resources for on-farm diversification. Third, higher and more stable yields produce people-level impacts on household food security and household income. Fourth, the combination of intensification and diversification creates further household level impacts on wider dimensions of household livelihoods and poverty reduction, including the off-farm effects on the local economy and in more distant cities.

Several studies in Africa show that adoptions of improved agricultural technologies, though variably and incompletely, had positive impacts on income, food security and poverty reduction (Wanyama et al., 2010; Solomon et al., 2010; Adekambi et al., 2009; Kassie et al., 2010). Increased productivity of potatoes can improve the livelihood of smallholder potato farmers in Ethiopia and is required to meet the growing demand. Despite the great opportunities that Ethiopia has which is suitable edaphic and climate condition for the production of high quality seed and ware potato, and about 70% available agricultural land is located at an altitude of 1800–2500 m which is suitable for potato production (Solomon, 1987 as cited in Tasew, 2008), there is a great gap between supply and demand for potato and the income from potato to the smallholder farmers is not as anticipated. This is because of problems of seed potato quality management, bacterial wilt late blight control, soil fertility management and marketing problems. SNNPR is one of the regional states and it is the third agriculturally potential crop producing regions in Ethiopia. The regional crop production data show that the total area allocated to potato production in 2015/16 was estimated at 15,978 ha and total production was 99,330 tons for Meher season (CSA, 2016).

In the region, the average potato yield was 6.95 t/ha which is very low and an estimated 455,382 people were involved in the production of potato in 2015/2016, which is about 22% of the households in the region (CSA, 2016). Jalenea potato technology package consisting of improved seed, seeding rate, fertilizer rate and spacing was introduced to the study area to improve the food security status by GOs and NGOs. People and institutions both outside and inside Ethiopia have conducted empirical studies on the adoption and diffusion of agricultural innovations. But the studies were mainly concerned with major cereals and thus, studies conducted in root and tuber crops particularly potato are very limited. So far there is no empirical information about the status of adoption of Jalenea potato variety and various factors influencing adoption of the variety in the study area. Therefore, this study was proposed to analyze determinants of adoption of improved Jalenea potato variety. This shows that there is need to conduct research work with the aim to asses factors affecting adoption of potato production.

METHODOLOGY

Description of the study area

This study was conducted in Chencha Woreda; located north east of Gamo Gofa zone of South Nations Nationalities People Regional

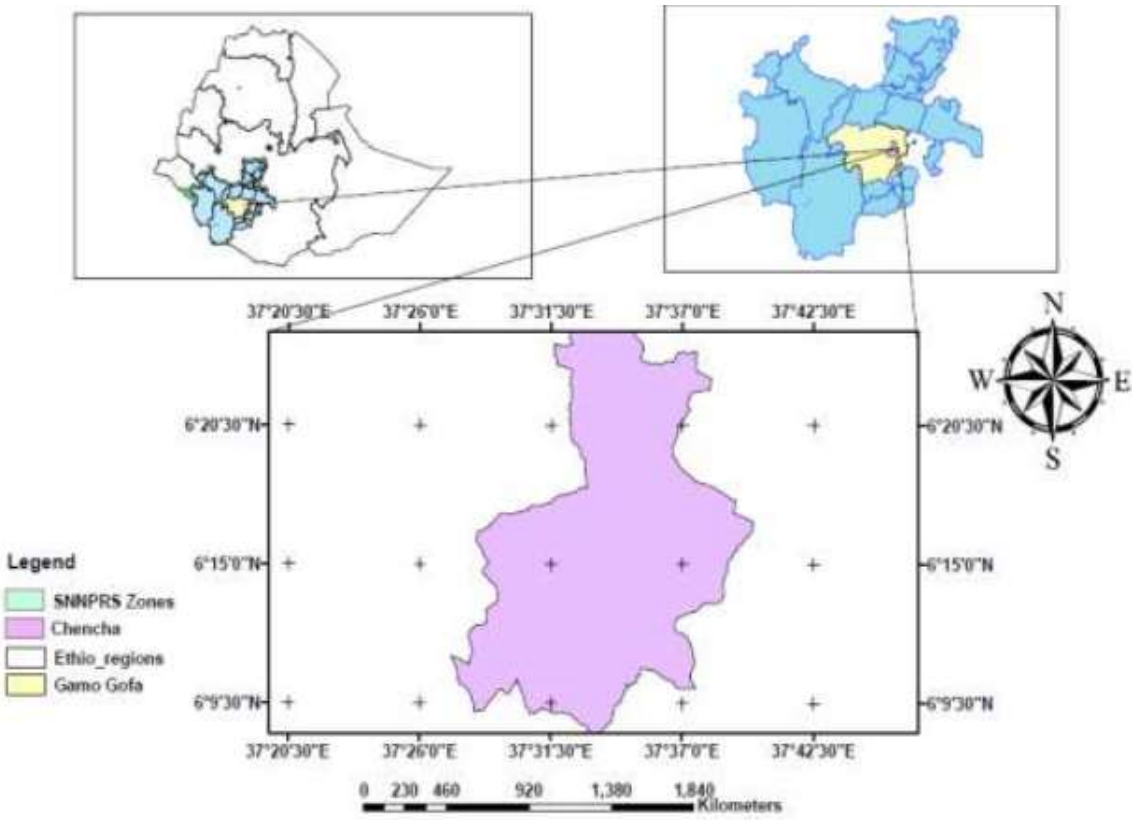

Figure 1. Map of the study area

State, Ethiopia. Chencha Woreda is located at 542 km from Addis Ababa towards South direction. It is geographically located at 6.13-6.41 latitude and 37.46-37.65 longitude. The district covers an area of 374 square kilometers and has 45 rural and 5 urban Kebeles. The Woreda had a total population of 145,750 persons of which 52.8% are females and with an average family size of six people per household. The altitude of the study area ranges from 1800-3,380 meters above sea level. Temperature ranges from 10 to 26.9°C and the mean annual rainfall ranges from 1,000-1,400 mm. The rainfall pattern is usually bimodal: January–June for belg season and July – October for Meher season. The potato-based farming system is found in almost all parts of the Woreda. The Woreda is divided into three major agro-ecological zones: lowland (*kola*), midland (*woinadega*), and highland (*dega*). Chencha Woreda is one of the 15 chronically food insecure Woreda of SNNPR. The district is characterized by mixed farming system (crop-livestock). Barley, Potato, Wheat, Maize, Enset, fruits; Cabbage and Head Cabbage are widely grown in the Woreda. Potato is the main crop in terms of production and it is a source of income in the study area. Even though potato is grown everywhere in the study area, the productivity is very low which is about 8 tons per hectares but plays a key role in food security. The major constraints that hinder the development of potato production and marketing are lack of sufficient quality seed, pest and diseases infestation and storage problem. Unless and otherwise these problems are solved the expansion and development of potato production is under question. The land use pattern of the Woreda shows that 40,260 hectare is cultivable, 2,629 ha is grazing land, 3,852 ha is covered by forest, bushes and shrubs, and 4,486 ha is being used for other purposes such as encampments, and infrastructure facilities (CSA, 2016) (Figure 1)

Research design

As the objective of this study is to investigate the factors affecting adoption of improved Jalenea potato variety, descriptive and diagnostic (analytical) research design was used. It is descriptive because the study intends to portray accurately the characteristics of respondents, current status of adoption of improved Jalenea potato seed and the nature of the potato producer. The socioeconomic characteristics of the study group were described by age, source and size of income, level of education, family size, and religion. The study is diagnostic as it investigates the relationship between the socio economic situation of the subjects under the study and their adoption status.

Sampling procedure and technique

A multi-stage sampling procedure was used to identify the sample households for data collection. The Woreda was selected purposively and potato producers of the *Kebeles* were identified based on the potential to produce potato. Four potato producing *Kebeles* were randomly selected. The sample size of the study was determined by using Yemane's formula. The sample respondents of the study were selected by using systematic random sampling technique. The sample size of each kebele was determined through probability proportional to size. The formula provided by Yamane is given as follows:

$$N = \frac{N}{1+N\,(e)^2}$$

Table 1. Sampling frame and sample size.

Name of selected *Kebeles*	Total number of potato producers	Sample
Gendo gemebela	591	18
Doko yoyera	1257	38
Doko losha	647	19
Doreze dosheky	1515	45
Total	4010	120

Where: n is the sample size considered from potato producer households in the selected kebeles, N is the total potato producer households in the selected kebeles (N = 4010) and e = 0.09 is the level of precision defined to determine the required sample size at 91% level of precision (Table 1).

Type and source of data

Primary data were collected from selected farmers using semi-structured interview schedule by using personal interview technique from sampled farmers. Secondary information relevant for this study was gathered from *Woreda* Office of Agriculture and Natural Resource, Central Statistics Agency (CSA).

Methods of data collection

Different tools were used to collect the data so as to develop a near accurate understanding of the topic of research. The main tool of data collection techniques used in the study was semi- structured interview schedule and focus group discussion.

Methods of data analysis

The statistical analyses employed in this study were mean, percentage, frequency, minimum, maximum values, t- test chi-square test and binary logistic regression analysis. Descriptive analysis was used to describe the socioeconomic characteristics of the sample households as it exists. The t-test was used to determine the existence of statistically significant mean difference between the groups, and chi-square test was used to determine whether there is statistically significant proportionate difference between groups. Binary logistic regression analysis was used to identify factors that affect adoption of improved jalenea potato variety (Table 2).

RESULTS AND DISCUSSION

Status of adoption of Jalenea potato variety

In this study, adoption of Jalenea potato variety refers to a continued use of the variety on an area of land. Here, the respondents who have cultivated improved Jalenea potato varieties in the study area during the survey year and in any one of the year before the survey year of this study are considered as adopters. Farmers who never adopted Jalenea potato variety are categorized as non-adopters of the variety. Accordingly, the study reveals that out of the total respondents 68 (56.7%) of them applied the variety on their piece of land whereas 52 (43.3%) of sample households used the local variety only in the process of producing the crop.

Status of adoption of inorganic fertilizer

Jalenea potato production, like any other crop, requires use of different inputs. Fertilizer application is one of the most important practices that need to be adopted by Jalenea potato growers. Moreover, proper application of the recommended rate (200 kg/ha) is also crucial to obtain the required yield. Out of the variety adopters (68 farmers) 60 farmers were found using fertilizer for Jalenea potato variety cultivation. From the 60 farmers who used DAP fertilizer for Jalenea potato cultivation 6 respondents (10%) applied below (120-180 kg) the recommended rate and 54 respondents (90%) used the recommended rate. Also from the 60 farmers who used Urea fertilizer for Jalenea potato cultivation 8 respondents (13.3%) applied below the recommended rate (120-180 kg) and 52 respondents (86.7%) used the recommended rate. Fertilizer adoption of sample respondents varies across adopter and non-adopter categories. The result of analysis indicated that there was significant mean difference between adopter and non - adopter categories ($\chi 2=1.200$, P= 0.000) in relation to fertilizer utilization at 1% significance.

Potato management practices in the study area

Spacing

Appropriate plant spacing is important because overcrowded sowing would result in slow and stunted growth and eventually in poor yield. The research recommended spacing for improved Jalenea potato production is 30 cm between plants and 70 cm between rows. This study about plant spacing in the study area reveals that from total adopter respondent 15 (22%) of them used below the recommended spacing whereas 46 (67.7%) used the recommended spacing and the rest 7 (10.3%) used above the recommended spacing (Table 3). Respondents have mentioned different reasons for not using the recommended spacing. According to the

Table 2. The summary of explanatory variables.

S/N	Independent variable	Units of Measurement	Expected sign	Justification about the expected relationship
1	Age of HHH	Years	±	The role of a farmer's age in explaining technology adoption is somewhat controversial in the literature. As farmer age increases probability of adoption is expected to decrease (Techane, 2006). Younger farmers were more likely to adopt and the effect of age on the probability of adoption was elastic (Hailu, 2008).
2.	Sex of the respondents	Dummy	±	Due to many socio-cultural values and norms, male have freedom of mobility and participation in different extension programs and consequently have greater access to information (Taha 2007; Mesfin 2005).
3.	Education level	Years	+	It is often assumed that educated farmers are better able to process information and search for appropriate technologies to alleviate their production constraints. Adoption is expected to correlate positively with education (Getahun et al., 2000).
4	Farm experience of HH	Years	+	Farmers with higher experience appear to have often full information and better knowledge and are able to evaluate the advantage of the Technology (Chilot 1994).
5	Off -farm activity	Dummy	+	Additional income earned from non-agricultural activities outside the farm increases the farmers' financial capacity and increases the probability of investing on new technologies (Techane, 2006).
6	Market distance	Km	+	As market distance decreases adoption and intensity of adoption was expected to increase (Dereje, 2006)`
7	Contact with extension agent	Dummy	+	Contact with extension agent is hypothesized to have positive influence on adoption of improved technologies.
8	Number of livestock	TLU	+	Livestock ownership is hypothesized to influence adoption positively
9	Participation in training	Number	+	Participation in training is expected to positively influence farmers' Jalanea potato variety adoption.
10	Participation in field day	Number	+	Attendance of agricultural training is positively and significantly related to adoption.
11	Participation in demonstration	Number	+	Participation in on-farm demonstration is expected to positively influence farmers' adoption of Jalanea potato variety.
12	Credit access	Dummy	+	Farmers without cash and no access to credit will find it very difficult to adopt new technologies
13	Seed multiplication member	Score	+	A farmer who is membership of farmer's association in rural kebeles and different Cooperatives are more likely to be aware of new practices as they are easily exposed to information
14	Farm Land size	Hectares	+	Farmers with larger farms are more likely to adopt an improved technology (especially modern varieties) compared with those with small farms.
15	Farm income	Birr	+	The effect of farm income on household's adoption decision is positive (Degnet and Belay, 2001) and Leggese (1998).
16	Labor availability	Man equivalent	+	Household's labor availability is hypothesized to positively influence adoption of the potato technology.

respondents, spacing requires additional labor and skill. Because of this, it is difficult for them to manage with labor that exists in the household.

Prevalence of potato disease

Maximum yield from a plot of land depends not only on the use of improved seed and inorganic fertilizer, but it also depends on measure taken to control insect/pest and disease when it occurs on

Table 3. Fertilizer utilization of households 2016/2017.

Fertilizer utilization	Adopter		Non-adopter		Chi-square value	P-value
	N	%	N	%		
No	8	11.8	52	100		
Yes	60	88.2	0	-	1.200***	0.000
Total	68	100	52	100		

. ***, Significant at 1% level.
Source: Own field survey (2017).

the plant. In this study assessment was made to investigate prevalence of disease occurrence and the result indicates that 53.3% of the respondents reported the existence of bacterial wilt disease problem in the study area.

Potato disease control measures

Respondents were also asked about methods they used to control disease. The result reveals that 47 (73.4%) respondents used cultural method and 17 (26.6%) respondents used chemicals.

Weed problem and its control practice

In this study attempt was made to assess the prevalence of weed problem and its control mechanism. The result indicates that 66 (97%) of the adopter respondents reported that they did not encounter weed problem in their potato farm. While 2 (3%) of adopter respondents reported weed occurrence (peritoneum weed) but they controlled them with hand weeding.

Comparison of variety adoption status based on age of household head

The role of age in explaining technology adoption is somewhat controversial. It is usually considered in adoption studies with the assumption that older people have more farming experience that helps them to adopt new technologies. On the other hand, because of risk averting nature older farmers are more conservative than the youngest one to adopt new technology. The mean age of adopter respondents was 43.18 years old and non-adopter respondents were 41.96 years old. The t-value (.555) indicates that the mean ages of the two groups were not significantly different (Table 4).

Comparison of variety adoption status based on sex categories

55% of female respondents adopted the variety whereas 57% of male respondents adopted the technology. The result of chi-square analysis ($\chi2=0.057$, $P=0.654$) revealed that there is no significant relationship between sex and the adoption of Jalenea potato variety. The result of this study is not in agreement with result of previous researchers who reported the significant relationship between sex and adoption of agricultural technologies (Degnet and Belay, 2001; Mulugeta et al., 2001) (Table 5).

Comparison of variety adoption status based on educational categories

The study shows that 60% of the non-educated farmers adopted the variety whereas 54 percent of educated farmers in the study area adopted the variety. The result also indicates that there is no statistically significant difference between educated and illiterate farmers in terms of adoption of the variety ($\chi2=9.344$, $P=0.638$) (Table 6).

Comparison of variety adoption status based on involvement in non-farm activities

Many farmers can earn additional income by engaging in various off-farm activities. This is believed to raise their financial position to acquire new inputs. The result of the present study reveals that 61 of non-farm activity participants adopted the variety whereas only 46% of the non-participants of non-farm activity adopted the technology. The result of chi- square test indicates participation in non-farm activities ($\chi2=2.504$, $P=0.065$) had significant relationship with adoption of improved Jalenea potato variety at 10% probability level. In the study area, weaving, trading, and daily laborer activities, were found to be some of the non-farm activities in which sample households participated in (Table 7).

Comparison of variety adoption based on membership in seed multiplication group

Participation in social organization is expected to have an indirect influence on the adoption behavior of farmers.

Table 4. Comparison of variety adoption based on Age of respondents.

Age of respondents'	Adopter	Non-adopter	
Mean	43.18	41.96	42.65
SD	12.88	10.43	11.85
t-value			0.555

P-value = 0.173.
Source: Own field survey 2017).

Table 5. Comparison of variety adoption status based on sex categories.

Sex of respondents'	Adopter		Non-adopter		Total		Chi-square value
	N	%	N	%	N	%	
Female	17	55	14	45	31	100	
Male	51	57	38	43	89	100	0.057*

P-value = 0.654, *, Significant at 10%level.
Source: Own field survey (2017).

Table 6. Comparison of variety adoption status based on education categories.

Education Level	Adopter		Non-adopter		Total	
	N	%	N	%	N	%
Illiterate	31	60	21	40	52	100
Read and write	11	42	15	58	26	100
Grade 1-4	9	90	1	10	10	100
Grade 5-8	14	61	9	39	23	100
Grade 9-12	2	28.6	5	71.4	7	100
Diploma	1	50	1	50	2	100
Total	68	56.6	52	43.4	120	100

P-value =0.638.
Source: Own field survey (2017).

Table 7. Comparison of adoption of variety based on involvement in non-farm activities 2016/2017.

Participation on non- farm activity	Adopters		Non-adopters		Chi-square value
	N	%	N	%	
No	17	46	20	54	
Yes	51	61	32	39	2.504***
Total	68	58	52	42	

P-value = 0.065, ***, Significant at 10% level.
Source: Own field survey (2017).

This exposure exposes them towards innovative ideas and practices (Tesfaye and Shiferaw, 2001). As seed multiplication cooperative is one of farmers' associations, it is expected to have significance relationship on adoption. Out of total participants of seed multiplication group 86.8% adopted the variety and only 13.2% of the non-participants adopted the variety. The Chi-square result reveals existence of statistically significant association between adoption and being member of seed multiplication cooperatives ($x^2 = 63.974$, P = 0.012) at 5% level of significance (Table 8).

Comparison of adoption the variety based on credit utilization

Access to credit is one way of improving farmers' access

Table 8. Comparison of variety adoption based on seed multiplication membership.

Seed multiplication group member	Adopters		Non-adopters		Chi-square value
	N	%	N	%	
No	9	13.2	45	86.5	
Yes	59	86.8	7	13.5	62.974**
Total	68	100	52	100	

P-value = 0.012, **, Significant at 5% level.
Source: Own field survey (2017).

Table 9. Comparison of adoption of the variety based on credit utilization.

Use of credit	Adopter		Non-adopter		Chi-square value
	N	%	N	%	
No	4	7.27	51	92.73	
Yes	64	98.46	1	1.54	1.009***
Total	68	56.67	52	43.33	

P-value = 0.000, ***, Significant at 1% level.
Source: Own field survey (2017).

Table 10. Comparison of adoption of the variety based on contact with extension agent.

Contact with extension agent	Adopter		Non-adopter		
	N	%	N	%	
Never	7	31.82	15	68.18	
Yes	61	62.24	37	37.36	
χ2=value					13.674**

P-value = 0.005**, Significant at 5% level.
Source: Own field survey (2017).

to new production technology. It increases the farmers' economy to purchase improved seed, fertilizer and other inputs (Tesfaye et al., 2001). Thus, it is expected that access to credit can increase the probability of adopting improved Jalenea potato variety but in the study area there is no access to credit in cash but there is access to credit of improved Jalenea potato seed and fertilizer in kind. Different types of improved potato varieties were available on credit basis to farmers from the Office of Agriculture and Natural Resource and NGOs in the cropping season. The result in Table 9 shows that 98.46% of the respondents who have access to credit adopted the improved variety and only 7% of the respondents who do not have access to credit adopted the variety. The result clearly indicates the crucial role that access to credit plays in adopting the technology. The result of this study also shows existence of statistically significant difference between adoption categories on access to credit at less than 1% percent probability level (χ2=1.009, P=0.000). Farmers without cash and no access to credit will find it very difficult to adopt new technologies. Previous authors verified this preposition on access to credit (Hailu, 2008; Teshale et al., 2006).

Comparison of adoption of the variety based on contact with extension agent

Adoption of the variety is higher among farmers who have contact with extension agent (62%) than those farmers who did not have contact with extension agent (32%). The chi-square result (χ2=13.674 and P=0.005) shows statistically significant difference between adoption categories with respect to farmer contact with extension agent. Lelisa et al. (2002), Mulugeta et al. (2001) also reported similar result (Table 10).

Comparison of adoption of the variety based on participation in training

Adoption of the variety is higher among farmers who have participated in agricultural development training

Table 11. Comparison of adoption of variety based on participation in training 2016/2017.

Participation on training	Adopters		Non-adopters		Chi-square value
	N	%	N	%	
No	9	15	51	85	
Yes	59	98.33	1	1.67	84.84***
Total	68	56.67	52	43.33	

P-value = 0.000, ***, Significant at 1% level.
Source: Own field survey (2017).

Table 12. Comparison of adoption of the variety based on field day participation 2016/2017.

Participation on field day	Adopter		Non-adopter		Chi-square value
	N	%	N	%	
No	11	34.38	21	65.63	
Yes	57	64.77	31	35.23	8.83**
Total	68	56.67	52	43.33	

P-value = 0.003, **, Significant at 5% level.
Source: Own field survey (2017).

programs (98%) than those farmers who did not attend the training (15%). The chi-square result ($\chi 2$=84.842 and P=0.000) shows existence of statistically significant difference between participants and non-participants of agricultural development training programs on their adoption status. In other words the proportion of adopters is higher among training participants than non-participants. The result of this study is in agreement with the findings of Tesfaye et al. (2001) and Teshale et al. (2006) who studied determinants of adoption of improved maize technology in Yelma Dansa Woreda in Ethiopia. According to their report, training is an important input that improves farmers' performance and equips farmers with new knowledge and skills (Table 11).

Comparison of adoption of the variety based on field day participation

As can be seen from Table 11, the proportion of variety adopters is higher among field day participants (65%) than their counterpart (34%) (Non-participants of the field days). The chi-square result ($\chi 2$=8.83, P=0.003) shows that there is statistically significant difference between participants and non-participants of field day program on their status of variety adoption. The result of this study is in agreement with the findings of Tesfaye et al. (2001). According to his report, in field days, neighboring farmers get an opportunity to observe how the new technology is practiced in the field. This situation may facilitate the adoption process (Table 12).

Comparison of adoption of the variety based on participation in demonstration

Demonstration is an important method of extension to create concrete awareness among the farm community. It is also a means of diffusing information to neighboring farmers practically. This situation facilitates the adoption process and it is hypothesized that there is a positive correlation with adoption. The result on Table 13 indicates that variety adoption is higher among participants of method and result demonstration (80%) than non-participants of the demonstration (40%). It also shows existence of statistically significant proportionate difference between participants and non-participants on their variety adoption status ($\chi 2$ =6.55, P=0.009) at 1% probability level. Similar results were reported by Kidane (2001) and Belay (2003).

Comparison of adoption of variety based on farming experience of the household head

Farmers with higher experience in Jalenea potato production appear to have often full information and better knowledge and supposed to evaluate the advantage of the technology. Hence it was hypothesized to affect adoption positively. With respect to the respondents' farming experience, the average farming experience of variety adopters was 11.86 years and that of non-adopter was 10.27 years. The t-test result (t=0.732 P=0.835) shows that there is no statistically significant mean difference among adoption categories. The result

Table 13. Comparison of adoption of the variety based on participation on demonstration2016/2017.

Participation on demonstration	Adopter		Non-adopter		Chi-square value
	N	%	N	%	
No	28	40	42	60	
Yes	40	80	10	20	6.55**
Total	68	56.67	52	43.33	

P-value = 0.009, **, Significant at 1% level.
Source: Own field survey (2017).

Table 14. Comparison of adoption of the variety based on experience of households.

Adoption categories	N	Mean	SD	t	R
Adopter	68	20.58	11.86		
Non-adopter	52	20.84	10.27	24.60	0.785
Total	120	20.7	11.15		

P-value = 0.835.
Source: Own field survey (2017).

of this study is in complete agreement with the findings of Chilot et al. (1996) (Table 14).

Comparison of adoption of the variety based on land holding

Land is perhaps the single most important resource, as it is a base for any economic activity especially in rural and agricultural sector. Farm size influences households' decision to adopt or to reject new technologies. Hence, land holding was hypothesized to have positive and significant relationship with adoption.

The result reveals that the mean land holding in the study area was 1.02 ha. The average land size of adopter and non-adopters was 0.92 and 1.16 hectare respectively. The t-test result (t=1.555, P=0.054) shows there is significant mean difference of the land holding size between adopters and non-adopter respondents' household at 10% significance level. This significance mean variation shows that the variation in the land holding size between two groups has its own implications on the adoption of Jalenea potato production package. The result reveals that farmers with smaller size of land are more likely to adopt improved variety than their counterpart as it helps them to get higher yield from smaller land size (Table 15).

Comparison of adoption of the variety based on livestock holding

Livestock holding is an important indicator of household's wealth position in rural context. The number of livestock owned by a farmer was hypothesized to affect the adoption of improved Jalenea potato variety positively. Livestock is the farmers' important source of income, food and draught power for crop cultivation in Ethiopian agriculture. Hence, a household with large livestock holding can have good access for more draught and it is one of the main cash sources to purchase inputs. As indicated in Table 16 the average livestock ownership of sample households in TLU was 3.5. The result of t test (t=1.218, P=0.269) revealed that there is no significant variation in average livestock ownership between adopter and non-adopters of the variety. The results of this study are not in conformity with earlier adoption studies. On the other hand, Doginet (2001) and Habtemariam (2004), in their studies reported that livestock holding has a positive and significance influence on adoption of agricultural technologies.

Comparison of variety adoption status based on labor availability

Large working labor force in a family means the household may not need to hire more additional labor and the money saved due to use of own labor force could be used for purchasing other crop production inputs. This will increase household's possibility to adopt improved Jalenea potato variety. Therefore, it was hypothesized to have positive relationship with adoption of improved Jalenea potato production package.

Overall the average labor availability in terms of adult equivalent for sample household in the study area was3.11 with standard deviation of 1.38. The average labor availability in the adopters and non-adopter household was 2.96 and 3.3 respectively. However, the t-test (t=1.168 and P=0.454) shows that there is no

Table 15. Comparison of adoption of the variety based on land holding.

Land size	Adopter		Non-adopter		Total	
	N	%	N	%	N	%
≤0.5	30	44.11	20	38.4	50	41.6
0.51-1	28	41.1	7	13.4	35	29.2
>1	10	14.8	25	48	35	29.2
Mean	0.92		1.16		1.02	
SD	0.74		0.89		0.81	
t-value					1.555*	

P-value = 0.054*.
Source: Own field survey (2017).

Table 16. Comparison of adoption of the variety based on number of livestock owned in TLU.

Livestock holding	Adopter		Non-adopter		Total	
	N	%	N	%	N	%
≤3	4	5.9	-	-	4	3.3
3.1-6	54	79.4	43	82.7	97	80.9
>6	10	14.7	9	17.3	19	15.8
Mean	3.8		3.69		3.5	
SD	1.67		1.67		1.68	
t-value						1.218

P-value = 0.269.
Source: Own field survey (2017).

significant mean difference between adoption categories (Table 17).

Comparison of variety adoption status based on farm income

Farm income is the main source of capital to purchase farm and other household inputs. In this study the household farm income was estimated based on the sales of crop, livestock and livestock products. The major cash income for sample households in the study area is from sale of potato and apple fruit.

The average annual farm income for the total sample households was birr 14,508 (1 Ethiopian birr is equivalent to $0.03 USD) whereas; the average farm income for non-adopter was Birr 5301.2 and that adopters mean on-farm income was 9206.3 Birr. The minimum and maximum farm income of the variety adopter households ranges from 0 Birr to 28,000 Birr, whereas the minimum and maximum farm income for non- adopters was 0 Birr to 25,000 Birr. Analysis of variance was conducted to test the relationship of farm income with adoption of Jalenea potato variety and the result (t=1.018 and p=0.479) showed that there is no significant mean difference among adopter and non-adopters of the variety (Table 18).

Comparison of variety adoption status based on distance to output/input market

Markets are communication centers both for producers, consumers and traders (Hailu, 2008). In this study, it is hypothesized that the distance between the respondents' residence and the nearest market place (measured in kilo meters) is negatively correlated with the decision to adopt newly introduced crop varieties with its associated agronomic practices. Regarding the distance taken to travel from home to the nearest market place, sample farmers reported that they had to travel an average of 10.13 km with standard deviation of 5.81 km. For sample respondents the minimum and the maximum distances that a farmer had to travel to access market center were, 1 and 23m, respectively. Results of t-test (t=2.303 and P=0.132) reveal that there is no statistically significant mean difference among adopters and non-adopter categories (Table 19).

Determinants of adoption of Jalenea potato variety using binary logistic regression analysis

In the binary logit model result, the maximum likelihood estimates reveal that adoption of improved *Jalenea* potato variety was determined by the interaction of

Table 17. Comparison of variety adoption status based on availability of labour in household in adult equivalent.

Labor	Adopter		Non-adopter		Total	
	N	%	N	%	N	%
0-2	40	58.8	5	9.6	45	37.5
2.1 –4	15	22	35	67.3	50	41.7
>4	13	19.2	12	23.1	25	20.8
Mean	2.96		3.30		3.11	
SD	1.21		1.57		1.38	
t-value						1.32

P-value = 0.454.
Source: Own field survey (2017).

Table 18. Comparison of variety adoption status based on farm income 2016/2017.

Adoption categories	N	Mean	SD	Min	Max	t-value	P
Adopter	68	9206.3	7782.3	0	28,000		
Non -adopter	52	5301.2	10121.3	0	25,000	1.018	0.479
Total	120						

P-value = 0.479.
Source: Own field survey (2017).

Table 19. Comparison of variety adoption based on market distance.

Adoption categories	N	Mean	SD	Min	Max	t-value	P-value
Adopter	68	10.29	5.98	1	19		
Non-adopter	52	9.93	5.63	1	23	2.303	0.132
Total	120	10.13	5.81	1	23		

Source: Own field survey (2017).

different factors: demographic, socio-economic and physical factors. The model results in Table 20 show that, among the 12 independent variables included in the model, eight variables were found to significantly affect adoption of improved *Jalenea* potato variety. These variables are briefly discussed as follows:

Age of respondent: The odds ratio implies that a unit increase in age of a household heads will reduce the probability of adopting the technology by 116.9%. In other words, as age increases the probability of adopting the variety decreases. This might be due to need for high physical labor. The elders are physically weak to adopt improved *Jalenea* variety. According to them, age is one of the factors that determine decision making of a person. Household heads with advanced age are more reluctant to accept new technology than younger household heads.

Sex of household head: It had significant and positive effects on the adoption of improved *Jalenea* potato variety at 10% significance level. The odds ratio implies that being male favors the adoption of improved *Jalenea* potato production package by a factor of 4.743.This shows that male headed households are more likely to have better access to information on improved *Jalenea* potato production technologies and more likely to adopt new technologies than female headed households. This result agrees with Tesfaye et al. (2001) and Mesfin (2005).

Total land size: Land size owned by farmers had positive and significant effect on the adoption of improved Jalenea potato variety at 10% significance level. The value of the odds ratio indicates that a unit increase in the land size of farmers will increase the probability of adopting improved *Jalenea* potato variety by 34.8%. Land is perhaps the single most important resource, as it is a base for any economic activity especially in rural and agricultural sector. Farm size influences household's decision to adopt or to reject new technologies. According to the information from focus group discussion

Table 20. Binary logistic regression results of independent variables.

Variable	B	S.E.	Wald	df	Sig.	Odds ratio
Age of household	-0.156***	0.059	7.044	1	0.008	1.169
Sex of household	1.557*	0.807	3.719	1	0.054	4.743
Land size	1.055*	0.548	3.713	1	0.054	0.348
Farm income	0.000***	0.000	7.545	1	0.006	1.000
Participation on field day	2.628***	0.861	9.315	1	0.002	0.072
Seed multiplication member	2.458**	0.973	6.379	1	0.012	0.086
Participation on training	4.818***	1.320	13.328	1	0.000	0.008
Education level	-0.066	0.259	0.065	1	0.798	0.936
Number of livestock	-0.224	0.177	1.590	1	0.207	0.799
Non-farm activity	1.609*	0.873	3.398	1	0.065	0.200
Labour availability	-0.497	0.369	1.810	1	0.179	0.608
Farm experience	-0.033	0.057	0.325	1	0.568	0.968
Constant	13.165	4.186	9.892	1	0.002	5.218E5

a. Variable(s) entered on step 1: LANDSIZE, PARTFILDAY, SEDMULMEM, TOTfarINC, AgeHH, SEXHH, EDULEVHH, NUMLISTO, TRAININGINJAL, NONFARACTI, Labour, and FARMEXPHH. *,** and***represent significant at 10, 5 and 1% level respectively.
Source: Computed from field survey data (2017).

(FGD) farmers who have better land have more chance to adopt improved *Jalenea* potato variety.

Total farm income: Farm income is the main source of capital to purchase farm and other household inputs. In this study farm income had positive and significant effect on the adoption of improved *Jalenea* potato variety at 1% significance level. The value of odds ratio shows that as farm income increases adoption of improved *Jalenea* potato variety will increase.

Participation in field day: Participation on field day is one of the means of teaching and learning process of improved technologies. Participation in field day had significant positive effect on the adoption of improved *Jalenea* potato variety at 1% significance level. The odds ratio implies that participation in field days will increase the likelihood of variety adoption by 7.2%. Farmers who have an opportunity to attend field day of improved *Jalenea* potato production are more likely to use improved *Jalenea* potato production technology than those farmers who have no similar opportunity. In other words, the result indicates that farmers who are exposed to formal extension information have a higher probability towards adoption than those with less exposure. This suggests that access to participation in field days for improved production of Jalenea potato farmers could be aware of the various aspects of the production and productivity of the crop. This result agrees with the findings of Tesfaye et al. (2001).

Membership of seed multiplication: Being member of seed multiplication association had significant and positive effect on the adoption of improved Jalenea potato variety at 5% significance level. The value of odds ratio implies that being member of seed multiplication group favors the adoption of improved Jalenea potato variety by 8.6%. Organizing of farmers to be a member of seed multiplication group would help them to get access to seed credit (received basic seed from research and NGOs for multiplication), access to extension information and also access to market. This implies strengthening and expansion of seed multiplication is of paramount importance to improve availability of sustainable seed supply system in the area and enhance adoption of improved Jalenea potato variety.

Participation in training: Training is one of the extension events where by farmers get practical skill and technical information for new technology. Participation in training had significant and positive effect on the adoption of improved Jalenea potato variety at 1% significance level. The odds ratio implies that participation in training improves the likelihood of adopting improved Jalenea potato variety by a factor of 0.008. This may be explained by the fact that farmers who have training gain better knowledge on production practices and technologies than non-participants of training program. The implication is that emphasis has to be given to farmers' training since it helps to enhance adoption of improved Jalenea potato production package. The result is agreement with findings of Tesfaye et al. (2001) and Asfaw et al. (1997).

Non-farm activities: Participation in non-farm activity had positive and significant effect on the adoption of improved Jalenea potato variety at 10% significance level. The value odds ratio indicated in Table 20 implies that participation in non-farm income generating activity improves the likelihood of adopting Jalenea potato variety by 20%. Many farmers can earn additional income by

engaging in various non-farm activities. This is believed to raise financial position to acquire new inputs.

Conclusion

The study reveals that out of the total respondents 68 (56.7%) of them applied the variety on their piece of land whereas 52 (43.3%) of sample households used the local variety only in the process of producing the crop. Out of the variety adopters (68 farmers) 60 farmers were found using fertilizer for Jalenea potato variety cultivation.

This study about plant spacing in the study area reveals that majority of variety adopters (67.7%) used the recommended spacing between rows and plants. According to the respondents, spacing requires additional labor and skill. Because of this, it is difficult for them to manage with labor that exists in the household. The result indicates that 53.3 percent of the respondents reported the existence of bacterial wilt disease problem in the study area and 47(73.4%) respondents used cultural method and 17 (26.6%) respondents used chemical to control disease problem. Most of the variables assumed to influence the adoption behavior were significantly associated with the adoption of improved Jalenea potato variety. The model results indicated that eight variables were found to significantly affect adoption of improved Jalenea potato variety. These are age of respondent, sex of household head, total land size, farm income, participation in field day, membership of seed multiplication, participation in training and non-farm activities. Among the personal and demographic factors age of the household was negative and sex of the household head was positive significantly related to the adoption of improved Jalenea potato production.

This implies that male farmers have better access to information on improved technologies and are more likely to adopt new technologies than females. Concerning economic and wealth related variables which were hypothesized to influence adoption of improved Jalenea potato variety, non-farm activity and farm income had positive and significant relationship with adoption. Out of the institutional variables, getting advisory service from extension agents, attending training, field day, and membership of seed multiplication group also had positive and significant relationship with adoption of improved Jalenea potato production.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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