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Factors Affecting Adoption of Improved Crops by Rural Farmers in Niger

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Abstract
Improved crops are advocated to meet the dual challenge of food security and the fight against poverty in developing countries. As most poor people in developing countries live in rural areas and depend on agriculture for their livelihood, an important key to get them out of poverty is to increase agricultural productivity by using technologies such as improved crops. However, the rate of improved crops adoption remains surprisingly low in Niger, one of the world poorest countries. In this paper, we examine the factors affecting adoption of improved crops by rural farmers focusing on Niger. Using the 2014's National Survey on Households Living Conditions and Agriculture, we investigate the effect of farmers' socioeconomic characteristics, the farm's quality, the geographic location, the production system, the access to improved seeds and the land tenure on the probability to use improved crops rather than local crops. Our results suggest that the ownership of a government land title is the most important driver in the adoption of improved crops by rural farmers. In addition, being a female, educated, practicing polyculture, having access to improved seed increase the probability to adopt improved crops. In contrast, household size, operating on the parcel for a long period and the parcel size reduces the probability to use improved crops. These determinants of improved crops adoption should be considered in Niger's agricultural policy to succeed in the dissemination of improved crops among rural farmers.
Keywords: Adoption, Improved crops, Farm, Farmer, Niger

Introduction

Agriculture in technologically lagging developing countries is a poor but pervasive source of livelihood for rural households (Mozumdar, 2012). In fact, in sub-Saharan African countries, agriculture represents a quarter of the gross domestic product (GDP) and employs about 70 % of the working population (World Bank, 2010). Agricultural production is used both for self-consumption and for income generation (Etoundi and Dia, 2008). Yet, recent studies in Africa report that food insecurity predominantly occurs in these countries especially in rural areas where agriculture is nearly the only source of livelihood (Bruno et al., 2013; FAO, 2015). Low agricultural productivity along with insufficient adoption of agricultural technologies such as improved crops continue to be an important barrier to get farmers out of poverty (Asfaw et al., 2011; Yong Ngondjeb et al., 2014; Issoufou et al., 2017).

Located in the heart of the West African Sahel, Niger -the site of our empirical analysis- is one of the most vulnerable countries in the world with more than 3.6 million people suffering from poverty and food insecurity (FAO, 2015). The performance of the agricultural sector is highly unstable due to its exposure to damaging climatic conditions (World Bank, 2016). In order to face these challenges and fight against poverty, a significant part of Niger's Ministry of Agricultural Development (2012) and the FAO (2016) development policies relies on improved crops dissemination among rural farmers. For this purpose, several varieties of improved seeds such as early productive, drought and pest-resistant seeds have been developed and proposed to farmers by national and regional research structures (Rabe et al., 2017). A large consensus exists in the literature about the productive efficiency of these crops. In a study in Niger, Issoufou et al. (2017) find that the use of improved millet seeds increases the farmers' production. This result is consistent with previous studies which confirm that the adoption of improved crops such as rice, wheat, cowpea, and corn lead to increased production and improves farmers' income (Nkamleu, 2004; Tesfaye et al., 2016; Nkamleu, 2004; Arouna et al., 2013; Awotide et al., 2012). Yet, according to FAO(2017) the results of the campaigns led by the government to encourage the dissemination of improved crops among rural farmers remained mixed. From our data, only 27.5% of farmers used improved crops in their farm, revealing the low adoption of these crops.

This paper aims to understand the determinants of this adoption, since improved crops are supposed to meet the dual challenge of food security and the fight against poverty (Tene et al., 2013). The explanations for the insufficient adoption of improved crops by rural farmers diverge. Roussy et al. (2015) argue that factors influencing farmers' decision to adopt an agricultural technology varies greatly among producers because of the heterogeneity of their preferences. An alternative explanation by Röling (2009) and Klerkx et al. (2012), for the non-adoption of improved crops is their inability to respond to socio-economic conditions and producers' expectations. Using a reduced sample of 612 farmers, Issoufou et al. (2017) focus on the determinants of improved millet adoption and find that farmer's risk perception, access to improved seeds, seeds characteristics,

farmers' age, education, household size and land tenure are the main determinants of improved millet adoption by these farmers. However, there is no evidence that these results hold for all improved crops in Niger.

To extend the results of Issoufou et al. (2017), we use the 2014 National survey on Households Living Conditions and Agriculture to examine the determinants of improved crops adoption focusing on all rural farmers. More specifically, we analyze the effect of farmers' socio-economic factors, soil quality, geographic location, land tenure and the production system on a farmer's probability to use improved crops rather than local crops. Our results suggest that being a female, educated, owning a government land title, practicing polyculture, having access to improved seed or living in regions like Dosso, Tahoua, Maradi, Tillaberi, and Zinder (compared to Diffa) increase the probability to adopt improved crops. In contrast, household size, operating on the parcel for a long time and the land size reduce the probability to use improved crops. These results are mainly consistent with findings in the literature (Issoufou et al., 2017).

The rest of this paper is organised as follows: Section 2 presents the data and the method. The empirical results are presented in Section 3. Section 4 discusses the results and finally, Section 5 concludes the paper.

2. Data and Method

This section describes the data we use to analyze the effect of farmers and their household characteristics, the farm characteristics, the geographic location and the other covariates on the likelihood that she/he adopts improved crops. It also outlines our empirical method.

2.1 Data

We use the data from the 2014's National survey on Households Living Conditions and Agriculture to examine the factors influencing the likelihood that a rural farmer adopts improved crops rather than local crops. The goal of this agricultural survey was to provide statistically representative data on agriculture in Niger and discuss the techniques for promoting efficiency and innovation in this sector. The survey collects information about farmers, households' demographic, socioeconomic characteristics, farms' descriptions, geographic locations (the area of residence, the region of residence...) and the land tenure. Our analysis focuses on the crops used by farmers. We define a dummy variable equals 1 if the farmer uses improved crops in his/her farm and 0 otherwise. Our sample contains 19.310 rural farmers.

The choice of Niger as the site of our empirical analysis is suitable the government of Niger have lunch many campaigns to disseminate improved crops among rural farmers in order to fight poverty, but the results remain mixed (Issoufou et al., 2017). In our data, only 25% of rural farmers used improved crops.

2.2 Method

Consider a farmer denoted i characterized by a vector of individual factors X_i, who decides whether to use improved crops or local crops. X_i includes all those factors that can determine the decision to use improved or local crops on the farm. These factors include the farmer's socioeconomic characteristics, the access to improved crops, the farm quality, the geographic location (region of residence) and institutional factors such as land tenure. Let denote Y_i the type of crops used by the farmer (equals 1 if the farmer uses improved crop and 0 otherwise). The decision to adopt the improved crop is a binary decision which can be described by the following model:

$$Y_i = \begin{cases} 1 \text{ if } Y_i^* = X_i'\beta + \varepsilon > 0 \text{ (Improved crops)} \\ 0 \text{ if } Y_i^* = X_i'\beta + \varepsilon < 0 \text{ (Local crops)} \end{cases}$$

Where Y_i^* is the latent variable which sign determines the adoption or not of improved crops by the farmer and is a normally distributed zero-mean error term. β captures the parameters of covariates that affect the improved crops adoption.

The probability of adopting improved crops can then be written as follows:

$$\begin{aligned} P(Y_i = 1|X_i) &= P(Y_i^* > 0) \\ &= P(X_i'\beta + \varepsilon > 0) \\ &= P(\varepsilon < X_i'\beta) \\ &= \Phi(X_i'\beta) \end{aligned}$$

where $\Phi(.)$ is the normal distribution. This probability and the parameters of the model are estimated using a maximum likelihood. We estimated a probit model. The explanatory variables included in the vector X_i are defined as follows:

We first include the farmer's socio-economic characteristics: such as the gender (1 if a female and 0 if a male), the age, the level of education (1 if No education, 2 if primary education and 2 if secondary and more) and the household size. We also include the farm's characteristics: The quality of soil (0 if glaze soil, 1 if loamy soil, 1 if clay soil, and 3 if rocky soil), the parcel size, a dummy for the access to water by irrigation and the years of exploitation of the parcel. We also include dummies for the region of residence to account for regional

heterogeneity in improved crops adoption. The region of Niger is not included in our analysis since we focus on rural farmers. The region of Agadez was also excluded from our analysis because of missing data on agriculture. Then, we include a dummy variable for polyculture equals 1 if the parcel is planted with more than one culture together and 0 otherwise and a dummy for the access to improved crops (1 if the farmer was subsidized by the government or an association for using improved crops and 0 otherwise). Finally, the explanatory variables include the land tenure equals to 1 if the farmer has no document, 2 if he has a government land title and 3 if he has a traditional certificate of ownership.

To deal with the potential clustering of observations at the neighbourhood level, we estimate the model using heteroskedasticity robust standard errors. For our interpretation, we estimate the marginal effect of each variable on the probability to use improved crops rather than local crops.

3. Descriptive Statistics

Table (1) presents the descriptive statistics. These statistics suggest that only 27.5% of rural farmers used improved crops rather than local crops. Farmers have access to these crops through several channels, among them the grants donated by cooperatives or the government. However, the data reveals that only 1.85% of the sample of farmers benefited from these donations. The analysis of household socio-economic characteristics indicates that the average age of farmers is 45 years. Moreover, we find that more than 82% of farmers have no education while only 10.9% have reached primary school. This low literacy rate in our sample reflects the adult literacy rate for the country, estimated at 15.45% (World Bank, 2012).

The statistics of farm characteristics show that the average size of the plots is estimated at about 3 hectares. This small plot size is accentuated by the fact that farmers tend to grow several crops on the same plot. Indeed, only 25.1% of the plots are devoted to monoculture. Another issue concerning farming in Niger is the land tenure. Indeed, land tenure remains one of the major challenges of agriculture in most countries of sub-Saharan Africa, especially with regards to the definition of property rights. This is clear from our sample, since 95% of farmers do not have documents defining the ownership of the plot they are farming on. The last 8 lines of Table (1) show the distribution of the sample by region. The region of Maradi is the most represented with 16.9% while the farmers of the capital Niamey represents only 5.24%.

Table (2) presents the correlation coefficients between the adoption of improved crops and the explanatory variables of our model. These coefficients provide a first insight into the relationship between farmers' adoption behavior and individual characteristics. A positive correlation coefficient indicates that the presence of this trait in a farmer is most often associated with a tendency for the latter to adopt improved seeds. In Table (2), we notice a positive relationship between the use of improved crops and covariates such as being female, the level of education, the ownership of a government land title or a certificate of sales. However, the household size, the practice of polyculture is associated with a negative use of improved crops. However, it is important to notice that correlation is different from causality. Thus, a significant coefficient of correlation does not necessarily imply that the associated variable influences the adoption behavior of the farmer. To estimate the parameters of causality, we call on econometric estimations.

Table 1: Descriptive statistics

	Mean	Standard deviation	Min	Max
Using Improved crops	0.275	0.446	0	1
Farmer's gender(Female)	0.0907	0.287	0	1
Farmer's age	45.00	14.61	17	95
Education				
No education				
No education	0.829	0.377	0	1
Primary	0.109	0.311	0	1
Secondary and +	0.0629	0.243	0	1
Household size	6.767	3.461	1	30
Access to improved seed	0.0185	0.135	0	1
Access to irrigated water	0.0676	0.251	0	1
Soil quality				
Glaze				
Rocky	0.711	0.453	0	1
Loamy	0.0879	0.283	0	1
Clay	0.141	0.348	0	1
Glaze	0.0599	0.237	0	1
Polyculture	0.749	0.434	0	1
Land tenure				
Government land title				
Government land title	0.0123	0.110	0	1
Traditional certificate	0.0266	0.161	0	1
Sale Certificate	0.0115	0.106	0	1
No document	0.950	0.219	0	1
Region				
Agadez	0.0650	0.246	0	1
Diffa	0.0945	0.293	0	1
Dosso	0.157	0.364	0	1
Maradi	0.169	0.37	0	1
Tahoua	0.158	0.364	0	1
Tillaberi	0.147	0.354	0	1
Zinder	0.157	0.364	0	1
Niamey	0.0524	0.223	0	1

Table 2: Estimated correlations between explanatory variables and improved crops using

	Improved Crops Using	P-value
Farmer's gender (1 if female)	0.0932***	0.0000
Farmer's age	0.0275***	0.0000
Farmer's Education in single years	0.1114***	0.0000
Household size	-0.0990***	0.0000
Soil quality		
Rocky	-0.1225***	0.0000
Loamy	-0.0052	0.3181
Clay	0.1161***	0.0000
Glaze	0.0700***	0.0000
Polyculture	-0.0016	0.7689
Access to Irrigation	0.2201***	0.0000
Years of exploitation	-0.0965***	0.0000
Access to seeds	0.0942***	0.0000
Land tenure		
Government land Tittle	0.0480***	0.0000
Traditional certificate	0.1309***	0.0000
Certificate of sale	0.0206***	0.0003
No document	-0.1305***	0.0000

*** p<0.01, ** p<0.05, * p<0.1

4. Estimation Results

The results of our estimation are presented in Table (3). We report the coefficients of the regression in column (1) and the marginal effect in column (2). Robust standard errors are presented in parentheses.

Focusing on the effect of farmers' socio-economic factors, the results suggest that female farmers have a higher probability to adopt improved crops than male farmers. The marginal effect shows that the chance of adopting the improved crop is 2.42 percentage points higher for a female farmer compared to a male farmer. Moreover, the results suggest that education positively affect the likelihood of a farmer to use improved crops rather than local crops. For instance, we find that a farmer with primary education has 4.17 percentage points more probability to use improved crops than a farmer with no education. A farmer with secondary or higher education level has around 5.28 percentage points probability to adopt improved crops than a farmer with no school education. The results also show that the increase in family size reduces the probability to adopt improved crops. Indeed, one additional member in the family reduces the probability to use improved crops by 0.17 percentage point. In addition, the probability that a farmer leaves the local crop to adopt the improved crop is reduced by the number of years he has been exploiting this plot. A plausible explanation for this fact is that these farmers have a better knowledge of their farm. Hence, they have more options they can choose from to improve their production such as the choice of the varieties.

Checking the effect of farm's quality, the results suggest that farmers who exploit rocky ground has 2.24 percentage points more probability to use improved crops than farmers exploiting glaze soil. Working on a loamy and clay soils reduces, respectively by 2.38 percentage points and 1.65 percentage points, the probability to use improved crops. We also check for the effect of geographic location on the probability of using improved crops. The results suggest that the probability to adopt the crops is higher in the regions of Tahoua (13.1 percentage points), Tillaberi (13.1 percentage points), Maradi (12.9 percentage points), Zinder (3.13 percentage points) and Dosso (2.13 percentage points), compared to the region of Diffa. Considering the production systems, we find that the farmers who practice polyculture have a higher probability (6.63 percentage point) to adopt improved crops than those who practice monocrops. As far as the issue of access to improved crops is concerned, the results suggest that a farmer's probability to adopt improved crop is 13.8 percentage points higher when he can easily get access to crop through grants from rural farmers' associations or the government.

As far as land tenure is concerned, the results show that farmers who have a government land title have a greater probability to use improved crops. Indeed, having a government title increases the probability to use improved crops by 30.2 percentage points. In contrast having a traditional ownership certificate does not affect the likelihood to use improved crops. So, land rights appear to be the most important determinants of improved crops adoption in Niger.

Table 3: Results: The dependant variable is improved crop (0/1)

VARIABLES	Probit coefficients	Marginal effects
Farmer and households' characteristics		
Gender (Female dummy)	0.203***	0.0242***
	(0.0551)	(0.00657)
Age	-0.00169	-0.000201
	(0.00730)	(0.000867)
Age square	1.47e-05	1.75e-06
	(7.46e-05)	(8.87e-06)
Education level (Base: No education)		
Primary	0.543***	0.0417***
	(0.152)	(0.00889)
Secondary and more	0.638***	0.0528***
	(0.146)	(0.00745)
Household size	-0.0142***	-0.00169***
	(0.00474)	(0.000563)
Farm's characteristics		
Type of soil (Base: Glaze)		
Loamy		
Loamy		
Loamy	-0.149**	-0.0165***
	(0.0584)	(0.00602)
Clay	-0.224***	-0.0238***
	(0.0547)	(0.00520)
Rocky	0.168***	0.0224***
	(0.0491)	(0.00704)
Parcel's size	-1.48e-06***	-1.76e-07***
	(3.55e-07)	(4.22e-08)
Access to water by irrigation	2.074***	0.247***
	(0.392)	(0.0460)
Years of exploitation of the parcel	-0.00291***	-0.000346***
	(0.000375)	(4.44e-05)
Region dummies (Base:Diffa)		
Dosso	1.846***	0.0213***
	(0.651)	(0.00303)
Maradi	2.846***	0.129***
	(0.649)	(0.00531)
Tahoua	2.856***	0.131***
	(0.649)	(0.00615)
Tillaberi	2.857***	0.131***
	(0.643)	(0.00743)
Zinder	2.033***	0.0313***
	(0.650)	(0.00350)
Production system		
Polyculture	0.558***	0.0663***
	(0.0573)	(0.00681)
Access to granted improved crops	1.163***	0.138***
	(0.0935)	(0.0111)
Land tenure (Base: No document)		
Government land title	1.386***	0.302***
	(0.110)	(0.0317)
Traditionnal certificate of ownership	0.174	0.0226
	(0.155)	(0.0220)
Constant	-5.568*** (0.707)	
Observations	19,310	19,310
Pseudo R-square	0.1795	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5. Discussion

We resume the factors affecting the probability to adopt improved crops in seven groups: The farmer's socio-economic factors, the farm quality, the geographic location, the production system, access to crops and land

tenure.

The farmer's characteristics: Our results reveal that women are more likely to adopt improved crops. However, this effect is different from results of Issoufou et al. (2017). In fact, they found that male farmers are more likely to adopt millet improved crops base on a smaller sample of 612 farmers. We use a much larger sample and focus on the overall behaviour of improved crops adoption by rural farmers.

Moreover, our results suggest that the lack of education is a barrier to the adoption of improved crops. This result is consistent with the literature showing that the lack of education is a barrier to the adoption of agricultural technologies (Yong Ngondjeb et al., 2014; Roussy et al., 2015; Yabi et al., 2016; Issoufou et al., 2017). Public policy that promotes rural females' education can then encourage the adoption of improved crops. We also find that family size reduces the probability to adopt improved crops. This result is consistent with Barry (2016). In fact, Barry (2016) shows that the lack of labor force in the household incites farmers to use improved crops rather than local crops.

The farm characteristics: The results show that the adoption of improved crops is negatively correlated with the parcel size and how long the farmer has been exploiting this farm. The type of soil also affects the probability to adopt improved crops. The low-quality soil such as rocky soil (most difficult to plant) is more likely to be planted with improved crops while the best quality soil such as loamy and clay soil are more likely to be planted with local crops.

The production system and access to seed: We find that improving the access to seed increases the probability that farmers adopt improved crops since they don't have to pay for the seeds at the market. This result is consistent with the literature Asfaw et al. (2011) on the adoption of improved seeds which shows that providing farmers with grants increased the usage of improved crops in a significant way. In fact, Asfaw et al. (2011) shows that seed constraint is one of the greatest barriers to improved crops adoption in developing countries. In addition, the results show the farmers who practice polyculture are more likely to use improved crops. The low confidence of farmers in use of improved crops may reflect their desire to reduce production risks. Issoufou et al. (2017) find that farmers perception on the risk of production and the characteristics of these improved seeds determine their willingness to adopt improved crops.

The land ownership: The results suggest that the ownership of a government land title is the most important determinant in the adoption of improved crops in Niger. In fact, a government title gives a secure land right to the farmer. This result confirms the idea that land rights have positive effects on agricultural technology adoption in sub-Saharan countries. Dorner (1972) and Harrison (1987) show that the traditional tenure systems provide insufficient tenure security to induce farmers to adopt new agricultural technologies.

The geographic location: Our results suggest that farmers from the regions of Dosso, Maradi, Tahoua, Tillaberi and Zinder are more likely to use improved crops than those living in the region of Dissa. In fact, these regions depend more on agriculture than the region of Diffa which tends to depend rather on livestock.

6. Conclusion

This paper analyses the factors influencing the adoption of improved crops by rural farmers in Niger using the 2014's National Survey on Households Living Conditions and Agriculture. We use a binary model to estimate the effect of the farmer's characteristics, the farm characteristics, the production system, the geographic location and the land tenure on the probability of a farmer to use improved crops.

We find that the ownership of a government land title is the most important driver in the adoption of improved crops by rural farmers. In fact, the government land title offers a tenure security that encourage farmers to invest in new agricultural technologies such as improved crops. Moreover, being an educated female farmer increases the probability to adopt improved crops. Such positive correlation between education and improved crops adoption is explained by the fact that farmers with higher education have better access to information and knowledge necessary to successfully use improved crops and realised expected results. In addition, we find that the practice of polyculture as a factor to manage risks also appear to be a determinant of improved crops adoption. Furthermore, the study has shown that when farmers are provided with the seeds through grants they are more likely to use improved crops rather local crops since they don't have to pay for the seeds at the market. The adoption of improved crops also depends on the geographic location and the type of soil exploited by the farmer. The farmers of the regions like Dosso, Tahoua, Maradi, Tillaberi and Zinder have a greater probability to adopt improved crops than those in the region of Diffa. In order to succeed in the dissemination of improved crops among rural farmers, the decision makers in Niger should particularly consider these factors.

An interesting direction for our future research will be to focus on the adoption of the integrated crop-livestock farming system by Niger's farmers which is also advocated, along with improved crops, to be promising in boosting food productivity in sub-Saharan developing countries (Ezeaku et al, 2015).

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Figure 1: Niger map

Source: Netmaps, 1997