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Gender differential Impact of NERICA adoption on Total Factor Productivity: evidence from Benin Republic

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Abstract.

This study examines the relationship between adoption of NERICA varieties and the Total Factor Productivity among men and women. Data were collected from 342 rice farmers randomly selected in the central and northwest Benin. Total Factor Productivity was estimated using a Cobb-Douglass production function. The impact was estimated using the Local Average Treatment Effect. Results show that the adoption of NERICA variety improves Total Factor Productivity of potential adopters and it benefits men and women differently. Potential women adopters got a higher gain on their Total Factor Productivity than men. This finding suggests that targeting women with NERICA increase significantly rice productivity more than the case where men are targeted.

Keywords: Impact assessment, NERICA Rice adoption, Total Factor Productivity, Gender, Benin

JEL codes: *C13*, C36, *O33*, *Q12*, *Q16*, R20

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1. Introduction

Worldwide, women share two third of working hours, produce half of the food, earn only 10% of total income, own less than 2% of the land and receive less than 5% of bank loans (HCCI, 2006). They are therefore 70% of those with less than one (1) dollar per day and they not participate to making decisions, both in their household and in the community (Sollie, 2005). The precariousness of women limits their contribution to national wealth and hinders the achievement of the third Millennium Development Goal of gender equality and women empowerment. Thus, several institutions and projects are increasingly focused on gender and development aspect in their activities, particularly in rural areas. Indeed, in farm households, men and women have different perceptions of technological packages (Kokki, 1997). Women not only perceive technology in terms of its workability and alimentary aspect but also consider aspects of drudgery, while men are mostly concerned with financial viability. Therefore any change in farm systems affects men and women differently (AWID, 2004), Jacoby (1991); Von Braun et al (1989).Thus, targeting women in agricultural technologies dissemination can have a greater impact on poverty reduction and food security than targeting men (IFPRI, 2005). Besides, women play a vital role in agricultural production in general, in rice production in particular (FAO, 2006; CTA, 2002; Quisumbing, 1996).

In 2010, the per capita consumption in rice in Benin ranged from 42 to 85 kg in rural area and from 33 to98 kg in urban areas (MAEP/SNDR, 2010). This demand exceeds the domestic per capita rice production and the gap between the consumption and the production is growing. To meet this growing demand, NERICA varieties have been introduced in Benin. That are improved varieties with higher yield and the objective of this introduction is to increase rice production and improve living conditions of farmers.

It must be remember that productivity growth is the foundation of improving income and welfare (Ouellette &Lasserre, 1985; Englander & Gurney, 1994; Giorno et al., 1995; OECD, 2001; Schreyer &Pilat, 2001). The adoption of NERICA rice varieties cannot improve the living conditions of adopters without significantly increasing the productivity of production factors. This study focuses on the relationship between adoption of NERICA rice varieties and the Total Factor Productivity and addresses two key questions: (i) what is the impact of NERICA adoption on TFP? and (ii) Is the impact of NERICA adoption on TFP the same for men and women?

2. Materials and methods

2.1. Study area, sampling design and data collection

The research was conducted in the Republic of Benin. It is located in West Africa between 6°30 and 12° North latitude and 1° and 3°40 East longitude. The study area is a set of five districts: Dassa-zoumè, Glazoué (Central Benin) and Tanguieta, Matéri, Cobly (North-West Benin) (figure 1). This area has been chosen because of its importance in rice production in Benin. Also, these are the areas where NERICA varieties were disseminated in Benin. The climate of the area is tropical and humid, Guinean Savanna type with a bimodal rainfall pattern. The average annual rainfall ranges between 773 and 1268 mm with unequal distribution throughout the year. The soils are tropical ferruginous with variable characteristics that are appropriate for rice production.

A total of 342 rice producers were selected in the study area. Respondents were selected using a two-stage sampling technique. First, 32 villages, most active in NERICA production were selected with the support of extension services. In the second stage, 10 rice producers (6 females and 4 males) were randomly sampled in each village. The selection is based on the list of all rice producers in the village. This list was provided by extension services. More women were selected compared to men because since the NERICA dissemination phase, they were prioritized.

Data were collected for the cropping year 2008-2009 in two levels: village level and household level. The village level data were carried out with focus group discussion. The household level data were collected with a structured questionnaire designed and tested previously.

2.2. Total Factor Productivity (TFP)

In the literature, several methods allow estimating productivity. From the methodological point of view, we can group into two: non parametric approaches and parametric approaches (Giorno et al.,1995 ; Schreyer and Pilat, 2001; OECD, 2011). The non-parametric methods include the various techniques of numerical indices. These include among others the Fisher's index, Törnqvist's index, Bennet-Bowley's index, Malmquist's index and Luenberger's index. Parametric methods are based on observations of output and volume factors. This theory goes back to the work of Solow (1957).

Hulten (2001) and OCDE (2001) note that there is no reason to consider the parametric methods and non-parametric methods as conflicting. Overall, the econometric approaches are suitable for individual studies. Their potential wealth and the opportunity to test their parameter make it a valuable supplement to non-parametric methods, which are the recommended tool for periodic statistical productivity.

Consider a Cobb-Douglass production function:

$$prod_{it} = A_{it} area_{it}^{\beta 1} lab_{it}^{\beta 2} seed_{it}^{\beta 3} fer_{it}^{\beta 4} pest_{it}^{\beta 5} cap_{it}^{\beta 6} e^{\varepsilon_{it}} \qquad (1)$$

$$A_{it} \; and \; \beta_i > 0$$

Where $prod_{it}$ represents total paddy rice production in Kg of household i in period t. *areait ; labit ; seedit ; ferit ; pesit* and cap_{it} are input of land area, labor, seed, fertilizer, pesticide and capital respectively. A_{it} is Hicks's neutral efficiency level of household i in period t. It is the Total Factor Productivity (OCDE, 2001; Lispey and Carlaw, 2001; Diewert and Nakamura, 2002 ; Zaimi, 2002 ; Van Beveren, 2010).

Taking logarithm of (1) it results a linear production function,

$$PROD_{it} = \beta_0 + \beta_1 AREA_{it} + \beta_2 LAB_{it} + \beta_3 SEED_{it} + \beta_4 FERT_{it} + \beta_5 PEST_{it} + \beta_6 CAP_{it} + \varepsilon_{it}$$
(2)

In equation 2, the upper-case letters denote the logarithms of production and production factors and

$$\ln(A_{it}) = \beta_0 + \varepsilon_{it} \qquad (3)$$

β_0 measures the mean efficiency level across household and over time. ε_{it} is the deviation from the mean efficiency level of household i in period t. Therefore, the Total Factor Productivity of household i in period t is:

$$TFP_{it} = e^{(\beta_0 + \varepsilon_{it})} \qquad (4)$$

It expresses the share of production which is not determined by the production factors. This way of calculating productivity is known as the "Solow residual". By definition, Solow residual refers to growth not explained by the accumulation of production factors. The main explanation of the Solow residual is technical progress.

2.3. Theoretical framework of impact assessment

The assessment of the impact of adoption of NERICA varieties on Total Factor Productivity is based on the agricultural household model framework. Any agricultural household make its production and consumption choices to maximize the utility of consumption subject to some constraints on available resources and technologies.[1] We assume that rice farming households choose among *J* rice varieties (including NERICA and other traditional and improved varieties) to produce rice and maximize the utility of consumption of food and non-food items subject to a budget constraint:

$$\max_{(c,b_1,\ldots,b_J)\in R^M} U(c,z_u)$$
$$s.t. \quad p^c \cdot c = m + p_\tau \tau + \sum_{j=1}^{J} p_j^r f(b_j, z_j) - \sum_{k=1}^{K}\sum_{j=1}^{J} p_{jk} b_{jk} \qquad \textbf{(1)}$$

where $U(.)$ is the agricultural household's utility function (here utility), R^M is the Euclidean space of dimension *M*, *c* is the consumption vector of food (including rice) and non-food commodities (including leisure) with p^c the corresponding price vector, z_u is a vector of household socio-demographic variables that affect utility, *m* is the income available to the household prior to making its production choices (including transfer and rental income on fixed owned factors), τ is the household total labor endowment valued at the market wage rate p_τ, p_j^r is the price of rice produced using variety *j*, *f* is a production function, $b_j = (b_{jk})_{k=1,\ldots,K}$ with b_{jk} being the quantity of the variable input *k* used in producing rice using variety *j* with p_{jk} the corresponding unit price and with seed corresponding to *k*=1 (i.e. b_{j1} stands for the quantity of seed of variety *j* and p_{j1} its unit price) and z_j is a vector of exo technological and environmental variables conditioning the production of rice using variety *j* (variety characteristics, plot soil characteristics, weather, etc.). Also included in the z_j vector are the quantities of the fixed inputs used in the production of rice with variety *j*.

The left hand side of the budget constraint equality in equation (1) is the total household consumption expenditure. The right hand side contains in its last two terms the household net crop income, which is the total value of production minus total variable cost. It is important to note that the household net crop income does not include total fixed costs (i.e. the total cost of the fixed inputs) and is therefore different from the household profit. The assumption that the household grows only rice is for simplicity and notational ease only and is without loss of generality as the

[1] See, for example, Just, Hueth and Schmitz (2004), Chapter 7, appendix 7G for a very general formulation of the Agricultural household model.

above formulation can be easily extended to include other crops and non-farm income generating activities by simply adding to b_{jk} , z_j and p_k another subscript for crop and non-farm income generating activities and adding the relevant terms for the different crops in the budget constraints. Therefore we will view the right hand side of the budget constraint as the total household net disposable income in coherence with the empirical analysis.

To further simplify the notation we will put $b = (b_1, ...b_J) = (b_{jk})_{k=1,..,K;\, j=1,...,J}$ $a = (b, c)$, $p^r = (p^r_j)_{j=1,...,J}$, $p^I = (p_{jk})_{k=1,..,K;\, j=1,...,J}$, $z^I = (z_j)_{j=1,...,J}$, $z = (z^u, z^I, m, \tau, p^c, p^r, p^I)$ and

$S\ (z)\ = \{(b, c) \in R^M : p^c \cdot c = m + p_\tau \tau + \sum_{j=1}^{J} p^r_j f(b_j, z_j)) - \sum_{k=1}^{K} \sum_{j=1}^{J} p_{jk} b_{jk}\}$. With these notations, the agricultural household optimal vector of inputs and consumption choices $a^* = (b^*, c^*)$, solution of the optimization problem (1), is a function of the conditioning vector *z*:

$$a^* \equiv \delta(z) = \underset{a \in S(z)}{\arg\max} \{U(c, z)\} \quad \textbf{(2)}$$

The vector *z* is usually called a parameter in the general optimization literature (see, for example, Topkis, 1998 and Milgrom *et al.*, 1994). But here we will call it a conditioning variable to differentiate it with what we call a parameter in the econometric section below. What is important here is that *z* is a vector of non-choice variables over which the household does not maximize. These non-choice variables may be exogenously given to the household (as in the case of age, gender, prices, rainfall and other market, community infrastructure and environmental variables) or they may be variables whose values are directly or indirectly determined (even partially) by some of the household choice variables in the vector *a* (as in the case of health and nutritional status, soil fertility, etc..). The subset of z variables that fall in the latter case are said to be *endogenously* determined even if their values still depend on the values of other variables exogenously given to the household. Thus, for the purpose of the analysis below we can distinguish between two types of variables making up the z vector: 1) the subset of *z* variables that are exogenously given to the household which we define as *exogenous* variables and which is noted by z_x and 2) the subset of *z* variables that are endogenously determined which we define as endogenous variables and which is noted by z_e . The choice variables in the vector *a* are also trivially defined to be endogenous. Hence, in summary, we have $z = (z_x, z_e)$ with z_x being the set of exogenous variables and (a, z_e) being the set of endogenous variables.

As we define the adoption of a variety by the use of its seed to produce rice, in what follows we will use the generic form of the household maximization problem (2) to make explicit how the rice output and factor demand and productivity outcomes depend directly on the quantity of NERICA seed used and indirectly through the dependence of its optimal choices of the quantities for the other input and consumption commodities on that same quantity of NERICA seed used. To proceed, first let $a_{\dot{N}} = b_{\dot{N}1}$ stands for the quantity of NERICA seed choice variable and let $a_{(\dot{N})}$ be the vector of other inputs and consumption variables (i.e. a without its component $a_{\dot{N}}$). We will also use a similar notation for the corresponding optimal input and consumption choice functions (i.e. the demand functions): $a^*_{\dot{N}} = \delta_{\dot{N}}(z)$ and $a^*_{(\dot{N})} = \delta_{(\dot{N})}(z)$. Second, we note that when the quantity of NERICA seed used by the household is fixed exogenously at some level $a_{\dot{N}}$ (not necessarily equal to $a^*_{\dot{N}}$), then the optimal demand for the other inputs and consumption bundles $a^*_{(\dot{N})}$ will in general be function of $a_{\dot{N}}$ in addition to the conditioning vector z. Consequently, we can write the expression of the factor productivity for the k^{th} input other than seed (k=2,..,K) as a function of $a_{\dot{N}}$ and z are given similarly:

$$\psi^*_k = \psi_k(a_{\dot{N}}, z) = \frac{q^*}{b^*_k} = \frac{q(a_{\dot{N}}, b^*_{(\dot{N})}, z)}{b^*_k} \quad \textbf{(3)}$$

Where $b^*_k = \sum_{j=1}^{J} b^*_{jk}$ and $q^* \equiv q(a_{\dot{N}}, b^*_{(\dot{N})}, z) = \sum_{j=1}^{J} f(a_{\dot{N}}, b^*_{(\dot{N})}, z)$ are respectively the total optimal quantity of input k used in rice production and the total quantity of rice produced when the quantity of NERCA seed used is rice production is fixed at the value $a_{\dot{N}}$.

In the above functions for the optimal choices and the outcomes in equation (3), we have kept the z argument to be same. But this is only for simplicity in the notation. In general, the z argument is different for each function and is made of a subset of the overall vector z defined earlier, with possibly the different subsets having common elements. In what follows, we use the variable y and the function g as generic notations for the outcome variables and the functions in the left-hand sides and right hand sides of equation (3) and the output and factor demand expressions, respectively. In other words, the outcome equation above will be represented by the following generic outcome equation:

$$y = g(a_{\dot{N}}, z) \quad \textbf{(4)}$$

By definition, adoption of NERICA takes place when the value of the variable $a_{\dot{N}}$ changes from zero to some strictly positive value $a_{\dot{N}}^1 > 0$. Hence, the causal effect of NERICA adoption on any outcome $y = g(a_{\dot{N}}, z)$ is measured by the difference $g(a_{\dot{N}}^1, z) - g(0, z)$.

2.4. Analytical framework of impact assessment

To assess the impact of adoption of NERICA varieties on Total Factor Productivity, the potential outcomes framework is used in a statistically robust fashion with a minimal set of assumptions compared to other available methods such as the structural econometric approach (Diagne *et al.*, 2013; Diagne, 2006). The potential outcome framework is increasingly becoming the standard for assessing the impact of programs or policy interventions (see, for example, Imbens and Wooldridge, 2009 for a review).

Under the potential outcome framework, each population unit with an observed outcome *y* has ex-ante two potential outcomes: an outcome when receiving a treatment and an outcome when not receiving a treatment. Here the treatment is adoption of at least an NERICA variety *j*. Let D_j be the binary variable indicating the adoption of NERICA variety *j* with $D_j = 1$ indicating adoption (i.e. $d_j = d_j^1$) and $D_j = 0$ indicating non adoption by a population unit (i.e. $d_j = 0$). Also, let $y_1 \equiv g(d_j^1, z)$ and $y_0 \equiv g(0, z)$ be the potential outcomes corresponding to the two mutually exclusive state of adoption and non-adoption, respectively. For any population unit, the causal effect of adopting an improved variety on the outcome y is defined as: $y_1 - y_0$. However, the two potential outcomes cannot be observed at the same time. With the observed outcome *y* given by $y = D_j y_1 + (1 - D_j) y_0$, we can only observe either y_1 or y_0 depending on whether D_j equal 1 or 0., thus making it impossible to measure $y_1 - y_0$ for any population unit. However, the average causal effect of adoption within a specific population can be determined: $E(y_1 - y_0)$, with E as the mathematical expectation. Such a population parameter is called the average treatment effect (ATE) in the literature (Heckman and Vytlacyl, 2005; Wooldridge, 2002; Heckman, 1996; Angrist *et al.*, 1996). One can also estimate the mean effect of adoption on the sub-population of adopters: $E(y_1 - y_0 \mid D_j = 1)$, which is called the average treatment effect on the treated and is usually denoted by ATT. The average treatment effect on the *untreated*: $E(y_1 - y_0 \mid D_j = 0)$ denoted by ATU is also another population parameter that can be defined and estimated. However, in the case of an endogenous treatment like what we have here with adoption, ATE, ATT and ATU are often not identified and therefore cannot be estimated (Imbens and Wooldridge, 2009). In this case, one can identify the *local average treatment effect* (LATE) introduced by Imbens and Angrist, 1994. The LATE assumes the existence of at least one instrumental variable *V* that explains treatment status but is redundant in explaining the outcomes and is defined as the the mean impact in the subpopulation of "compliers" who are defined as the population units who were induced to change treatment status by the instrument *v*: *LATE*= $E(y_1 - y_0 \mid C(v))$, where $C(v)$ is the complier subpopulation with respect to (Heckman and Vytlacil, 2005; Imbens, 2004; Abadie, 2003; Imbens and Angrist, 1994). We should note that in the case where the population unit of impact analysis is the village and *y* is the village poverty headcount index, then ATE is the mean reduction in the percentage of poor people in the village. Similarly for ATT, ATU and LATE.

The population means impact parameters ATE, ATT, ATU and LATE can generally be identified under some statistical independence assumptions between the population distributions of the treatment status variable D_j and the two potential outcomes $y_1 = g(d_j^1, z)$ and $y_0 = g(0, z)$ (possibly conditional on some observed component z' of z), without making any functional form assumption about the (structural) relationship $y = g(d, z)$. Two alternative statistical independence assumptions are made to identify ATE, ATT and ATU (see, for example Imbens and Wooldrige, 2009).[2] The *unconditional independence* assumption and the *conditional independence* assumption also called "selection on observables".

When one of the two independence assumptions cannot be made then we are under the case of "selection on unobservable" and ATE, ATT and ATU cannot be identified without making additional functional form assumptions (Heckman and Vytlacil, 2005). Under all circumstances (unconditional independence, "selection on observables" or selection on unobservable") the LATE parameter can be identified using instrumental variables methods and estimated by 1) the wald estimator, 2 Stage least squares estimators or 3) by use of the Abadie (2003) local average response function (LARF) and weighing least squares or maximum likelihood estimator (Angrist and Pischke, 2009; Imbens and Angrist, 1994; Abadie, 2003). Depending on the outcome in question, valid instruments can be found among variables in the observed component z using exclusion restrictions implied by the Agricultural household maximization and knowledge of the institutional context which the NERICA varieties were disseminated and made accessible to farmers.

In this paper, since the adoption variable is endogenous, the LATE parameter is estimated with the

[2] These independence assumptions are accompanied by some regularity conditions on the support of the conditional and unconditional distribution of D_j (see Imbens and Wooldridge, 2009)

combined variable of awareness and access to seed of a NERICA as instrumental variable. With this non-random instrumental variable in the target population, the OLS with interaction local average response function (LARF) is used to estimate the LATE parameter for the impact of NERICA varieties adoption Total Factor Productivity.

3. Results and discussions

3.1. Descriptive statistics by treatment status and test of mean difference

Table 1 presents the socio-demographic characteristics of respondents and their households. The results indicate that 64.6% of respondents are female and 35.4% are male. Only 44.7% of rice farmers including 58.2% of female farmers have adopted NERICA. It follows that female farmers have more adopted NERICA than male farmers. The average age of adopters is 47 years old while the non-adopters are 46 years old. There is no statistical difference between adoption status or between farmers' gender. We note a significant difference between NERCA adopters and NERICA non-adopters regarding education level. Adopters have in average, 2 years of formal education while the non-adopters have just one year. It follows that NERICA adopters are better educated than non-adopters. The analysis across gender shows that men have higher educational level than women. In regards the farmers' marital status, 81.6% of the respondents are married. The average size of the households is 6 persons and significantly different not only according to the gender of farmers, but also to NERICA adoption status. The households headed by men have higher size than those headed by women and the households headed by adopters have higher size than those headed by the non-adopters. As regards the economic activities, agriculture is the principal occupational activity of 95% of surveyed farmers. Rice is one the major crops grown and is an important source of income for the producers. It represents 44% of their annual agricultural income and it is an important component of their diet. About to rice farmers, 52.9% of rice farmers were trained in agriculture. The proportion of men trained in agriculture is higher than women. It is the same when considering the adoption status. 76.9% of producers are belonging to an association and 43.27% of them are in contact with the national extension services. Being in contact with the agricultural extension services is supposed to facilitate a better awareness and access to agricultural technologies. It should be noted that there are more men belonging to an association and being in contact with the national extension service than women.

Table 2 presents a description of the explanatory variables included in the model. Analysis of the table shows that the NERICA are known by 69% of respondents, 60% have access to seeds and

45% have adopted. The type of ecology use by producers is another explanatory variable included in the model. Lowland is used 89% of respondents. Sex and age of the producer is already presented in socio-demographic characteristics. However, note that the youngest farmer is 20 years old and the oldest is 83 years. 57% of farmers were trained in agriculture. This allows them to increase their technical and managerial capacities.

3.2. Input utilization level

Table 3 compares input use levels between adopters and non-adopters of NERICA and between men and women. Significant differences are observed in land cultivated and labor use between adopters and non-adopters. This reveals that NERICA adopters use more land and less labor than the non-adopters. There is no significant difference between these two categories in terms of seeds, fertilizers and weed killer use. As regards the comparison between female and male farmers, one can note that male farmers are using more land and less labor than female farmers. This is showing that land issue is still a problem between male and female farmers. In the cultural system of Benin women do not have right to land and this is affecting their performance in agricultural activities because the land is the most used input in agriculture in Benin (Kokoye et al. 2013).

3.3. Impact on factors productivity using mean difference

The average productivity of the main production factors is presented in Table 4. The results shows that the average rice yield in the sample is 1889 kg / ha. The adopters get 1905 kg / ha against 1876 kg / ha for non-adopters, a difference of 29 kg / ha which is not significant. This can be explained by the fact that non-adopters of NERICA are not necessarily exclusive users of traditional varieties. The farmer who did not adopt the NERICA use other high-yielding improved varieties. Its yield may be more or less equal to that of the adopters. However, it should be noted that the yield is lower than the yields of improved varieties. On average, the yield of NERICA is about 3 tons and that of other improved varieties is 2.5 tons au Benin (Adomou et al., 2006). This is due to the fact that farmers do not renew their seed. They take the seed in the previous harvest. The trend of yield is the same when comparing the average yield of men than women. Men get 1969 kg / ha and the seconds 1846 kg / ha. The difference is not significant. Like the yield, seeds productivity and fertilizers productivity are statistically equal follow adoption’s status and farmer’s sex. Only labor productivity presents a statistical difference. The adopters get 20.4kg of paddy rice per man-day against 11.37kg /man-day for non-adopters. It follows, then a difference of 9.04kg /man-day which is significant at 1%. In other words, for a man-day use, the adopters are getting 9kg of paddy rice more than non-adopters.

3.4. Impact of NERICA adoption on Total Factor Productivity

Table 5 presents the results of LARF OLS regression model on Total Factor Productivity. The model is globally significant at 1%. 56.7% of the variation of the explanatory variables included in the model explains the variation of the TFP. Analysis of this table reveals four determinant factors of TFP that are: *NERICA adoption, lowland ecology, gender of farmer and agriculture training.* The positive and significant coefficient of the variable adoption of NERICA shows that NERICA adoption improves TFP. The influence of ecology is due to the elevated potential rice yield of lowland. On the other hand influence of other factors would explain itself by the capacity of management of the producers. As regards the interaction terms, *lowland ecology*, *gender of farmer* and *training in agriculture* positively affecting the Total Factor Productivity.

Table 6 presents the values of Local Average treatment Effect (LATE) for the whole sample, male farmers and female farmers. The LATE value is positive and statistically different from zero for all the categories, we deduce that NERICA adoption has a positive impact on Total Factor Productivity. The value of LATE for the whole sample reveals that Total Factor Productivity increase in average of 10.7 within the NERICA rice adopter. As regards the comparison across gender, we note that the additional TFP is higher within female farmers than within male farmers. Potential women adopters got 13.2 while potential men adopters obtained 6.1. This suggests that female rice farmers are gaining more from NERICA varieties adoption than male rice farmers. The findings suggest that targeting women with NERICA increase significantly productivity more than if the NERICA are targeted men.

These results are contrary to those of Kinkingninhoun et al. (2008) who studied Gender Discrimination and Its Impact on Income, productivity, and technical efficiency in Benin. They concluded that productivity is higher in men than in women because women have little access to inputs. It should however be noted that they conducted their study in scheme of koussin-lélé. This is the lowland rice that is practiced in this area and the conditions of access to resources are different from that of our study area. In addition, the data of kinkingninhoun et al. (2008) were collected in August 2004 and at that time, the NERICA rice varieties not yet introduced in the scheme of koussin-lele. Unlike kinkingninhoun et al. (2008), Adekambi et al. (2009) and Diagne et al. (2011)have shown that the adoption of NERICA rice varieties has a higher impact on performance, income and poverty reduction in women than in men. They assumed that this improvement is due to an increase in productivity. This study therefore confirms this hypothesis. We can now say the adoption of NERICA rice varieties improves the Total Factor Productivity, which has a positive impact on income and living conditions of farmers.

4. Conclusion and recommendations

The ultimate goal of the introduction of NERICA varieties in Benin is to increase production and the living conditions of farmers. However, the NERICA rice varieties cannot improve the living conditions of farmers without significantly increases the Total Factor Productivity (TFP). That is why this study is assessing the impact of NERICA varieties adoption on TFP. It came out that NERICA adoption have a positive and significant impact on farmers' TFP. This reveals that NERICA could really enhance farmers' TFP and therefore farmers' household welfare if they were widely promoted, disseminated and adopted by African rice farmers, and if they are cultivated in the appropriate conditions. The study had also brought out that the impact of NERICA adoption was higher within female farmers than within male farmers. This can be explained by the fact that, the female farmers with low income from their marginal land and resources were more keen to adopt the new varieties. The findings reveal the importance to check for the heterogeneity of impacts in impact assessment studies for group-targeted policy implications. It suggests that targeting women with NERICA increase significantly rice productivity more, than if the NERICA are targeted men. Given the importance of women in African rural households, it is hoped that the improved productivity has positive outcomes on children and the whole household.

Tables and Figures

Table 1 : Farmers socioeconomic characteristics by gender and adoption status

	Male			**Female**			**Total**		
	Adopter	**Non-adopter**	**All**	**Adopter**	**Non-adopter**	**All**	**Adopter**	**Non-adopter**	**All**
Number of observation	64	57	121	89	132	221	153	189	342
Proportion of farmers (%)	52.9	47.1	35.4	40.3	59.7	64.6	44.7	55.3	100
Age (years)	45	49	47	46	45	46	46	46	46
Household size (number of person)	7	6	7	6	5	5	6	5	6
Marital status (% of married)	96.9	96.5	96.7	68.2	80.9	73.3	87.6	76.7	81.6
Access to Nerica varieties (%)	100	38.6***	71.1	100	34.8***	61.1	100	36***	64.6
Education (Number of years at school without repetition)	3	3	3	1	1***	1	2	1***	2
Agriculture as major activity (%)	96.9	100	98.35	95.5	94.7	95.5	96.1	96.3	96.2
Having mobile phone (%)	64.1	40.3***	52.9	39.3	26.5**	31.7	49.7	30.7***	39.2
Watching TV (%)	23.4	8.8**	16.5	18	9.1**	12.7	20.3	9***	14.0
Listening radio (%)	87.5	75.4*	81.8	62.9	53.0	57.0	73.2	59.8***	65.8
Receiving agricultural training (%)	71.9	54.4**	63.6	60.7	37.9***	47.1	65.4	42.9***	52.9
Practicing upland (%)	50	8.8***	30.6	39.3	7.6***	20.4	43.8	7.9***	24
Practicing lowland (%)	85.9	93	89.3	86.5	90.1	88.7	86.3	91	88.9
Membership in association (%)	90.6	70.0***	81	79.8	71.2	74.7	84.3	70.9***	76.9
Contact with CeRPA (%)	62.5	40.3**	52.1	55.0	27.3***	38.5	58.2	31.2***	43.3

*Legend: * significatif à 10%; ** significatif à 5% and *** significatif a 1%.*

Table 2: Description of the variables introduced in the models

Variables	Average	Stand. Dev.	Mini.	Maxi.
Awarness of NERICA	0.69	0.46	0	1
Access to NERICA seeds	0.60	0.49	0	1
Being in lowland ecology	0.89	0.31	0	1
Female sex	0.35	0.48	0	1
Receiving training in agriculture	0.57	0.50	0	1
Age of farmers	46.55	11.90	20	83
Education level	1.53	2.81	0	13
Household size	5.80	2.70	1	19
Contact with rice extension services	0.43	0.50	0	1
Household income of last year (FCFA)	3783357	6242324	0	9300000
Living in central region of Benin	0.54	0.50	0	1

Table 3: Inputs utilization level for all improved varieties and NERICA from male and female farmers.

Average of:	Men *n=121*	Women *n=221*	Adopters *n=153*	Non-adopters *n=189*	All *n=342*
Land area (ha)	0.95 (0.09)***	0.54 (0.05)	0.96 (0.09)***	0.46 (0.03)	0.68 (0.05)
Seeds (kg/ha)	61.83 (2.39)	60.78 (2.37)	58.32 (2.93)	65.78 (2.37)	63.25 (1.53)
Fertilizer (kg/ha)	275.74 (40.23)	220.51 (20.44)	235.54 (31.22)	218.10 (24.39)	225.90 (19.39)
Pesticides (L/ha)	1.05 (0.83)	1.41 (0.80)	1.05 (0.66)	1.47 (0.93)	1.28 (0.59)
Labor (man day/ha)	213.72 (25.85)***	339.55 (26.27)	199.16 (17.28)***	372.64 (31.39)	295.03 (19.53)

Robust standard errors in parenthesis

****=Significant at 1%, **= significant at 5%, *=significant at 10%.*

Table 4: Average productivity of factors

Input	**Men** ***n=121***	**Women** ***n=221***	**Adopters** ***n=153***	**Non-adopters** ***n=189***	**All** ***n=342***
Yield(Kg/ha)	1969..2 (99.01)	1845..51 (77.85)	1905.42 (92.67)	1876.20 (81.91)	1889.27 (61.29)
Seeds productivity (kg of paddy/Kg of seed)	39.07 (2.23)	35.59 (1.77)	37.04 (2.06)	36.64 (1.89)	36.82 (1.39)
Fertilizer productivity (Kg of paddy/Kg of seed)	10.21 (0.89)	16.30 (4.24)	13.78 (1.72)	14.47 (4.80)	14.16 (2.76)
Labor productivity (Kg of paddy/Man-day)	22.30 (4.19)	8.05*** (1.59)	20.41*** (2.02)	11.37 (1.02)	15.42 (1.09)
Total Factor Productivity	108.81 (4.85)	97.96 (4.21)	104.63 (4.79)	99.51 (4.36)	101.80 (3.22)

Robust standard errors in parenthesis

****=Significant at 1%, **= significant at 5%, *=significant at 10%.*

<u>Table 5:</u> Results of LARF OLS regression model on Total Factor Productivity

Variables	Coefficient
NERICA adoption dummy	164.003*** (23.61)
Lowland ecology dummy	38.95*** (14.82)
Gender of famer (female) dummy	30.49*** (6.49)
Receiving training in agriculture dummy	40.74*** (5.98)
Age of farmers	-0.31 (0.26)
Lowland ecology_adoption	-39.80** (16.31)
Gender of famer_adoption	0.22*** (8.39)
Receiving training in agriculture_adoption	-64.10*** (8.06)
Age of farmer_adoption	-1.77 (0.36)
Constant	25.44 (19.87)
Number of observation	173
F(9 ;163)	23.74
Prob> F	0.0000
R-squared	0.5672
Adj R-squared	0.5433
Root MSE	25.025

Robust standard errors in parenthesis

****=Significant at 1%, **= significant at 5%, *=significant at 10%.*

<u>Table 6:</u> Local Average treatment effect (LATE) on Total Factor Productivity

	LATE
Male	6.01*** (1.63)
Female	13.16*** (2.19)
All	10.67*** (1.68)

Robust standard errors in parenthesis

****=Significant at 1%, **= significant at 5%, *=significant at 10%.*

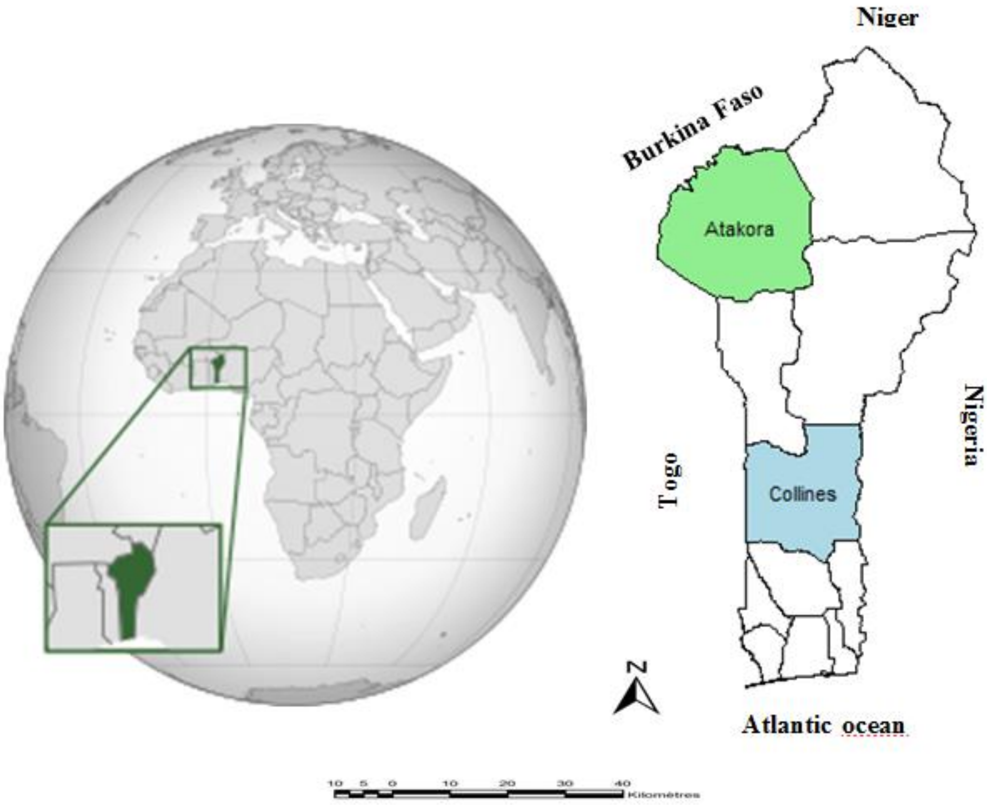

Figure 1: Study area

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