2

Improved Seeds and Agricultural Productivity of Family Farms in Cameroon

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2.1 Introduction

Like in many Sub-Saharan African countries, Cameroon has an economy dominated by agriculture which employs nearly 60% of the labour force, generates about 15% of budgetary resources and accounts for 30% of GDP (World Bank 2008). In addition, the agricultural sector has the highest ripple effect on the other sectors, thereby contributing significantly to poverty reduction.

Agriculture is still dominated by family farms,¹ which are mainly located in rural areas (ECAM 3 2007). Family farms play a vital role in agricultural development. In Cameroon, they supply nearly 95% of the food products (cocoyam, sweet potato, maize, etc.) and retain about 80% of their production for on-farm consumption (ACDIC 2008). Despite their importance, family farms always face numerous challenges, including low productivity (World Bank 2008; Mugisha and Diiro 2010).

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The low productivity of family farms is due to the numerous problems facing the agricultural sector. These include the poor organization of actors, biotic constraints (diseases and pests), road infrastructure-related constraints (degraded rural roads and obsolescent and inadequate means of transportation) and production-related constraints (limited and high cost of good quality seeds, small crop areages (or areas), etc.).

Many solutions have been proposed to boost agricultural productivity, in particular improvement of infrastructure, supply of fertilizers, implementation of institutional reforms, as well as the introduction of innovations (Mead 2003; Fan et al. 2004; Scarpetta and Tressel 2004; Pedelahore and Tchatchoua 2010; Awotide et al. 2012; Adofu et al. 2013). Innovations help to improve agricultural performance, provide benefits and bring about social change. Furthermore, many studies have confirmed that innovations can serve as a powerful lever for improving the productivity of family farms (Edwin and Master 2005; Ntsama 2007; Ogunniyi and Kehinde 2015).

However, it should be noted that the concept of innovation comprises various aspects; hence, one can talk of institutional, political, social, organizational innovations, as well as knowledge and practice innovations and material innovations. This study focuses mainly on material innovations, and more specifically on improved seeds.

In Cameroon, many research bodies (IRAD, IITA, etc.) have included many seed improvement programmes and projects in their activities. Though the innovations ensuing from these research efforts have produced positive impacts at the macro level, the same is not true at the micro level, particularly regarding the performance of farmers (Oehmke and Crawford 1993). The purpose of this chapter is therefore to assess the impact of improved seeds on the productivity of family farms in Cameroon.

This study is divided into four main parts: (1) Data Source and Selected Variables, (2) Analytical Tools, (3) Findings, and (4) Discussion of Findings.

2.2 Data Source and Selected Variables

2.2.1 Data Source

This study specifically focuses on maize. This is because maize is the most widely consumed grain in Cameroon (Gergely 2002). It is grown in virtually all the regions of the country. Furthermore, maize cultivation is an economic, policy and social issue in Cameroon.² In addition, statistical records show that the maize sub-sector faces serious performance-related problems, namely:

- low agricultural incomes reflected in the high poverty rate among agricultural households which, according to the National Institute of Statistics (2008), stands at about 60% and
- a serious and ever-growing production deficit (ACDIC 2008).

The study was conducted based on data collected during a survey carried out in August 2007 under the Project to Strengthen Agricultural Research Partnerships in Cameroon designed by the Institute of Agricultural Research for Development. The data base initially comprised 497 family farms located in the West and Centre Regions of Cameroon. These family farms were divided into two groups, namely adopters and non-adopters of improved maize seeds. After carrying out several data processing operations using various criteria, 259 family farms were selected for the study.

2.2.2 Selected Variables

The factors that influence agricultural productivity can be divided into two main groups, namely socio-economic factors and farm assets.

Family farms have many socio-economic features or characteristics whose impact on productivity has been widely studied. Udry (1994) analyses gender efficiency in agricultural production in Burkina Faso and concludes that women-headed family farms are less productive than men-headed family farms. On the other hand, in a study conducted in Kenya, Saito et al. (1994) show that the gender variable has a positive but

minor impact on agricultural yields. Findings on the impact of the level of education on agricultural yields are mixed. While some studies confirm that education has a positive and significant impact on agricultural yields (Evenson and Mwangi 1998; Tiemey et al. 2009), others prove the contrary (Aguilar 1988). This also applies to farmland. Authors like Bhalla and Roy (1988) and Ntsama (2007) argue that the size of farmland has a positive and significant impact on agricultural productivity. These findings, however, differ from those obtained by authors like Berry and Cline (1979) and Piette (2006).

Farm assets include agricultural equipment (tractors, hoes, etc.), improved or local seeds, insecticides, herbicides, workforce among others (Edwin and Master 2005; Pycroft 2008; Mugisha and Diiro 2010; Okoboi 2010).

The Table 2.1 below presents the variables used in this study.

Table 2.1 Description of model variables

Variables	Description	
Dependent		
<i>rd</i>	Neperian logarithm Agricultural productivity of family farms	Ln (Quantity of maize produced/total area sown with maize)
Independent		
<i>Binary</i>		
<i>Opa</i>	Membership of a farmer organization by the family farm head	1 = member, 0 = not a member
<i>Smat</i>	Marital status of the family farm head	1 = live as a couple, 0 = contrary case
<i>Sex</i>	Sex of family farm head	1 = man, 0 = woman
<i>Sam</i>	Adoption of improved maize seeds	1 = adopt, 0 = do not adopt
<i>Continuous—truncated at zero</i>		
<i>Eagr</i>	Agricultural equipment	Number of tools
<i>Super</i>	Area sown with maize	ha
<i>Mo</i>	Size of workforce	Number of persons employed
<i>Age</i>	Age of family farm head	year

2.3 Analytical Tools

In order to achieve the study objectives, a methodology comprising descriptive and econometric analysis was used to process the sample data. In the first case, the univariate and Bivariate analysis of specific variables were carried out to identify the main characteristics of family farms. The mean difference testing technique was used to conduct a comparative analysis of the average yields obtained by the adopters and non-adopters of improved maize seeds. In the second case, the Blinder-Oaxaca decomposition technique was used to identify and assess the sensitivity of physical agricultural productivity to the adoption of new varieties of maize seeds (Dilling-Hansen et al. 1999; Neuman and Oaxaca 2004; Pycroft 2008).

2.3.1 Econometric Model

$$r\bar{d}^A - r\bar{d}^{NA} = (\bar{X}^A - \bar{X}^{NA})\hat{\beta}^A + \bar{X}^{NA}\left(\hat{\beta}^A - \hat{\beta}^{NA}\right)$$

where $r\bar{d}^A - r\bar{d}^{NA}$ is the average agricultural productivity gap between adopters and non-adopters, $(\bar{X}^A - \bar{X}^{NA})\hat{\beta}^A$ the difference due to the observable characteristics of family farm heads, and $\bar{X}^{NA}\left(\hat{\beta}^A - \hat{\beta}^{NA}\right)$ the difference due to the yields of such characteristics. More specifically, $r\bar{d}^A$ and $r\bar{d}^{NA}$ represent the logarithms of the agricultural yields of adopters and non-adopters respectively. X_i is the vector of the independent variables that can influence productivity, which are presented in Table 2.1. This vector is the same for adopters and non-adopters. Lastly, $\hat{\beta}^A, \hat{\beta}^{NA}$ are coefficients, each measuring the relative contribution of the related independent variable.

It should be pointed out that tests were also conducted to determine selectivity and endogeneity problems; the tests are the maximum likelihood ratio test for selection bias (Hurlin 2002) and the Hausman-Wu-Durbin (or enhanced regression) test for endogeneity bias. Concerning this last test, the financial assistance received by family farm heads and

education were retained as instrumental variables. Financial assistance is a potential source of income for farmers. Since improved maize seeds cannot be obtained free of charge, the availability of income can encourage their adoption. Regarding education, it should be noted that the possession of expertise by family farm heads can help in assessing the quality of a proposed product and, hence, encourage its adoption, particularly in terms of the ensuing profitability.

2.4 Findings

2.4.1 Characteristics of Family Farms and Results of Mean Difference Testing

The data analysis showed that there are two types of maize seeds, namely local and improved maize seeds. The statistics obtained indicate that 61.78% of family farm heads use improved maize seeds, while only 38.22% use local varieties. Most of the farmers using improved maize seeds expressed satisfaction with their colour (54.05% of family farm heads), their yield (51.74% of family farm heads) and their quality (53.28% of family farm heads). However, these opinions contrast with those concerning their cycle, taste, size, competitiveness in the market, disease resistance and tolerance to weevils (i.e. 50.58%, 50.97%, 52.51%, 55.98%, 65.64% and 69.88% of family farm heads respectively).

It should also be noted that improved seed varieties are derived from diverse sources (IRAD, seed producers, previous harvests, phytosanitary shops, the local market, etc.). This also applies to the methods used to obtain improved seed varieties, of which the main one is purchasing (79.15% of family farm heads).

The mean difference testing results show that though insignificant, the output of the adopters of improved maize seeds is higher than that of non-adopters (see Table 2.3 in Appendix). However, it is necessary to note that these conclusions are assumptions that will be verified using inferential analytical tools.

2.4.2 Existence and Consideration of Selectivity Bias

The findings show that there is a clear selectivity bias for the two productivity equation regimes. The test for independence of equations or maximum likelihood ratio test showed that the coefficients of selection terms or inverse Mills ratio are statistically different from zero at the 1% and 5% thresholds for adopters and non-adopters respectively (see Table 2.4 in Appendix).

This bias was corrected using the Heckman technique (Heckman 1979; Wooldridge 2002; Goulet 2008), which comprises two main stages. At the first stage, the equation of the adoption of improved maize seeds was formulated using the probit model. The estimated coefficients of this equation were used to calculate the inverse Mills ratio for adopters and non-adopters. These ratios were then incorporated into the corresponding agricultural productivity equations. At the second stage, the maximum likelihood (ML) method, instead of the ordinary least squares (OLS) method recommended by Heckman, was used to minimize the inefficiency of the estimators obtained using OLS (Chevassus-Lozza and Galliano 2001). It should be noted that this correction procedure was taken into account when estimating the productivity equations, which accounts for two explanatory components in the agricultural productivity gap decomposition model.

The results of the estimation of agricultural productivity equations are presented again in columns (1) and (2) of Table 2.5 in Appendix.

2.4.3 Agricultural Productivity Gap Between Adopters and Non-adopters

The results of the productivity gap decomposition show that the predicted or estimated values of the average agricultural yield for adopters and non-adopters are 7.286 kg/ha and 6.935 kg/ha respectively, that is, a difference of 0.351 kg/ha (see Table 2.2).

Table 2.2 Results of agricultural productivity gap decomposition

Variables	Predicted values					Gap {(A) – (NA)}	
ln (yield)	Adopters (A)				7.286	0.351	
	Non-adopters (NA)				6.935		
Gap decomposition (in %) due to							
	Ln (area)	Age	Ln (m.o.)	Ln (equipt.)	Sex	FO	Stat.mat
Difference of characteristics (E)	–33.9	–8.4	1.7	10.0	0.3	0.1	–0.6
of coefficients (C)	12.0	305.9	–248.1	166.2	24.4	–62.8	59.4
Total aggregate	–21.9	297.5	–246.4	176.2	24.6	–62.7	58.8
effects {E + C}							
Between the constant model terms (U)							Aggregate
Raw differential (R) {E + C + U}							effects
Adjusted differential (D) {C + U}							1.9
% characteristics (E/R)							639.8
% coefficients (D/R)							641.7
							–606.5
							35.1
							33.2
							5.5
							94.5

Source: Prepared by the author based on REPARAC 2007 survey data

NB: Positive and negative values respectively represent advantages and disadvantages to adopters

It should also be noted that the constant of the productivity equation of adopters is relatively less than that of non-adopters, which is reflected in the negative value (-606.5%) of the advantages expressed in $\{U\}$.

On the whole, the findings show that differences due to the characteristics of individuals and their yields indicate an average agricultural productivity gap between adopters and non-adopters of 1.9% and 639.8% respectively. Furthermore, the immediate consequence of the slight difference in the characteristics of individual of these two groups of farmers is reflected in the narrow gap between the contribution of all model components $\{E + C + U\}$ and that of the coefficients of the characteristics $\{C + U\}$ only.

Consideration of the aggregate effects of the characteristics of individuals and their yields $\{E + C\}$ helps to emphasize that age, number of farm equipment, sex and marital status provide advantages to adopters. This is far from the case for variables such as area sown with maize, workforce and membership of a farmers' organization.

2.5 Discussion of the Findings

The agricultural productivity gap between the adopters and non-adopters of improved maize seeds is positive and is estimated at 0.351 kg/ha. This would mean that, on average, the yield obtained by farmers who adopt improved maize seeds is 1.42 times more than that obtained by those who do not. This finding validates those of many studies conducted by authors like Allogni et al. (2004), Ntsama (2007), Pycroft (2008), Tiamiyu et al. (2009), Mugisha and Diiro (2010), Maruod et al. (2013), Adofu et al. (2013), Kwaku et al. (2014) and Ogguniyi and Kehinde (2015).

It should be pointed out that 5.5% of the gap identified is due to the difference in observable characteristics and 94.5% to the difference in the yields of such characteristics. This implies that if the characteristics of non-adopters were similar to those of adopters, their

agricultural yields would increase by 5.5%. Conversely, if the levels of yields of the specific characteristics of adopters were similar to those of non-adopters, their agricultural productivity would drop by 94.5%. The significant contribution of the difference in the yields of specific characteristics in the explanation of this productivity gap could be due to the fact that the use of improved maize seeds often leads to an improvement in the yields of other factors of production. It can therefore be concluded that innovations have a ripple effect on other factors of production.

These findings also show that although there is a productivity gap between the two groups of farmers, it is small compared to the theoretically expected result.³ This may be due to failure by producers to comply with the conditions associated with obtaining the expected theoretical yield of the said seed varieties. These include the use, method and period of application of fertilizers, the use of herbicides and weeding. In this connection, the sample data show that only 7.5% of adopters carry out weeding on their farms, while 10.6% use herbicides. These low percentages can be explained by the high cost of complying with the relevant guidelines.

2.6 Conclusion

The purpose of this chapter was to assess the impact of improved seeds on the agricultural productivity of family farms in Cameroon. To that end, data collected from 259 family farms which grow only maize were used. The findings show that improved seeds help to increase the productivity of family farms. Some recommendations have therefore been made based on these findings.

It is necessary to facilitate access to some farm inputs (such as pest control products). This is because when they are combined with improved seed varieties, they help to obtain at least the expected theoretical yield of such seed varieties.

Appendix

Table 2.3 Mean difference and mean square deviation testing of farm yields

- Hypotheses and decision rule of mean difference and mean square deviation testing of physical yields

Testing hypotheses	
<i>Mean difference testing</i>	<i>Mean square deviation testing</i>
H_0 : Mean (rd_{NA}) = Mean (rd_A)	H_0 : $Sd (rd_{NA})/Sd (rd_A) = 1$
Diff = 0	Ratio = 1
H₁: * Bilateral	H₁: * Bilateral
Mean (rd_{NA}) $\neq$ Mean (rd_A)	$Sd (rd_{NA})/Sd (rd_A) \neq 1$
Diff $\neq 0$	Ratio $\neq 1$
H₁: *Unilateral	H₁: *Unilateral
Mean (rd_{NA}) < Mean (rd_A)	$Sd (rd_{NA})/Sd (rd_A) < 1$
Diff < 0	Ratio < 1
Mean (rd_{NA}) > Mean (rd_A)	$Sd (rd_{NA})/Sd (rd_A) > 1$
Diff > 0	Ratio > 1
Decision rules	
<i>With respect to the statistics used</i>	
Where $t_{cal} > t_{lur}$ H_0 is therefore rejected	Where $f_{cal} > f_{lur}$ H_0 is therefore rejected
Where $t_{cal} < t_{lur}$ H_0 is therefore accepted	Where $f_{cal} < f_{lur}$ H_0 is therefore accepted
<i>With respect to the computed probability P or α</i>	
Where $P < \alpha_{thr}$ H_0 is therefore accepted	
Where $P > \alpha_{thr}$ H_0 is therefore rejected	

Source: Prepared by the Author. Mean and Standard Deviation (*Sd*); α_{th} represents the actual or theoretical significance level. This may be 1%, 5% and 10%; *t* and *f* are the Student t-test and the Fisher t-test, respectively

- Results of the mean difference and mean square deviation testing of farm yields

Variable		Groups	
		Adopters	Non-adopters
Ln (farm yield)	Number of observations	160	99
	Mean	7.286452	6.935129
	(Standard deviation)	(1.248448)	(7.021797)
	Mean difference testing	DL = 257 $t = -0.6180$ $P_{diff < 0} = 0.2686$	$P_{diff\#0} = 0.5371$
	Mean square deviation testing	DL = 98.159 $f = 31.6341$ $P_{ratio > 1} = 0.0000$	$P_{ratio\#1} = 0.0000$

Source: REPARAC Survey 2007. *t* and *f* are the Student and Fisher-tests

Table 2.4 Selectivity bias testing

Variables	Substantial or productivity equations by group		
	Column (1) Equation 1: Adopters of improved maize seeds Dependent variable: rd_i^A	Column (2) Equation 2: Non-adopters of improved maize seeds Dependent variable: rd_i^{NA}	Column (3) Selection or adoption equation Dependent variable: Sam
Level of education	0.1529676 (0.70)	0.15359 (0.68)	0.0116556 (0.07)
Area sown with maize	-0.6714924 (4.96)***	-0.1694169 (2.03)**	0.0573592 (0.91)
Age of the family farm head	-0.2059581 (4.05)***	0.0189203 (0.67)	0.0265628 (3.17)***
Membership of a farmers' organization	0.1561473 (0.64)	-0.0685603 (0.28)	-0.0124464 (0.07)
Financial assistance received	-9.556315 (3.94)***	0.868744 (0.88)	1.214225 (3.49)***
Sex of the family farm head	0.6401305 (2.44)**	0.0235961 (0.09)	-0.0810641 (0.45)
Marital status of the family farm head	0.3715151 (1.23)	-0.0034117 (0.01)	-0.0222804 (0.10)
Region of residence	-1.837812 (3.11)***	0.5553122 (1.50)	0.315762 (1.69)*
Distance from the market			0.012048 (0.55)
Size of workforce	0.1483943 (4.03)***	0.0286309 (1.02)	-0.0128088 (0.62)
Number of agricultural equipment	0.1304015 (2.97)***	0.1509966 (3.32)***	
Use of fertilizers	0.3335662 (1.51)	0.3278144 (1.37)	

Use of insecticides	0.112043 (0.63)	0.0939586 (0.50)	
Inverse Mills ratio	9.540569 (3.81)***	2.856177 (1.39)	
Constant	7.194357 (12.51)***	3.97002 (1.52)	-1.107775 (2.50)**
Number of observations	259	259	
Number of censored observations	99	99	
Number of uncensored observations	160	160	
Wald chi2(k)	52.67	38.20	32.51
Log (Pseudo)likelihood	-387.5456	-393.8335	(-152.51484)
Prob > chi2	0.0000	0.0003	0.0003
For equation 1: LR test of indep. eqns. (rho = 0): chi2(1) = 8.24 Prob > chi2 = 0.0041			
For equation 2: LR test of indep. eqns. (rho = 0): chi2(1) = 5.79 Prob > chi2 = 0.0161			

Source: Calculations by author using STATA 11.0. The figures in parentheses represent the absolute value of the z statistic test. The one in parentheses and in italics is the value of the Pseudo-likelihood logarithm. *significance at 10%; **significance at 5%; ***significance at 1%. "k" represents the number of independent variables (excluding the constant)

Table 2.5 Results of estimation of farm yield equations

Variables	Column (1)	Column (2)
	Equation 1: Adopters of improved maize seeds Dependent variable: rd_i^A	Equation 2: Non-adopters of improved maize seeds Dependent variable: rd_i^{NA}
Ln (Super) or Area sown with maize	-0.5967682 (5.40)***	-0.3670263 (1.53)
Age of the family farm head	-0.0146481 (1.80)*	-0.0925562 (0.94)
Membership of a farmers' organization	0.0059788 (0.03)	1.485121 (1.26)
Sex of the family farm head	0.2238034 (1.30)	-0.1307447 (0.13)
Marital status of the family farm head	-0.1354805 (0.73)	-0.8896212 (0.48)
Ln (Mo) or Size of workforce	0.1817548 (1.70)*	2.007764 (1.14)
Ln (Eagr) or Agricultural equipment or number of agricultural equipment	0.7936329 (3.67)***	-0.2611372 (0.51)
Inverse Mills ratio	0.7433835 (3.30)***	-4.309337 (0.99)
Constant	5.42132 (11.10)***	11.48678 (1.90)*
Number of observations	160	99
R ²	0.3077	0.0402
F (k, n-k-1)	7.35	3.39
Prob > F	0.0000	0.0019

Source: REPARAC Survey 2007. The figures in parentheses represent the absolute value of the Student (t) test. *significant at 10%; **significant at 5%; ***significant at 1%. "n" and "k" represent the sample size and number of independent variables of the model (excluding the constant), respectively

Table 2.6 Estimation of expected theoretical average yield of improved maize seeds

Data sources	Types of seeds	Farm yield (tonne/ha)		
		Median values	Mean values	Gap
MINADER (2006)	Local	1.5–2.5	2	2.5
IRAD (2009)	Improved (composite families)	3–6	4.5	

Sources: Calculations made by the author using informations obtained from MINADER (2006) and IRAD (2009)

Notes

1. They represent about 97% of the agricultural labour force (Njonga 2012).
2. From the **sociocultural standpoint**, maize is used for human and animal consumption, as well as for agro-industrial purposes. **At the economic level**, maize production involves a little more than 6 million smallholder farmers in Cameroon (PRP OP Maïs 2008). The activity is very profitable (NEPAD 2004). In addition, demand in maize consumer markets is high and is increasing rapidly in virtually the entire Central African sub-region. Regarding policy, almost all multipurpose projects and programmes of the Ministry of Agriculture and Rural Development (MINADER) have a maize component.
3. **(Computed Yield Gap)** $\Delta \text{rd}_{\text{cal}} = 432.11 \text{ kg/ha} < \Delta \text{rd}_{\text{th}} = 2000 \text{ kg/ha}$ **(Theretical Yield Gap)**.

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