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Abstract

We examine the viability of inorganic fertiliser use in Uganda, using the 2005/06 Uganda National Household Survey data. We also explore the farmers' characteristics under which fertiliser use is more profitable. We find that inorganic fertiliser use is more profitable for only a few crops and less profitable or unprofitable for most crops, even when their yield is high. Furthermore, we find that farmer profit with fertiliser use increases with access to extension services and/or use of improved seeds. Thus, blanket promotion of fertiliser use, without a case-by-case consideration of fertiliser-crop profitability is likely to be counter-productive to the drive of increasing agricultural productivity and household income in Uganda. Hence, the drive to increase fertiliser use in Uganda can succeed only if farmers are widely sensitized not about the potential of fertiliser to increase yield but the crops on which fertiliser use is more profitable and the preconditions for its profitability.

Key words: fertiliser use, economic viability, Uganda
JEL Classification: Q12, Q16

1 Introduction

In most countries of Sub-Saharan Africa (SSA), increased agriculture remains the most important path to growth in household incomes (World Bank 2007). Unfortunately, in most of these countries, agricultural sector growth is lagging other sectors of the economy. In the case of Uganda, for example, growth in the agricultural sector has averaged 1% for the past five years (2004 - 2008), yet growth in the services and industrial sectors, as well as the economy overall has averaged 7% per annum (MFPED 2009). And specific to the crop sub-sector, growth in the food-crop sub-sector, which is critical for food security, lags the cash-crop sub-sector. Again, for example referring to statistics, average five-year growth in Uganda's food-crop sub-sector is 0.1% while for cash-crops growth has averaged 2.3% (MFPED 2009).

The challenge of low growth in the agricultural sector has aggravated the problem of food insecurity in Uganda (MFPED 2008). Furthermore, the food insecurity problem has been heightened by the upsurge in demand for agricultural output from neighboring countries such as Rwanda, Kenya, DR Congo, and South Sudan (Karugia et al. 2008). As such, the need to increase agricultural output and productivity in Uganda has become an urgent matter (MFPED 2008; 2009).

Options to increase agricultural output and yield lie mainly in adoption and use of improved inputs such as fertiliser. Evidence about the capacity of fertiliser to increase yield is abundant and consistent [for example Viyas 1983; Hiesey & Mwangi 1996; Tittonell 2007]. Consequently, in the draft national development plan (NDP), government of Uganda policy to increase agricultural productivity is focused on supporting farmers to increase the use of fertiliser (NPA 2009). But, support or encourage farmers to increase fertiliser use on which crops? This is a critical question that has not received adequate attention in the endeavor to increase fertiliser in Uganda. As noted by FAO, even if an input is known to enhance yield, farmers are unlikely to increase its demand until they perceive that the input is profitable (FAO 1999). Moreover, Kelly (2006) notes that farmers in Africa still base their decision about fertiliser use on profit even though they face significant information, liquidity, and risk constraints that limit effective demand for and use of fertiliser.

In this paper, we investigate if fertiliser use is profitable in Uganda's agriculture. We do this for over 10 key crops on which farmers use fertiliser. In particular, we explore the following questions: (i) to what extent does the profit of farmers using fertiliser differ from those not using? (ii) Under what conditions may fertiliser use be more profitable? Before answering these questions however, we compare the physical productivity (yield) of fertiliser users and nonusers, to verify the stylised fact of fertiliser productivity.

In Section 2, we provide a brief literature on fertiliser use and its implications on farmer profit. We give details of the data and process through which it was generated in Section 3. In Section 4, we explain the method of analysis adopted, while in Section 5 we give details about the variables used in the study. We present and discuss the results in Section 6, and Section 7 concludes the paper with policy implications arising from the results.

2 Related literature

There are numerous studies on agricultural productivity/efficiency -which simply means maximizing output per unit of input. Some studies have focused on yield to measure efficiency arising from the inputs used while others have focused on profit arising from the cost of inputs.

In terms of methodology, some studies use descriptive statistics including analysis of variance methods, yet others use econometric techniques such as the stochastic frontier analysis (SFA) method.

Kieft & Coulibaly (1993) estimated returns to cotton farmers in Mali using fertiliser as well as animal dung, by comparing the costs of these inputs with the income increase obtained by applying them. The authors concluded that it appeared that use of both inorganic and organic fertiliser was feasible at existing price levels of cotton. Furthermore, higher doses of inorganic fertiliser were found not to be economically feasible given the costs. But for organic fertiliser higher doses were found to be feasible and necessary but not available in sufficient quantities.

A study based on farm-level research experiments in Rwanda reported that inorganic fertiliser use was generally profitable for maize and beans but unprofitable for sorghum, peas, wheat and cassava (Kelly & Murekezi 2000). The authors noted that some of the factors that affected crop-fertiliser profitability included low price of output compared to cost of fertiliser, low output response of the crop (e.g. peas) to fertiliser, and long gestation periods for crops such as cassava.

Other than the high fertiliser cost that is alleged to inhibit its increased use and profitability, farmers' knowledge about the correct use of fertiliser is also critical for increased adoption. FAO (1999) points out that there is widespread lack of knowledge about efficient use of inorganic fertiliser. Furthermore, FAO notes that adoption is unlikely unless programs on fertiliser use efficiency such as demonstrations on farmer fields, farm visits, and radio and television campaigns are intensified, including local research into soil and crop conditions, balanced fertilization and training of farmers to make their own organic manure.

Xu et al. (2009) report that delayed farmer access to fertiliser has significant implications on their profitability. The authors found that farmers in Zambia who practiced rain-fed agriculture and depended on subsidised fertiliser under government programs often received it late, thereby affecting their cropping cycle, yield as well as profit.

The effect of farmer education and access to extension on their productivity has been widely studied. Using Uganda household survey data, Appleton & Balihuta (1996) found a positive but insignificant relationship between the level of farmer education and output. Evenson & Mwabu (1998) also found similar results regarding of the relationship between education level and productivity for Kenyan farmers. Regarding the effect of farmer access to agricultural extension on yield, Evenson & Mwabu, conclude that it had limited effect.

There are hardly national level studies focusing on the economic viability of fertiliser use in Uganda. A study by Kaizzi (2002) is the closest we find. Kaizzi carried out experimental studies on fertiliser use in eastern Uganda, which indicated that inorganic fertiliser use on maize was profitable in some highland areas with high rainfall and less profitable in lowland areas with less rainfall. It is well known however that results from scientific experiments generally differ from actual farmer outcomes –since experiments follow controlled or recommended procedures on the quantity and quality of inputs to be used. Furthermore, Kaizzi's study was very limited in geographical scope as well as the crops under study. In our study, we use a nationally representative dataset –the Uganda National Household Survey data of 2005/06 and include over 10 crops in the analysis. Rather than only exploring the correlation of farmer profit with fertiliser use, we include interaction terms of fertiliser use with other farmer characteristics such as use of improved seed, education level and access to extension services, which are recognized to augment fertiliser efficiency.

3 Data

The principal dataset used in this study is the Uganda National Household Survey of 2005/06 (UNHS 2005/06), produced by Uganda Bureau of Statistics (UBOS). UBOS follows scientific methods in data collection. The scope of UNHS 2005/06 is national, covering all districts of Uganda. In terms of data, UNHS 2005/06 included the socioeconomic module, agricultural module (crop and livestock), and community module. At household level, agricultural data was collected for individual crops cultivated in two seasons (2004 season B and 2005 season A). The dataset on crops contained over 58,000 observations, including for example land under fallow.

The data for analysis was generated by merging several pieces of data from the three modules. In the agricultural module, data was derived on input use and output. From the socioeconomic module we derived data on the characteristics of the farmer, such as location, education level, and age. And from the community module, data on community wage rates, access to extension services and membership to farmer group was pulled out. Though the agricultural dataset included even information such as land under fallow or backyard vegetable cultivation, it was incomplete in many aspects such as the land under cultivation or inputs (quantities and values) used in production. As such, a large proportion of observations in this category were dropped.

After merging, the next steps taken to get to the final dataset were as follows. First, a preliminary analysis of crop by fertiliser use was done, which resulted in the identification of 15 crops that farmers cultivated and applied fertiliser most (Table 1). Second, a further analysis of the 15 crop data revealed unrealistic yield outcomes arising from either very low or very high values ascribed to land under cultivation. For example, there was an observation where data indicated that a farmer obtained 30kg of maize from land equivalent to 0.0002 acres, which translates to a yield of 371 tonnes per hectare (t/ha). With further preview of data, we found that observations within the range of area cultivated as 0.3 -21 areas were ideal. Thus all observations outside this range were dropped. This left us with about 18,000 observations (Table 2). But considering that crop specific responses from fertiliser use were low, crops were grouped in categories such as grains, legumes, root-crops and plantains (Table 3).

4 Method of analysis

To compare profitability as well as yield of farmers using vis-à-vis not using fertiliser, we utilize the analysis of variance (ANOVA) method. The answer to the second question is obtained by examining the effect of interaction terms of fertiliser use and other farmer characteristics on profitability as compared to the effect of the individual characteristics only. To perform this analysis, we make use of the stochastic frontier analysis (SFA) technique. The SFA technique allows us to simultaneously examine the effect of farmer characteristics on their profit on one hand and the extent to which input costs contribute to profitability on the other hand.

Following Battesse & Coelli (1995) or Kumbhakar & Lovell (2002), the stochastic frontier profit model of the Cobb-Douglas function, is specified as:

$$(1) \qquad \pi_i = f\left(P_{mi}, A_{ki}, x_{ji}, \beta\right).e^{\varepsilon_i}; \; i = 1, \ldots\ldots N,$$

Where π_i is gross profit of farmer *i,* defined as gross revenue less total variable costs; p_{mi} is the price received by farmer *i* for output *m;* A_{ki} is the area *k* under cultivation by farmer *i*, x_{ji} is the cost of input *j* used in production by farmer *i*, β is a vector of coefficients to be estimated. *e* is the expression for exponential, and ε_i is the error term, consisting of the idiosyncratic error term, ν_i and the inefficiency variables –farmer characteristics, u_i. That is; $\varepsilon_i = v_i - u_i$. The ν_i*'s* are assumed to be normally distributed and independent of u_i*'s*. While u_i*'s* are non-negative random variables associated with the (in)efficiency in the profit. Since the data we use is cross-sectional, a half-normal distribution of the inefficiency variables is assumed in order to obtain efficient estimates (Bauer, 1990).

In general, the model in Eq (1) is composed of two parts –the general model-*f*(**.**) and the inefficiency model (ε). In the explicit form, Eq (1) is specified as in Eq (2)

(2) $$\pi_i = \alpha + \beta \ln P_{mi} + \delta \ln A_{ji} + \sum_{j=1}^{6} \gamma_j \ln X_{ji} + [v_i - (\theta_0 + \sum_{k=1}^{10} \theta_k Z_{ki})]$$

In Eq (2), **ln** implies natural logarithm, $X_{1i}, X_{2i}, ..,X_{6i}$ are costs of hired labour, seed, fertiliser, manure, traction power, and herbicides or fungicides respectively for farmer *i*. On the other hand, $Z_1, Z_2, ..,Z_{10}$ are farmer characteristics including family labour use (quantity), age, education level, cropping pattern, fertiliser use, seed type, and extension services access. The Z's also include the interaction terms of fertiliser use with seed type, extension access, and education level.

Positive values of the inefficiency covariates indicate the contribution of the variable towards overall profit inefficiency. However, if the value of the inefficiency covariate is negative, the variable brings about efficiency rather than inefficiency towards the overall profit of the farmer.

To ensure reliable results, both the descriptive as well as the econometric estimates are weighted using the inflation factors which are provided in the UNHS 2005/06 dataset. As Deaton (1997) observed, regressions and other estimators derived from cross-sectional survey data are likely to be biased, inconsistent and inefficient if not corrected for the design effect and the problem of heteroscedasticity. Finally, all the analysis was performed in STATA/SE 10.0 SE. Estimation of the parameters (α, β, δ, γ, θ, ν) in Eq (2) was carried out in one-step using the maximum likelihood estimation technique.

5 Variables used in the analysis

5.1 Gross profit

In this paper, gross profit is taken as the indicator of economic viability, which is our dependent variable. We report gross profit as revenue (which is producer price times output) from a given crop less actual costs incurred in production of the crop. In this case imputed costs for family labour and own land used in production are not included. Actual costs include for example, cost of seed, hired labour, fertiliser and traction power hire. The gross profit and the costs of production are denominated Uganda shillings (UGX).

5.2 Yield

We include yield to compare the agronomic outcome of farmers who used fertiliser with those who did not. Yield as measure of physical productivity of factor is a valuable comparative statistic in the analysis the economic viability of fertiliser. That is, comparison of yield and gross profit allows us to know whether physical productivity of a factor is equivalent to economic viability as is some times assumed. Yield is measured as tonnes per hectare (t/ha), which is equivalent to output in tonnes divided by the area (standardized in hectares) planted.

5.3 Inorganic fertiliser use

In UNHS 2005/06, this control variable, which is of our main interest, was captured at farm-level for each parcel of land cultivated by the farmer. In the survey, inorganic fertiliser or simply fertiliser was captured qualitatively –i.e. did or did not farmers apply fertiliser on the parcel of land. In UNHS 2005/06, the cost of fertiliser was also inquired but the quantity or the particular type of fertiliser used (for example DAP or Urea) was not inquired.

In the analysis, the fertiliser use variable is therefore categorical and not quantitative and the unit of analysis is the parcel of land. The cost of fertiliser is however incorporated as a quantitative variable in the SFA of profit efficiency.

5.4 Other control variables

Variables representing the characteristics of the farmers are included. These variables are: location, gender, education level, access to extension services, seed type planted, cropping pattern, and membership in government extension programme of the National Agricultural

Advisory Services (NAADS). Additional variables are generated as interaction variables between fertiliser use and other farmer characteristics including seed type planted, education level, and access to extension services. Other than the education level, these variables are assigned dummies, 1, if the farmer has the characteristic in question, and 0, otherwise.

Table 4, lists the variables used in the analysis. The table also includes their mean/ proportion, standard deviation, minimum and maximum values as well as the units of measurement. From the mean values, it shows that just 1% of the parcels of land that farmers cultivated were applied with fertiliser. Taking all the sample farmers into consideration, average expenditure on fertiliser was only UGX 700 per hectare, which was much less than their average expenditure on seed, hired labour or traction power. The gross profit taking into account all the crop categories shows that farmers obtained an average of less than UGX 0.21 million per hectare. However, a clear picture of the average profit per crop is presented in Table 7.

[Place Table 4 here]

6 Results

6.1 Characteristics of farmers using vis-à-vis not using fertiliser

Table 5 compares the proportion of farmers using fertiliser across some key characteristics including location, gender, education level, access to extension services, seed type planted, cropping pattern, and membership in NAADS. The results show that a higher proportion (1.2%) of male farmers used fertilisers compared their female counterparts (0.5%). The results further indicate that a higher and significant proportion of farmers with more education used fertiliser.

[Place Table 5 here]

Similarly, a higher and significant proportion of farmers who accessed extension services or planted improved seed, applied fertiliser relative to their counterparts who did not receive extension services or planted local seed. In the case of farmer location, there was no significant difference in the proportion of farmers who used fertiliser on the basis of their being located either in urban or rural areas. Also, the results indicate that the farmer's being in NAADS programme or planting crops in pure-stand did not have a significant influence on their likelihood to use fertiliser.

6.2 Crop yield of fertiliser users and nonusers

In Table 6, we compare the crop yield of farmers who reported using fertiliser against the yield of farmers who reported not using fertiliser. The last three columns of the table provide the actual and proportional difference in yield and the significance statistic. The results indicate that the yield for most crops except legumes, cotton and tea of farmers who used fertiliser were significantly higher than that of farmers who did not use fertiliser. For example, the results show almost a 10-fold increase in yield for farmers who applied fertiliser on tobacco, 2-fold increase for grains, plantains (bananas), and root-crops. In addition, the results show a slight but not significant increase in yield of tea farmers who used fertiliser.

[Place Table 6 here]

Though insignificant, the results indicate that legume and cotton farmers who used fertiliser, had lower yield than those who did not use. Some studies show that improper use of fertilisers can be counter productive (Ohallorans 2009). Other studies suggest that since legumes have nitrogen fixing organisms that improve soil fertility, inorganic fertiliser use may have an insignificant impact on yield (Hung et al. 1991). In the case of cotton yield, studies show that its yield significantly increases under fertiliser (Makhdum et al. 2001; Makhdum, et al. 2006). Whichever the case, in our study, we have no clear explanation why the yields of legume and cotton farmers who used fertiliser were lower.

6.3 Comparison of the profit of fertiliser users and nonusers

The average profits obtained by farmers who use fertiliser as well as those who do not use fertiliser are shown in Table 7. In absolute terms, the results show that tea farmers who do not use fertiliser, earn the highest gross profit of UGX 1.37 million per hectare. Tobacco and grain farmers who use fertiliser earn a gross profit of about UGX 1 million per hectare. For crops such as tea and legume where farmers applied fertiliser, they made losses. For cotton farmers, the results show that those who apply fertiliser obtain profits that are lower than their counterparts who do not use fertiliser. The profit loss by legume farmers who use fertiliser is likely to be related to the low yield as indicated in Table 6. However, for tea farmers who make losses, the probable reason is the high cost of fertiliser arising possibly from the higher quantity of fertiliser used in production.

[Place Table 7 here]

The crops for which farmers use fertiliser and obtain significantly higher profit (as well as yield) are grains and plantains. Regarding tobacco farmers, results show that those who use fertiliser obtain high but not significantly different profits than those who do not use fertiliser.

Comparing fertiliser productivity on the basis of yield and profit, it is clear the difference in the yield of farmers who use fertiliser vis-à-vis those who do not use is generally high, but the difference in profit is generally low. For example, the percentage difference in profit (58.3%) of tobacco farmers is not as high compared to the yield difference (940.6%). Furthermore, the difference in yield for root-crops farmers was equivalent to 5.6 t/ha but there is no difference in the profit. Also, the difference in the yield of tomato farmers is about 4.1 t/ha but difference in profit is only UGX 0.08 million. This may suggest that farmer expenditure on fertiliser was higher than the revenue arising from increased output from fertiliser use.

6.4 Sources of improving profitability from fertiliser use.

In Table 8, we present results of the SFA of farmer profitability, taking a kin interest in the influence of fertiliser use interaction terms on gross profit. A half normal distribution of the inefficiency term (u) was assumed in the estimation. Wald Chi^2, representing the robustness of the model is significant at less than 1%. Considering the general model, the signs associated with the elasticity values for seed, herbicide and traction hire costs, and output price and area cultivated are as expected. However, the signs for fertiliser cost, and hired labour were positive; indicating that increasing these inputs by a unit quantity (value) is likely to bring in increased profit by 24% and 7% respectively. The coefficients for fertiliser cost and hired labour are significant at less than 5% and 10 respectively. The coefficient for manure cost is also positive but not significant.

[Place Table 8 here]

Regarding the inefficiency model, all the coefficients of variables are significant at less than 5%, except for seed type and the interaction term of fertiliser use and seed type. The sign of the coefficients of the variables are mixed, implying that some of the control variables are associated with profit effciency while the others are associated with profit inefficiency. For example, use of more family labour in production is associated with higher profitability while advancement in the age of the farmer is inversely associated with increased profitability.

Considering individual characteristics, results show that farmers with higher education level were associated higher profitability. Also farmers with access to extension services were linked with higher profitability. But farmers who used fertiliser or improved seeds are shown to be profit inefficient. It is possible that farmers with access to extension services for example are likely to have better agronomic skills that enable them for example to prepare and apply manure in production hence increasing yield and profit. But for farmers who used fertiliser or improved seeds only, it seems the high cost of these inputs outweigh the return from increased output.

However, to gain most out of fertiliser use, it is apparent from the results that farmers have to compliment fertiliser use with access to extension services, which is significant at less than 1%. The interaction term of fertiliser use and improved seeds use is also shown to increase farmer profit efficiency although the result is not significant. But the interaction term of fertiliser use and education level is associated with profit inefficiency. This result is not surprising given the coefficients of the individual variables of fertiliser use or education level. But our expectation was that farmers with higher education who use fertiliser to be more profit efficient than their colleagues with only higher education.

7 Conclusions and implications

This study assessed the economic viability of inorganic fertiliser use in crop production in Uganda. In the analysis, we have shown that only grain and plantain farmers who use fertiliser earn considerably high profit compared with their counterparts who do not use fertiliser. For legume and tea farmers, we have shown that those who do not use fertiliser are better-off financially compared to their colleagues who invest in fertiliser. Moreover, for root-crops, coffee and tomatoes, the difference in pprofit between farmers using fertiliser and those not using, is not significantly different. These results suggest that even if the physical productivity of fertiliser is high it may not be economically viable. Thus, blanket promotion of fertiliser use –one size fits all; without a case-by-case due consideration of fertiliser-crop profitability may be counter productive to the otherwise good intentions of government policy of increasing agricultural productivity. Moreover, in the analysis we have not taken into account the cost of family labour allocated in application of fertiliser. If included, the economic viability of fertiliser use is expected to be much lower.

We have also shown in the analysis that farmer profit efficiency from fertiliser use can increase if they have access to extension services and/or use improved seeds. Consequently, we envisage that the drive to increase fertiliser adoption in Uganda can only succeed if farmers are widely sensitized not just about the potential of fertiliser use in increasing yield but more importantly about the conditions under which fertiliser is economically productive and the crops on which fertiliser use is highly profitable. For enhanced fertiliser uptake, there is need for Uganda's Ministry of Agriculture Animal Industries and Fisheries (MAAIF) to carryout a comprehensive mapping of fertiliser-crop profitability as well as the conditions under which fertiliser use is profitable in all the agricultural zones of Uganda.

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Table 1: Frequency of fertiliser use by crop

Crop name	yes	no	Total
Maize	74	7582	7656
Bananas	53	6252	6305
Beans	45	6177	6222
Cassava	20	5975	5995
Sweet potato	17	4106	4123
Millet	12	3994	4006
Coffee	37	3373	3410
Groundnuts	9	1778	1787
Sorghum	2	1428	1430
Cotton	5	462	467
Irish potato	1	439	440
Wheat	4	230	234
Tomatoes	11	156	167
Tobacco	28	55	83
Tea	6	21	27
Total	**324**	**42028**	**42352**

Source: Own calculations based on UNHS 2005/06

Table 2: Dataset after weeding-off unreliable cultivated area data.

	Fertiliser use		
Crop name	Yes	No	Total
Rice	2	198	200
Maize	42	3,471	3,513
Millet	4	1,505	1,509
Sorghum	1	682	683
Beans	25	3,018	3,043
Groundnuts	4	895	899
Tomatoes	8	82	90
Cotton	3	330	333
Tobacco	17	54	71
Irish potato	0	139	139
Sweet potato	7	1,741	1,748
Cassava	7	1,829	1,836
Bananas	20	2,850	2,870
Coffee	12	1,106	1,118
Tea	3	11	14
Total	155	17,911	18,066

Source: Own calculations based on UNHS 2005/06

Table 3: final crop dataset

	Fertiliser use		
Crop	yes	No	Total

	Freq	percent	Freq	Percent	Freq	Percent
Grains	49	0.83	5,856	99.17	5,905	100
Legumes	29	0.74	3,913	99.26	3,942	100
Plantain	20	0.7	2,850	99.3	2,870	100
Root-crops	14	0.38	3,709	99.62	3,723	100
Coffee	12	1.07	1,106	98.93	1,118	100
Cotton	3	0.9	330	99.1	333	100
Tea	3	21.43	11	78.57	14	100
Tobacco	17	23.94	54	76.06	71	100
Tomatoes	8	8.89	82	91.11	90	100
Total	155	0.86	17,911	99.14	18,066	100

Source: Own calculations based on UNHS 2005/06

Table 4: Summary statistics of variables used in analysis

	Mean / Proportion	Std. Dev.	Min	Max
Gross profit (UGX/ha)	214447	1418301	-4200700	157000000
Hired labour cost (UGX/ha)	18671	93854	0	4324250
Seed cost (UGX)	4682	32163	0	2471000
Traction power cost (UGX/ha)	3575	29962	0	1779120
Fertiliser cost(UGX/ha)	706	15597	0	1173725
Manure cost (UGX/ha)	1339	91875	0	12100000
Herbicide /pesticide cost (UGX/ha)	1095	10883	0	543620
Area cultivated (ha)	0.4	0.5	0.1	8.4
Age (years)	45.4	15.3	15	99
Family labour (man-days/ha)	67.2	560.4	0.0	74163.9
Hired labour (man-days/ha)	9.7	69.6	0.0	7413.0
Education level (0=no formal education, 1=primary, 2=secondary, 3=tertiary)	1.4	0.7	0	3
Gender (1=male, 0=female)	0.79	0.41	0	1
cropping pattern (1=pure stand, 0=intercrop)	0.49	0.50	0	1
Seed type (1=improved, 0=local)	0.08	0.27	0	1
Fertiliser use (1=yes, 0=no)	0.01	0.10	0	1
Manure use (1=yes, 0=no)	0.04	0.21	0	1
Herbicide /pesticide use (1=yes, 0=no)	0.04	0.19	0	1
Access to extension training and visits (1=yes, 0=no)	0.19	0.39	0	1
NAADS member (1=yes, 0=no)	0.24	0.43	0	1

Source: Own calculations based on UNHS 2005/06

Table 5: Comparison of the characteristics of fertiliser users and nonusers

		Fertiliser use					
		Yes		No		Pearson	Prob.
Characteristic	Group	Freq	%	Freq	%	Chi^2	
Location	Urban	21	1.4	1,494	98.6		
	Rural	134	1	13,343	99	2	0.15
gender	Female	14	0.5	3,050	99.5		
	Male	141	1.2	11,786	98.8	12.5	0
education level	Primary or less	86	0.8	11,018	99.2		
	Secondary or more	69	1.8	3,819	98.2	28.2	0
extension training & visits	Not accessed	96	0.8	12,036	99.2		
	Accessed	59	2.1	2,779	97.9	37.2	0
NAADS membership	No	119	1	11,271	99		
	Yes	36	1	3,566	99	0.1	0.82
seed type planted	Local	94	0.7	13,150	99.3		
	Improved	57	4.9	1,097	95.1	183	0
cropping pattern	Intercrop	81	1.1	7,471	98.9		
	Pure stand	74	1	7,349	99	0.2	0.65

Source: Own calculations based on UNHS 2005/06

Table 6: Yield comparison for fertiliser users or non-users

	Fertiliser use						
	Yes		No		Mean yield difference.		
Crop	Freq	Mean yield (t/ha)	Freq	Mean yield (t/ha)	(t/ha)	% change	p-value
Grains	49	5.47	4845	1.81	3.66[a]	202.2	0
Legumes	29	0.52	3114	0.62	-0.10	-16.1	0.64
Plantains	20	13.74	2521	4.71	9.03[a]	191.7	0
Root-crops	14	8.41	3017	2.86	5.55[b]	194.1	0.02
coffee	12	3.19	940	1.12	2.07[c]	184.8	0.08
cotton	3	1.12	298	1.17	-0.05	-4.3	0.51
Tea	3	2.47	9	2.27	0.20	8.8	0.43
Tobacco	17	7.18	31	0.69	6.49[b]	940.6	0.05
Tomatoes	8	7.77	62	3.72	4.05[b]	108.9	0.04

Source: Own calculations based on UNHS 2005/06

Table 7: Profitability from fertiliser use or non-use

	Fertiliser use				
	Yes	No	Mean profit difference.		
Crop	Mean profit (UGX -million)	Mean profit (UGX -million)	(UGX –million)	% change	p-value
Grains	1.01	0.22	0.79	366.1	0.01
Legumes	-0.03	0.11	-0.14	-122.6	0
Plantains	0.78	0.35	0.43	124.6	0.04
Root-crops	0.18	0.18	0.00	0.7	0.5
coffee	0.47	0.36	0.11	32.3	0.37
cotton	0.09	0.35	-0.26	-73.2	0.38
Tea	-0.37	1.37	-1.74	-127.3	0.21
Tobacco	1.03	0.65	0.38	58.3	0.3
Tomatoes	0.43	0.35	0.08	21.7	0.33

Source: Own calculations based on UNHS 2005/06

Table 8: Stochastic frontier profit model -half-normal distribution

dependent variable= gross profit explanatory variables	elasticity	Coef.	z	P>|z|
General model:				
ln(hired labour cost)	0.07	0.01	2.23	0.03
ln(seed cost)	-0.05	0.00	-2.11	0.04
Ln(fertiliser cost)	0.24	0.02	1.82	0.07
Ln(herbicide /fungicide cost)	-0.03	0.00	-0.78	0.43
Ln(manure cost)	0.16	0.01	1.18	0.24
Ln(traction hire cost)	-0.02	0.00	-0.49	0.62
Ln(area cultivated)	0.99	0.09	2.04	0.04
Ln(output price)	0.79	0.07	2.47	0.01
Intercept		-0.15	-1.77	0.08
Inefficiency model				
ln(sigma_u^2)				
Ln(household labour)		-0.34	-5.02	0.00
Ln(age)		1.73	3.32	0.00
Education level		-18.28	-5.04	0.00
Extension access		-44.89	-36.93	0.00
Cropping pattern		2.09	1.94	0.05
Fertiliser use		5.33	8.30	0.00
Seed type		0.59	1.26	0.21
Fertiliser*seed type		-2.53	-0.82	0.42
Fertiliser*extension access		-23.88	-3.54	0.00
Fertiliser *education		18.36	4.94	0.00
Intercept		-15.40	-5.86	0.00
ln(sigma_v^2)		-0.59	-0.74	0.46
Sigma_v		0.74		
Number of observations		14297		
Wald Chi^2		25.97		
Prob > chi^2		0.00		
Log pseudolikelihood		-11594607		

Elasticity (e_i) is derived as: $e_i = \frac{1}{\bar{\pi}}\left(\partial \pi_i / \partial \ln x_i\right) = \frac{\partial \pi_i}{\partial x} \bullet \frac{\bar{x}}{\bar{\pi}}$; where x_i is the i-th variable, and $\bar{\pi}$ = mean profit

Source: Own calculations based on UNHS 2005/06