

## Intricacies of Organic and Chemical Fertilizer Application on Arable Land Crop Production in Cameroon

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**ABSTRACT.** This study emphasizes on the contribution of organic and chemical fertilizer application to arable land on Crop production in Cameroon". The objective of this research is to determine the correlates of fertilizer application on arable land and determine their effects on arable land production as well as decompose the arable land effected by the application of organic and chemical fertilizer. The analysis method used was the instrumental-cum-control function model in Cameroon household consumption survey. The result shows that fertilizer is strongly correlating with arable land production. The magnitude of this effect is stronger in organic fertilizer than in chemical fertilizer. Besides, land size, professional training, average annual precipitation, the use of modern technology, male household head, urban residence and the cost of fertilizer are factors positively and significantly influencing the application of fertilizer on arable land in Cameroon. In terms of policy, this study recommends that the government of Cameroon should increase and subsidize the supply of Fertilizer to farmers given the right conditions. This is an essential booster of agricultural production in this era of food security.

**Keywords:** *Organic fertilizer, food security, farmer, arable land, Cameroon*

**JEL Classification:** Q12, Q18, Q20

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### INTRODUCTION

The challenge of mass agricultural production to meet the nutrition need of the fast-growing world population is a significant concern for all economies. Fertilizer application in soils is one of the principal ways in which most countries can ensure mass production of food crops. Most soils of Cameroon are characterized by drought, low soil fertility, high erosion, porous soils, sandy soils, and lateral soils mainly in the tropical part of the country. Moreover, most soils show constrains in nitrogen, phosphorus and potassium deficiencies and hence, they are likely to decrease cereals and food legumes production (Cox & Cox, 2000). Those substances have lowered agricultural productivity in

the country. Many studies have shown that the application of organic and inorganic Fertilizer increase growth and yield of crops (Halder, Kabir, Sarker, Sultana, & Islam, 2003). It has also been proven that in any agroecosystem, soil organic matter plays an essential role in supporting nutrient availability and crop productivity (Duong, Penfold, & Marschner, 2012).

As noted in agronomy documents, fertilizer is any material of natural or synthetic origin that is used to supply plant nutrients essential to the growth of plants. There are two types of fertilizer, organic and chemical fertilizer. Organic fertilizer is naturally obtained and commonly called manure. This type of fertilizer is simply the decomposition of natural materials such as grass, cow dunk and excreta from other animals. The chemical Fertilizer are generally needed to support plants to grow and develop by providing some chemical elements that are more abundant than the organic Fertilizer. The chemical fertilizer is usually purchased by farmers

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in the market for their farms. The chemical Fertilizer generally contain macronutrients that are needed by plants such as nitrogen, phosphorus, or potassium. Other types of chemical Fertilizer contain secondary nutrients such as sulfur, calcium, magnesium; and micronutrients such as boron, cobalt, copper, iron, manganese, molybdenum and zinc.

Both the chemical and organic fertilizer contain nitrogen, phosphorus, and potassium elements so that the plant can grow. The chemical fertilizer is processed industrially and packaged in bags with specific compositions of elements. Whereas, organic fertilizer is such that in nature and often comes from the decay of plants that have died. If any of the macronutrients are missing or hard to obtain from the soil, this limits the growth rate for the plant. The fertilizer improves the soil structure and increases its ability to hold water and nutrients, as long as the amount of decomposed organic material in the soil. Thus, developing soil fertility management options for increasing productivity of food crops is a challenge in most parts of Sub-Saharan Africa (Tauro, Nezomba, Mtambanengwe, & Mapfumo, 2010).

The effectiveness of fertilizer on soil depends on the soil type and quality, soil pH, temperature, moisture, and management practices and other soil properties. Farmers traditionally own prolonged experiences related to fertilization application and its effect on plant growth (Flavel & Murphy, 2006). This matter explains why fertilizer is regarded as crucial for crop production by most small-scale farmers (Zhou, Yang, Mosler, & Abbaspour, 2010), and there is a strong positive correlation between annual food production and annual consumption of Fertilizer (Shehu, Kwari, & Sandabe, 2010). The study of (Wamba, Taffouo, Youmbi, Ngwene, & Amougou, 2012) shows that incorporation of poultry manure into soil promoted the transformation and mineralization of the soil which resulted in higher root concentrations and higher total nutrient uptake by plants. Poultry manure could be a valuable fertilizer and serve as a suitable alternative to chemical fertilizer. There is little knowledge available on their effects of poultry manure on crops for efficient utilization.

Farmers in Cameroon have applied the organic and chemical Fertilizer in their farms. It is about

22.4 percent of farmers use organic fertilizer, while 77.6 percent of them use chemical fertilizer. This figure might explain the fact that most farmers do not know how to compose the organic manure. They shall rather spend getting chemical fertilizer from the market. Among the agricultural households in Cameroon, only 40.1 percent applies fertilizer in their farms. The farmer in the north region uses the highest fertilizer with about 79.7 percent followed by the west region with about 75.8 percent. On the other side, utilization of the organic fertilizer by the farmer is relatively low. The central region uses a low use of organic fertilizer on 4.2 percent. These statistics are demonstrated in Table 1.

**Table 1.** The proportion of Households Using Fertilizer by Region in Cameroon

Region	Agricultural households using Fertiliser	Type of Fertilizer	
		Organic fertilizer (Manure)	Chemical fertilizer
		.....%......	
Adamawa	41.2	23.4	76.6
Centre	31.9	4.2	95.8
East	11.8	9.8	90.2
Far North	52.2	27.2	75.8
Littoral	39.2	39.8	70.2
North	79.7	40.2	79.8
North West	69.6	18.7	81.3
West	75.8	18.7	83.3
South	29.2	7.5	92.5
South West	31.1	46.1	56.9
Total	40.1	22.4	77.6

Source: (MINADER, 2015)

In Cameroon, most studies in fertilizer and crop production are in agronomy (Tebah, 2006). It is also essential that has attempted econometrically to link issues related to fertilizer and agricultural production as done by (Sotamenou & Parrot, 2014). They analyzed the determinants of organic Fertilizer use in urban and peri-urban agriculture. Their study conducted in three ways: (i) they worked with a binomial logit model to identify factors encouraging the use of compost in the urban and peri-urban lowlands; (ii) they used primary data with a representative sample of 288 farmers and (iii) their study was focus on urban and peri-urban areas of Cameroon. Whereas, this research would use demographic and health survey on urban, peri-urban and rural areas of Cameroon. Further, this research equally used instrumental variable and control function model that is different from theirs.

This study used the modified version of the agricultural production function model as proposed by (Rosenzweig & Schultz, 1983) and (Mwabu, 2009). Agricultural production commonly is a function of many factors influencing it such as weather-rainfall variability, earnings from agriculture, women in agriculture, ownership of agricultural assets, farmers' cooperatives, education, age, sex of household head and farm size. In practice, human characteristics such as age and sex are as inputs into agricultural production functions. Cebu Study Team provided examples of this approach for estimating child health production functions (Cebu Study Team, 1992).

The production function is generally considered static, so the current output is a function of only the current input. However, many agricultural variables that might be stock, whose value does not flow. For instance, farm size and rainfall variability are cumulative measures that depend on inputs in different periods and possibly on past soil fertility outcomes as well. The study approach is likely to study on demand for health treats health as a capital stock (Pole & Grossman, 1974), which depends on past values and current inputs. In Grossman's model, the demand for health is for investment and consumption purposes. In the spirit of this framework, agricultural productivity produces direct benefits for an individual and also increases labor income through the sale of agricultural products based on increasing work effort.

This work of the research is bridging this gap in an attempt to verify the role of organic and chemical fertilizer application in agricultural production in Cameroon with an application of the instrumental variable and control function estimation model. All studies revealed that organic and chemical Fertilizer strongly influence plant growth and productivity; however, the question is; does the effect of fertilizer in Cameroon the same as in other countries especially with the use of secondary data.

This research aims to examine the impact of fertilizer use on arable land, to determine the factors influencing the use of fertilizer by agricultural households, and to decompose the arable land effects by the application of organic and chemical fertilizer.

## RESEARCH METHOD

This study was conducted in Cameroon. Cameroon's land area is 472.7 thousand km<sup>2</sup>, with 2.73 thousand km<sup>2</sup> of water. The country is located in Central and West Africa, bordering the Bay of Biafra, in a position between Equatorial Guinea and Nigeria. Cameroon is occasionally described as "Africa in miniature" because it displays all the main climate and vegetation of the continent: mountains, deserts, rain forests, savannah grasslands, and coastline. Cameroon can be divided into five geographical zones. These distinguish geographical properties in term of its dominant physical, climatic and vegetative features. The coastal plain extends 20 to 80 kilometers inland from the Gulf of Guinea (part of the Atlantic Ocean) to the edge of the plateau. This densely forested terrain includes areas of Central African mangrove especially around Douala and in the estuary of the Cross River on the border with Nigeria.

### Modeling Approach

From empirical specification, as noted in the literature (Mwabu, 2009), agricultural production technology is represented in equation (1). This equation is the actual structural equation of interest whose estimated parameters. However, considering the simultaneous determination of fertilizer and arable land production, there is likely going to be a reverse causality in the equation (1) caused by the unobserved complementarity among fertilizer, arable land production and other agricultural inputs omitted from the equation. Precisely equation (1) is presented as follows:

$$\log AL = \psi' q_{ap} + \sum_j \Psi_j F_j + \xi_1, j = 1, \dots, 4 \quad \dots (1)$$

Here,  $AL$  represents arable land;  $F_j$  is endogenous determinant of agricultural production inputs such as fertilizer (organic, chemical fertilizer);  $\psi_1$  simply represents the control variables such as the exogenous demographics (farm size, household size, climate change...);  $\Psi_j$  is the parameter of the potentially endogenous explanatory variable in the arable land production function;  $q_{ap}$  is the vector of parameters to be estimated and  $\xi_1$  is the error term that captures both random effects and unobservable variables;  $\log$  is the logarithm of arable land. Mathematically,

the estimation of the parameter  $\Psi_j$  would show the effect of organic and chemical fertilizer as well as other agricultural inputs into arable land.

From the outcome equation, it derived equation (2), which is a linear relationship of the endogenous determinant of agricultural production (fertilizer) on all the exogenous variables. It means that equation (2) is a reduced form linear probability model of the endogenous inputs into agricultural production.

$$F_j = \psi_1 q_{fj} + \psi_2 X_{fj} + \xi_{2j} \quad \dots (2)$$

Where,  $\psi_2$  is a vector of exogenous instrumental variables affecting inputs into agriculture such as  $F_j$  but have no direct influence on  $AP$ . Further,  $q_{fj}$  and  $X_{fj}$  are vectors of parameters of exogenous explanatory variables in the reduced form endogenous input function to be estimated and  $\xi_{2j}$  is the error term. The predicted values of the endogenous determinants are used to compute residuals that enter the equation (3) below, which is equation (1), augmented into a control function. To repair potential endogeneity and non-linear interactions of unobservable variables in equation (1), the equation model then is developed as equation (3):

$$\log AL = \psi_1 q + \sum_j \Psi_j F_j + \sum_j \alpha_{1j} \hat{\xi}_{2j} + \mu, j = 1, \dots, 4 \quad \dots (3)$$

Drawing from previous studies as indicated earlier and considering that the set of instruments indicated above are absent from equation (3). We imposed exclusion restrictions on this equation. In this case,  $\xi_{2j}$  is considered as the control function variables. Thus, in the above equation,  $\xi_{2j}$  is fitted residual of fertilizer derived from the reduced form models;  $\mu$  is a composite error term comprising  $\xi_1$  and the unpredicted part of  $\xi_{2j}$  under the assumption that  $E(\mu) = 0$  and  $q, \Psi, \alpha$  are parameters to be estimated. Finally, we conclude that the reduced form residual  $\xi_{2j}$  serves as the control for unobservable variables that correlate with fertilizer.

Considering the control variables, Mugo (2012) revealed that the control for the effects of unobservable factors would contaminate the OLS estimates of the structural parameters of agricultural production. So  $\xi_{2j}$  serves as a control

for unobserved variables correlated with  $F_j$ , while  $\alpha \xi_{2j}$  controls for effects of neglected non-linear interactions of the unobservable variables with agricultural production measures. In this perspective, the equation (3) is the correct specification (Mwabu, 2009) in the absence of a priori information on the econometric problems present and that the equation can be estimated using the maximum likelihood estimation procedure in STATA statistical software.

From the above explanation, econometrically, control functions are statistical methods to correct for the endogeneity in the error term. The control function approach has some advantages over another two-step approach. The advantage of 2SLS estimators from IV estimators is that 2SLS can easily combine multiple instrumental variables, and it also makes including control variables easier identified. This condition explains the inclusion of these two econometric models in our analysis.

### Identification Strategy and Endogenous Instrument

One major problem may arise in the course of estimating the arable production function vis-a-vis fertilizer used by farmers. This problem is a possibility of including variables that may be endogenous in our regression due to farm heterogeneity observable to the farmers. These mean that if the farmers amend their ways depending on the heterogeneity, the explanatory variables and error term. Glewwe (1999) noted that in this situation, the estimated parameters for all variables might end up. From this problem, we can identify two structural effects: (i) the effects of the endogenous inputs from unobservable variables that correlate with these input, and (ii) the effects of endogenous inputs from those of neglected non-linearities of the structural model.

From these issues, identification of strategies alternative is formulated through a standard set of exclusion restrictions. These instruments are expected to influence the agricultural inputs as demonstrated in equation (2) without directly affecting production from arable land as presented in equation (1). The validity (instrument relevance and strength) of our instruments was sanctioned using Sargan's test statistic and Cragg Donald statistics for instrument strength and relevance

while Durbin-Wu-Hausman test is also at the second-stage regression for the test for exogeneity of the potential endogenous variable.

Therefore, it is essential that agricultural production effects of the endogenous inputs identified. With our lonely endogenous inputs, identification requires at least two exclusion restrictions since two equations that need to be solved simultaneously. It needs at least two instruments for the endogenous input and all the instruments should be excluded from the arable land production equation (Wooldridge, 2010) (Stock, Wright, & Yogo, 2002).

Critically, the endogenous instrument used in this study was financial liquidity. The financial liquidity constraint is often cited as an essential determinant of fertilizer use (Zhou et al., 2010). In the case, there are three variables as proxies for the availability of liquidity to the agricultural households, (i) institutional support, (ii) agricultural aid in kind, (iii) agricultural aid from friends and tontines. These three variables were used as instrumental variables to instrument for fertilizer use in household farms.

It should be noted that some of the variables, such as farm size may raise the concern of endogeneity. However, considering the case of Cameroon where land is equally allocated over the rural population, the farm size is not significantly influenced by farmers' capabilities (Zhou et al., 2010). It is often found that leasing land occurs on a small scale in the region. Therefore, farm size can be regarded as exogenous in the models. It can be said that institutional support, agricultural aid in kind, agricultural aid from friends and tontines are valid excluded instruments for agricultural production.

### **Data Setting**

This study used the 2007 Cameroon Household Consumption Survey (CHCS) collected by the National Institute of Statistics. The Ministry of Economic Affairs, Programming and Regional Development is the executing agency of the CHCS. The survey sample was about 11931 households with men and women of 15 to 49 years old. The women were those of the reproductive age, alive and living within the selected zones. The variable used was the outcome variable. It was food crop

production measured in terms of the value of the quantity of agricultural food crop production in Cameroonian households between the period of 2005 – 2007 that the data were collected. This variable was in the Cameroon household consumption survey and as the values of agricultural products produced in the agricultural exploited land. The agricultural exploited land is what is known as arable land.

The primary endogenous variable was fertilizer applied in the farm by a typical agricultural household. Data of households using organic and chemical Fertilizer were obtained from the department of statistics of the Ministry of Agriculture and Rural Development (MINADER). The exogenous characteristics are weather-rainfall variability, earnings from agriculture, women in agriculture, ownership of agricultural assets, farmers' cooperatives, education, age, sex of household head and farm size. The variables used as an instrument to resolve the problem of endogeneity bias in this study were institutional support and agricultural aid from friends and tontines. These variables were all obtained from the 2007 Cameroon household consumption survey.

Our data were practically from secondary sources as we used the household consumption survey (HCS); though, we imported the fertilizer variable from records of the Department of Statistics of Ministry of Agriculture, given that this variable was not captured in the household consumption survey. Therefore, it became relevant to import it from a tangible and authentic source such as the Ministry of Agriculture in Cameroon. The details of this data set concerning sample selection and technique of analysis were already discussed in (Tambi, 2019) while the nature and behavior of the several variables as well as the way they are presented in Table 2 of weighted sample statistics.

The variable of food crop production was captured by rice, yams, maize, and cocoyam. The principal endogenous variable was agricultural training; the instruments for the endogenous variable were cluster mean of household ownership of radio and television. The exogenous demographics were household head education such as primary, secondary and higher education, farm

experience, number of workers' in agricultural sector, male household head, household size, banking financial support, non-poor households, farm size and farm input such as seeds and Fertilizer geographical location of the household.

## RESULT AND DISCUSSION

### Sample Descriptive Statistics

The descriptive statistics table shows that 27.2% of agricultural farmers applied organic and chemical fertilizer in their farms with a maximum of

more than 8 bags per season. Most of the crops planted on a given that a piece of land can contain both food crops such as yams, plantains, maize, rice and cash crops such as coffee, cocoa, pineapple, etc. Among the farmers in the agricultural sector, only about 45% had professional training in agriculture or farm management. This training could either be in the form of attending professional schools, internship, workshops or on the form of training. The average annual precipitation for 2002 – 2007 was moderate for the production of crops.

**Table 2.** The Description of Sample Statistics of Household

Variables and Sources	Mean	Std Dev	Min	Max
<b>Dependent Variable</b>				
Value of Agricultural food crops from arable Land – HCS	642.31	3501.39	0	99988889
<b>Potentially endogenous Variable</b>				
Fertilizer application on arable land – MINADER	4662.27	0.46	7.07	8.98
<b>Variables Identifying Fertilizer Application</b>				
Application of Organic fertilizer – MINADER	2545.06	1478.33	420	4610
HH Application of Chemical fertilizer – MINADER	7964.31	1133.74	5690	9580
<b>Dependent Variable Exogenous Explanatory Variables</b>				
Use of modern technology in farm land (1= yes, 0 otherwise) – HCS	0.1203	0.3254	0	1.000
Climate Change (captured by average annual precipitation in milliliters for 2002 - 2007 ) – MINADER	470.25	235.74	216.36	941.08
HH had Farm Professional training - MINADER	201.45	100.47	80	370
Arable land size – HCS	18939.78	10277.92	6802.85	39801.71
Ownership of arable land – (1= Yes, 0 otherwise) – HCS	0.5393	0.4985	0	1.000
Average number of persons working in the farm – HCS	2.3015	3.2108	0	106
Cost of fertilizer applied – HCS	8.9674	126.16	0	13500
Household size – HCS	4.3930	3.0253	1	43
Cost of seeds use on farms – HCS	5.1759	63.6779	0	4000
Household experience in farms – HCS	42.0061	15.4333	0	95
Sex of HH head (1= male, 0 otherwise) – HCS	0.7438	0.4366	0	1.000
HH Residence (1= urban, 0= otherwise) – HCS	0.3702	0.4829	0	1.000
<b>Potential instruments for endogenous inputs</b>				
HH received Institutional farm Support (1= Yes, 0 otherwise) – HCS	0.1795	0.3838	0	1.000
HH received other farm Support (relatives, friends, network) – HCS	0.2177	0.4127	0	1.000
<b>Control Variables</b>				
Error_hat, resid	-5.46e-07	1599.969	-5891.43	3263.232
Residfertilizer = ferror_hat*hhfertilizer	2559496	6363186	-2.04e+07	2.27e+07

Source: Computed by the Stata 13.0. Note that MINADER represent variables gotten from ministry of agriculture while HCS is standing for variables from Household Consumption Survey; HH = household

The agricultural statistics indicated that only 12% of the households in Cameroon used modern technology in producing their crops in an average farmland size of minimum 6802.85 meters square and a maximum farm size of 39801.71 meters square. Practically, although Cameroon are being an agricultural country, only 53.9% of the farmers own their farms and only about 30% of households

work permanently as farmers without any other secondary activity. Most of the farmers still have large households which served as labor supply to the farms. The seeds used in the farms was either owned or bought by the farmers. However, most of the farmers especially those in the rural sector used their seeds.

The oldest of the household heads are 95 years, and this depicts a considerable experience. In terms of the gender of household head, about 74.37% of the households are headed male households, of which at least 37% of them involved in agricultural production living in urban centers. It implies that most of the farm producers live in rural milieu where there is still much land for agricultural exploitation. The descriptive statistics shows that about 21.77% of households received farm support material from their relatives, friends, and network which enabled them to foster their agricultural activities as well as augment the production capacity. In this light, only 17.9% received institutional farm support. Among those were farm equipment, fertilizer, and new seeds. This figure shows that individual households are more financing the agricultural farm production than otherwise.

### **Factors Influencing Fertilizer Application**

Among the factors influencing the application of fertilizer by agricultural households and land size, household had farm professional training and average annual precipitation, used of modern technology, male household head, urban residence and cost of fertilizer applied are positively and significantly influencing the application of fertilizer (see, Table 3, column one for details). The larger the arable land size, the more fertilizer required to meet the ends of the land. This matter explains why the size of land under cultivation has significantly correlation with the quantity of fertilizer use. Zhou et al. (2010) analyzed the factors influencing the farmers' decisions on fertilizer. The results show that irrigation, gains in crop yield and higher-earning goals are positively correlated with fertilizer use of intensity. Meanwhile farm size, manure application, soil fertility and the distance to fertilizer markets are negatively correlated. Investigation of overuse fertilizer shows that higher education level significantly reduces the probability of over-fertilization.

The acquisition of farming professional training is an advantage for the use of agricultural training. Training changes one's perception of the use of agricultural input. Thus, when farmers are agriculturally educated, they applied fertilizer the more and the right quantity. The decision to use either chemical or organic fertilizer depended on

the quantity of knowledge. The average annual precipitation can equally determine the quantity of fertilizer applied in a given exploited land. The higher the precipitation, the more the fertilizer applied is washed away. It implies that during the rainy season, which usually lasts for about six months in Cameroon, the quantity of fertilizer applied also increase drastically and vice versa.

The used of modern technology in agricultural farms also necessitates the application of fertilizer. Modern agriculture is agriculture towards the market, which required mass production to satisfy the food security problem. This technology can only be met through the application of fertilizer coupled with other associated inputs. The presence of a male household head significantly correlates with fertilizer application. In Cameroon, while the women focus on crop production, the men work more emphasized on cash crop production, which is usually large and vast farms and necessitates fertilizer use.

Sotamenou & Parrot (2014) explained that land pressures and pollution resulting from the solid waste generation in urban and peri-urban agriculture become real issues in agriculture in Cameroon. Urban and peri-urban agriculture activities are potential regular users of large quantities of household wastes and compost.

Meanwhile, variables such as land property rights, membership in farmers' cooperatives, food cultivation, farm income and the distance between farmers' dwellings and their farms have a significant effect on compost used in urban and peri-urban areas. Further, it also shows that variables like land-property rights, food cultivation, the available chemical input budget and the distance between dwellings and farms explain fertilization at all levels (Sotamenou & Parrot, 2014).

Urban dwellers are more conscious of fertilizer application of agricultural farmers as compared to farmers in the rural zones. The arable land located around the periphery of the urban center is easily contaminated with toxic chemicals and environmental pollution from urban industries and so reducing the quality of soil fertility. To regain this fertility, farmers need to apply much fertilizer. The cost of fertilizer applied to agricultural farmers

is also a major determinant of fertilizer. Applying the principle of demand and supply, when the cost of fertilizer increases, the quantity of fertilizer used

falls and vice versa. The detail of this result is in Table 3.

**Table 3.** Factors Influencing Fertilizer Application and Its Effect on Arable Land

Variable	RFE	LR	2SLS	Control Function	
				a	b
Log of Fertilizer application in kgs	n/a	-0.121*** (3.74)	0.032*** (3.87)	0.025*** (5.75)	0.055*** (5.90)
Use of modern technology in farm land	0.717* (1.93)	0.649*** (2.92)	0.278*** (3.23)	0.277*** (4.81)	0.054*** (4.88)
Average Annual Precipitation in Milliliters	0.885*** (33.36)	-0.663*** (2.78)	0.588*** (3.38)	0.588*** (5.02)	0.802*** (5.75)
HH had Farm Professional training – MINADER	0.270*** (4.70)	0.883*** (2.72)	0.426*** (3.87)	0.626*** (5.76)	0.050*** (6.37)
Arable land size	0.129*** (44.87)	0.015* (1.82)	0.379*** (3.84)	0.790*** (5.71)	0.401*** (6.03)
Ownership of arable land	-0.310*** (6.66)	0.573*** (8.74)	0.203 (0.54)	0.203 (0.80)	0.501 (0.83)
Average number of persons working in the farm land	0.188 (1.36)	0.098 (0.58)	0.321 (1.26)	0.321* (1.87)	0.972* (1.80)
Cost of fertilizer applied	454.388*** (3.03)	-0.046 (0.14)	654.031* (1.82)	231.011*** (2.70)	643.995*** (2.61)
Household size	-0.315* (1.93)	0.952 (0.21)	-0.208 (1.40)	-0.218** (2.08)	-0.724* (1.91)
Cost of seeds use on farms	-0.317 (1.25)	0.291** (1.98)	0.385 (0.39)	0.111 (0.57)	0.321 (0.48)
Household experience in farms	0.196 (0.90)	0.675 (1.36)	0.890 (1.53)	0.280** (2.28)	0.672** (2.22)
Male HH head	0.452*** (5.22)	0.290*** (4.04)	0.679*** (4.57)	0.619*** (6.79)	0.707*** (6.74)
HH urban Residence	-0.667*** (12.35)	0.814*** (2.65)	-0.358*** (2.82)	-0.250*** (4.18)	-0.837*** (4.16)
Constant term	24.91*** (10.09)	-0.363 (1.600)	0.682*** (2.78)	0.687*** (4.13)	0.050*** (3.45)
HH received Institutional farm Support	-0.721 (1.20)	n/a	n/a	n/a	n/a
HH received other farm Support	-0.855*** (5.02)	n/a	n/a	n/a	n/a
Fertiliser Residual	n/a	n/a	n/a	2.822*** (5.52)	3.248*** (6.27)
Fertiliser Interaction	n/a	n/a	n/a	n/a	-0.000*** (4.77)
R <sup>2</sup> /Pseudo-R <sup>2</sup>	0.4659	0.4282	0.9604	0.0329	0.0364
Wald $\chi^2$ ( <i>p</i> -value)/F-Stat [df; <i>p</i> -val]	393.40 [14,6315; 0.0000]	14.12 [13,6316; 0.0000]	17.07 [13,6316; 0.0000]	15.35 [14,6315; 0.0000]	15.90 [15,6314; 0.0000]
F test of excluded instruments/ Joint F / $\chi^2$ ( <i>p</i> -value) test for Ho: coefficients on instruments = 0	n/a	n/a	12.63 [2,6315; 0.0000]	n/a	n/a
Angrist-Pischke multivariate F test of excluded instruments:	n/a	n/a	25.212 [0.0000]	n/a	n/a
Sargan statistic (overidentification test of all instruments): (Chi-sq(2) <i>P</i> -val)	n/a	n/a	7.518 [0.0061]	n/a	n/a
Weak identification test: Cragg-Donald F-Stat [5% maximal IV relative bias]	n/a	n/a	12.627 [19.93]	n/a	n/a
Durbin-Wu-Hausman $\chi^2$ test for exogeneity of variables /( <i>p</i> -value)	n/a	n/a	30.441 [0.0000]	n/a	n/a
<b>Number of observation</b>		<b>6,330</b>			

**Source:** Computed by the author. *N/B:* RFE = Reduced Form Estimate, LR = Linear Regression, 2SLS= Two Stage Least Square. *N/B:* \*\*\*, \*\*, \* indicate 1%, 5% and 10% levels of significance respectively; n/a = not applicable; absolute value of robust *t*-statistics are in parentheses beneath estimates.

### Impact of Fertilizer on Food Crop

In general, arable land is land capable of being plowed and used to grow crops. Geographically, arable land is a form of agricultural land use, which can be used for growing crops. The result as seen in Table 3 (2SLS i.e. column 3, control function without interaction i.e. column 4 and control function with interaction i.e. column 5) shows that fertilizer strongly and positively correlates with

arable land agricultural production. According to 2SLS and control function results, fertilizer influences arable land crop production by 3.2 percent, 2.5 percent and 5.5 percent respectively. As a result, the low fertility of soils is due to soil pollution (caused by continuous use of pesticides, herbicides, and Fertilizer, plays a significant role in soils being unproductive and barren), acidic nature of soils (Nitrogenous Fertilizer, for example,

notorious at making the soil more acidic) and structure of the soil (when the soil has many large particles, it becomes highly oxygenated but drains water quickly). In opposite, soil particles are too small, so the water flows at a decreased rate but the oxygen levels drop.

Since the magnitude of the coefficient of the interaction term and residual error of the control function (column b) estimate is significant while others are not and given that the Wald test for  $p = 0$  (p-value) is higher in the case of column (b) of control function estimate (15.90 [15, 6314; 0.0000] it makes the control function estimate preferred to others. This parsimonious result is preferred to 2SLS which is understated and OLS which is insignificant and not relevant for inference, in association with the residual and interaction term. This result confirms the drop of our hypothesis that, there is no heterogeneity in arable land production.

Therefore, going by the result of column (b) of control function estimate, this result reveals that fertilizer has a strong probability of increasing arable land production especially on soil infertility. These are caused by the shortage of manure, tillage practices, continuously cropping, limited crop rotation, indiscriminate cutting of trees, burning of crop residues and bush fires. Fertilizer helps to supply abundant nutrients which is essential to the growth of plants. In association with fertility, household experience in farms, household size, household head, annual rainfall, the use of modern technology and size of land strongly corroborates with fertilizer to influencing arable land production.

Zhou et al. (2010) analyzed farmers' decision making on fertilizer use for crop production by small-scale Chinese farmers. They mentioned that intensive use of fertilizer in conjunction with improved seed varieties and expanded irrigation has brought about the rapid growth in China's grain production. In the same period, the grain yields grew from 3.7 tons to 5.3 tons per hectare. It also suggested that there is a strong positive correlation between annual food production and annual consumption of Fertilizer during the period of 1949-1998 (Zhou et al., 2010).

## Effects of Organic and Chemical Fertilizer

Table 4 shows that fertilizer application on arable land marginally positively correlates with agricultural production. The issue is the application of chemical fertilizer is more effective in soils that initially lose their fertility as it increases the level of nutrients found in the soil. An essential issue of using nitrogen Fertilizer is groundwater contamination. Nitrogen fertilizer breaks down into nitrates and travels easily through the soil. Nitrate is water-soluble and can remain found in groundwater for decades.

The variable associated with chemical fertilizer to increase arable land production is the use of modern technology in farmland, average annual precipitation, households' professional farm training, arable land size, average number of persons working in the farm, cost of fertilizer supplied, household experience in farms, sex of male household head and urban household residence. Organic fertilizer application on arable land strongly correlates with the arable land production of crops. The organic fertilizer provides a beneficial effect as follows: suppress pests, more efficient irrigation and agricultural activities on soils. Hence, the organic fertilizer catalyzes plant growth and subsequently increases agricultural production.

Wamba et al. (2012) evaluated the growth and yield parameters of Bambara groundnut under organic and inorganic fertilization. Using poultry organic manure fertilizer and three chemical Fertilizer (nitrogen, potassium and phosphorous) in a randomized completes block design experiment with (Saint Macary et al., 2010). The application of the Fertilizer (both poultry and chemical) significantly increases leaf water content, plant dry weight and total chlorophyll content in the plant, increases the number of pods per plant, the number of seeds per pods, revealing a higher response of cultivar to fertilization.

In Cameroon, the organic manure is found as cow dung, compost manure, and fowl droppings. These materials are natural products that greatly enrich soil fertility and will not negatively affect soil content including impacts on soil erosion and pollution. The variables associated with organic fertilizer to increase arable land production are the use of modern technology, the average annual

precipitation, arable land size, household experience in farms, sex of male household head and urban household residence.

Organic waste generated by human activity continuously increases worldwide due to urban development-wastewater, sludge and municipal waste where they are often applied on cultivated lands on the outskirts of cities (Saint Macary et al., 2010). The organic wastes are sources of organic matter that may increase soil fertility and reduce the need for chemical Fertilizer and so enhance

sustainable agricultural production. They equally recognized that contaminants and inappropriate application from fertilizer might lead to an accumulation of mineral, organic, or metallic contamination. Thus, it will degrade soil quality and possibly increase the risk of pollutant transfer to the harvested crops. The disadvantage situations in which the fertilizer produced and used are factors that should be considered to enhance organic waste management in agriculture. There is a growing need for organic Fertilizer that results from reliable waste recycling.

**Table 4.** Arable Land Effected by the Application of Organic and Chemical Fertilizer

Variable	Chemical Fertilizer	Organic Fertilizer
Fertilizer application on arable land	0.005* (1.60)	0.717 *** (4.66)
Use of modern technology in farm land	844.056 *** (4.88)	829.867*** (4.23)
Average Annual Precipitation in Milliliters	8.802*** (5.75)	6.995 *** (3.94)
HH had Farm Professional training	6.050*** (6.37)	1.031 (0.79)
Arable land size	0.401*** (6.03)	0.303*** (3.91)
Ownership of arable land	196.501 (0.83)	177.034 (0.65)
Average number of persons working in the farm	31.972* (1.80)	-2.206 (0.10)
Cost of fertilizer supplied	0.995*** (2.61)	0.572 (0.57)
Household size	-39.724* (1.91)	-5.151 (0.21)
Cost of seeds use on farms	0.321 (0.48)	-0.436 (0.59)
Household experience in farms	0.672** (2.22)	0.000** (2.09)
Sex of male HH head	-0.724* (1.91)	0.263*** (6.12)
Urban HH Residence	-0.837.163*** (4.16)	0.0554*** (2.75)
Fertiliser Residual	0.248 *** (6.27)	0.830*** (4.74)
Fertiliser Interaction	-0.000*** (4.77)	-0.000 (0.69)
Constant	0.482.055*** (3.45)	0.298.557*** (5.06)
R <sup>2</sup> /Pseudo-R <sup>2</sup>	0.6364	0.8046
Wald $\chi^2$ ( <i>p</i> -value)/F-Stat [df; <i>p</i> -val]	15.90[ 15, 6314; 0.0000]	10.90[ 14, 4258; 0.0000]
Number of Observation	6330	4,273

Source: Computed by using STATA 13.0. N/B: \*\*\*, \*\*, \* indicate 1%, 5% and 10% levels of significance respectively; absolute values of robust *t*-statistics are in parentheses beneath estimates.

Pascault et al. (2010) revealed that alfalfa residues caused more significant modifications of bacterial communities and their activity indicates that biochemical composition and recalcitrant substances in plant residues is an essential factor in this effect. Similarly, Lejon et.al (2007) noticed changes in the bacterial and fungal communities as a result of organic amendment application. In addition to livestock manures, cattle and ruminant manures, cereal and legume plant residues commonly become a resource of organic matter due to their abundant nitrogen (Abera, Wolde-meskel, & Bakken, 2012).

### Policy Implication

From the result above, the fertilizer strongly correlates with arable land crop production. In terms of policy, this study recommends that the

government of Cameroon should increase and subsidize the supply of fertilizer to farmers given the right conditions. Fertilizer is an essential booster of agricultural production in this era of food security. Furthermore, the magnitude of this effect is stronger in organic fertilizer than in chemical fertilizer.

Generally, it is easier for households to access organic than chemical fertilizer, given that organic fertilizer is simply the decomposition of natural materials such as grass, cow dung and excreta from other animals as well as the decomposition of other natural materials. In terms of policy, it recommends that the decision-makers through the councils and civil society organizations should organize seminars and workshops to educate agricultural households. Farmers are demanded to understand the relevance and quantity of organic

fertilizer in promoting agricultural production while also considering chemical fertilizer. Fertilizer application is especially true given that land size, professional training, the average annual precipitation, the use of modern technology, male household head, urban residence and the cost of fertilizer are factors positively and significantly influence the application of fertilizer on arable land in Cameroon.

## CONCLUSION AND SUGGESTION

The fertilizer strongly correlates with arable land production. The magnitude of the effect is stronger in organic fertilizer than in chemical fertilizer. Besides, land size, professional training, the average annual precipitation, the use of modern technology, male household head, urban residence and the cost of fertilizer are factors positively and significantly influence the application of fertilizer on arable land in Cameroon.

The use of organic and chemical Fertilizer has an essential influence on agricultural production. Farmers are required to understand more about the use of organic fertilizer following environmental conditions so that they can be wiser in the use of chemical Fertilizer. It is the right condition to encourage agricultural production now. It is an essential booster of agricultural production in this era of Cameroon second generation agriculture.

This research recommends that the government of Cameroon should increase and subsidize the supply of fertilizer to farmers given the right conditions. This policy can further have intergenerational implications for wealth, health, economic growth and household standards of living in Cameroon.

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