Agricultural technology and living conditions of rice farmers in Cameroon:

Case of the Northwest region

Rice and food security

ANKI YAMBARE

Statistician engineer economist

June 2016

ABSTRACT

In Cameroon, the rice occupies a strategical place in the agricultural sector because of its growing importance in national consumption and exchanges with outside. This study appreciates the impact of the adoption of agricultural technology on the productivity of rice and paddy rice farmers income householders in the North West of Cameroon in using the method of instrumental variables (Local Average Treatment Effect « LATE »), inspired by the work of Abadie (2003). At this effect and relatively of the available data (2013-2014 investigation rice), two types of technology have been retained: the New Rice for Africa (NERICA) and contract farming system. The results reveal that rice productivity increases of **1.04 ton / ha** when the rice farmers adopt New Rice for Africa. Moreover, rice farmers who have produced at least one agricultural contract increase their income **288,565.2 FCFA / ha**. Therefore, this study suggests to broaden the base of the development of the rice value chain which offers access to seeds for all, technical frameworks including training, strengthening agricultural contracts and access financing.

Keywords: Impact, LATE, NERICA, agricultural Contract, Farm Household

INTRODUCTION

Rice occupies an important place in the eating habits of the population. According to the Cameroonian Household Survey (ECAM 3, 2007), rice is the staple food for the population and is the most consumed cereal after maize. Also, in 2007, about 138 billion CFA francs were spent on the purchase of rice in the household food budget. Domestic rice consumption is significantly higher than the local production. The deficit is covered by commercial imports. So, rice is one of the products for which the country is experiencing strong vis-à-vis the outside addictive despite its rich subsoil (MINEPAT, 2012). Moreover, the great potential available to Cameroon, indicate good prospects for the development of the rice sector. The regions of the far North and Northwest remain the main centers of rice production. Processing and marketing of rice are provided by millers and traders intermediaries. The transformation is done by individuals on small husking, but the introduction of mini mills and private facilities progressively contribute to the improvement of the quality of local rice.

Furthermore in order to ensure food security, fighting against poverty and the problem of low yields, innovations to increase productivity and improve access to rice markets have been introduced, it is including improved rice varieties, contract systems, including the Rice financing. In this perspective, the project to improve the competitiveness of rice in Central Africa funded by the "Common Fund for Commodities (CFC) 'was launched in 2008, the National Strategy for Rice Development was established in 2009 and this with the sole aim to reduce poverty by improving food security and incomes of rural populations by promoting the production and the competitive marketing of locally produced rice. Note also that since 2012, several strategies (new technologies) and policies were undertaken to boost rice productivity.

This growing importance of agricultural technology in national rice development strategy raises questions about his real contribution to increasing rice productivity and improving the income of rice farmers. Some studies in Cameroon have examined the issue and concluded to a positive impact from the adoption of improved rice varieties on food security of rice households.

These studies, however, have some specific features that suggest their results into perspective, especially in view of their scope and methodological approach. Indeed, to achieve their goals,

the authors used the counterfactual approach based on propensity scores (observable characteristics). Outside, some unobservable variables such as motivation, the level of wealth can be determinative of the adoption of agricultural technology.

This section provides further analysis of the contribution of agricultural technology on rice productivity and improving the incomes of rice farmers in the Northwest region in a more comprehensive framework and through a methodological approach more appropriate. To this end, it holds two types of agricultural technologies, which seem essential in the context of Cameroon for the development of rice namely (i) the adoption of the New Rice for Africa (NERICA) and (ii) the adoption of an agricultural agreement (Rice training, membership of a cooperative credit in kind or in cash etc.). From a methodological point of view, the article draws on the work of Abadie (2003) based on instrumental variables.

The rest of the article is structured around three parts. The first part presents the conceptual framework of the study and review of the literature on the relationship between technological innovation and agricultural productivity of rice. The second part deals with the methodological approach. The third part examines the empirical results.

1. LITERATURE REVIEW

New Rice for Africa (NERICA) was developed by AfricaRice ex WARDA in 1996 following interspecific crosses between Oryza sativa Asian rice and African rice Oryza glaberrima (WARDA, 2008). Asian rice at a high yield potential, but has a low adaptation to rainfed upland rice conditions. While African rice has a low yield but is a rich reservoir of genes for resistance to local stress. In other words, rice is more resistant to local stresses and insect pests.

And combined these two rice varieties was a major challenge which had engaged AfricaRice researchers and a number of international partner. For the two rice species have evolved separately over millennia. Then, using molecular biology, AfricaRice researchers were able to overcome the main problem in the crossing of two species: the hybrid sterility.

According to Rice Centre for Africa (WARDA, op.cit.), NERICA varieties have a yield advantage over their parents O. glaberrima and O. sativa. It is, for example, earlier maturity (30 to 50 days less), better weed competitiveness, tolerance to drought and resistance to insect pests or disease or simply potential higher yield (50% increase without fertilizer and more than 200% with fertilizer). Also, grain quality of some of the NERICA is often better than that of their

parents. For example, some protein NERICA is 25% higher than the Asian rice market (WARDA, op.cit.).

Empiric review

How to evaluate the effect of technology adoption? How this adoption she changed the income of the households concerned? How this adoption would it have changed household incomes, which could adopt? In recent years, these issues have been at the center of a rich econometric literature methodological advances. In the literature, there are several micro econometric methods to capture the effect of the adoption of agricultural technology. The statistical methods available are certainly numerous, but their specificity and assumptions strongly influence the results. These methods are generally based on a comparison of individuals benefiting from the adoption of technology that we want to assess and individuals not qualifying.

According INRAB (1996), the adoption of a technology is determined by the complexity of the technology, the establishment of necessary initial background, the expected net profit and opportunities for technology integration in the social scheme -culturel operator.
CIMMYT (1993) meanwhile believes that the adoption of a technology depends primarily on:

- factors specific to producers such as the education level of the operator, his farming experience, age, gender, level of wealth, the size of its operations, the availability of labor and its aversion at risk ;
- factors related to technology such as the complexity of the technology, the relative cost of innovation;
- institutional market factors of production factors and information
- Characteristics of the parcel to receive technology such as the nature of the soil, its fertility level before the adoption of technology, climate.

Indeed, individuals who decide to adopt innovation are by definition different from those who choose not to adopt it. However, the interpretation of this difference as a causal relationship between the fact of adopting technology and income of individuals, many problems. The principal is the existence of selectivity bias (Diagne, 2003).

Therefore, different methods have been developed and used in the literature to assess the impact of programs, policies and adoption of improved agricultural technologies on the reduction of poverty and well-being of farm households.

For example, Patrice Y. Adegbola et al (2011) in their report on the impact of the adoption of improved varieties of maize and cowpea in Benin show from the method of Local Average Response Function (LARF) that adoption of improved varieties of maize and cowpea has a positive impact on agricultural productivity. Specifically, the authors show that the adoption of improved rice varieties allows farm families to increase their income from 2427 FCFA per hectare. Moreover, they showed that the adoption of maize varieties has no noticeable effect on food expenditure of households said.

In the rice sector, ADEKAMBI SA (2005) adopted the estimation by matching method on the propensity score to estimate the impact of the adoption of improved rice varieties on the education and health of children in Benin. He noted that the improved rice varieties in general and the new NERICA in particular have a fairly significant impact on school enrollment and child health in Benin. According to its study that the impact of improved rice varieties (all ranges) on the education of children is 3% and 4.925 FCFA respectively on enrollment and school expenses by schoolchildren. The author has also shown that new NERICA rice varieties, induced an impact of 6%, 9%, 7% and 8.425 FCFA respectively on enrollment, retention rates at school, the index of gender disparity and school spending per child enrolled. As for the investment in children's health care, the results from the study showed that improved rice varieties have improved the attendance rates of hospitals and expenditure on curative care for children 7% and approximately 2,875 FCFA.

Similarly Mendola M. (2007) chose the estimation by matching method on the propensity score to estimate the impact of the adoption of agricultural technologies on reducing poverty in Bangladesh and observes that adoption of improved varieties with high yield has a positive effect on the well-being of households in so far as this adoption allows rice farmers to increase their income. For Fao (1995b), income is one of the determinants of food expenditure.

Kijima et al (2008) conducted a study on the impact of the adoption of the New Rice for Africa (NERICA) on the welfare of rice farmers in Uganda, using econometric panel data. The authors use a panel of 347 households between 2004 and 2006. The results of their analysis show that

the adoption of NERICA possible to reduce poverty and increase the income of rice households. However this method has few if some individuals leave the panel.

Diagne (2006) also evaluates the impact of the adoption of NERICA rice yield in Côte d'Ivoire using the method based on the propensity score and manage to show that this has a positive and significant impact on yield especially among women rice farmers.

Dontsop-Nguezet et al (2011) also examined the impact of the adoption of NERICA on welfare of rice farmers in Nigeria using the method of instrumental variables to estimate the local average treatment effect (LATE). The results of the study show that the adoption of NERICA varieties has a positive and significant at the 1% income and well-being of farm households. It enables adopt to increase their income 63 771.94 NAIRA.

Malaa et al (2013) cited in the 3rd Africa Rice Congress conducted a study on the impact of the adoption of improved rice varieties on food security of rice households in Cameroon based on data from the 'rice investigation 2009. To achieve their goals, the authors used the counterfactual approach based on propensity scores. According to their study that the adoption of improved rice varieties positively affects the well-being of farm households. Also the adoption of improved rice varieties allows adopters to increase their annual income and their rice production, respectively of 8466 and FCFA 1.6 tonnes per hectare. Furthermore, this study shows that the adoption of improved rice varieties allows adopters to increase their food spending to 33,800 FCFA per year.

Other studies also show that in adopting the improved variety NERICA rice-growing households are more likely to improve their income. However a study by Hossain et al (2003) in Bangladesh reveals that the adoption of improved rice varieties had a positive impact on rich households, but has a negative effect on poor households. According to the authors, the richest households have the opportunity to develop large areas, use of production factors such as herbicides, pesticides but also to have access to credit.

Review on contracting

In the case of agricultural innovations, Chambers et al (1994) show that farmers do not think in terms of adoption or rejection as do researchers. The individual tries to read this innovation, its

features, its advantages and disadvantages, then made his own opinion of the new idea and determines the attitude to observe either the adoption or rejection.

However, regarding contracting in agriculture, Ambaliou et al, in a study on "Agricultural Agreement and its evaluation on the Benin rice producers' income" analyzed the characteristics of the agricultural contract for the production of rice, and impact on producers' income. Thus the semi-parametric method of the average treatment effect was used to determine the rate of adoption of agricultural contract and estimate the various factors explaining the latter. The impact of agricultural contract is estimated using counterfactual approach instrumental variables to take into account the selection bias due to observable and unobservable characteristics. It appears from this study that potential and actual participation rates are 50% and 55.10% respectively. Regarding the impact on income, he reveals significant and positive. Indeed, the agricultural contract increases income adopters of about 72,352 FCFA.

Similarly, Priscilla W et al, in a study on "Impact of contract farming on smallholder poultry farmers' income in Kenya" assesses the impact of agricultural contracts on the income of small poultry farmers. They use data from 180 small poultry farmers stratified by participating in agricultural contracts. The methodology used is that of matching by propensity score. The result of this study, contract farming could improve the welfare of small farmers participating because it increases their income by about 27%.

Diagne and Arouna (2013) study the impact of rice seed production on yield and income of farm households. By the method of instrumental variables, they show the positive impact of access to credit on the income of producers. For these authors, one of the constraints faced by producers is access to finance for the purchase of carry-in inputs. On the issue of access to credit, the authors state that the credit allows producers to invest in the acquisition of inputs in sufficient quantity for production, thereby increasing productivity and income.

Other similar studies in Africa and elsewhere have implicitly proven the positive effect of access to credit. These include: (Ellasser 1994) in Burkina Faso, Freeman, Ehui, Jabbar (1998) in Ethiopia and Kenya, Obwana (2000) in Uganda, Sial and Carter (1996) in Pakistan, Duong and Izumida (2002) at Vietnam ... etc. The list is not exhaustive.

In a context of weak rural savings, Fall (2006) uses the method of the effect of treatment to assess the impact of access to inputs on credit on the income of rice farmers in the Senegal River valley. He first studied the access to credit instruments and the demand factors. In its analysis, it appears that access to credit is basically determined by the debtor status of the rice farmer group or rice farmer himself vis-à-vis its affiliates. It shows more than any other factors or individual characteristics have no impact on access to credit, and then uses the two variables to summarize the distribution of the quality of access to credit variable. To the question of the application inputs on credit, the author shows that it is influenced by the area of residence, number of years in rice growing activities, education level and ethnicity membership Wolof. By estimating the technical efficiency of rice by the approach of the border production, it shows that access to credit producers who produce in their production frontier. Indeed the author retained by management regression results of levels of technical efficiencies on the variables indicate that age, access to credit, the minimum level of secondary instruction and the number of years 'rice experience are factors statistically determinants of technical efficiency at the 5% threshold. The efficiency of the producers is also subject to the negative action of factors such as getting a second profession and household size producers. The author estimated the effect of access to credit on the income of producers according to their type: the poorest class, the class of the poor, the class means and class of the wealthy. It appears that access to credit is beneficial to medium producers and rich, while it has almost no effect on technical efficiency and income qualified producer's poor. The diversion of production targets in order to meet the priority needs such as food and health could explain this result in poor households groups.

2. MATERIALS AND METHODS

2.1. Methodology

Methods of estimating the impact of the adoption of NERICA

The basic principle is to use the information available on the rice farmers have not adopted the NERICA to construct, for each rice farmer who adopted a counterfactual, that is to say an estimate of what would have been its situation if it had not adopted the NERICA, with the goal of having a sample of rice farmers 'comparable' to rid the estimation of any potential bias.

In this respect, we consider the variable D (treatment) that takes the value D = 1 if the individual adopts the NERICA and D = 0 otherwise Y and the output variable of interest (consumption expenditure, rice income). This takes the value Y_1 when D = 1 and Y0 otherwise.

The average effect of NERICA on consumer spending or the rice income of those who have adopted NERICA is noted ATET. Formally ATET is given by:

$$ATET = E(Y_1 - Y_0 \mid D = 1) = E(Y_1 \mid D = 1) - E(Y_0 \mid D = 1) \quad \textbf{(1)}$$

In this equation (1), the first term $E(Y_1 \mid D = 1)$ is observed for all rice farmer who benefits from the program, which is not the case the counterfactual $E(Y_0 \mid D = 1)$. A challenge in causal inference is that the quantity $E[Y_0 \mid D = 1]$ is unobservable in other words, we cannot observe the results of households have adopted NERICA if they had not adopted, once that they did (Diagne et al, 2007; Holland, 1986).

The ATET estimator is however subject to two types of bias (Rosenbaum, 2001; Lee, 2005). This is the bias due to the difference between the observable characteristics (overt bias) and that due to the difference between the unobservable characteristics (hidden bias) affecting producers' access to information and their decision to adopt or not innovations.

To eliminate or minimize through observable and unobservable, the method of instrumental variables (IV) is often used (and Imbens Angrist, 1994; Heckman and Vytlacii, 2005. Abadie, 2003).

This method assumes the existence of at least one instrument called z variable that directly affects the adoption status but indirectly the results Y_1 and Y_0 once the independent x variables are controlled. The instrument should satisfy both conditions (Angrist and Pischke, 2008): Z must be correlated with treatment D indicator and it should not be correlated with the outcome variable y.

In addition, there is possibility of bias of heterogeneous processing (Heckman et al. 2006). This stems from the fact that individuals can receive different treatment according to their idiosyncratic character. For example, rice farmers with a better financial position to better know what variety funded and may also have a great ability to understand the benefits and the costs for growing NERICA. Therefore, they strive to get the most benefit on the variety. Similarly, a rice farmer having to risk aversion may also benefit from better treatment than with less risk averse because it is less likely to adopt the technology (Fall , 2005).

Thus, the impact of the adoption of NERICA rice farmers may vary depending on their level of financial support, their educational level, their knowledge about the varieties of NERICA and risk preference in models of fertilizers and productivity. This is why post heterogeneity.

So we first start by using the method of instrumental variables to estimate without using the local average treatment effect (LATE) is the average impact of the adoption of NERICA on income and spending consumer potential adopters (compliers).

Estimated by the Local Average Response Function (LARF)

Different estimators VI can be calculated according to the functional form of the model and assumptions about the instruments. Two IV estimators are often calculated.

The first is proposed by Wald and Imbens Angrist (1994) and requiring only the indicator Y result, the "adoption status" D and instrument Z.

$$\boldsymbol{y_i = \delta + \alpha D_i + u_i} \qquad (\mathbf{2})$$

In this case the consistent estimate of α can do so by least squares. It is obtained by regressing Y (here the income or expenditure on food) no longer on the endogenous variable D, but on his prediction $\boldsymbol{D_i^*}$ after the first stage of regression D on Z. In the case of an instrument binary Wald's estimator proposed by and Imbens Angrist is:

$$\boldsymbol{\alpha_{IV,LATE} = E(Y_1 - Y_0 | D_1 = 1) = \frac{E(Y|Z=1) - E(Y|Z=0)}{E(D|Z=1) - E(D|Z=0)}} \qquad \mathbf{(3)}$$

The second estimator proposed by Abadie VI (2003) and is nothing but the generalization of the first (Wald estimator) in case the z instrument is not totally independent of potential outcomes Y_1 and Y_0. The estimator Abadie has the advantage of relying on independence conditionally on observable X (that is to say that the chances of adoption and potential revenues are not related to the knowledge of the improved variety if the factors that determine income are the same).

$$\boldsymbol{y_i = \theta + \alpha D_i + \gamma X_i + u_i} \qquad \mathbf{(4)}$$

Thus, by selecting $\mathbf{f(X, D) = E(Y|X, D; D_1 = 1)}$ the result of the response function for potential adopters g and any other function of (**Y, X, D**), we have:

$$\boldsymbol{f(X, 1) - f(X, 0) = E\left(Y_1 - Y_0 \middle| X, D_1 = 1\right)}, \text{ and}$$

$$\boldsymbol{E(g(Y, X, T)|D_1 = 1) = \frac{1}{P(D=1)} E\big(k * g(Y, D, X)\big)} \qquad \mathbf{(5)}$$

Where $\boldsymbol{k = 1 - \frac{Z}{P(Z = 1|X)}(1 - D)}$ is a function that takes the value 1 for a potential adopter and a negative value, otherwise.

$\boldsymbol{f(X, T)}$, function is called Local Average Response Function (LARF). For estimation, we proceed by setting the LARF function:

$\boldsymbol{f(\Theta, X, D) = E(Y|X, D; D_1 = 1)}$

With $\boldsymbol{g(Y, D, X) = \left(Y - f(\Theta, X, D)\right)^2}$, the ɵ parameter is estimated by ordinary least squares (minimizing $\boldsymbol{E\{k(Y - f(\Theta, X, D))^2\}}$).

The conditional probability **P (D = 1 | X)** which appears in the expression of k is estimated by a probit model. The estimator ɵ thus obtained is robust and asymptotically normal (ABADIE A. (2003)). Once estimated ɵ, equation (4) is used to retrieve the conditional average treatment effect as a function of X.

The LATE finally obtained by always using equation (1). If LARF takes a linear form, that is to say $\boldsymbol{f(\Theta, X, D) = \alpha_0 + \alpha D + \beta X}$, **(6)**

With $\Theta = (\alpha_0, \alpha, \beta)$, the LATE equivalent to the estimated parameter α (constant treatment effect in the sub-population of potential adopters).

Two specifications with and without interaction between D and x can be used in the estimation equation (6). The interaction between the variable "adoption status" D and the explanatory variables X ensures the heterogeneity of the impact of a potential adopter to another. In the case of the overall significance of the interaction terms, the causal effect of the treatment can be considered as non-homogeneous in the rice farmers of rice. If, however, we accept the overall invalidity interaction terms, we conclude the absence of variability of the causal effect with the attributes of potential adopters. As part of this work, we use the interaction with specification.

2.2 Data Used

This study use the baseline data collected from the western highlands of Cameroon in 2014 using the Mlax software. A two stage stratified sampling technique, was used to collect data from 188 rice growing households in the rice growing villages of the western highlands. With the aid of focused group discussions and structured questionnaires uploaded in the tablet data were collected on the socio demographic characteristic of the rice growing households, rice ecology, rice productivity constraints, management strategies of main constraints, rice varietals

heritage, rice varietals evaluation, knowledge, access and management of rice seed, varieties and other inputs, as well as production and output.

3. RESULTS AND DISCUSSION

3.1 Profile of farmers

Descriptive analysis

Within the sample of 188 rice farmers householders considered for this study, 87 adopted the New Rice for Africa 33% against 176 who have not adopted (67%). Their profile depending on the age, sex and household size provides the following indications.

The gender of household head and household size

Within the household, the power of decision always comes back to the household head. The function occupies the latter is then likely to influence the exercise of this power to the household members. Also according to the head of household is male or female, can have an impact on the welfare of the household.

The gender analysis of the farmer shows that in 68.3% of rice farmers have suffered Rice formations are male against 31.7% female.

In this study, the studied rice households are mainly headed by men. In fact 68.3% of them are headed by men against 31.7% those headed by women. At the whole sample, there is almost 8 people on average per household, the observed maximum size is 20 persons per household. Within the rice heads of households surveyed in this study, 46.8% of rice farmers run a household whose size is between 3 and 6 people

- The age of the household head can be a determining factor of choice for production and household consumption. Thus, according to the age groups, the sample is dominated by rice farmers between 35 and 49 years, 41.44% of the sample (see Table 1). By cons, in the rice farmers who adopted the NERICA, the 35 to 49 predominate with a rate of 45.98% against 33.33% for rice farmers whose age is between 50 years and older. The opposite trend is obtained at non-adopters rice: 40.34% for rice farmers 50 and older, and 39.20% for the age group 35 to 49 years. For the age group 20 to 34 years the proportion is almost identical among adopters as among non-adopters.

Table 1: Distribution of rice farmers depending on the status of adoption and the age group

Age group	The rice farmer adopted the variety (%)		Total
	Yes	No	
20 to 34 years	20,69	20,45	20,53
35 to 49 years	45,98	39,20	41,44
50 years and older	33,33	40,34	38,02
Total	100,0	100,0	100,0

Source: IRAD, rice survey 2014

- Within the sample as a whole, 87.83% of rice farmers principal activity is agriculture. This proportion is about 85% of rice farmers who have adopted NERICA varieties against 89% for rice farmers have not adopted the NERICA. Rice farmers who do not have agriculture as their main activity are small proportion is 12.17% of all rice farmers.

Training and knowledge of NERICA

The fact that a household head has received agricultural or rice training and be informed about the benefits of NERICA cultivation can be a factor in the adoption of NERICA varieties. In this context, Table 2 shows that 41.5% of rice farmers in our sample as a whole have received training in agriculture against 58.5% who have no training in agriculture. Among rice farmers who have adopted NERICA varieties 52.7% received training in agriculture against 47.3% who did not receive training. As for non-adopters, 36.8% of household heads were trained in agriculture.

Table 2: Distribution of rice depending on the status of adoption and agricultural training

A received agricultural training	The rice farmer adopted the variety (%)		Total
	Yes	No	
Yes	52,7	36,8	41,5
No	47,3	63,2	58,5
Total	100	100	100

Source: IRAD, rice survey 2014

Compared to training in rice, shown in Table 3 that 38.3% of rice farmers have benefited from a training Rice, against 61.7% who have not received training in rice production. Regarding those who have adopted NERICA 50.9% were trained in rice against 49.1%. However, only 33.1% of non-adopters rice farmers were trained in rice against 66.9% who grow without training in this area.

Table 3: Distribution of rice depending on the status of adoption and rice training

A received training Rice	The rice farmer adopted the variety (%)		Total
	Oui	Non	
Oui	50,2	33	38,3
Non	49,8	67	61,7
Total	100	100	100

Source: IRAD, rice survey 2014

Another essential element is the knowledge of NERICA in its contours by rice farmers. So in terms of our analysis, 53% of rice farmers have perfect knowledge of NERICA against 47% who remain ignorant of assets that can generate this culture.

Training in rice cultivation, agronomy and membership in a group

Training and membership are key factors that can affect the adoption and income of rice farmers. Indeed, this is the factors that can readily make available to producers a body of knowledge on agricultural contracts and encouraged to participate. And Figure 4 shows the distribution of rice farmers by participation status depending on whether they received or no training in rice production. Thus it is clear from this that the proportion of contractors who have received training is far higher than that of rice farmers who have not benefited, with a differential of 35.6% and vice versa.

3.2 Impact of the adoption NERICA on rice productivity

The results of the MCO-LARF regression model to estimate the impact of the adoption of NERICA rice productivity are presented in the following Table:

Table 4: Econometric results of the determinants of productivity

LARF Ols regression

productivite	Coef.	Std. Err.	t	P>|t|
adoption	1.047671	.1952095	5.37	0.000
surfacec	.0924718	.0285543	3.24	0.002
gestionherb	.0778928	.1678186	0.46	0.643
engraip	.6433433	.190366	3.38	0.001
formation	.7504780	.1404435	5.34	0.000
syspro	-.3115972	.1303647	-2.39	0.019
ecologie	.1945661	.0686038	2.84	0.005
_cons	.4123595	.3091698	1.33	0.185

Number of obs = 117
F(7, 109) = 35.07
Prob > F = 0.0000
R-squared = 0.6919
Adj R-squared = 0.6731

productivite	parameter	Robust Std. Err.	z	P>|z|
LARF				
late	1.047671	.4812686	2.18	0.029

Source: IRAD, rice survey 2014

The model is globally significant at 1%. In addition, the variation in productivity is explained by 67.31% of independent variables included in the model. The model is generally satisfactory. The results show that the coefficient of the variable adoption of NERICA is positive and significant at the 1% level. So there is a positive correlation between rice productivity and the adoption of the New Rice for Africa (NERICA). Fertilizer use also has a positive effect as expected, productivity rice. Indeed according to the Rice Centre for Africa, improved varieties of NERICA have potential for higher returns compared to some traditional varieties (50% increase without fertilizer and more than 200% with fertilizer). Moreover, supervision of rice farmers, ie training received by rice producers can improve rice productivity.

The results show that the estimated value of the LATE is positive and statistically significant at the 1%. Thus the adoption of NERICA can increase productivity 1,046tonnes / ha. The results showed that among potential adopters, i.e. the compliers, the adoption of NERICA can increase rice productivity.

3.3 Impact of the adoption an agricultural contract on rice income

The table below shows the results of the MCO-LARF regression model to estimate the impact of the adoption of an agricultural contract on rice income. As for the impact model of the adoption of NERICA rice productivity, the model is globally significant at 1%.

Table 5: Econometric results of the determinants of farm income

LARF Ols regression

revenu_riz12	Coef.	Std. Err.	t	P>|t|
adoptcontra	289192.7	40803.3	7.09	0.000
engrai	207708.8	15515.11	13.39	0.000
tranctailm	-273219.6	16955.81	-16.11	0.000
institution	342270.4	33523.93	10.21	0.000
coutmdoeuv	7.458469	.7192384	10.37	0.000
formherb	-877438.6	43716.83	-20.07	0.000
nivsco	44374.01	9724.488	4.56	0.000
syspro	59746.11	27479.38	2.17	0.031
credit	275951.1	27968.64	9.87	0.000
actsec	-25940.05	3654.053	-7.10	0.000
_cons	70960.78	68837.83	1.03	0.304

Number of obs = 166
F(10, 155) = 64.58
Prob > F = 0.0000
R-squared = 0.8058
Adj R-squared = 0.7941

revenu_riz12	parameter	Robust Std. Err.	z	P>|z|
LARF				
late	288565.2	124.1919	2323.54	0.000

Source: IRAD, rice survey 2014

In addition, the change in income is explained by 79.41% of the independent variables included in the model. The model is satisfactory.

Indeed, the coefficient of the adoption variable of an agricultural contract (adoptcontra) is positive and significant at the 1%. This would mean that the adoption of an agricultural contract including contracts on prices, quantities produced, training in rice fields but also contracts with buyers have a positive effect on income. So there is a positive correlation between rice income and adoption of an agricultural agreement, which is consistent with the results obtained by Ambaliou et al (2010) and Arouna et al (2013).

The use of fertilizers by farmers has a positive effect, as expected, on the rice income. More access to credit (credit) of rice farmers positively influences the rice income as expected. Indeed, among the constraints facing rice farmers, access to financing for the purchase carry-in inputs is the main constraint, because access to credit is fundamental for the development of an agricultural production system (Wampfler et al, 2003). In this way, access to credit enables producers to invest in the purchase of inputs sufficient for the production thereby increase productivity. This result consistent with that found by Haidara, 2000, cited by A. Diagne (2011). Moreover, it corroborates that obtained by Diagne (op.cit.) And that obtained by Mbétid-Bessane (2014) according to which, access to credit allows rice farmers to increase their production and in turn increase their income.

As access to credit, the coefficients of the institutional affiliation (institution), production system management (SYSPRO), the level of household survey (nivsco) and the labor costs of work used (positive and significant Csont threshold respectively 1% excluding management of the production system which is 5%. the institutional affiliation allows rice farmers to have easy access to agricultural contracts and thereby improve their income. At the cost of labor of external work, the (+) was not expected. This little as though explained by the fact that a sizeable workforce helps to develop the land areas quite substantial. in addition, this labor is extremely cheap in the plain of Ndop.

The results show that the estimated value of the LATE is positive and statistically significant at the 1% for income. In other words, the effect of the contracting system income is significant in the population of potential adopters. The impact of the adoption of an agricultural contract on

the income of the population of potential adopters is estimated at 288 FCFA 565.2 / ha. Thus, the development of a system of contracts in the various production areas is a cost effective policy and contributes to the improvement of farm household income.

CONCLUSIONS AND RECOMMENDATIONS

For the development of the rice sector, NERICA (New Rice for Africa) is an advanced technology for Africa. This technology is perfectly suited to harsh production environments and conditions of low input, where rice farmers lack resources for irrigation and the application of chemical fertilizers or pesticides. Similarly, the contracting system is a device that fits best to the situation of small producers in the agricultural sector. In addition, the contract system best meets the needs of funding and support for producers.

Thus, this study estimated the one hand, the impact of the adoption of NERICA rice productivity, and secondly, the impact of the adoption of an agricultural contract income. The impact assessment was done with the method of "Local Average Response Function" (LARF). This LARF function was used to estimate without using the local average treatment effect (LATE) which is the average impact of technology adoption on an outcome indicator. The data were collected from 263 rice farms in the Northwest region.

The results show that the adoption of NERICA has a positive and significant impact on rice productivity. This adoption allows the producer to increase rice productivity of 1.04 tonnes / ha. On the other hand, the adoption of an agricultural contract also has a positive and significant effect on income and household food expenditure. Indeed, the adoption of an agricultural contract allows rice farmers to increase their annual income of about 288,565.2 CFA Francs.

The results of this study reveal that the development of the rice sector in the North West region cannot be achieved only through the involvement of producers in the development process.

Thus, in consideration of the results of this study, to prevent the danger of poverty and struggle against food insecurity, several recommendations were made: improve and strengthen access to improved varieties of rice through promotions including suppliers of input accompanied by

rice farmers. Indeed, the use of traditional varieties with resistance to insect pests and diseases is insufficient, undoubtedly leads to lower yields and productivity. And thus increasing the yield potential can be achieved through the cultivation of NERICA varieties.

- Strengthen existing contractual systems and extend them to all rice farmers who are currently excluded, as well as access to finance. For easy access and availability of inputs, credit, and other production factors have the effect of increasing rice productivity. Because the inclusion of fertilizers could help to reverse the declining trend in productivity. This is to regulate the contracting system to prevent the abuse of certain players.

- Providing training in crop management, including training in rice production and in the management of weeds, as well as membership of a farmers' association. Because it is stronger and more competitive when networking.

BIBLIOGRAPHIE

[1] **Abadie, A., (2003).** «*Semiparametric instrumental variable estimation of treatment response models*». Journal of Econometrics 113, 231–263.

[2] **AfricaRice, (2011).** *Rice Trends in Sub-Saharan Africa. Cotonou, Bénin*, 31 p.

[3] **Aminou Arouna & Aliou Diagne (2013)** « *Impact de la production de semence riz sur le rendement et le revenu des ménages agricoles: une étude de cas du Bénin* »

[4] **Angrist, J., Imbens, G., (1994)**. «*Identification and estimation of local average treatment effects*». Econometrica 62,

[5] **Angrist, J., Graddy, K., Imbens, G., (2000).** *«The interpretation of instrumental variables estimators in simultaneous equations models with an application to the demand for fish»*. Review of Economic Studies 67, 499–527. 467–475.

[6] **Angrist, J. D. and Pischke, J.-S. (2008).** Mostly harmless econometrics: An empiricist's companion. Princeton university press.

[7] **Arouna, A. (2002).** *«Impact socio-économique des systèmes de conservation/stockage de maïs au Sud-Benin*». Thèse d'Ingénieur Agronome. FSA/UAC. 147p.

[8] **Banque Mondiale, (2002).** *«Returns to Investment in Education*». A Further Update". Document de travail.

[9] **Banque Mondiale, (2011)** *« L'évaluation d'impact en pratique »*

[10] **Cymmit (1993).** *«The adoption of agricultural technology: a guide for survey design*». DF: Cymmit, Mexico

[11] **Diagne, A. (2003).** *«Evaluation de l'impact: synthèse des développements méthodologiques récents»*, ADRAO/ Conakry. 15 p.

[12] **Diagne, A. (2006).** *«Diffusion and adoption of NERICA rice varieties in Cote d'Ivoire»*, The Development Economics

[13] **Diagne, A. et Demont, M. (2007).** *«Taking a new look at empirical models of adoption: average treatment effect estimation of adoption rates and their determinants»*. Agricultural Economics 37 (2007) 201–210; 10p

[14] **Dontsop-Nguezet, P.M, A. Diagne, V.O.Okoruwa and V.E.T. Ojehomon (2011).** *«Impact of Improved Rice Technology Adoption (NERICA varieties) on Income and Poverty among Rice Farming Households in Nigeria: A Local Average Treatment Effect (LATE) Approach»*. Quarterly Journal of International Agriculture 50(2011).

[15] **Heckman, J. (1997).** *«Instrumental variables: a study of the implicit assumptions underlying one widely used Estimator for Program Evaluations»*. Journal of Human Resources, N°32; pp 441-462.

[16] **Heckman, J. et Vytlacil, E. (2005),** Structural Equations, Treatment Effects and Econometric Policy Evaluation. Econometrica 73

[18] **Heckman, J. J., Urzua, S., and Vytlacil, E. (2006).** Understanding instrumental variables in models with essential heterogeneity. The Review of Economics and Statistics, 88(3):389{432.

[19] **Heckman, J. (2010).** «Building Bridges between Structural and Program Evaluation Approaches to Evaluating Policy." *Journal of Economic Literature* 48(2), 356–398.

[20] **Holland, P. D. (1986).** *«Statistics and Causal Inference»*, Journal of the American Statistical Association, **81**, 945–960.

[21] **Hossain S, Alamgir M and Croach R (1992)** *«Patterns and Determinants of Adoption of Farm Practices: Some evidence from Bangladesh. Agric. Systems»*.

[22] **INRAB, (1996).** *«Plan directeur de la recherche agricole du Bénin»*. INRAB, Cotonou, Bénin ; p29

[23] **Institut National de la Statistique (2013),** *« Annuaire statistique »*, CAMEROUN.

[24] **Institut National de la Statistique (2008), «** *Tendances, profil et déterminants de la pauvreté au Cameroun entre 2001-2007. Rapport préliminaire de l'ECAM III* », REPUBLIQUE DU CAMEROUN.

[25] **Kijina, Y., Sserunkuuma, D, (2008) «***The adoption of NERICA rice varieties at the initial stage of the diffusion process in Uganda»*

[26] **Malaa, D. et NZODJO, P., (2011),** *« Strengthening the availability and access to Rice Statistics for Sub-Saharan Africa ; a contribution to the Emergency Rice initiative »*

[27] **Malaa, D., Agbor N.N et Mbemya, S.M. (2013). «** Improve rice variety and food security of rice farming household in Cameroon **»,** 3ème Congrès du riz en Afrique

[28] **MINEPAT, (2012),** « *Sécurité alimentaire* : *l'urgence de dynamiser la production de riz* » BIMENSUELLE ECONOMIQUE, première quinzaine de mars 2012

[29] **Patrice Y. ADEGBOLA Aminou AROUNA Souleimane A. ADEKAMBI (2011),** *« Impact de l'adoption des impact de l'adoption des variétés améliorées de maïs et de niébé au Benin »*, rapport d'étude