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Determinants of Rice Production in Hydro-Agricultural Layout in Niger

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Abstract

Rice production in Niger is characterized by low productivity gains combined with poor accessibility to mineral fertilizers, despite their important contribution to food security. However, the introduction of new irrigation techniques which has the advantages of reducing working time, with the fall in fertilizer prices, the application of the fallow technique, and the extension of cultivated areas should make it possible to achieve to good yields. It is in this context that this research aims to determine the major factors of rice cultivation. The methodological approach combines descriptive statistics and econometric analysis. A survey was carried out among 194 operators in the Kirkissoye and Saagiya sites and Saga. The analysis of the determinants of rice production has shown that accessibility to mineral fertilizers and area extensions are major determinants of the increase in rice production in the developed areas in Niger. A policy of food self-sufficiency in rice can be based on agricultural intensification and the development of new irrigated areas.

Keywords: Production; Productivity; Mineral Fertilizers; Area; Rice

Abbreviations: DP: Director of Perimeter; RDS: Rural Development Strategy; OLS: Ordinary Least Squares.

Introduction

During the last decades, the use of modern inputs and the adoption of new technologies have been sufficient to revive agricultural production in the countries of sub-Saharan Africa. It is common to take as a reference the positive experiences of the Green Revolution in East Asia. Moreover, for years most African countries, especially sub-Saharan countries, the low growth of agricultural production observed, there are some years, was accompanied by population growth exponentially. As a result, there is an increasingly growing demand for food [1]. To ensure food security and reduce poverty, West African agriculture is expected to grow at a minimum rate of 4% per year or more than twice the rate achieved incomes previous decades [1]. Rice is now one of the cereals has most consumed in the world and becoming more food preferably African countries [2]. The demand for rice in West and Central Africa is growing by 6% per year [3]. This growth is higher all over the world. However, local rice production does not compensate for the consumption needs of this commodity [4]. This observation is valid for Niger, which nevertheless benefits from the natural potential that can enable it to ensure food security through local production [5]. Furthermore, the in growth of cereal production which is 2.5% in flagrant mismatch with high population growth [6]. This not only generated a strong extension of cultivated land and the fragilization of the ecosystem and the environment in general, but also caused a break with traditional fallow systems. Current agricultural productivity does not allow the medium- and long-term satisfaction of food needs, with a constant growth of the population.

Faced with such a demographic and context to the climatic constraints rather drastic (dry climate and decreasing trend in rainfall over the last thirty years), the E state of Niger has developed several policies and strategies. Thus, we have, among others, the rural development strategy (SDR) which is the only reference framework in terms of economic and social policy in the rural sector, the national strategy for the development of irrigation and the collection of water from runoff (SNDI / CE) and recently the national rice development strategy (SNDR). The Agriculture Niger is a food subsistence agriculture dominated by rain fed cereal including millet and sorghum alone occupy nearly 70% of the area planted annually. Irrigated agriculture contributes about 20% of rice agricultural production of about 135,000 tons [7].

In Niger, the has rice is mainly practiced in the Niger River valley, in the regions of Niamey, Tillabery and Dosso. In the Diffa region, there are also areas cultivated with rice. It is estimated that local rice accounts for only 1.7% of the turnover of the primary agricultural production sector and only 2.3% of the average volume of cereals produced annually. Rice is the third after the cereal millet and sorghum as the level of the area used as the production. The upland rice production Fashion Most e Niger, practiced on new clearings to get beyond natural fertility the soil for more than two years. To cope with declining fertility that follows several solutions have been proposed are in particular:

- A mineral fertilizer which compensates for deficiencies nitrogen, phosphate and potassium [8]. This method, although effective is applied e in rice growing lowlands because of the high cost of chemicals [9].
- The African fertilization fallow improved legumes [10], compost, green manure, manure, droppings poultry and liquid manure [11]. These various techniques of organic fertilization have interesting possibilities that are not highlighted in the in upland rice.
- Of art cultivation techniques such as the association [12], crop rotation, and rotation [13].

Of all the above solutions, mineral fertilization remains essential [14]. However, except for occasional agricultural projects through the s what s rice farmers receive free of are chemical fertilizers, few indexes for information on the use of storm tray Rice mineral fertilizer that is most common. Hence the following research question: what are the major determinants of rice production in irrigation schemes in Niger?

The agriculture Niger, especially rice cultivation encounter difficulty knowing good yields. For half the problems facing Nigerian agriculture, there is also including the lack of availability of fertilizers. Nowadays, CAIMA estimates that producers need 60,000 tons of fertilizer, but it has only been able to make 24,000 tons available to them [15]. Rice cultivation has fertilizer needs which are expressed in various forms; diffuse demand from individual farmers and concentrated demand from groups of farmers mainly on hydro-agricultural developments. Added to this, the supply delay in mineral fertilizers, the soil infertility, lack of some machines like the huller, the harvester to name it. All of these contribute to lower rice yields (CAIMA).

Niger must therefore increase the productivity of rice to meet the consumption needs of the population. Therefore, it is necessary to know the effects of mineral fertilizers and developed areas on rice production. Hence the specific questions:

- What is the effect of mineral fertilizers on rice production in ONAHA.
- What is the effect of the area sown on rice production in ONAHA.

The general objective of our study is to determine the major factors of rice cultivation in the perimeters of hydro-agricultural developments in Niger.
Specifically, it is:

- To analyze the effect of the use of mineral fertilizers on rice productivity.
- To determine the effect of area on rice production in ONAHA.

At the end of these specific objectives, we set the research hypotheses which will be verified following the study: and the main hypothesis.

Hypothesis 1: Mineral fertilizers help improve rice yield.

Hypothesis 2: The area has a positive effect on rice production.

The rest of the research revolves around 2 parts. The Premier is devoted to the methodological approach, the second presents the results and interpretation of the econometric model.

Methodology

Theoretical and Empirical Models of the Analysis of the Determinants of Rice Production

For the analysis, we use a classical production function model, modified by the integration of variables controlling soil quality and natural shocks. Changes in land and labor productivity can be viewed as the combination of two factors: the direct change due to the difference in the use of inputs and the indirect effects of soil quality and shocks Natural.

The value of rice farmers' output is a function of the amount of physical capital and labor used: y = f (K ,L)
where:
y: value (annual) of the rice farmer's production in kg.
K: quantity of physical capital used per hectare.
L: quantity of labor used per hectare in the municipality.

Here, following the methodology, we are careful to differentiate between adult and juvenile labor. The work of men and women is evaluated equally. On the other hand, the work of children under 14 is estimated at 50% of that of adults. Under the assumption that the returns to scale on the earth are constant, the Cobb Douglas function is written like this:

$$Y = AK\text{^}^{\alpha}\, L\text{^}^{\gamma}\, Z\text{^}^{\theta}$$

O ù is a coefficient representing all factors that affect the productivity of rice farmers other than the amount of capital and labor used.α et γ and are the elasticities of the value of output with respect to the amount of physical capital used and the amount of labor used respectively. Z is the vector of variables relating to household characteristics.

By resorting to linearization and the theoretical econometric model is:

$$\ln Y_i = \alpha_0 + \alpha \ln K_i + \beta \ln L_i + \theta \ln Z_i + \varepsilon_i \text{ for } i=1\ldots\ldots n$$

The dependent variable Y_i is the quantity of rice produced by household i,
K_i is the vector of the household explanatory variables relating to the capital factor.
L_i is the vector of the household explanatory variables relating to the labor factor.
Z_i is the vector of variables relating to household characteristics,
ε_i the vector of error terms, α_ithe constants and finally β et θthe vectors of the coefficients to be estimated.
The variables of interest in this model are: rice productivity, fertilizer subsidy and area sown.

Specifying the Model for Estimation

The functional form of the model is as follows:

$$\text{lnquatriz}_i = \alpha_i + \beta_1 \text{Lnsupemb}_i + \beta_2 \text{Lnrevmenag}_i + \beta_3 \text{typsem}_i + \beta_4 \text{utileng}_i + \theta_1 \text{ninst}_i + \theta_2 \text{ etamatri}_i + \theta_3 \text{taille}_i + \theta_4 \text{expchef}_i + \theta_5 \text{sexchef}_i + \theta_i \text{Agechef}_i + \varepsilon_i$$

Presentation of the Study Area and Analysis Data

Description of study areas: The investigation was carried out on three perimeters developed around Niamey. They are Saagiya, Saga and Kirkissoye. The Saagiya farm has been created in 1986 and covers 25 hectares of cultivated area. It is organized as a cooperative producing certified rice seeds and has 58 farmers. It is located 5km south-east of Niamey. Its main missions are: (i) to produce each cropping season on the 25 hectares of R1 seeds (certified first-generation seeds) of improved varieties capable of meeting the needs of around 6,500 hectares of paddy fields; (ii) carry out this seed production in collaboration with the seed farmers organized in cooperatives; (iii) organize and ensure the marketing of the seeds produced, and (iv) monitor collaboration with INRAN to maintain varietal purity.The Kirkissoye perimeter is one of the oldest on the banks of the Niger River. It was created in 1964 and covers an area of 96 ha, has 426 plots and 406 farmers. It is located southwest of Niamey. Its objectives (i) improve the living conditions of producers; (ii) new techniques for the development of rice fields; (iii) ensure good collaboration between cooperative and producers.

As for the irrigated perimeter of Saga, it was created in 1966 in the urban commune of Niamey. It is in a basin on the left bank of the Niger River at 10km from the south exit of Niamey on the road to Kollo. It was built on the southern edge of Saga village which he took the name. Its objectives are: (i) food self-sufficiency through the option of total water control; (ii) improving the living conditions of producers by increasing productivity while respecting the natural potential (water, soil) through its preservation and restoration; (iii) the development of other economic activities and the establishment of infrastructures for harmonious development; and (iv) the increase in the capacity of the populations to take charge of their own development. This section is devoted to the description of the survey areas, the data collection, the theocratical's model and empirical.

The collected data: The database s used in this study is that of the National Survey on the Living Conditions of Households and Agriculture (ECVM/A) of 2015. This database was designed by the National Institute of Statistics (INS) with the support of the World Bank. It contains multiple variables to absorb information on the daily life of rice farmers. This study was based on the different cities of Niger, but for our present report we were only interested in the city of Niamey more particularly on three sites: Kirkissoye, Saagiya , Saga. Through a very concise questionnaire, a field survey (cooperatives, farms) made it possible to reach the identified farms. The president of the cooperative and the Director of Perimeter (DP) were considered as facilitators in this study.

The sample size is 194 households. This survey, carried out on 194 producers, contains the socio-demographic and economic characteristics of agricultural households which are as follows: age of head of household (in years), level of education of head of household (1 = educated 0 = otherwise), marital status of household head (1 = married 0 = otherwise), household size (in person), experience of head of household in rice cultivation (in years), area of rice cultivation of head of household (in hectares), income excluding rice cultivation of household head (in FCFA), quantity of rice produced (in kg), quantity of rice produced by the household (in kg), gender of head of household (1 = male 0 = otherwise), fertilizer subsidy (1 = subsidized 0 = otherwise) and type of seeds (1 = selected 0 = otherwise).

Based on the literature review, we can specify our model. Indeed, this review will suggest the relevant explanatory variables. Considering the relevant variables is essential to eliminate the bias in the regression. Omitting a relevant variable can cause a bias situation.

Variables	Variable type	Coded	Expected sign
Quantity of fertilizer	Continuous	quartz	
Age of head of household	Continuous	Agchef	+
Educational level	Categorial	Ninst	+
Marital status	Categorial	Etamatri	undetermined
Household size	Continuous	Taille	undetermined
Head of household experience	Continuous	Expchef	+
Log of sown area	Continuous	Lnsupemb	+
Log of household income	Continuous	Lnrevmenag	+
Adoption of mineral fertilizer	Categorial	Utileng	+
Gender of household head	Dummy	Sexchef	undetermined
Type of seeds	Dummy	Typsem	+

Table 1: Definition of the Model Variables and expected sign.
Source: author through the literature review.
The quantitative variable = continuous
The qualitative variable = Categorial

Presentations and Interpretations of the Results

Descriptive analysis of the relationship between fertilizer and rice production: The following part gives a statistical description of the main variables of interest as well as the socio - demographic characteristics of rice-growing households. The objective of this section is to analyze the characteristics of Nigerien rice farms. It has two sub issues: socio-demographic characteristics of the rice cleaning in general and particularly the head of household and the characteristics of production agricultural of respondents.

Sociodemographic characteristics of the rice-growing household: The survey covered 194 households made up of 838 people: or an average of 4.64 people per household. This average is close to that of the municipality of Niamey, which is 4.87 people per household. Table 2 gives the distribution by sex of the sample.

Variables	Average (frequency)	Standard deviation	Minimum	Maximum
Quantitative variables				
Age of household head	42.10	10.31	23	76
Household size	4.64	3.84	0	24
Head of household experience	16.45	10.86	1	40
Qualitative variables				
Sex (proportion of Men in%)	78			
Marital status (Married, in%)	64.43			

Table 2: Sociodemographic characteristics of the rice-growing household.
Source: 2015 survey data

The analysis of the demographic gender composition of together people surveyed revealed a predominance the number of men (7 to 8%) of women (22 %). However, compared to national statistics, we have a reversal of the trend in favor of the male sex to the study sample. In fact, at the national level, the sex ratio was 78.88 men per 100 women in 2015. The survey also reveals that most of the surveyed population is uneducated (73.71%) with 64.43% married.

Characteristics agricultural production of respondents: Table 3 shows that in areas developed a rice area under crops Nigerian operations averaged 0.44 hectares for an average production per farm of 928.78 kilograms. From these analyzes, we note that the rice plots are on average very small sizes with relatively low average yields per hectare. However, the areas are between 0.1 ha and 2.2 ha for respective minimum and maximum productions of 100 and 6,500 kg. This can be explained on the one hand by the quality of seeds used and on the other hand by a low use of fertilizers. Indeed, a small proportion (31.96%) uses selected seeds against a large majority (68.04 %) who still turn to traditional seeds. In addition, most rice farmers (73.7%) do not use fertilizer. In terms of the use of chemical fertilizers, the results in Table 3 show that farm rice uses an average of respectively 95.5 and 186.77 kilograms of fertilizer chemical urea and NPK. These results show that farms rice schools Nigerien use very low chemical fertilizer. However, there is some disparity in the volume of fertilizer used as shown in Table 3.

Variables	Average (frequency)	Standard deviation	Minimum	Maximum
Quantitative variables				
Sown area	0.75	0. 44	0.1	2.22
Rice production	928.78	658.56	100	6500
Amount of urea	95.35	125.03	0	1333
Quantity of NPK	186.77	248.45	0	2,666
Quantitative variables				
Selected seeds (in%)	31.96			
Traditional seeds (in%)	68.04			
Non-use of fertilizers (in%)	73.71			

Table 3: Sociodemographic characteristics of the rice-growing household.

Presentation of model validity tests and interpretation of econometric results

This section first assesses the quality of the models and secondly interprets and discusses the results.

Appreciation of the specification: The ordinary least squares method being legal in the estimation of this model because it is a general linear regression model. As a result, the explanatory power of this model is determined by the level of adjusted R^2, its validity by the Fisher test and the individual significance of the parameters by the probability associated with each of them. As for robustness, it can be identified by various tests such as the autocorrelation, multicollinearity, heteroskedasticity test and the test on functional form. In order to avoid violating the OLS assumptions, the robust command was used during the regression as shown in Table 4. The reliability of the results is very often dependent on the quality of the fit. It is the coefficient of determination which conventionally measures the goodness of fit of the estimates of the regression equation under the Ordinary Least Squares (OLS) method. From our estimates, it is respectively 0.75 for model 1 without decomposition by type of fertilizer and 0.77 for model 2 with decomposition by type of mineral fertilizer used. In these cases, the adjusted values attest that the different exogenous variables used explain respectively 75% in model 1 and 77 % for model 2, the variability of rice production in hydro-agricultural developments.These results are very correct by the economic literature, in particular [16].

Variables	(1)	(2)
	Lnquatriz	Lnquatriz
Ln of area	0.825***	0.814***
	-0.0524	-0.0588
Household size	-0.0189**	-0.0140*
	-0.00855	-0.00723
Age of household head	-0.00254	-0.00079
	-0.00369	-0.00336
Experience of household head	-0.000634	0.000111
	-0.00264	-0.00255
Cross effect of fertilizer and area	0.000916***	
	-0.000322	
Quantity of urea		0.00820***
		-0.00251
Quantity NPK		-0.00426***
		-0.00124
Household head Gender (1=male)	0.321**	0.337***
	-0.126	-0.117
Sol type	0.262***	0.313***
	-0.0805	-0.0801
Household income	-1.14E-06	-4.58e-06*
	-2.60E-06	-2.51E-06
Education level	-0.0824	
	-0.0606	
Fertilizer used	-5.21e-08***	
	-1.65E-08	
Constant	6.799***	6.705***
	-0.224	-0.209
Observations	194	194
R-squared	0.75	0.774

Table 4: Econometric results on the determinants of rice production on ONAHA in Niger.
Robust standard errors in parentheses (robust standard errors in parentheses)
*** p <0.01, ** p <0.05, * p <0, 1
Source: Author's estimate based on fertilizer survey data, 2015

Interprets and discusses the results on the determinants of rice production: We analyze in this spot in the individual significance of these. To do this, the conventions in econometrics use Student's t or standard errors in general and in this case, robust standard errors. On this basis and considering the results of Table 4, we can make the following comments.

Sociodemographic variables: In the literature, many socio-demographic factors affect the productive capacity of farmers. Thus, in the present research, the sex of the head of household is positively and significantly (5% at least) linked to rice production. This result shows that men are more productive than women. All of this is linked to the fact that women spend much more time in commerce than in agriculture. The other demographic factors (age, level of education and experience of the head of household) did not have a significant effect on rice production. Lataille household spring with a significant but negative effect. Thus, its coefficient which is respectively - 0.019 and -0.014 reflects that an increase in the size of the population of a person leads to a decrease in rice production of 1.9% and 1.4% for models 1 and 2. This result could be explained by the fact that rice cultivation is not very labor intensive. Income has in our estimation a negative effect on rice production. Its coefficient in model 2 is to -4.58×10^0.6. Pour Fontaine [17], this situation is linked to the fact that the African farmer is a member of a household where several budgets, in kind or in cash, are managed by different decision-makers for different reasons. Diverse and not automatically substitutable objectives. This results in rigidities in the allocation of money for the acquisition of factors of production, because it can compete with other destinations of this resource. According to Larson and Frisvold [18], inadequate supply, lack of on-time availability, lack of credit, for example, are factors, non-price, which slow down much more the demand for inputs, and for fertilizers. Apart from these socio-demographic factors, there are factors intrinsically linked to rice production.

Production variables: Among the production factors, we have retained the area sown, the type of seeds and the use of fertilizers. Estimates show that the area sown has a positive effect on rice production in AHAs in Niger according to the two estimation models used. Indeed, the elasticity's of rice production in relation to the sown area are respectively 0.83 and 0.81. This elasticity's are statistically significant at 1%. Thus, any increase in the area sown by 1% leads to an increase in rice production in AHAs of 0.83% and 0.81% respectively depending on whether the fertilizer is considered in aggregate (model 1) or detailed by type. Fertilizer (model 2). These results corroborate economic theory and those of many authors [19, 20] who have underlined the positive effect of intensification on linked production (the reduction-elimination of the subsidy on inputs. This confirms our second hypothesis which states that the area down a positive effect on rice production in the AHA in Niger. The overall amount of fertilizer negatively and significantly affects rice production in AHAs in Niger. In fact, the estimates show a semi-elasticity of -5.21×10^(-8). Which means that any increase in the quantity of fertilizer used by one kilogram leads to a decrease in rice production by 5.21×10^(-6)%. This counter-intuitive result can be linked to the failure to master the technological package and the failure to respect the doses to be used, as revealed by the descriptive analysis. Moreover, this result is qualified by considering the combined effect of the area sown and the quantity of fertilizer used. This joint effect is positive and statistically significant at 1%. It is 0.0009. This confirms the first result which postulates that the negative effect of fat on production is linked to the wrong dosage. In fact, any increase of the combined effect of the area and fertilizer by one lead to increased production of 0.09% rice. A more refined analysis by type of fertilizer shows differentiated effects between urea and NPK. While urea has a positive effect on rice production, NPK has a negative effect. These semi-elasticity's are statistically significant at 1% and respectively of the order of 0.008 and -0.004. Any increase of either 1 kg results in an increase of 0.8% and a decrease of 0.4% respectively in rice production. Thus, the more the producer uses the urea more his production increases compared with non-adapted. It also corroborates the work of Gerber [21]. This confirms in the case of urea, our hypothesis 1 which states that mineral fertilizer increases rice production.

Finally, the type of seed used affects rice production. Our results show that the use of modern seeds improves rice production compared to traditional seeds. These coefficients are 0.26 and 0.31 respectively. These results are in line with those of [17] who notes in a more detailed analysis by distinguishing between "modern inputs" requiring monetary outlays and inputs manufactured on the farm itself, that if the hypothesis of a VCR close to unity can be accepted for the second type of input, this is not the case for "modern inputs", the efficiency of factor allocation is therefore only limited. This economic rationality means that price signals to encourage the use of agricultural inputs must be more inciting today towards small farmers in the African region considered.

Conclusion

The object of our study was to determine the explanatory variables at the level of rice production in irrigation schemes in Niger. To achieve this, we set up an analysis plan based on an econometric model with the following economic variables: the area sown, quantity of fertilizer and the characteristics of the head of household (age, level of education, sex, marital status, experience). In order to answer our questions and our research hypotheses, we utilize a database made during a survey of household rice production in Niger in Niamey specifically at the Kirkissoye, Saagiya and Saga sites. Rice production has a positive impact on the country's agriculture. This positivity would not be possible without the contribution of its determinants which are among others: the area sown, the accessibility of mineral fertilizers. The analysis confirms the assumptions stated above. Namely that the main determining factors of rice production on irrigation schemes are the area sown, the use of mineral fertilizers, the characteristics of the head of the household such as sex, experience etc. An action on such variables could improve rice production because it is an important sector in agriculture more precisely in the economy of the country. It should help improve the living conditions of households.

At the end of this report, we therefore recommend:

- Increased mobilization of professional organizations.
- Facilitate rice growers' access to mineral fertilizers by granting them loans.
- Carry out experiments in order to establish the relationships between yield levels and fertilizer doses.
- Teach rice growers the techniques of integrated soil fertility management.
- Extend a lot of irrigated perimeters in order to achieve good yields.
- Ensure that all farmers respect the cropping calendar.
- Adopt new irrigation technique.

One limitation of this study is that the database s date of 2015. In recent years other areas were carried out. There is also the reluctance of donors.

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