Comparing the Benefits Between Producing Maize for Seeds or Consumption in Cameroon

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Summary

This paper compares the benefits between seed maize producers (using pure seed) and consumption maize producers (using residual seed) in the Western upper plateau zone of Cameroon. From the field survey, seed maize producers record higher crop yields and gross margins. The estimated Cobb-Douglas production functions show the highest significant coefficient for pure seed used by seed maize producers indicating that pure seed is the most productive input in both groups and thus using pure seed is more advantageous than residual seed. Results from the financial gain assessment by increasing other factor inputs indicate that mineral fertilizer, pesticides, sowing and weeding labour are more productive and beneficial to the seed maize producers. Hence, in spite of the high seed price and investment cost for this activity, farmers producing maize seed benefit more than those cultivating maize meant for food consumption. However, the low replacement rate of maize seed in the field (5% per year) could explain the timidity of adoption of this activity by farmers. Cooperation is therefore recommended between different stakeholders (farmers, extension agents, research institutions, development partners, etc.) in order to sensitize farmers on the necessity to regularly renew their maize seed, which in turn would increase the country's maize production. These actors should convene on a good plan of action which would favor maize seed advertisement, rapid transmission of information to farmers, adhesion of farmers into cooperatives, subscription of farmers to journals/newspapers, financial and training assistance to farmers, creation of marketing board and micro-finance institutions to address the farmers' problems, etc.

Résumé

Comparaison de la rentabilité de la production de semences et de grains de maïs pour la consommation au Cameroun

Cet article compare les bénéfices obtenus par les producteurs de semences de maïs (utilisant les semences pures) et par les producteurs de maïs de consommation (utilisant des semences tout-venant) dans la zone des hauts plateaux de l'Ouest du Cameroun. Les résultats obtenus montrent que les producteurs de semences de maïs obtiennent des rendements élevés et de grands profits par rapport aux producteurs de maïs de consommation. L'estimation des fonctions de production de Cobb-Douglas a montré un coefficient de corrélation hautement significatif pour les producteurs de semences pures. Cela montre que l'utilisation des semences pures représente un meilleur intrant par rapport aux semences tout-venant. L'évaluation du gain financier lorsqu'on augmente l'utilisation d'autres facteurs de production indique que l'engrais minéral, les pesticides, la main d'œuvre pour le semis et le désherbage sont plus productifs et bénéfiques aux producteurs de semences de maïs. Par conséquent, malgré le prix d'achat élevé des semences pures et le coût d'investissement élevé pour cette activité, les agriculteurs produisant des semences hybrides gagnent plus que ceux produisant du maïs de consommation. Le faible taux de renouvellement des semences de maïs dans la zone d'étude (5% par an) expliquerait la timidité d'adoption de cette activité par les agriculteurs. Une collaboration entre différents acteurs (agriculteurs, agents de vulgarisation, instituts de recherche, partenaires de développement, etc.) serait nécessaire en vue de sensibiliser les agriculteurs à l'intérêt de renouveler régulièrement leurs semences. Ces acteurs devraient s'entendre sur un plan d'action commun qui favoriserait la vulgarisation des semences de maïs, la transmission des informations, l'adhésion des agriculteurs aux coopératives, l'abonnement aux magasines de vulgarisation, l'assistance financière et la formation des agriculteurs, la création d'offices de commercialisation et d'institutions de micro-finance en vue de bien cerner les problèmes auxquels sont confrontés les agriculteurs, etc.

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Introduction

The Cameroonian economy relies mainly on agriculture which contributes to about 35% of Gross Domestic Product (GDP), employs two-thirds of the active population and generates more than half of the total export earnings (13). Within the agricultural sector, the contribution of food crops is important to the country's economy. During the previous decade, this sub-sector employs 54% of rural people, contributes to about 19% of the country's GDP and 42% of the revenue earned by the rural population (9, 10).

Among the mostly cultivated food crops, maize ranks third in terms of volume of production after cassava and banana. The high demand of maize for human consumption, animal feeding or beer production motivated most farmers to give their preference on the cultivation of this crop. However, in spite of the increasing number of maize producers over the years and the fact that this crop is currently cultivated by almost one million farmers in Cameroon, its production still remains insufficient to satisfy the demand of the ever increasing population. The reason could be that, the increase in maize production in Cameroon and several African countries is generally done by expansion of cultivable land area (crop extensification) rather than improving the productivity per unit area (crop intensification). However, the use of quality seeds is important in obtaining high crop yields (2, 10).

In Cameroon, there has been little structural change in production since the country's independence in 1960. Nowadays, production is still at the rudimentary stage using simple and traditional farm implements. Under these conditions, most farmers cultivate maize without using the improved pure seeds and modern inputs. This explains the low crop yields of 1-2t/ha in traditional farms as compared to high yields of 3-10t/ha obtained in modern farms which use improved varieties of pure seeds (3, 5). The low productivity of the crop requires the country to meet the domestic deficits in demand with maize imports from other countries.

In 2010 for instance, Cameroon imported about 17,343 tons of maize in order to compensate the deficit of its domestic production and demand estimated at 1,040,442 tons/year. Hence, with the increasing demographic rate of the population (2.8% per annum), there is an urgent need to improve the conditions of domestic production of maize in order to reduce the importation of this crop in future (7, 13). However, for a developing country like Cameroon to do so, good quality seeds which are adapted to the farmer's needs should be made available (6). As earlier mentioned, poor quality seeds contribute to the reduction of potential yield of maize and other food crops (6, 16).

Consequently, the availability of numerous varieties of seeds of improved quality remains a condition prior to the achievement of a good level of agricultural productivity for Cameroon which aims to become a middle income country by the year 2035.

Since the 1990s, the liberalization of seed production has enabled a few farmers to invest in the business of pure seeds' multiplication imported from overseas countries in order to produce hybrid seeds which are then sold to other local maize producers. Hence, two main businesses are currently existent for maize production in Cameroon: a few farmers are engaged in the local production/multiplication of imported pure seeds while other farmers produce the consumption maize from the residual seeds sorted out from their previous production. Among the one million maize farmers counted throughout the country, about 13.66% are "seed maize producers" and 86.34% are "consumption maize producers" (12, 14). That means, more than three-quarters of maize farmers prefer to produce maize for consumption rather than seeds because they are not sure of higher returns, inputs' efficiency or productivity of their investment (9).

Most farmers believe that, the business of seed maize production is costly to them because they lack capital to purchase imported pure seeds and other inputs necessary for this activity. The market price accounts so much in their decision because pure seeds are imported from overseas and sold at 1,500 FCFA/kg i.e. about eight times more expensive than the residual seeds sort out from the consumption maize (which costs 190 FCFA/kg). The pure seeds are still more expensive than the hybrid seeds which are locally multiplied by the seed maize producers and sold at 605 FCFA/kg i.e. three times more expensive than the residual seeds sort out from the consumption maize (7,13).

In short, the sale price of seed is an important determinant affecting the decision of farmers to engage in any maize production activity. Therefore, is it gainful for a farmer to invest in the production of maize seed or consumption maize? Thus, this paper compares both options by computing the inputs' productivity and gross margin earned by farmers engaged in the production of maize seed and consumption maize.

Materials and methods

Study area and data collection

This study uses the data collected from February to July 2014 in the western upper plateau zone of Cameroon. Administratively, this zone covers the West, North-West and South-West regions of the country. It is characterized by an equatorial climate of Guinean type with moderate temperature (13°C to 27°C), large precipitations (varying from 1500 to 2600 mm annually) and two cropping seasons, allowing farmers to produce maize throughout the year.

Hence, the cultivation of maize all over the year enables agro-dealers of seeds to sell their maize seed to producers at any period (10, 14).

This zone is chosen based on the diagnosis of seed systems undertaken by the project SSR4D (Strengthening Seed Systems Research for Development in West and Central Africa) which reveals that, the commercial maize seeds are mainly used in the western upper plateau (zone III) and humid bimodal forest (zone V) of Cameroon (10). Besides, the western upper plateau zone is convenient for this study because of the existence of the seed certification process in the area, the high demand for commercial maize seed in the zone, the fact that it is the country's highly cultivated maize zone in terms of land area (229,753 ha representing 27.15% of the country's cultivated maize area) and production (475,285 tons/year representing 28.45% of the national maize production) (5).

A stratified random sampling was used to select a total of 219 farmers comprised of 105 seed maize producers and 114 consumption maize producers. Since the western upper plateau covers the West, North-West and South-West regions of the country, 35 seed maize producers and 38 consumption maize producers were selected in each of the three regions. This is summed up to a total of 3*35=105 seed maize producers and 3*38=114 consumption maize producers throughout the three regions. The selected seed maize producers were farmers using pure seeds[1] as main input whereas the consumption maize producers were those using residual seeds[2] as major input.

Using a structured questionnaire and interview schedule, cross-sectional primary data of the cropping season 2013/2014 were collected from the two groups (seed maize producers and consumption maize producers). The data collected were estimation made from own assessment of each farmer and concerned mainly the maize yield and the intensity of the use of inputs to produce the crop (land area, pure seeds, residual seeds, mineral fertilizer, animal manure, pesticides, sowing and weeding labour and (post)-harvest labour).

Those data were supplemented by secondary data such as the sales prices of seeds, maize, inputs and other information collected from available literature in the domain of sustainable maize seed production in Africa and Cameroon in particular.

Data analysis

In order to achieve the study objective, this paper uses the gross margin and Cobb-Douglas production functions estimated from each group of maize producers.

Gross margin

By definition, the gross margin is the enterprise's contribution towards fixed costs and profit after the variable costs have been paid (4, 8). Hence, the farmer's gross margin (GM) from maize cultivated either for seeds or food consumption is derived by subtracting the total variable costs (TVC) [i.e. costs for purchasing inputs] from the total revenue (TR) [i.e. gains from the sales of maize harvested from the farm]. It is mathematically expressed in the Equation I.

$$GM= TR-TVC \qquad (I)$$

In this study, the variable costs for maize production include namely the: land rent ($P_{X1}X_1$), pure seed cost ($P_{X2}X_2$), residual seed cost ($P_{X3}X_3$), mineral fertilizer cost ($P_{X4}X_4$), animal manure cost ($P_{X5}X_5$), pesticides cost ($P_{X6}X_6$), sowing and weeding labour cost ($P_{X7}X_7$) and (post)-harvest labour cost ($P_{X8}X_8$).

Hence, the total variable costs (TVC) are mathematically expressed in the Equation II.

$$\mathrm{TVC}=P_{X1}X_1+P_{X2}X_2+P_{X3}X_3+P_{X4}X_4+P_{X5}X_5+P_{X6}X_6+P_{X7}X_7+P_{X8}X_8 \qquad (II)$$

In equation (1), the total revenue (TR) is equal to the price of maize times quantity ($P_y.Y$). Hence, the producer's gross margin (GM) computed by replacing the TVC expression of equation (II) into equation (I) is written in equation III.

$$\mathrm{GM}=P_yY- P_{x1}X_1-P_{X2}X_2-P_{X3}X_3-P_{X4}X_4-P_{X5}X_5-P_{X6}X_6-P_{X7}X_7-P_{X8}X_8 \qquad (III)$$

Where: X_1, X_2 ....., X_8 are the intensities of the inputs X_1 to X_8 with X_1: land area; X_2: pure seed; X_3: residual seed; X_4: mineral fertilizer; X_5: animal manure; X_6: pesticides; X_7: sowing and weeding labour; X_8: (post)-harvest labour; P_{X1}, P_{X2}....., P_{X8}: prices of the inputs X_1 to X_8; Y: maize quantity; P_Y: maize price; GM: gross margin of producer; TVC: total variable costs.

Cobb-Douglas production function

To analyze the inputs' productivity and profit earned by farmers engaged in the production of maize seed and consumption maize, the literature of economics suggests four main types of production function: linear, quadratic, exponential and Cobb-Douglas (4, 8, 15).

Among the four functional forms, the Cobb-Douglas type is preferred in this paper mainly due to its convenience in estimation which employs an Ordinary Least Squares (OLS) technique, its simplicity in the interpretation of coefficients (the coefficients of this function represent the elasticities of production) and its perfect inputs substitution property. Furthermore, this study lacks requisite detailed data in a single-off

[1]Pure seeds=seeds which have never been crossed. Their multiplication produces the hybrid seeds (Mendel's F1 generation).

[2]Residual seeds=seeds sorted by farmers themselves from their previous crop harvests (part of maize produced for consumption used by farmers as seeds). They are totally obtained from the local production multiplied several times (Mendel's F2 generation onwards).

survey for using flexible functional forms, hence the Cobb-Douglas form is more appropriate (4, 9). The non-linear mathematical form of the Cobb-Douglas type of production function used is expressed by equation IV.

$$Y_i = \beta_0 X_{1i}^{\beta_1} X_{2i}^{\beta_2} X_{3i}^{\beta_3} X_{4i}^{\beta_4} X_{5i}^{\beta_5} \ldots\ldots\ldots\ldots X_{ji}^{\beta_j} e^{u_i} \quad \text{(IV)}$$

Where: Y_i is maize yield at i^{th} farm; X_1, X_2, X_3,...............,X_j are the explanatory variables (inputs); i= 1,2,3,…………, N is the number of farmers interviewed in each of the two groups (N= 105 for seed maize producers and N= 114 for consumption maize producers); β_1, β_2, β_3, ..., β_j are the partial elasticities of production for the variable inputs; β_0 represents the intercept; e is the exponential function and u_i is the stochastic disturbance term. For the purpose of estimating the linear regression, this function has been transformed into natural logarithms and computed by using the SPSS software program (version 20.0). More precisely, by specifying the variables with respect to the study objective and by taking the natural logarithms in both sides of equation IV, the log-log/double log form of the Cobb-Douglas type of production function is further specified in equation V.

$$\ln Y_i = \ln\beta_o + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i} + \beta_6 \ln X_{6i} + \beta_7 \ln X_{7i} + \beta_8 \ln X_{8i} + u_i \quad \text{(V)}$$

Where: Y= maize yield (in t/ha); X_1= Land area (in ha); X_2= pure seeds' intensity (in kg/ha); X_3= residual seeds' intensity (in kg/ha); X_4= mineral fertilizer intensity (in kg/ha); X_5= animal manure intensity (in kg/ha); X_6= pesticides intensity (in liter/ha); X_7= sowing and weeding labour (in personday/ha); X_8= (post)-harvest labour (in personday/ha); u=error term; ln=natural logarithmic function; β_0= constant, to be estimated; β_1, β_2, β_3, β_4, β_5, β_6, β_7, β_8, β_9 are the partial elasticities of production for the respective inputs, to be estimated.

Nevertheless, while running the linear regression for the Cobb-Douglas type of production function of equation V, the transformation to logarithms becomes mathematically a problem for the "zero" observation of pure seeds and residual seeds respectively for the seed maize producers and consumption maize producers. To avoid that problem, the "residual seeds" variable was excluded from estimating the production function of seed maize producers whereas the "pure seeds" variable was not considered in the production function estimation of consumption maize producers (8). Hence, the study assumes that, the producers of maize seed use only the pure seeds and no quantity of residual seeds. On the other hand, the producers of consumption maize do not use pure seeds but utilise only the residual seeds.

Results

Results of field survey

The results of field survey in table 1 indicate that, the producers of consumption maize cultivate large parcels of land (0.51 ha) as compared to the producers of maize seed (0.29 ha). On average, the yield recorded by the producers of maize seed (4.19 t/ha) is about 3.27 times higher than the output for the producers of maize for consumption (1.28 t/ha). However, the intensity of inputs used for maize production differs between the two groups. The producers of maize seed do not use residual seeds but utilise on average 21 kg/ha of pure seeds whereas the producers of maize for consumption do not utilise pure seeds but use on average 5 kg/ha of residual seeds (Table 1).

The mineral fertilizer intensity is higher for the producers of maize seed (293 kg/ha) as compared to the consumption maize producers (56 kg/ha). Likewise, the producers of maize seed utilise higher pesticides amount (4.59 liters/ha) as compared to the consumption maize producers (0.03 liter/ha). However, the intensity of animal manure is lower for producers of maize seed (9 kg/ha) as compared to the consumption maize producers (243 kg/ha) (Table 1).

The producers of maize seed need sowing and weeding labour (19 persondays /ha) in higher amount as compared to the consumption maize producers (10 persondays/ha). However, the consumption maize producers need (post)-harvest labour in higher quantities (45 persondays/ha) as compared to the producers of maize seed (18 persondays/ha) (Table 1).

The corresponding budgets for maize crop for the producers of maize seed and producers of maize for consumption (tables 2 and 3, respectively) show that, in total, the producers of maize seed spend much more money for purchasing inputs (245,825 FCFA/ha) as compared to the producers of consumption maize (157,675 FCFA/ha). These computations are done by assuming that pure seeds are purchased at higher price (1,500 FCFA/kg) as compared to residual seeds (190 FCFA/kg), which affects the highest total variable costs for purchasing inputs for the producers of maize seed (Tables 2 and 3).

Likewise, the fact that the multiplied hybrid seeds are sold at higher prices (605 FCFA/kg) than the maize for consumption (sold at 190 FCFA/kg) largely influences the revenue difference in the two groups. Hence, the total revenue gained is higher for producers of maize seed (2,534,950 FCFA/ha) as compared to producers of consumption maize (243,200 FCFA/ha).

Table 1

Average crop yield and inputs utilisation for the producers of maize seed and consumption maize.

Input or yield		Seed maize producers (N=105)	Consumption maize producers (N=114)
Input	Land area (ha)	0.29	0.51
	Pure seeds (kg/ha)	21	-
	Residual seeds (kg/ha)	-	5
	Mineral fertilizer (kg/ha)	293	56
	Animal manure (kg/ha)	9	243
	Pesticides (liter/ha)	4.59	0.03
	Sow ing and w eeding labour (personday/ha)	19	10
	(Post)-harvest labour (personday/ha)	18	45
Yield (t/ha)		4.19	1.28

Table 2

Crop budget for producers of maize seed (one hectare) [N=105].

Item		Unit	Quantity	Price (FCFA/Unit)	Amount (FCFA)
Input	Land rent	ha	1	50,000	50,000
	Pure seeds	kg	21	1,500	31,500
	Residual seeds	kg	0	190	0
	Mineral fertilizer	kg	293	300	87,900
	Animal manure	kg	9	30	270
	Pesticides	liter	4.59	4,500	20,655
	Sow ing and w eeding labour	personday	19	1,500	28,500
	(Post)-harvest labour	personday	18	1,500	27,000
TOTAL VARIABLE COSTS (TVC)					245,825
Sales of multiplied hybrid seeds or TOTAL REVENUE (TR)		t	4.19	605,000	2,534,950
GROSS MARGIN (GM)=TR-TVC					+ 2,289,125

Notes: In this table,

(i) The amount of each input is equal to: the input quantity multiplied by its price.

(ii) The total variable costs (TVC) is equal to: the sum of amounts of land rent, pure seeds, residual seeds, mineral fertilizer, animal manure, pesticides and labour (for sowing, weeding and (post)-harvest).

(iii) The sales of multiplied hybrid seeds i.e. the total revenue (TR) is equal to: the crop yield (4.19 t) multiplied by its sales prices (605,000 FCFA/t).

(iv) The gross margin (GM) is equal to the: total revenue (TR) minus total variable costs (TVC).

Table 3
Crop budget for producers of consumption maize (one hectare) [n=114].

Item		Unit	Quantity	Price (FCFA/Unit)	Amount (FCFA)
Input	Land rent	ha	1	50,000	50,000
	Pure seeds	kg	0	1,500	0
	Residual seeds	kg	5	190	950
	Mineral fertilizer	kg	56	300	16,800
	Animal manure	kg	243	30	7,290
	Pesticides	liter	0.03	4,500	135
	Sowing and weeding labour	personday	10	1,500	15,000
	(Post)-harvest labour	personday	45	1,500	67,500
TOTAL VARIABLE COSTS (TVC)					157,675
Sales of maize production or TOTAL REVENUE (TR)		t	1.28	190,000	243,200
GROSS MARGIN (GM)=TR-TVC					+85,525

Notes: Figures in this Table are computed by using similar formulas described in footnotes of Table 2.

Therefore, the gross margin earned by producers of maize seed (+2,534,950 FCFA/ha) is also higher than in the group of producers of maize for consumption (+85,525 FCFA/ha). The difference of gross margin between the two groups indicates that, farmers who are not engaged in the business of maize seed production lose about 2,289,125 minus 85,525= 2,203,600 FCFA/ha per cropping season (Tables 2 and 3).

Results of the estimated maize production functions

Table 4 presents the maize production functions (Cobb-Douglas type) for the producers of maize seed and consumption maize, as estimated by using the Ordinary Least Squares (OLS) method. The common problem with regressions of this type, multicollinearity, was examined through estimation of the Pearson correlation coefficients between explanatory variables (15). In most cases, these correlation coefficients were low and insignificant, indicating the absence of serious multicollinearity.

For all explanatory variables, the regression coefficients have the expected positive signs, indicating that an additional use of any of the inputs utilised would have a positive impact on maize yield (Table 4).

In the group of seed maize producers, the t-value proves that the coefficient of pure seeds is statistically significant (at 1% level) and it is the highest among the variable inputs. This shows that, the input of pure seeds is the most productive one within this group. The estimated partial elasticity suggests that, a 10% increase in the intensity of pure seeds would be associated with an increase in maize yield by 2.95% for the producers of maize seed (Table 4).

As proven by its highest partial elasticity (0.277) which is significant at 1% level, the residual seed is the most productive input within the group of consumption maize producers. In this group, the coefficient for residual seeds suggests that, a 10% increase in the intensity of residual seeds would be associated with an increase in maize yield by 2.77% (Table 4).

With a coefficient of 0.259 (significant at 1% level), the land area is the second most important factor for the producers of consumption maize. This factor is however less important to the seed maize producers. The computed production elasticities indicate that, a 10% increase in land area would lead to an increase in maize yield by 0.19% and 2.59% for the seed maize producers and consumption maize producers, respectively (Table 4).

The use of mineral fertilizer is statistically significant (at 5% level) in explaining the maize yield variation in the two groups. The computed production elasticities indicate that, a 10% increase in mineral fertilizer intensity would be associated with an increase in maize yield by 1.47% and 1.25% for the seed maize producers and consumption maize producers, respectively (Table 4).

In the two groups, the weak significant production elasticities for animal manure indicate that, if the intensity of animal manure is increased by 10%, then the maize yield would increase by 0.07% and 0.79% for the seed maize producers and consumption maize producers, respectively (Table 4).

The use of pesticides is also significant at 10% level in explaining the maize yield variation in the two groups. The estimated production elasticities for pesticides indicate that, a 10% increase in the intensity of pesticides application would lead to an increase in maize yield by 0.96% and 0.84% for the seed maize producers and consumption maize producers, respectively (Table 4).

Table 4
Estimated Cobb-Douglas production elasticities for maize

Explanatory variables	Seed maize producers [N=105]	Consumption maize producers [N=114]
Constant	1.269 (0.611)	1.085 (0.956)
Land area	0.019*** (5.236)	0.259*** (3.655)
Pure seeds	0.295*** (4.501)	-
Residual seeds	-	0.277*** (6.237)
Mineral fertilizer	0.147** (2.036)	0.125** (2.451)
Animal manure	0.007* (1.749)	0.079* (1.783)
Pesticides	0.096* (1.856)	0.084* (1.850)
Sow ing and w eeding labour	0.085* (1.915)	0.033* (1.798)
(Post)-harvest labour	0.021** (2.446)	0.233*** (8.298)
TOTAL	R^2 = 0.603 F-value = 190.842*** ∑elasticity = 0.670	R^2 = 0.584 F-value = 116.795*** ∑elasticity = 1.090

*** Significant at 1% ** Significant at 5% * Significant at 10% ( ) = t-value

The t-values of labour in each of the two groups prove that, all types of labour used are statistically significant in explaining the maize yield variation. For the seed maize producers, the estimated coefficients suggest that, a 10% increase in labour would be associated with an increase in maize yield by 0.85% and 0.21% respectively for the sowing & weeding labour and (post)-harvest labour (Table 4). For the consumption maize producers, a 10% increase in labour would be associated with an increase in maize yield by 0.33% and 2.33% respectively for the sowing & weeding labour and (post)-harvest labour (Table 4). By comparing the production elasticities of each input in the two groups, the seed maize producers record the highest coefficients for the inputs of pure seeds, mineral fertilizer, pesticides, sowing and weeding labour. Hence, these inputs are more productive to the seed maize producers and less productive to the consumption maize producers. However, the partial elasticities of production are rather higher for the four other inputs (land area, residual seeds, animal manure, (post)-harvest labour) in the group of consumption maize producers.

Hence, these four inputs are more productive in that group and less productive in the group of seed maize producers (Table 4).

The sum of elasticities is less than one (0.670) for the seed maize producers expressing a decreasing return to scale of maize yield with respect to all factor inputs. However, it is more than one (1.090) for the consumption maize producers, expressing an increasing return to scale of maize yield with respect to all factor inputs (Table 4). The estimated sum of elasticities indicate that, a 10% increase in the intensity of all the factor inputs would lead to an increase in maize yield by 6.70% and 10.90% for the seed maize producers and consumption maize producers, respectively (Table 4).

In both groups, the R-squared is greater than the 50% value recommended by Wooldridge (2009) to validate any regression model (15). The computed R-squared indicate that, 60.3% and 58.4% of the variations in the (log of) maize yield are explained by the (log of) inputs used for the regression in the groups of producers of maize seed and consumption maize, respectively (Table 4). The F-values of the R-squared are also highly significant for the two groups, implying that the data pertaining to the selected variables significantly fit the regression lines (Table 4).

Results from the financial gain assessment by increasing production factors

The efficacy of production factors is assessed from tables 5 to 11 by comparing the cost of each input to the financial value of the yield gain (supplementary revenue) induced by a 10% increase in the intensity of the application of this input.

In table 5, concerning the input of pure seeds, the seed maize producers gain higher supplementary revenue (74,781.025 FCFA/ha) than consumption maize producers (6,736.64 FCFA/ha) when the intensity of pure/residual seeds is increased by 10%. In table 7, when we add 10% more mineral fertilizer, the supplementary revenue gained is 37,263.765 FCFA/ha for seed maize producers and only 3,040 FCFA/ha for consumption maize producers. Likewise, if 10% more pesticide is available (Table 9), it would be better to increase it on seed maize producers who gain higher supplementary revenue (24,335.52 FCFA/ha) as compared to consumption maize producers (2,042.88 FCFA/ha). The sowing and weeding labour is more efficient to the seed maize producers who record higher supplementary revenue (21,547.075 FCFA/ha) than consumption maize producers (802.56 FCFA/ha) (Table 10).

Table 5
Effect of a 10% increase in pure or residual seeds' intensity (one hectare)

Item	Seed maize producers [N=105]	Consumption maize producers [N=114]
Pure/residual seeds applied on field (kg)	21	5
10% increase in intensity of pure/residual seeds (kg)	2.1	0.5
Price of pure/residual seeds (FCFA/kg)	1,500	190
COST INDUCED BY SUPPLEMENTARY PURE/RESIDUAL SEEDS (FCFA)	3,150	95
Average maize yield (t)	4.19	1.28
Partial elasticity of pure/residual seeds	0.295	0.277
Maize yield gain from 10% increase in pure/residual seeds (t)	0.123605	0.0354456
Price of multiplied hybrid seeds or consumption maize (FCFA/t)	605,000	190,000
SUPPLEMENTARY REVENUE GAINED (FCFA)	74,781.025	6,736.64

Notes:
In this table, in each group (seed maize producers and consumption maize producers),
(i) The pure seeds were taken as main input for computing figures in the seed maize producers' group whereas the residual seeds were considered as major input for the consumption maize producers.
(ii) The 10% increase quantity in pure/residual seeds intensity is equal to: the average field pure/residual seeds multiplied by 10%.
(iii) The cost induced by supplementary pure/residual seeds is equal to: the 10% increase intensity in pure/residual seeds multiplied by the pure/residual seeds' price unit.
(iv) The maize yield gain from 10% pure/residual seeds increase is equal to: 0.1 times the partial elasticity of pure/residual seeds multiplied by the average field survey maize yield.
(v) The supplementary revenue gained is equal to: the maize yield gain (from 10% pure/residual seeds increase) multiplied by the maize price unit.

Source: Computed from tables 1, 2, 3 and 4 data.

Table 6
Effect of a 10% increase in cultivated land area.

Item	Seed maize producers [N=105]	Consumptio maize producers [N=114]
Land area cultivated on field (ha)	0.29	0.51
10% increase in land area (ha)	2.9	5.1
Land rent price (FCFA/ha)	50,000	50,000
COST INDUCED BY SUPPLEMENTARY LAND AREA (FCFA)	145,000	255,000
Average maize yield (t)	4.19	1.28
Partial elasticity of land area	0.019	0.259
Maize yield gain from 10% increase in land area (t)	0.007961	0.033152
Price of multiplied hybrid seeds or consumption maize (FCFA/t)	605,000	190,000
SUPPLEMENTARY REVENUE GAINED (FCFA)	4.816,405	6,298.88

Notes: Figures in this Table are computed by using similar formulas described in footnotes of Table 5.
Source: Computed from tables 1, 2, 3 and 4 data.

Table 7
Effect of a 10% increase in mineral fertilizer (one hectare).

Item	Seed maize producers [N=105]	Consumption maize producers [N=114]
Mineral fertilizer applied on field (kg)	293	56
10% increase in mineral fertilizer (kg)	2.93	5.6
Mineral fertilizer price (FCFA/kg)	300	300
COST INDUCED BY SUPPLEMENTARY MINERAL FERTILIZER (FCFA)	879	1,680
Average maize yield (t)	4.19	1.28
Partial elasticity of mineral fertilizer	0.147	0.125
Maize yield gain from 10% increase in mineral fertilizer (t)	0.061593	0,016
Price of multiplied hybrid seeds or consumption maize (FCFA/t)	605,000	190,000
SUPPLEMENTARY REVENUE GAINED (FCFA)	37,263.765	3,040

Notes: Figures in this Table are computed by using similar formulas described in footnotes of Table 5.

Source: Computed from tables 1, 2, 3 and 4 data.

Table 8
Effect of a 10% increase in animal manure (one hectare).

Item	Seed maize producers [N=105]	Consumption maize producers [N=114]
Animal manure applied on field (kg)	9	243
10% increase in animal manure (kg)	9.0	2.43
Animal manure price (FCFA/kg)	30	30
COST INDUCED BY SUPPLEMENTARY ANIMAL MANURE (FCFA)	270	72.9
Average maize yield (t)	4.19	1.28
Partial elasticity of animal manure	0.007	0.079
Maize yield gain from 10% increase in animal manure (t)	0.002933	0.010112
Price of multiplied hybrid seeds or consumption maize (FCFA/t)	605,000	190,000
SUPPLEMENTARY REVENUE GAINED (FCFA)	1,774.465	1,921.28

Notes: Figures in this Table are computed by using similar formulas described in footnotes of Table 5.
Source: Computed from tables 1, 2, 3 and 4 data.

Table 9

Effect of a 10% increase in pesticides (one hectare).

Item	Seed maize producers [N=105]	Consumption maize producers [N=114]
Pesticides applied on field (liters)	4.59	0.03
10% increase in pesticides (liters)	45.9	0.3
Pesticides price (FCFA/liter)	4,500	4,500
COST INDUCED BY SUPPLEMENTARY PESTICIDES (FCFA)	206,55	1350
Average maize yield (t)	4.19	1.28
Partial elasticity of pesticides	0.096	0.084
Maize yield gain from 10% increase in pesticides (t)	0.040224	0.010752
Price of multiplied hybrid seeds or consumption maize (FCFA/t)	605	190
SUPPLEMENTARY REVENUE GAINED (FCFA)	24,335.52	2,042.88

Notes: Figures in this Table are computed by using similar formulas described in footnotes of Table 5.
Source: Computed from tables 1, 2, 3 and 4 data.

Table 10

Effect of a 10% increase in sowing and weeding labour (one hectare).

Item	Seed maize producers [N=105]	Consumption maize producers [N=114]
Labour use in field (persondays)	19	10
10% increase in sow ing and w eeding labour (persondays)	1.9	1.0
Labour price (FCFA/personday)	1,500	1,500
COST INDUCED BY SUPPLEMENTARY SOWING AND WEEDING LABOUR (FCFA)	2,850	72.9
Average maize yield (t)	4.19	1.28
Partial elasticity of sow ing and w eeding labour	0,085	0,033
Maize yield gain from 10% increase in sow ing and w eeding labour (t)	0.035615	0.004224
Price of multiplied hybrid seeds or consumption maize (FCFA/t)	605,000	190,000
SUPPLEMENTARY REVENUE GAINED (FCFA)	21,547.075	802.56

Notes: Figures in this Table are computed by using similar formulas described in footnotes of Table 5.
Source: Computed from tables 1, 2, 3 and 4 data.

Table 11
Effect of a 10% increase in (post)-harvest labour (one hectare).

Item	Seed maize producers [N=105]	Consumption maize producers [N=114]
Labour use in field (persondays)	18	45
10% increase in (post)-harvest labour (persondays)	1.8	4.5
Labour price (FCFA/personday)	1,500	1,500
COST INDUCED BY SUPPLEMENTARY (POST)-HARVEST LABOUR (FCFA)	2700	6750
Average maize yield (t)	4.19	1.28
Partial elasticity of (post)-harvest labour	0.021	0.233
Maize yield gain from 10% increase in (post)-harvest labour (t)	0.008799	0.029824
Price of multiplied hybrid seeds or consumption maize (FCFA/t)	605,000	190,000
SUPPLEMENTARY REVENUE GAINED (FCFA)	5,323.395	5,666.56

Notes: Figures in this Table are computed by using similar formulas described in footnotes of Table 5.
Source: Computed from tables 1, 2, 3 and 4 data.

On the contrary (Tables 6, 8 and 11), the consumption maize producers gain higher supplementary revenue than seed maize producers when a 10% additional quantity of either land, animal manure or (post)-harvest labour is supplemented to their farms. In table 6, when we add 10% more cultivable land, the supplementary revenue gained is only 4,816.405 FCFA/ha for seed maize producers as compared to an additional earning of 6,298.88 FCFA/ha for consumption maize producers. In table 8, concerning the animal manure, the supplementary revenue gained by seed maize producers is 1,774.465 FCFA/ha which is lower than the amount of 1,921.28 FCFA/ha earned by consumption maize producers. Likewise, the (post)-harvest labour provide high efficacy to consumption maize producers who record higher supplementary revenue (5,323.395 FCFA/ha) than the seed maize producers (5,666.56 FCFA/ha) (Table 11).
All in all, results from tables 5, 7, 9 and 10 show that, the seed maize producers gain higher supplementary revenue when there is a 10% additional application of the inputs of pure seeds, mineral fertilizer, pesticides, sowing and weeding labour. These results confirm the high productivity of these inputs to the seed maize producers as already highlighted by the field survey results (Table 1) and Cobb-Douglas production elasticities (Table 2). However, we obtain divergent results for the inputs of land area, animal manure or (post)-harvest labour confirming that these inputs are rather efficient to the consumption maize producers (Tables 6, 8 and 11).

Discussion

Seed maize producers record higher crop yields and gross margins

The results of field survey show that, the yield of seed maize producers is 3.27 times higher than that of consumption maize producers (Table 1). Although the total variable costs for purchasing inputs is 156% higher for seed maize producers, these expenses are easily compensated by significant revenues earned from selling large quantities of maize seed harvests (Tables 2 and 3).
Thus, the gross margin gained is 27 times higher for the seed maize producers meaning that, the local production/multiplication of hybrid seeds from imported pure maize seeds is a profitable business (Tables 2 and 3). Hence, it is more beneficial to use pure rather than residual seeds for maize production.
The higher crop yield or gross margin recorded by seed maize producers could be explained by the various agronomic benefits or sustainable effects of using improved pure seeds (plant resistance to diseases, high germination rate, etc) which contribute to large volume of crop harvests (1, 3, 11).
Furthermore, all the seed maize producers benefit from a good/regular follow up of their farms by agricultural extension agents of the Ministries of Agriculture, Scientific and Technical Research which manage/host several projects on maize production throughout the country. Through these projects, the government aims at improving the country's self-sufficiency of maize supply and would like to increase the country's maize production. In this view, he has to make sure that seeds of good quality which produce high yields are effectively produced and sold to various farmers (2).
Hence, the regular field visits of agricultural extension agents aim to popularize the improved maize seeds

under this government policy.

These results are consistent with those of a previous study by Etoundi and Kamgnia (2008) which reveals that, the use of improved seeds' varieties lead to an increase in maize yields by 300-400% in the Centre region of Cameroon (5).

Consequently, the government policies (e.g. credit awards, subsidies) which could facilitate an easy acquisition and use of improved pure seeds for maize production could be advantageous to Cameroonian farmers.

However, the computed results consider that the maize and inputs used to produce this crop are sold at the current market prices but do not take into account the subsidy offered from time to time to the maize producers who operate legally. Hence, the gross margin earned by seed maize producers could be higher because all of them own official government licences to produce/multiply the maize seeds, which allow them to produce legally without any fear (1).

This is in contrast to most consumption maize producers who operate without valid official permits (most of them without licences to cultivate) hence do not benefit from any government support to get subsidized seeds and other inputs (such as pesticides, mineral fertilizer, etc) (12, 16).

Inputs' application rate and productivity differ between seed maize producers and consumption maize producers

As compared to the consumption maize producers, the seed maize producers use higher amount of pure seeds, mineral fertilizer, pesticides, sowing and weeding labour (Table 1). The estimated production elasticities (table 4) and the results from the financial gain assessment by increasing these production factors (tables 5, 7, 9 and 10) also testify that these inputs are more productive and beneficial to the seed maize producers. The difference in productivity between the pure and residual seeds is genetically explained by the fact that, the imported pure seeds (used by seed maize producers) have never been crossed whereas the residual seeds (used by consumption maize producers) have been crossed several times from the hybrid varieties (3, 5). The high amount of mineral fertilizer, pesticides, sowing and weeding labour used by seed maize producers (Table 1) is justified by the current government legislation which obliges the cultivation of maize seed by applying these inputs in conformity with standard requirements set up by the country's Ministries of Agriculture, Scientific and Technical Research (7).

The same legislation instigates the regular follow up of seed maize producers by agricultural extension agents from these Ministries in order to make sure that they multiply seeds of good quality necessary for the country's maize production to increase over the time.

Unfortunately, the consumption maize producers do not benefit from such follow up (2). They utilise low rates of mineral fertilizer, pesticides, sowing and weeding labour because they lack money to purchase high amounts of these inputs (about 40% of them live below the poverty line) (13).

Table 1 shows however that in comparison with seed maize producers, consumption maize producers use higher land area, residual seeds, animal manure and (post)-harvest labour. The computed production elasticities (Table 4) and the results from the financial gain assessment by increasing these production factors (Tables 6, 8 and 11) also demonstrate the high productivity and profitability of these inputs for the consumption maize producers. But generally, these inputs do not have too much effect since their use leads to lower crop yield as compared to the crop output of seed maize producers. The consumption maize producers believe that, they can compensate their loss of production (i.e. their low crop yield) by expanding their land area rather than improving the techniques of production. They use vaste land area but record low maize yield (i.e. they practise an extensive farming system) contrary to the seed maize producers who record high crop yield in small land area (i.e. they practise an intensive agricultural system) (1).

The high use and productivity of animal manure for the consumption maize producers (Tables 1 and 4) could be justified by the high poverty rate of this group of farmers who cannot purchase mineral fertilizer. From the field observation, it is believed that, they use high amount of animal manure because this input is taken "free of charge" from their own livestock. For this group of farmers, the locally made animal manure is affordable and easy to use in the place of expensive mineral fertilizer imported from overseas (9, 16).

The fact that consumption maize producers apply low quantities of pesticides on their crops also affects the labour use in their farms (Table 1). The high infestation rate of their crops by various diseases (resulting from the poor treatment of their plants with pesticides) forces them to employ a lot of people to sort out their crop harvests. They need a lot of time or people to sort out the residues, the good grains for consumption and the best ones to be used as seedlings during the following cropping season. This field reality is econometrically explained by the high productivity or partial elasticity of (post)-harvest labour for this group of farmers (Table 4).

To sum up, it would be recommended that the government should advertise the inputs used by seed maize producers (their crop produces high yield thanks to the inputs of pure seeds, mineral fertilizer, pesticides, sowing and weeding labour) at the detriment of the inputs used by consumption maize producers (they get low yield thanks to the inputs of land area, residual seeds, animal manure and (post)-harvest labour).

Seed maize producers use modern techniques whereas consumption maize producers apply archaic methods of production

In the agronomic literature, the distinction between traditional and modern agriculture stands from the techniques of production and mostly from the quality and quantity of inputs used in each case (7, 9). From the field survey results (Table 1), the seed maize producers use pure seeds which are good quality seeds (imported from overseas) whereas the consumption maize producers use residual seeds sort out from the previous crop harvests (with seeds quality declining over several cycles of production). For the most important inputs, the seed maize producers use higher amount than the consumption maize producers (Table 1). By comparing the application rate to standard requirements, the inputs are optimally applied in the first group whereas the second group does not use them appropriately (Table 1).

In the previous sections, the crop yield and land use allowed us to differentiate between intensive agriculture practised by seed maize producers and extensive farming system used by the consumption maize producers (3). The cropping system practised by this latter group of farmers does not change over the time since they use the land and other inputs according to traditional laws and customs (12). They rely mostly on archaic techniques inherited from their parents, which in turn lead to low crop yields (e.g. sorting out the seeds from previous crop harvests, sowing seeds with irregular spacing between rows, with undetermined number of seeds in a single pocket, etc).

The production method applied by seed maize producers is rather different because they use pure seeds. For this group of farmers, no seed is sort out from previous crop harvest, spacing the seeds between the rows is regular in the field, limited number of seeds are sowed in a single pocket, etc. In short, seeds are sowed by seed maize producers by following the standard requirements set up by the Ministries of Agriculture, Scientific and Technical Research. Hence, the high crop yield recorded by this group of farmers results from the modern techniques which they apply to produce (5, 11).

Seed maize producers and consumption maize producers operate at different stages of neoclassical production function

From table 4 results, the sum of production elasticities is less than one for the seed maize producers and more than one for consumption maize producers. Hence, the two groups of farmers operate at two different stages of the neoclassical production function[3] (4, 8).

The consumption maize producers operate at stage I of the neoclassical production function (because of their more than one production elasticities) implying that more supplementary or addition of any input would increase the crop yield at an increasing rate (Table 4). In other terms, doubling the intensity of all the factor inputs used by this group of farmers would lead to more than the double of crop output. Hence, an increasing return to scale is observed because farmers of this group are putting less quantity of inputs (than the standard requirements) in their farms so that the maize plants would react quickly to any additive input application (9). They are generally small-scale farmers with primary objective to sell maize in order to earn money which is necessary to provide their families with adequate food. In most cases, they belong to very poor families and undertake this activity just to meet up with the basic needs (health and school fees) of their spouses and children. They generally lack money and can hardly afford the inputs' expenses to produce the maize according to the standard requirements (11).

On the other hand, seed maize producers operate at stage II of the neoclassical production function because of their less than one production elasticities (Table 4). Stage II being the rational stage of production, it is obvious that inputs are optimally used by this group of farmers. This stage generally displays a decreasing return to scale i.e. doubling the intensity of all the factor inputs used by the seed maize producers would lead to less than the double of crop output (4, 9). From the theory, economic efficiency is achieved at stage II so that there is no need for farmers operating at that stage to purchase additional inputs' amount (4, 8, 15). In the field, this efficiency is justified by appropriate inputs' amount used by this group of farmers who can afford the inputs to cultivate the hybrid seeds and who benefit from the regular follow up of their farms by agricultural extension agents from the Ministries of Agriculture, Scientific and Technical Research. Unfortunately, that is not the case of the consumption maize producers who work with no supervisory facility at their disposal (16).

Conclusion and recommendations

This study analyses whether producing maize seed is

[3]The neoclassical production function displays three stages. These are stages I, II, III which exhibit respectively an increasing return to scale, a decreasing return to scale and a decreasing marginal return (4, 8).

more beneficial than producing maize meant for consumption in the western upper plateau zone (Cameroon). The results reveal that, as compared to consumption maize producers, seed maize producers record higher crop yields, gross margins, inputs' productivity, apply modern techniques of production, fulfill the economic efficiency conditions (operate at stage II of neoclassical production function). However, one could imagine that these benefits gained by seed maize producers would encourage large number of farmers to invest in this activity. On the contrary, only a few farmers have opted to produce the maize seed because of the high price of pure seeds, which discourages them so that they continue to use the residual seeds sort out from their previous crop harvests.

As a consequence, the replacement rate of maize seed by farmers is very low (5% per year) (13). It is however believed that, as most farmers continue to recycle the seeds from one season to another, they will lose the vigour over time until such a moment that this group of farmers will need to buy new seed. Hence, for Cameroon to maintain its food-self sufficiency and continue to export its maize production to neighbouring countries, it would be urgent that different stakeholders involved in maize production cooperate each other in order to sensitize farmers on the necessity to regularly renew their maize seed. This could be through a communication plan which integrates and assign a role to each actor (farmers, extension agents, research institutions, development partners, etc).

For such a plan to be successful, research institutions should make sure that they always put various results of their new discoveries of maize seed at the disposal of government authorities and farmers.

For instance, the national research institutions (such as IRAD[4], PNAFM[5]) should regularly advertise information on maize seed to the farmers so as to enable them to adopt it. On their side, the extension agents should facilitate this advertisement by ensuring that the informal communication channel (such as conversation between colleagues, friends, neighbours, classmates, etc) is well developed to transmit oral information. These agents should mobilize all maize farmers to form themselves into constructive group so that they can derive maximum benefit of collective union. They should also facilitate the subscription of farmers to periodic newspapers, journals, magazines, etc which better advertize the new varieties of maize seed and new methods of producing them.

Since most farmers cannot afford the pure seeds, the government should also provide financial assistance to farmers who lack capital to engage in the business of multiplication of pure seeds. Government funds should be accompanied with adequate training of farmers in production techniques, in the use of appropriate farm tools and implementation of good marketing system (e.g. creation of a marketing board in order to regularly inform farmers on the market price variation of maize seed). Public and private financial institutions such as agricultural and community banks should be established with simple procedure of securing loans to farmers willing to produce the hybrid maize seeds.

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[4]IRAD=Institut de Recherche Agronomique pour le Développement.
[5]PNAFM=Programme National d'Appui à la Filière Maïs.

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