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Full Length Research Paper

Analysis of maize production and supply for food security improvement in the Borgou region in Northeast of Benin

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The analysis of maize production and supply in Borgou region was conducted using data collected from 186 producers of maize. The analysis was done by commonly using means comparison tests and a multiple regression model. It comes out from this analysis that only 20.44% of the production is self-consumed, against 79.56% supplied on the market. Also, when the maize cultivated areas increase by 1%, its supply raises by 0.15%. As well, the use of mineral fertilizer and plough and/or tractor induces an increase by 65.86% in the supplied quantity. In contrast, the difficulties of access to production factors have a negative impact on the maize supply and the producers who are men supply 35.4% of maize quantity less than the women. Thereby, it is important that agricultural policies focus on easing access to production factors to widen the cultivated areas for more maize quantity to be supplied.

Key words: Production, supply, maize, regression, Borgou.

INTRODUCTION

In Benin, as in other developing countries, the issue of food security becomes nowadays and increasingly, a concern both for policymakers and for analysts. In fact, pockets of food insecurity resulting from poor access to food for a significant part of the population are persistent, despite a relative general sufficiency in productions of cereals, tubers and legumes. According to the data for progress monitoring of the World Food Summit objectives, 16% of Benin's population suffered from undernourishment in 1999 to 2001, and the situation was more or less the same since 1990 to 1992 (FAO, 2008). Moreover, according to the results of the second survey on the living conditions of rural households, at least 33% of households in Benin are unable to meet minimum food needs, despite the predominance of food expenditure (70%) in global expenditure (INSAE, 2007). This situation of food insecurity is exacerbated by the effects of the food crisis of 2007 as prices of foods raised unexpectedly. For example, the price of maize, which is the most consumed cereal in the country, recorded an increase of 220%, raising from 300 U.S. to $ 950 U.S. per ton during the last 12 months of 2007 (197% in real terms). Even, this increase was not interrupted during the harvest, while it usually dropped during this period (ONASA, 2008). At the same time, the promotion of biofuels based on the processing of agricultural products was one of the main causes of the word food crisis. Actually, it significantly increased the demand for agricultural products and made the food crisis to be structural. According to the program 'World Situation of Agriculture and Food' of the Food and Agriculture Organization (SMAA/FAO, 2008), the development of liquid biofuels will exert its effects on all countries, whether or not participating directly in this sector, because all agricultural markets may be affected. Following the ongoing discussion, achieving and guarantying food security in Benin become an important challenge for agricultural development policies. In this sense, a better understanding of the supply of food crops in general and in particular that of maize may allow to achieve the goal of providing food security for all. Thereby, the imperative is to identify factors that determine the maize supply and to derive recommendations for agricultural development policies for food security improvement. In order to contribute to achieve this issue, this study addresses the analysis of production systems and the determinants of maize supply in the Borgou region in northern Benin, which remains one of the greatest producers of food crops in the country.

MATERIALS AND METHODS

Study area and data base

The study area is the Borgou region, which is located in the north-east of Benin. It is situated between latitudes 8°90' and 10°20' N and between longitudes 1°80' and 3°70' E, and covers a surface area of 25,415 km², which represents 22.57% of the whole surface area (112,600 km^2) of Benin. The climate is of continental Sudano-Guinean type with alternation of a rainy season and a dry season in a year. The relief consists mainly of plains and plateaus topped in some places by hills with maximum heights of 300 m. The soils are those of the basement granite-gneiss mostly iron and generally suitable for agriculture. In alluvial plains, alluvial soils predominate, and are fertile enough for agricultural production because of the contribution of organic matters coming from annual high water rivers. In the Borgou region, the vegetation is of the Sudano-Guinean type, and is covered by a set of plant formations ranging from savannas planted with trees to shrub-lands, and of gallery forests in swamp areas.

The study was conducted in three municipalities of the Borgou region, namely Nikki as the highest maize producer, N'Dali as a medium producer and Perere as the lowest producer. The data used are mainly primary, collected from 186 maize farmers selected at random in the villages of Soubo and Sakanbanssi (municipality of Nikki), of Suanin and Marégourou (municipality of N'Dali), and of Sontou and Guinangourou (municipality of Perere). These data were collected in 2009 by using a structured questionnaire for each sampled producer and by focus groups, and were related to maize production (cultivated areas, inputs, outputs and prices), to maize supply (consumed quantity, supplied quantity and selling prices) and to socio-demographic, economic and cultural characteristics of producers for the agricultural year 2008 to 2009.

Theoretical analysis approach

The theoretical analysis of production and supply are mostly based on the fundamental law of supply and demand. Thus, economic theory states that the supply and, in turn, the production into a market economy are decreasing functions of prices (Sadoulet and de Janvry, 1995). However, alongside the so called 'pricists' school, various authors developed the so-called 'structuralists' current of thought. The latter defend the existence of other exogenous factors other than price such as socio-economic, demographic and cultural factors, which can determine the quantity of a product supplied on the market (Koffi-Tessio, 1997). In agricultural economics, other approaches of analysis have included, in addition to the two previous approaches, the dynamic relationship between supply and its determinants. In fact, the interactions between production and supply of agricultural products may be specific because of the non-simultaneity between the time the production decision is taken and the date of marketing the product. Several models of "Cobweb" type, developed by Ezekiel (1938) and Waugh (1964) to explain the instability of the market performance for agricultural products, are based on this specificity. These models stipulate that producers anticipated their production level regarding prices of the previous period.

According to Nerlove (1956, 1958), there are two important dynamics that must be considered in estimating the supply of agricultural products. First, by producing, the farmer expects to sell his product at a price that may be different from the current market prices. Usually, the observed prices after the production process are the ongoing market prices or on-field prices, while the production decision was based on prices that the producer expects to be prevailed on the market at the harvest time (first dynamic). Second, the observed amounts of product to be supplied may differ from those expected to be produced when the decision of production was taking. Actually, a desired adjustment in the reallocation of variable production factors may occur because of certain socio-economic, demographic and cultural factors, which can negatively affect the harvest (second dynamic).

In the generalized model of Nerlove, the analysis of supply response can be formulated in terms of yield, cultivated areas, produced quantities, etc. In terms of area, it can be mathematically computed as:

$$q_t^d = \alpha_1 + \alpha_2 p_t^e + \alpha_3 Z_t + \mu_t \quad (1)$$

Where, q_t^d stands for cultivated area at period t, p_t^e is the expected price a time t and Z_t are a set of exogenous factors, mainly socio-economic, demographic and cultural factors related to the producers at the time t. The μ_t indicate the error terms to be a normal distribution with mean equal to 0 and a constant standard deviation $\sigma_{\mu t}$ and the α_i are estimates to be determined. In particular, α_2 is the coefficient of a long-term response of the supply to the price change. Generally, the expected prices may differ from current market prices (1^{st} dynamic of Nerlove). Thus, it is appropriate to define a model of anticipation adjustment, in which the specification can be obtained using the following equation:

$$p_t^e - p_{t-1} = \gamma (p_t^e - p_{t-1}) + w_t, \text{ with } 0 \le \gamma \le 1 \quad (2)$$

or, after processing:

$$p_t^e = \gamma p_t^e + (1- \gamma) p_{t-1} + w_t, \text{ with } 0 \le \gamma \le 1 \quad (3)$$

Where p_{t-1} stand for the effective market price when the production decision is taken at the time t, γ is a coefficient of anticipation adjustment and the w_t are the error terms to be a normal distribution with mean equal to 0 and a constant standard deviation σ_{Wt}.

By combining Equations 1 and 3, it is possible to write a single equation of Nerlove dynamic model as:

$$q_t^d = \alpha_1 + \alpha_2 [\gamma p_t^e + (1- \gamma) p_{t-1})] + \alpha_3 Z_t + \mu_t \quad (4)$$

However, the dynamic model of Nerlove is only valid under the assumptions that the entire quantity produced is supplied on the market and that the time series data are also available. Even better, considering the cultivated areas as a proxy for the supplied quantity implies that the yield and the produced quantity estimates are known as it is the case in developed countries. However, in rural areas of developing countries, yields may vary significantly from one producer to another. In addition, a significant proportion of agricultural production is used for food self-consumption of the household as only the surplus is supplied on the market. Likewise, the temporal data are often not available or reliable if at all. To reflect these realities of rural areas, several analytical approaches have developed a static model adapted from that of Nerlove, but taking into account directly the amount actually supplied on the market as the dependent variable. Mathematically, this quantity directly supplied on the market after the self-consumption can be expressed by:

$$Q^0 = f(p, Zm, \beta, e) \quad (5)$$

Where, Q^0 represents the quantity of the product directly supplied on the market, p is the selling price on the market. As previously described, the Zm are a set of exogenous factors, mainly socio-economic, demographic and cultural factors related to the producers. The 'e' indicates the error terms to be a normal distribution with a mean equal to 0 and a constant standard deviation σ_e and the β are estimates to be determined. The estimation of Equation 5 allows evaluating both the effects of price and those of other exogenous and non-price factors on the supplied quantities. Therefore, it takes into account both 'pricist' and 'structuralist' theoretical currents of thought in supply analysis. By following this approach, the main assumption of the study is that, the supply of maize in the study area is not only determined by the price, but also by various socio-economic, demographic and cultural factors related to the producers.

Specification of the empirical model

By applying a function of a Cobb-Douglas form to directly derive the factor elasticities of the supply, it is possible to estimate the response of maize supply to changes in prices and in a certain socio-economic, demographic and cultural factors related to producers. It can be mathematically expressed as:

$$QTO_i = e^{\beta_0} p_i^{\beta_1} \left(\prod_{k=2}^{m} Z_{ki}^{\beta_k}\right) e^{e_i} \quad (6)$$

Where $e^{(.)}$ represents the exponential function. To obtain a linear relationship, let us apply for each member of Equation 6 the natural logarithm function, but only for quantitative variables. It comes that:

$$\ln(QTO_i) = \beta_0 + \beta_1 \ln(p_i) + \left[\sum_{k=2}^{m} \beta_k \ln(Z_{ki})\right] + \left[\sum_{k=(m+1)}^{l} \beta_k Z_{ki}\right] + e_i \quad (7)$$

With $k = 2, 3, \ldots, m, m+1, \ldots, l$. As well, the $Z_{1i}, Z_{2i}, \ldots, Z_{mi}$ stand for quantitative variables related to various socio-economic, demographic and cultural factors related to the producers and the $Z_{(m+1)i}, Z_{(m+2)i}, \ldots, Z_l$ are for qualitative ones. From the explanatory variables to be introduced in the model and described in Table 1, the complete equation of the empirical model for supply estimation can be written as:

$$\begin{aligned}\ln(QTO_i) &= \beta_0 + \beta_1 \ln(p_i) + \beta_2 \ln(SACCES_i) + \beta_3 \ln(SUPMAIS_i) + \beta_4 \ln(TAILLE_i) \\ &+ \beta_5 \ln(HALIM_i) + \beta_6 \ln(INDBE_i) + \beta_7 ACTSE_i + \beta_8 EDU_i + \beta_9 ETAVOI_i \\ &+ \beta_{10} SYSPRO_i + \beta_{11} SEXE_i + e_i\end{aligned} \quad (8)$$

In Equation (8), QTO_i stands for the total amount of maize expressed in kg supplied by the ith producer, pi represents his supplied price. The e_i indicate the error terms to be a normal distribution with a mean equal to 0 and a constant standard deviation σ_{ei}, and the β are estimates to be determined. The estimates β_1 to β_6 gives directly the factor – elasticity of the supply for quantitative variables, and the β_7 to β_{11} allow to know the change in percentage of the supplied amount when an explanatory dummy variable vary from one modality to another, that is $(e^{\beta i}-1)*100$ (Gujarati, 2003)[1]. In particular way, β_1 is the price elasticity of maize supply, as well as β_{10} allows capturing the impact of using mineral fertilizer and plow and/or tractor on maize supply in the study area. For a given producer i, it existed three (3) periods during which price changes are negligible during the same period, but very significant from one period to another. These three periods were distinguished for QTO_i measurement so as: (a) the period just after the harvest corresponding to abundance in maize stock availability, (b) the intermediate period corresponding to medium availability of maize stock and (c) the lean period corresponding to shortage of maize stock availability. QTO_i is then computed as the sum of the total amounts offered during each of these three periods. As well, the pi is obtained by calculating the price index. This index is the average of the prices at which the producer supplied his product on the market during the three periods defined above, but weighted by the supplied quantities. Thus, if QTO_{1i}, QTO_{2i} and QTO_{3i} represent quantities of maize that the producer i supplied on the market for these three periods at, prices p_{1i}, p_{2i} and p_{3i}, respectively, the price index p_i is computed by the following equation:

$$p_i = \frac{(p_{1i} * QTO_{1i}) + (p_{2i} * QTO_{2i}) + (p_{3i} * QTO_{3i})}{QTO_{1i} + QTO_{2i} + QTO_{3i}} \quad (9)$$

Regarding the other variables in the model, the explanatory variable $SACCES_i$ expresses the degree of difficulty that the producer i had to access production factors. This score is calculated to comprehensively define the degree of difficulty of access to all factors of production. Factors taken into account are land, seeds, fertilizer, herbicides, hired labor, ploughs and tractors. The level of difficulty of access to each of these factors has been assessed and codified as: Very easy (Code 1); easy (2), neutral (3), difficult (4) and very difficult (5). From these, the score of accessibility (SACCES) was calculated for all these factors by averaging the scores of access codes given to the considered production factors. Hence, the higher the score, the more difficult is the access to production factors. In the same way, the index of social welfare, namely INDBEi in Equation 8, gives a general idea about the level of income and assets of the ith producer. For this, income levels and assets owned (housing, land, animals and moving means) were assigned to such terms and codes: Very low (Coded 1), low (2), medium (3), high (4) and high (5). From these codes, the index of welfare was obtained by calculating their average. Thus, a high index indicates a better welfare of the producer.

The estimation of Equation 8 was made using the method of ordinary least squares (OLS). The errors of multicolinearity were tested using the detection method of Farrar-Glauber. These errors of multicolinearity, when existed, have been corrected by stepwise method of estimation, which eliminate step by step variables strongly correlated with others in the model until the estimates become free of multicolinearity errors. Finally, errors of autocorrelation and hétérocédasticity were tested by the methods of Durbin - Waston and of Goldfeld - Quandt, respectively.

RESULTS AND DISCUSSION

Descriptive statistics of variables introduced in the model

The descriptive analysis shows that producers are

[1]For an explanatory dummy variable D, the model equation is lnYi= $\beta_0+\beta_1 Di$. When D varies from 0 to 1, Yi varies from 1 to $e^{\beta i}$, and the variation change in percentage of Yi is given by $100*(e^{\beta i}-1)$.

Table 1. Names, types, codes, modalities and expected signs of explanatory variables introduced in the model of Equation 8.

Names of variable	Codes	Modalities	Expected signs
Price index (in fcfa)	P	Quantitative variable	+
Score of accessibility to production factors	SACCES	Quantitative variable	-
Maize cultivated areas (in ha)	SUPMAIS	Quantitative variable	+
Household size	TAILLE	Quantitative variable	-
Food habit (number of months in the year for consumption of foods made of maize)	HALIM	Quantitative variable	-
Social welfare index	INDBE	Quantitative variable	+
Secondary activity	ACTSE	ACTSE = 1 if a secondary activity exists ACTSE = 0 if not	+
Education	EDU	EDU = 1 if the producer has received in the past a formal education EDU = 0 if not	+
Quality of roads to reach the village of the producer	ETAVOI	ETAVOI = 1 if the roads are of a good quality ETAVOI =0 if not	+
Type of production system	SYSPRO	SYSPRO=1 if the producer uses fertilizer and plough and/or tractor SYSPRO=0 if not	+
Sex of the producer	SEXE	SEXE =1 if the producer is a man SEXE= 0 if not	+

predominantly male (84.9%) and more than half have never attended formal school (61.3%). Their index of social welfare is on average 2.52 (±0.69) on a scale of 5, and among them, 50% have at least one secondary activity. The household size extends from 1 to 48 persons with an average of about 15 (±9) persons per household. The number of months in the year that these households consume maize as their staple food is 3.59 (±2.96) months, but it can vary from 0 to 12 months throughout the study area. Overall, the roads to reach the villages are of poor quality (83.3% of respondents). As a consequence, the access to production factors is not quite good, with 3.25 (±0.6), on a scale of 5, as the average score of accessibility difficulty. The analysis of maize production systems allows categorizing them into four (4) main types, namely: (S1) as the traditional system (different cultural operations are manually done) with the use of neither mineral fertilizer, nor plow and nor tractor (32.5% of producers), (S2) as the traditional system with use of mineral fertilizers, but without plow and/or tractor (7%), (S3) as the traditional system with the use of plow and/or tractor, but without mineral fertilizer (14.5) and (S4) as the traditional system with use of mineral fertilizer and plow and/or tractor (46.2%). These results show that a mechanization of agricultural production is initiated in the study area, even if it is at low level, and it may be essential to evaluate its effect on maize supply on the market.

Regarding the cultivated areas in maize, they vary between 0.5 and 25 ha with an average of 4.15 ha. These allow producers to supply on the market, on average, 4409.5 kg (±602.4) of maize per year at a price, on average, of 160.40 (±33.34) fcfa (Table 2).

Production, household self-consumption and supply of maize

The total quantity of maize supplied on the market (QTO) is computed as previously described. For a given producer, it comes that the total amount of maize used for the household self-consumption (QTC) is gotten by subtracting the supplied amount (QTO) from the total amount of maize harvested at the end of the production process (QTR), namely the gross product. The results allow drawing Figures 1 and 2 which illustrate the distribution of the average quantities of QTR, QTC and QTO calculated according to the types of production systems and to the municipalities, as well as for the entire study area.

The results reveal for the entire study area that the average of QTO (4410 kg per producer) is much greater

Table 2. Descriptive statistics of the variables introduced in the model, agricultural year 2008 to 2009.

Qualitative variables					
Variable names	**Absolute frequencies**	**Relative frequencies (%)**	**Variables Names**	**Absolute frequencies**	**Relative frequencies (%)**
Sex			**Quality of roads**		
Man	158	84.9	Good	31	16.7
Female	28	15.1	Not good	155	83.3
Total	186	100	Total	186	100
Education			Types of production system*		
Yes	72	38.3	S_1	60	32.3
No	114	61.7	S_2	13	07.0
Total	186	100	S_3	27	14.5
Secondary activity			S_4	86	46.2
Yes	93	50	Total	186	100
No	93	50			
Total	186	100			

Quantitative variables		
Variables names	**Means**	**Standard deviation**
Quantity of maize supply (kg)	4409.54	602.4
Price index (fcfa)	160.40	33.34
Score of difficulty of access to production factors	3.25	0.60
Cultivated areas of maize (ha)	4.15	2.03
Food habit (number of months in the year for consumption of foods made of maize)	3.59	2.96
Household size	14.96	9.38

*S1 = The traditional system (different cultural operations are manually done) with the use of neither mineral fertilizer, nor plow and nor tractor; S2 = the traditional system with use of mineral fertilizers, but without plow and/or tractor; S3 = the traditional system with the use of plow and/or tractor, but without mineral fertilizer; S4 = the traditional system with use of mineral fertilizer and plow and/or tractor. Source: Results of data analysis, July-August 2009.

than that of QTC (1132 kg per producer). A statistic test of means comparison proves that the difference is significant at 5% (Student statistic t = 80,902 with df = 185 and a probability of significance p = 0.001). Thus, the quantity of maize supplied on market per producer exceeds by 3278 kg that of household self-consumption. As well, it appears that 79.56% of the produced maize is market oriented, against only 20.44% for the household self-consumption.

According to the types of production systems, it is clear from the analysis of variance that the averages of maize quantity supplied on market (QTO) and that of household self-consumption (QTC) per producer vary significantly from a production system to another (for QTO, Fisher statistic F = 11.08 with df1 = 3; df2 = 182 and a probability of significance p = 0.000). Regarding the supplied quantity for instance, the system (S4) remained the highest with an average of 6902 kg per producer followed by (S3) and (S2) which provide on averages 3165 and 2831 kg, respectively. Finally, the production system (S1) supplies the lowest amount estimated on average at 1739 kg per producer as it is of traditional type (Figure 1). Here, the low average value of the system (S2) compared to that of (S3) may be attributed to the increase in cultivated areas by (S3) supported by the use of plough and/or tractor.

The analysis of variance, according to the municipalities, reveals also a significant difference among them regarding the averages of maize quantity supplied on market (QTO) and that of household self-consumption (QTC) per producer (for QTO, Fisher statistic F = 7.09 with df1 = 2; df2 = 183 and a probability of significance p= 0.001) (Figure 2). Actually, the municipality of Perere, where maize production is less mechanized, gives an average of supplied quantity, which is lower than those of the two other municipalities, namely Nikki and N'Dali (Figure 2).

Determinants of maize supply

The estimation results of the model of Equation 8 are

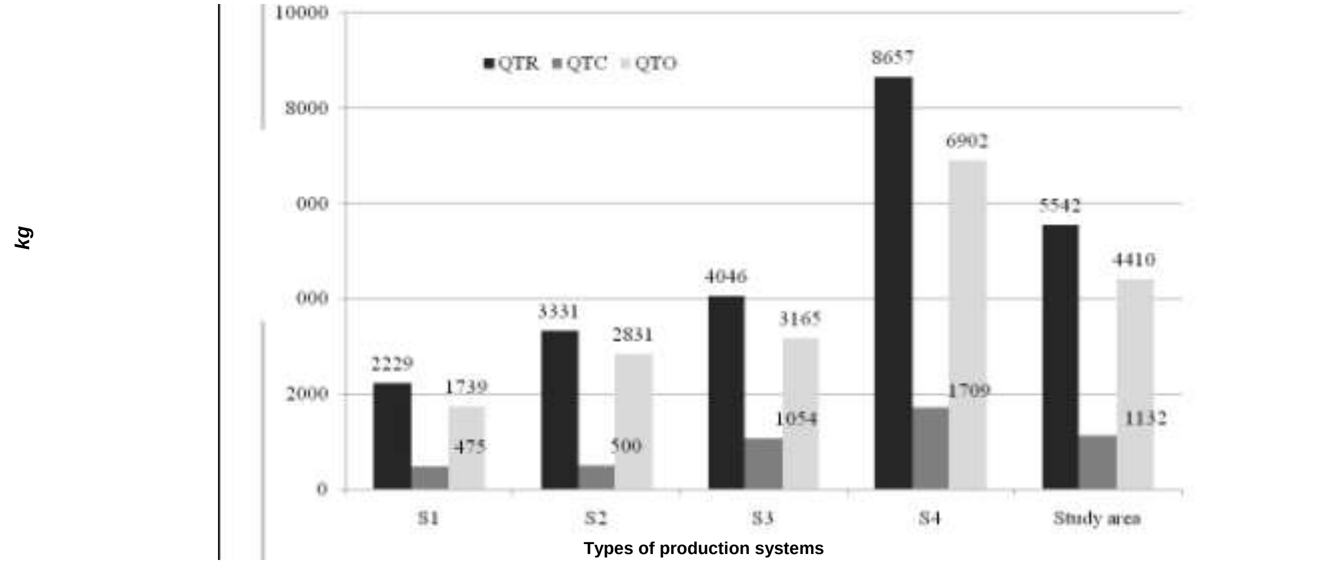

Figure 1. Means of total quantity of maize (in kg) produced, self-consumed and supplied on the market according to the types of production systems for the agricultural year 2008-2009. Source: Results of data analysis, July-August 2009. *S1 = The traditional system (different cultural operations are manually done) with the use of neither mineral fertilizer, nor plow and nor tractor; S2 = the traditional system with use of mineral fertilizers, but without plow and/or tractor; S3 = the traditional system with the use of plow and/or tractor, but without mineral fertilizer; S4 = the traditional system with use of mineral fertilizer and plow and/or tractor. *QTR = Total quantity of maize produced; QTC = total quantity of maize for household self-consumption; QTO = total quantity of maize supplied on the market.

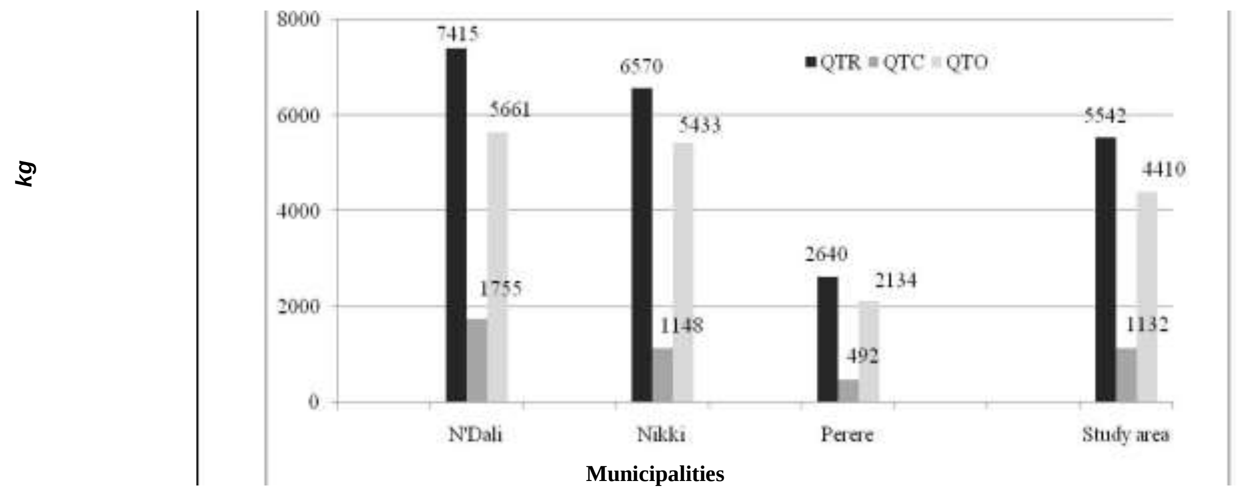

Figure 2. Means of total quantity of maize (in kg) produced, self-consumed and supplied on the market according to the municipalities for the agricultural year 2008 to 2009. Source: Results of data analysis, July-August 2009.

presented in Table 3. The value of Durbin-Watson, which is close to the value 2, shows the absence of significant autocorrelation. Likewise, the statistic χ^2 of multicolinearity test and the statistic F of hétérocédasticity test are both significant at 1%. Thus, there is no significant error of multicolinearity and hétérocédasticity in the estimation. In addition, the model is globally significant at 1 and 69% of the variations in the supplied quantity of maize in Borgou region are mainly explained by variations in explanatory variables introduced into the model. The unexplained remaining variations (31%) may be due to factors not easily controllable and measurable, which are not included in the model, such as climatic factors, factors related to soil characteristics, etc.

Table 3. Estimation results of supply modeling in Equation 8, agricultural year, 2008 to 2009.

Exploratory variable	Estimates (β)	Standard error	Student statistic t	Significance probability p
Price index (in fcfa)	0.093	0.069	1.353	0.178
Maize cultivated area (in ha)	0.150***	0.015	10.120	0.000
Score of access to production factors	-0.308**	0.124	-2.479	0.014
Household size	0.008	0.007	1.154	0.250
Consumption of foods made of maize	-0.011	0.021	-0.523	0.602
Welfare index	0.020	0.088	0.232	0.817
Existence of secondary activity	0.084	0.117	0.719	0.473
Education	0.002	0.068	0.033	0.974
Quality of roads	-0.099	0.128	-0.775	0.440
Production system with fertilizer and plough and/or tractor	0.506***	0.188	2.697	0.008
Sex of respondent	-0.437**	0.172	-2.545	0.012
Constant	8.221***	0.711	11.559	0.000
Dependent variable (QTO)		Total quantity of maize supplied (in kg)		
Number of observations		186		
R^2		0.69		
Fisher statistic F		21.54*** (df1 = 174; df2 = 10 and p = 0.000)		
Durbin-Waston coefficient (autocorrelation)		2.057**		
χ^2 of Farrar-Glauber test (multicolinearlity)		24.8** (df = 66 and p = 000.1)		
F of Goldfeld-Quandt test (heterocedasticity)		9.7** (df1= df2 = 118 and p = 0.041)		

***, Significant at 1%; **, significant at 5%. Source: Results of data analysis, July-August 2009.

According to the results presented in Table 3, it comes out that the factors that significantly determine the supply of maize in the study area at 5% level are: cultivated area, difficulty degree of access to production factors, sex of the respondent and production system which utilizes fertilizer + plow and/or tractor, namely the production system (S4). The cultivated area with an estimated coefficient β = 0.150, and the production system of type (S4) with an estimated coefficient β = 0.506, positively affect the quantity of maize supplied on the market. In contrast, the score of access to factors of production with an estimated coefficient β = -0.308 and the sex of the respondent with an estimated coefficient β = -0.437 affect it negatively. Hence, the main assumption of the study is verified only for these four (4) factors, and the empirical model of maize supply in the study area can be expressed as:

$$ln(QTOi) = 8.221 + 0.15*ln(SUPMAISi) - 0.308*ln(SACCESi) - 0.437*ln(SEXEi) + 0.506*ln(SYSPROi) + e_i$$

Regarding the cultivated area, the elasticity of supply is 0.15, which means that an additional increase of 1% in cultivated area of maize leads to an increase of 0.15% in maize supply. In fact, the increase in cultivated area induces an increase in the produced quantity and in turn that supplied on the market increases. Similarly, the practice of the production system (S4), which utilizes mineral fertilizer and plow and/or tractor, allows highly improving the quantity of maize supply on the market in the Borgou region. By moving from a producer who does not practice the system (S4) to a producer who does it, the quantity of maize supply grows by 65.86% [=100*($e^{+0.506}$-1)]. Indeed, the use of the plow and/or tractor can increase the cultivated area and favors plowing, weeding and hilling in recommended dates. The utilization of chemical fertilizers such as NPK and urea enhances the mineral nutrition of the plants and therefore increases the yield and the productivity. As a result, both the quantities produced and supplied on the market may significantly increase.

In opposite to the cultivated area and the practice of production system (S4), the degree of difficulty of access to production factors negatively influences the maize supply in the study area. In fact, when the score of access increases by 1%, maize supply decreases by 0.31%. Actually, access to production factors is essential and indispensable in agricultural production in general, and in that of maize in particular. In the study area, a difficulty in access to required labor frequently occurs because of the unavailability of family members for education reasons and of the shortage of hired labor. As a result, producers postponed many cultural operations, what may have negative impact on yields. Also, it should be noted that the poor access to inputs, due to the lack of fertilizers which are specific for maize production and the shortage of cotton fertilizers does not allow producers to apply the normal recommended doses of these inputs. Finally, the difficult access to agricultural credit limits producers in the allocation of production resources. Consequently, these difficulties of access to production inputs lower the yields and the quantities produced and thereby reduce considerably the quantity of maize supply. Regarding the sex, a producer, who is a woman supplies on the market about 35.4% [=100*($e^{-0.437}$-1)] of maize quantity more than a man. Indeed, the majority of the women sold almost all their produced quantity. Actually, from the perspective of socio-cultural rules in the study area, the deposit of food crops for household consumption is of a man duty, and may explain the low maize supply of the men.

Another interesting result on supply analysis found by the study is that the supply does not significantly response to price change. Actually, the price-elasticity of supply obtained (0.093) is positive, but very low and not significant at 5% level. It follows that economic theory on supply (law of supply), although remains theoretically valid, but is not verified in the study area. In fact, 69.9% of respondents said that they sell the maize on the market regardless of the price that prevails, but rather because of urgent needs of money to solve everyday problems such as health of household members, children schooling, various cultural ceremonies, purchase of non food goods, etc. Consequently, the supply remains inelastic to change in maize market prices. As partial conclusion, the main assumption of the study is not verified for the price.

The first part of the results found that farmers market their maize production than they consume it. In other words, maize is produced prior for marketing, and only the surplus is utilized for consumption in the household. In this sense, many studies including that of Yallou (1994) had already emphasized this character of cash crop that has been maize initially in Borgou region, since its importance was very little in food habits of rural households. However, Alingo (2008) explained that the prevalence of the priority given to maize marketing is attributable to the decline in cotton production, which was once the main income source for producers. He argues that most producers in the Borgou region prefer producing maize as an alternative to cotton regarding the contribution to farm income since they recently face up to many problems in the cotton sector.

Regarding the estimation of factors determining maize supply, the results fit well with various debates that authors from different backgrounds have carried out as regards the determinants of supply of agricultural products. The results found in this study were similar to the views of Koffi-Tessio (1997) who revealed that the price elasticity of aggregate agricultural supply is low and does not support the argument that high prices induce a positive response of supply of agricultural products. Also, some studies shown that these price elasticities of the response function of aggregate supply are generally low, ranging between 0.2 and 0.4 (Beynon, 1989). However, the results of various researches invite to overcome these general considerations of the overall supply response and to interest in a comparative analysis of the behavior of the price elasticity of supply response in presence of factor-price alone and a mixture of factor price and non-price in the model. Such results show a decrease in the value of the price elasticity of supply as non-price variables are introduced into the model. For example, by incorporating in a model price with and without a variable to take into account different levels of technology, Koffi Tessio (1997) found that the elasticities obtained are reduced from 1.66 to 1.17. Chibber (1989) introduced an irrigation variable to the same data and reduced the elasticity to 0.9. As well, according to Koffi Tessio (1997), it is possible to arrive to a negative elasticity by introducing different structural variables. It means that, although at low values, prices do not encourage and motivate farmers to produce more (Samlaba, 1992), but they remain a factor with limited effect on the supply of agricultural products.

Moreover, the limited effect of prices on supply of agricultural products could be explained by the close relationship between the quantity supplied and that produced. This means that even if prices are high on the market, one must first have the product before marketing it. The production implies a good accessibility to production factors and a skill at combining them to obtain the output (technology). It may be these aspects which explain the significant response of maize supply in the Borgou region to a change in non-price factors such as the total cultivated area, the degree of difficulty of access to production factors, the producer sex and the practice of production system (S4). Koursanga (2007) obtained similar results in his study on modeling grains supply in Burkina Faso. Indeed, by introducing in his model variables similar to those of the present study and by estimating the supply equation by the seemingly unrelated regression method, this author concluded that prices had almost no significant influence on the supply of grains in Burkina Faso. In contrast, the non-price factors showed different significant effects on the supply of different cereals. For the author, the household size is a factor discouraging the supply on the market, while per capita production, acreage and investment in agricultural equipment increased the marketing of cereals in Burkina Faso. These were also the findings of Mundlak (1985) who showed that access to production factors was the most decisive element of a product supply.

Conclusion

This study leads to the conclusion that the quantities of maize supplied on the market are much higher than those consumed by the household regardless of the type of production system and of the municipality. As for the determinants of supply, the estimated regression model showed that the total cultivated area and the practice of the production system, which utilizes fertilizer + plow and/or tractor increase the supplied quantity of maize, while difficulties of access to production factors and the fact that the producer is a male reduce maize supply in the study area. By considering these results, rural development policies may facilitate access to production resources to increase the supply of maize in the Borgou region. Efforts in this direction could be to empower the institutions, which market and distribute to producers specific fertilizers for maize growing. Similarly, the construction of rural roads would ease difficulties of access to production inputs and improve the production and commercialization of maize. Finally, greater access to credit for producers and producer awareness about the recommended use standards of fertilizers and herbicides might encourage a greater production and a higher maize supply on the market. However, to put the results of this study to better advantage regarding food security, it is important that further researches focus their analysis on maize demand and its determinants and on the supply and demand of other food crops in the same research area and in other localities of Benin. The results of these may be complementary to those of this study, and could together contribute to achieve food security in Benin.

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