AGRICULTURAL INFORMATION AND FERTILIZER USE AMONG FARMERS IN UGANDA

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Abstract

In Uganda, agriculture is the backbone of the economy, more than 70% of Uganda's workforce is engaged in agriculture; however, it is not clear where they obtain information about modern farming innovations, including fertilizer use, which are crucial in improving agricultural productivity. This study investigates how sources of information influence fertilizer use amongst farmers in Uganda. The analysis is based on micro-data of 2018 Uganda Annual Agricultural Survey. A multinomial logistic regression and multiple linear regression were used. Our findings showed that farmers who used radio, television, newspapers, extension services and farmer-farmer were more likely to use either organic, inorganic, both inorganic and organic fertilizer compared to farmers who never used any form of fertilizer. Again, the intensity of inorganic fertilizer use among farmers whose agricultural source of information was radio, television, newspaper, and extension workers were higher compared to farmers who used other forms of source of information. Other factors that influenced intensity of inorganic fertilizer use include type of transport used, access to transport type, and type of seeds used. Evidence from this study shows that the agricultural policies on fertilizer use should be streamlined taking into consideration different sources of agricultural information especially the use of radio, television, newspapers, extension workers, and farmer to farmer to ensure a boost in agricultural production. We recommend that governments and other agriculture stakeholders should focus on advertising through different communication media to reach out to farmers on the importance of fertilizer use in farming.

Keywords: Organic, Inorganic, Fertilizer use, Agricultural information.

I. Introduction

Fertilizer use is crucial in raising and sustaining agricultural production, food security and thus reducing persistent poverty (Apori and Byalebeka, 2021; World Bank, 2018; Namazzi, 2008). Prior to the advancement in chemical fertilizers, organic and other agricultural fertilizers were being utilized to boost agricultural production (Ashitha et al, 2021). As the global population rises to some 9.7 billion people by 2050, fertilizers have become an important production and global market commodity of immense economic value in agricultural production. Fertilizers are important for improving soil characteristics, as enablers of plant growth and performance and improving food security (Randive et al., 2021). Sufficient availability in a timely manner and correct balance is critical in closing the gap between nutrient supply from soil and organic sources and nutrient demand for optimum crop development (Brentrup, 2009).

Global fertilizer demand has been rising since the 1950s; for example, between 1959 and 1990, fertilizer demand rose by 5.5% annually from 27.4 million tons to 143 million tons (Bumb and Baanante, 1996). By 2019, global fertilizer consumption was 188 million tons, signifying a leap in demand with considerably skewed average per hectare usage across regions and countries. For example, Singapore had the highest per hectare use estimated at 34,707.5 kg, Egypt (674.6 kg), China (519.3 kg), Netherlands (247.9 kg) and India (142.8 kg) among others countries (Randive et al., 2021). Whereas global fertilizer demand and consumption is rising, most of this demand is driven by developing countries in East Asia, South Asia, Latin America and East Africa, which account for about 70% of the global demand (Bumb and Baanante, 1996).

Although agriculture is the mainstay of Uganda's economy employing over 70% of the total population, the country has one of the highest levels of soil nutrient depletion with only 5% of farmers use fertilizers (World Bank, 2018). This percentage is still very low and what drives this minimal adoption remains unclear. This study seeks to investigate how sources of agricultural information for example radio, television, internet, newspapers, extension services influence fertilizer use in Uganda using micro data of 2018 Annual agricultural survey of the second season. We used two models, the multinomial logistic regression and multiple linear regression model. Our results show that farmers whose agricultural source of information was radio, television, newspaper and extension services were more likely to use either organic, inorganic or both organic and inorganic fertilizers compared to those farmers who never used any source of agricultural information.

In addition, this study tests the following hypothesis: 1) There is a relationship between media (radio, television, newspapers) and fertilizer use, 2) Farmer to farmer influences fertilizer use, and 3) Provision of extension workers influence fertilizer use. This study offers national level perspectives into how sources of agricultural information and fertilizer use could be used to improve agricultural productivity

This paper has been organized in five different sections, Section II is literature review, here we relate this study to already existing work on information and fertilizer use. Section III is data, here, the study design and setting, sampling design used is presented. Section IV shows methods used in this paper. Two models used in the study were clearly explained here, that is, multinomial logistic and multiple linear regression. Section V shows the research results, discussions of the finding, summary, conclusions, and recommendations of the study.

II. Literature Review

According to the study done by Barekye et al., (2003) on-farm experiments were carried out to investigate the effect on nematodes of clean planting materials and fertilizer in Masaka district, Uganda. There results show that use of fertilizers in cleaning planting materials especially banana stems was not significantly different from bananas where fertilizers were not applied although preliminary results indicated that fertilizer application increases yield in bananas and banana productivity was expected to improve in the consecutive cycles. This study used fertilizer directly on a banana farm plantation yet the current study is using the 2018 Annual Agricultural Dataset second season to examine the effect of sources of information on fertilizer use. The results in Barekye et al., (2003) indicate that fertilizer application promote high yield in matooke while results in current study indicate that use of different sources of information influence fertilizer use hence high productivity in plants.

The use of fertilizers in the world started from ancient times, where even today, huge number of agricultural fertilizers is used to support intensive agriculture and high yield production among crop varieties (Singh et al., 2021; Ashitha et al, 2021). Although there is various type of fertilizers available on market, both organic and inorganic, fertilizers improve plant growth and yield as they support in the crucial role of supplying of nutrients in the crops. The current study investigates how sources of information influence use of fertilizers (both organic and inorganic) as well as the intensity of inorganic fertilizer use among farmers.

According to Morris et al, (2007), uptake of fertilizers is still low among most farmers in Africa yet investing in fertilizer use can enhance improvement in yields (Dulflo et al., 2011). In the research done by Adong et al., (2020) the different reasons that limit fertilizer use among small farmers in sub-Saharan Africa include; farmer's lack of liquidity and risk aversion, lack or no training of farmers in fertilizer use, limited access to information on fertilizer use, availability of counterfeit fertilizers, poor access to information type on fertilizer use among others factors. The current study is in agreement with these findings as many farmers in Africa face quite many and similar challenges that affect their farming yet if farmers are trained on innovative farming technologies like how and when to use fertilizers through communication medias like radio, television and newspaper this will increase their yields hence boosting their standards of living.

Furthermore, use of organic fertilizers in East Africa for example green plant cover crops, ash, use of legumes have supported the transformation of community food systems that have enhanced human health and environmental sustainability (Global Panel, 2016; Willett et al., 2019) hence fertilizer application, especially for N applied to bean and P applied to groundnut and soybean, can be highly profitable with sustainable production increases for smallholder farming in Kenya, Rwanda and Ethiopia. The results in this study will support the current study in terms of knowledge about fertilizer use since it investigates how sources of information can be used to influence use of fertilizers among farmers in Uganda which has similar characteristics with the rest of other East African Countries.

In addition, Apori and Byalebeka (2021) results show that poor agricultural practices, low technological adoption, low access to agricultural information type, lack of credit, unclear sources of agricultural information, and low-quality inputs of use of fertilizers has continued to hinder the agricultural sector from realizing its full potential in Uganda. Furthermore, Uganda has one of the highest soil nutrient depletion rates in the world with the lowest rates of annual organic and inorganic fertilizer application yet the use of organic and inorganic resources in management of degraded soils has been reported to improve productivity of soils which result into high crop production (Apori and Byalebeka, 2021; World Bank 2018; Namazzi, 2008). This current research explored how sources of agricultural information influences fertilizer use controlling for other factors cost of fertilizers. Cost of fertilizers has been seen to influence fertilizer use due to the fact that when cost of fertilizers are high, there demand among farmers tend to be very low and when they are low, most farmers tend to use them because they become affordable to most of them even those in low-income status.

Despite the fact that many Uganda farmers are smallholder farmers whom you think can use fertilizers in there manageable plots, there is still low prevalence rate of fertilizer use among farmers in Uganda and this is associated to the fact that uptake is well below 5% as farmers finds it hard to use agricultural information and available sources of agricultural information to access fertilizers for their crops which deters them from obtaining sufficient and appropriate returns of crop yields which could be supported by fertilizer use (Todd et al., 2012). Thus, the current study tends to investigate how sources of information influences fertilizer use among farmers.

In addition, Adong et al. (2020) in their experimental study found risk-free sales gradually improvising fertilizer adoption. Meanwhile, Freeman and Qin (2020) have shown that higher levels of information access especially through the mobile telephones drive smallholder farmers to use more agricultural inputs but how information access shapes fertilizers remain fuzzy. This current study supports the argument Freedman and Qin (2020)’s work as it looks at how sources of information like radio, television, extension services, newspaper can influence fertilizer use among farmers.

III. Data

Study design and setting

This study was based on secondary data from the 2018 Annual Agricultural Survey (AAS). To come up with a suitable sampling frame, the survey considered Uganda to consist of 80,183 Enumeration Areas (EA) covering the entire territory.

Initially, Uganda was divided into 10 different agro-ecological zones represented by the 10 Zonal Agricultural Research Development Institutes (ZARDI). The 10 ZARDIs covered all the 112 districts in Uganda. Furthermore, the ZARDIs were considered to have similar agro-ecological characteristics like climate and cropping patterns. According to Uganda Bureau of Statistics (UBOS), the ZARDIs are the largest units (maximum level of geographical disaggregation) against which statistical inferences should be drawn and conclusions made about the agricultural practices of farmers in Uganda.

Sampling design

A two-stage sampling design was adopted. From each of the 10 ZARDIs, the primary enumeration areas were selected and, from these, secondary (household samples) were further selected. A household was given a unique identifier for data collection. Figure 2 shows a schematic presentation of the sampling design as seen in Section IX.

We used the 2018 Uganda Annual Agricultural Survey of the second season. We considered different datasets that include; inorganic dataset, organic dataset, household members dataset, agriculture information dataset, transport dataset, and plot roster dataset. These datasets were emerged in R programing language into one dataset.

From the Household members dataset, we used the following variables, age, sex, marital status, education level, and main economic activity for the household. The agriculture information dataset had the following variables, radio, television, telephone, internet, newspaper, magazines, farmer to farmer, Operation wealth creation, agricultural shows, NGOs, word of mouth and demonstration farms. In the transport dataset we considered type of transport (car, lorry, head/back loading, tractor, motor cycle, bicycle, oxen, donkeys/mules, boat, ferry and wheelbarrow) used and how transport was accessed (here we considered if the farmer owned, hired or borrowed the type of transport used) variables. In the plot roster dataset, we considered only the plot size variable.

We first merged both inorganic and organic datasets and the emerged dataset had four categories of farmers, that is, those who used organic fertilizers only, inorganic fertilizers only, both organic and inorganic fertilizers and other farmers who never considered any type of fertilizers. We grouped these four groups into one variable called fertilizer use. Fertilizer use is used as our

dependent variable. Since fertilizer use had four categories employed a multinomial logistic regression to investigate how sources of information influenced fertilizer use. We had a total number of 31331 farmers in this dataset as shown in Table 3.1 in Section IX

Table 3.1 show that slightly more than half (50.3%) of the farmers never used any type of fertilizer, while one quarter (25.7%) used organic fertilizers, and 15. 6 % used both inorganic fertilizer and organic fertilizer while only 8.46 % used inorganic fertilizer. This implies that most farmers never used fertilizers yet according to the World Bank report of 2018 (World Bank, 2018), promoting appropriate fertilizer use is very crucial to sustainably increase crop production in Uganda among farmers. Furthermore, the same report and (Namazzi, 2008) show that poor agricultural practices, low technological adoption, lack of credit, poor access to extension services, poor transport means, continues dependence on rainfed agriculture and low-quality inputs has continued to hinder the agricultural sector from realizing its full potential in Uganda.

In addition, we emerged inorganic dataset with household dataset, agricultural information dataset, transport dataset, household members dataset and plot roster dataset using R programming language. We had 800 farmers who used inorganic fertilizer only. In this second merged dataset, we considered intensity of inorganic fertilizer as our dependent variable. Since it was continuous, we employed a multiple linear model to determine how agricultural source of information influence intensity of inorganic fertilizer use. In this same model, we also considered other control variables like type of transport, access to type of transport, cost of fertilizer use, type of seed used to check how they also influence intensity of fertilizer use apart from source of information. Hence this paper considered two models, the multinomial logistic regression and multiple linear regression.

Dependent Variables

This study considered two regression models: a multinomial logistic regression model and a multiple linear regression model. In the former model, fertilizer use is used as the dependent variable. This variable is categorical with four levels; that is, we considered farmers who used organic fertilizers only, inorganic fertilizers only, those who used both organic and inorganic fertilizers and lastly those that never used any form of fertilizer. In the latter model, intensity of inorganic fertilizer use is used as the dependent variable. This variable is continuous and is measured as ratio of total fertilizer used by farmers to total area (plot size) in liters per hectares. Again, in the second model we only considered inorganic fertilizers because they were easy to quantify for example these fertilizers were bought in either kilogram (Kg) or litres. We converted the kilograms into litres such that we have a uniform unit while we did not consider organic fertilizers because they were had to quantify, for example, most farmers used animal droppings, animal urine, chicken dropping, green plant cover, ash, municipal waste, sewage and plant residue. In this case, farmers only mentioned the type of organic fertilizer they were applying in their plots.

Independent Variables

This study considered sources of agricultural information as the main independent variable with the following levels: radio, television, telephone, internet, newspaper, magazines, extension workers, farmer to farmer, National Agricultural Advisory Services (NAADS)/Operation Wealth Creation, agricultural shows, NGOs, word of Mouth/Peers, demonstration farms and others. Table 3.2 shows the distribution of sources of information with farmers who never used any source (No) and farmers who used fertilizers (Yes) as seen in Table 3.2 Section IX.

Table 3.2, most farmers used radio (46.4%), farmer to farmer (28.9%), Television (4.3%), extension workers (3.2%) as their main agricultural sources of agricultural information.

Other variables considered include, household characteristics (sex, age, marital status, education level, main economic activity of the household), transport type, access transport type, cost of inorganic fertilizer, how inorganic fertilizers were obtained (homemade, purchased, received for free), type of seeds used (traditional or improved), and if seeds used were purchased or not. Only significant variables were reported in the research findings.

IV. Methods

We employed two models in this study, that is, a multinomial logistic regression and linear regressions to determine how agricultural sources of information influences fertilizer use among farmers.

Model One: Multinomial logistic regression

Here, we considered our dependent variable to be fertilizer use. Since it has four categories (organic fertilizers, inorganic fertilizers, both organic and inorganic fertilizers and never used any type of fertilizer, it is the reason why we opted for a multinomial logistic regression.

Considering fertilizer use with four categories, let j equals the number of categories, that is, j=4, meaning that there are j – 1 different ways to dichotomize the levels. This implies that we have a total of three possible ways to compare with the reference category. Here, never used any type of fertilizer is considered as a reference category and other remaining three categories (organic fertilizer, inorganic fertilizer and both organic &inorganic fertilizers) were compared in relation to the reference category (never used any type of fertilizer) as illustrated in Table 4.1 in Section IX.

From Table 4.1, none (never used any form of fertilizer) is our Reference Category (RC) which is compared with the rest of the other m categories. Organic fertilizer is coded (m=1), inorganic fertilizer is coded (m=2) while both organic and inorganic fertilizer is coded (m=3). Thus, we consider multinomial logistic regression as stated in Equation 4.1, for m = 1, 2 and 3, where m refers to the coding of other categories of fertilizer use apart from the RC to determine how agricultural sources of information influence fertilizer use.

$$\text{In}\frac{P(Yj=m)}{P(Yj=RC)} = \alpha_m + \sum_{k=1}^{k} \beta_{mk} X_{jk} \quad 4.1$$

The left-hand side shows the log odds of being in m category to the reference category, that is, it shows the log odds of probability of either using organic fertilizers, inorganic fertilizers or both organic and inorganic fertilizer compared with none (never used any form of fertilizer). α_m is the intercept of the m category, k refers to the number of independent variables to be considered ($k = 1$), β refers to the regression coefficients and X refers to independent variables in the model. Agricultural sources of information are the independent variables considered in Equation 4.1. The sources of information considered include radio, television, telephone, internet, magazines, extension workers, farmer to farmer, agricultural shows, NGOs and demonstration farms. Furthermore, no causal relationship is claimed among the sources of information stated.

We reported the odds ratios and p-values to establish which agricultural sources of agricultural information are more likely or less likely to affect fertilizer use with level of significance set at 10%, 5%, and 1%.

Model Two: Multiple linear regression

In model two, we only considered farmers that applied inorganic fertilizers only that totaled to 800 farmers. We further considered intensity of inorganic fertilizer use as our dependent variable. This is measured as a ratio of total fertilizer used by farmers to total area (plot size) in litres per hectares. The independent variables considered for this model are the agricultural sources of information. We also consider the following control variables, household characteristics (sex, age, marital status, education level, main economic activity of the household), how inorganic fertilizer were obtained (purchased or received for free), cost of inorganic fertilizer, transport type, access to transport type, type of seed used (traditional or improved), and if seeds for planting were purchased or not. The multiple linear equation model is summarized in Equation 4.2

$$y = \alpha_0 + \sum_{i=1}^{n} \beta_i X_i + \epsilon \quad 4.2$$

where y is the intensity of inorganic fertilizer use, α_0 is a model intercept, β_i, for i= 1, 2 ,…, n are regression coefficients, and ϵ is the model error. Equation 4.2 is used to determine how agricultural sources of information influence intensity of inorganic fertilizer use controlling for other variables mentioned above. Also, in this model, we did not claim causal effects on agricultural sources of information on intensity of inorganic fertilizer use but they are opinions on how agricultural sources of information can influence the intensity of inorganic fertilizer use adding control variables.

V. Results and discussion of findings

Under this section, we discuss the research finding obtained from both the multinomial logistic regression and multiple linear regression models. First, considering the multinomial logistic regression model. This model is used to investigate how agricultural sources of information influences fertilizer use. Again, this model is used because fertilizer use as a dependent variable has four categories. Among the four levels (organic fertilizers, inorganic fertilizers, both organic and inorganic fertilizers, and None (never used any fertilizer). None is used as the reference category and is discussed in relation to other three categories as presented in Table 4.1 seen in Section IX.

Comparing farmers who used both (organic and inorganic fertilizers) and those that never used any fertilizer

Considering farmers who used both organic and inorganic fertilizers compared to those that never used any type of fertilizer in Table 4.1. Farmers whose source of information was Radio (OR= 2.31, p=0.00, CI = 2.02 – 2.64), Television (OR= 19.83, p=0.00, CI = 16.50 – 23.83), Farmer to farmer (OR= 3.51, p=0.00, CI = 11.12 – 22.14), Newspapers (OR= 4.94, p=0.00, CI = 2.66 – 9.17), and Extension workers (OR= 2.78, p = 0.00, CI = 3.17 – 4.89) were more likely to use both organic and inorganic fertilizers compared to farmers who never used any form of fertilizer. These results can be explained as follows; Radios are more likely to be used because they are cheap to acquire and can easy be accessed by farmers. Also, Radio as a source of information tends to have a big coverage of farmers both in rural and urban areas. Like the radios, also many farmers have televisions which they use as source of information regards of the wealth status of a farmer.

Furthermore, most farmers are engaged in farmer groups, these groups share agricultural information among themselves for example, on how and when to use organic and inorganic fertilizers. Again, farmer groups attached to NGOs, are given access to extension workers who train them on different innovative agricultural strategies like fertilizer use which is crucial in agricultural productivity. This finding is in line with the Agriculture Sector Strategic Plan (2015/16-2019/20) (MAAIF, 2016) where farmers use extension workers, television, radio, ICTs platforms as means of disseminating agricultural information including use of both organic and inorganic fertilizer.

Comparing farmers who used inorganic fertilizer and those that never used any fertilizer

Also, like farmers who used both organic and inorganic fertilizer, farmers who used only inorganic fertilizers used similar sources of information, that is, radio (OR = 1.57, p=0.00, CI=1.37 – 1.79), Newspapers (OR = 4.86, p=0.00, CI=2.65 – 8.92), Television (OR = 2.75, p=0.00, CI=2.12 – 3.56) and Extension workers (OR = 3.20, p=0.00, CI=2.21 – 3.50) compared to farmers who never used any form of fertilizer. The possible explanation for these results is that inorganic fertilizers can

easily be quantified in different measures like litres and kilograms. This implies that explaining to farmers how to use inorganic fertilizers through radio, television, newspapers is very easy and directions of use can easily be understood by farmers. This result is in agreement with finding of Larson et al. (2015), whose results state that the use of radios, newspapers, and extension workers among smallholder farmers improve access to fertilizers and extension services among farmers in Uganda.

Comparing farmers who used organic fertilizer and those that never used any fertilizer

Additionally, from Table 4.1, farmers who used organic fertilizers only were more likely to use radio (OR = 1.09, p=0.00, CI=1.00 – 1.18), Television (OR = 2.03, p=0.00, CI=1.71 – 2.42), Extension workers (OR = 1.45, p=0.00, CI=1.23 – 1.75), Agricultural shows (OR=0.51, p=0.00, CI=0.28 – 0.92) as compared to those who never used any type of fertilizer. The possible explanation for use of radio, television, extension workers, and agricultural shows as a source of information is that these sources can easily be used by farmers. These results are in line with research finding of Nyachwo and Mwesigwa (2010). There results show that use of media channels like radio, television can be used to promote locally made fertilizers (organic fertilizer) and their use. There results further show that agricultural information on fertilizer use is estimated to reach over 10 million listeners through different radio programs.

Results and Discussion for Model Two: Multiple linear regression

Under this section, we present results for multiple linear regression. Intensity of inorganic fertilizer use in litres per hectares is used as our dependent variables. During the analysis of this model, the data for dependent variable was highly skewed and we did a log transformation on this variable. This was done to ensure that the assumption of multiple linear regression models are not violated. Since the dependent variable was log-transformed, we interpreted our results as a unit increase in the considered independent variable is associated with an average of 100x(regression coefficient)% increase in the intensity of inorganic fertilizer use. The results for this model are presented in Table 4.2 with a sample size n = 800 as seen in Section IX.

From Table 4.2, marital status has a statistically significant effect on the intensity of inorganic fertilizer used by a farmer. The possible explanation for this could be attributed to fact that married farmers might have large families they need to look after and to maintaining a big family, food is paramount yet fertilizer use enhances high yield which results into high productivity. The intensity of inorganic fertilizer used by a farmer who is married is 86.2 percent (p=0.00) higher than that used by a farmer who is single or separated. The findings of a study conducted by Hailu & Mezegebo (2021) found out that individual farmers who married were more likely to adopt fertilizer use compared to the single farmers which is in agreement with the findings of this study.

Furthermore, sources of agricultural information that include radio, farmer to farmer, NGOs, television have a statistically significant effect on the intensity of inorganic fertilizer used by a farmer, that is, the intensity of inorganic fertilizer used by farmers whose main source of information are radio, farmer to farmer, NGOs, and television are 236.7% (p=0.06), 296.2% (p=0.02), 267.2% (p=0.06) and 290.4% (p=0.04) respectively higher compared to farmers who used other agricultural sources of information. These results could be attributed to the fact that many farmers can easily get acquire and get access to radios, farmers can easily get agricultural information from their fellow farmers, also, many NGOs to support farmers in innovative farming technologies including use of inorganic fertilizer use have been established in the country and a lot of agricultural information has been disseminated to farmers through both local and international television.

Most of the local televisions are in local languages and farmers can easily understand how and when to use inorganic fertilizers on their farms. The current results are supported by findings of a study done by Patrick et al. (2018) that revealed that source of information had a significant influence on inorganic fertilizer intensity, more specifically, there study found out that access to information media increased likelihood of use of fertilizer. Farmers who have had access to information through television, radio or any other social media were considered to have access to information media (Patrick et al., 2018).

Additionally, type of seed used by a farmer has a statistically significant effect on the intensity of inorganic fertilizer used by a farmer. This is attributed to the fact that farmers used improved type of seeds for planting. When improved varieties are supported with fertilizers the quantity of yield always increases as stated in the (UBOS, 2016) report. The intensity of inorganic fertilizer used by farmers who used improved seeds is 512.3 percent (p=0.000) greater than intensity of fertilizer used by farmers who used traditional seeds. This finding is in line with study carried out by Nambiro & Okoth (2013) that also found out that farmers that used improved maize seed had a high probability of using inorganic fertilizer compared to those who did not use improved maize seeds and this was attributed to the responsiveness of the improved maize seed to inputs, thus becomes an important catalyst for the adoption of the inorganic fertilizer.

Transport type also has a statistically significant effect on the intensity of inorganic fertilizer used by a farmer. The intensity of inorganic fertilizer used by farmers whose transport type is car/pickups is 353.7 percent (p=0.000) higher than intensity of inorganic fertilizer used by farmers whose transport type is bicycle. Similarly, the intensity of inorganic fertilizer used by farmers whose transport type is donkeys is 665.3 percent (p=0.000) higher than that used by farmers whose transport type is bicycle. Access to transport type has a statistically significant effect on the intensity of inorganic fertilizer used by a farmer.

Furthermore, the intensity of inorganic fertilizer used by a farmer who owns the transport type is 205 percent (p=0.002) higher than that used by a farmer who borrows a transport type. Similarly,

intensity of fertilizer used by a farmer who hires the transport type is 265 percent (p=0.000) higher than that used by a farmer who borrows a transport type. These findings echoes a study done by Patrick et al. (2018) that found out that there is positive relationship between asset ownership and fertilizer use intensity and results showed that assets specifically like motorcycle, bicycle ownership and radio ownership statistically influenced fertilizer use in the study area. This is an implication that asset ownership reduces the transaction costs related to transport to purchase inputs from traders and they can act as financial capital of the farmer and can be used as collateral when the farmer accesses the bank credits.

The intensity of inorganic fertilizer used by farmers who purchased seeds for planting is 69.4 percent (p=0.002) higher than intensity of fertilizer used by farmers who did not purchase seeds. This finding is similar to findings of a study done by Todd et al (2012) that found out that purchase of seeds reduce the probability of being poor by 4% and therefore, increases the ability to be able to buy inorganic fertilizers

VI. Conclusion

The main goal of this research is to investigate how the agricultural sources of information influence fertilizer use among farmers in Uganda. The research results showed that listening to the radio, watching television, reading newspapers and speaking to extension workers were positively associated with fertilizer use among farmers. Also, other factors that influence fertilizer use include type of transport used by farmers, access to transport type, type of seeds used and if seeds planted were purchased or not.

The results underscore the importance of media channels (radio, television, farmer to farmer and extension services) in influencing farmers' decision to adopt fertilizer use. The study recommends that different ministries in agriculture, other agricultural stakeholders at local, national and international level should focus on advertising through radio, televisions or newspapers and use of extension services to boost fertilizer use among farmers.

This study also recommends that agricultural information on fertilizer use can be disseminated in local languages using radio, television and newspapers to create awareness on and uptake of fertilizer use among farmers. Targeted messages on importance of fertilizer use should be developed in different local languages that can easily be understood by farmers.

In addition, the study recommends that the implementers in the agricultural sector both at regional and international level should focus on advertising through different communication media to reach out to farmers on the importance of fertilizer use in farming. The study concludes that agricultural sources of information affect fertilizer use among farmers in Uganda.

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IX. Figures and Tables

Here, we present the figures and tables of results used in this research as detailed.

Figure 2 shows a schematic presentation of the sampling design described in Section III

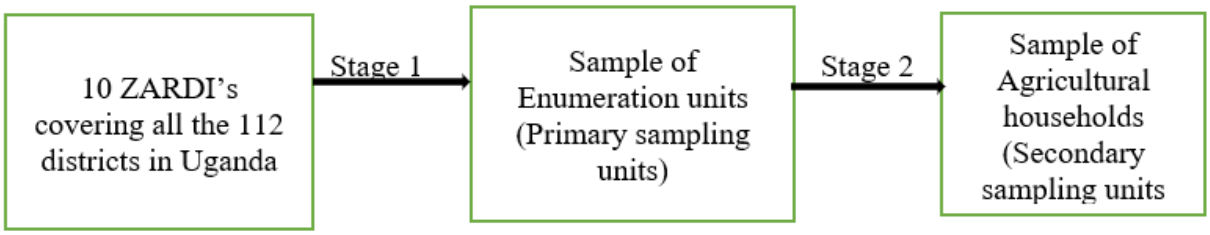

Figure 1: schematic presentation of the sampling design

This study considered a total number of 31331 farmers as shown in Table 3.1

Table 3.1: Distribution of fertilizer use among farmers

Fertilizer use	**Frequency**	**Percentage (%)**
Organic fertilizer	3038	25.7
Inorganic fertilizer	2650	8.5
Both (Organic & inorganic)	4871	15.6
None	15772	50.3
Total	31331	100

Distribution of main source of information

Table 3.1: Distribution of main source of information among the farmers

Variable Source of Information	Freq (%) No	Freq (%) Yes
Radio	16607 (53.6)	143393 (46.4)
Television	29665 (95.7)	1335 (4.3)
Telephone	30864 (99.6)	136 (0.4)
Internet	30981 (99.9)	19 (0.1)
Newspaper	30915 (99.7)	85 (0.3)
Magazines	30994 (99.98)	6 (0.02)
Extension Workers	30014 (96.8)	986 (3.2)
Farmer to Farmer	22048 (71.1)	8952 (28.9)
Agricultural shows	30805 (99.4)	195 (0.6)
NGOs	30539 (98.5)	461 (1.5)
Demonstration	30946 (99.8)	54 (0.2)

Distribution of Fertilizers use with its categories under model one: multinomial logistic regression

Table 4.1: Fertilizer use with its categories

Dependent variable	**Categories of fertilizer use**	**Coding**
Fertilizer use	Organic fertilizer	m=1
	Inorganic fertilizer	m=2
	Both (Organic and inorganic fertilizers)	m=3
	None (never used any form of fertilizer)	Reference Category (RC)

Results for model one: Multinomial logistic regression model

Table 2.1: Sources of information and fertilizer use

Fertilizer use	**Odds Ratio**	**p-value (SE)**	**95% Confidence Interval**
Both			
Radio	2.31	0.00 (0.07)***	(2.02 – 2.64)
Television	19.83	0.00 (0.09)***	(16.50–23.83)
Telephone	0.99	0.93 (0.35)	(0.48 – 1.95)
Newspaper	4.94	0.00 (0.32)***	(2.66 – 9.17)
Extension Workers	3.94	0.00 (0.11)***	(3.17 – 4.89)
Farmer to Farmer	3.508	0.00 (0.07)***	(3.06 – 4.02)
Agricultural shows	15.69	0.00 (0.00)***	(11.12 – 22.14)
NGOs	1.381	0.09 (0.09)	(0.957 - 1.99)
Inorganic			

Radio	1.57	0.00 (0.07)***	(1.37 – 1.79)
Television	2.75	0.00 (0.13)***	(2.12 – 3.56)
Telephone	1.40	0.26 (0.29)	(0.78 – 2.49)
Newspaper	4.86	0.00 (0.31)***	(2.65 – 8.92)
Extension Workers	2.78	0.00 (0.12)***	(2.21 – 3.50)
Farmer to Farmer	1.08	0.26 (0.08)	(0.94 – 1.26)
Agricultural shows	3.20	0.00 (0.26)***	(1.93 – 5.30)
NGOs	1.52	0.02 (0.17)**	(1.08 – 2.14)
Demonstrations	0.55	0.42 (0.73)	(1.32 – 2.33)
Organic			
Radio	1.09	0.00 (0.04)***	(1.00 – 1.18)
Television	2.03	0.00 (0.09)***	(1.71 – 2.42)
Telephone	0.68	0.08 (0.22)	(0.44 – 1.05)
Newspaper	1.58	0.11(0.28)	(0.91 – 2.75)
Extension Workers	1.45	0.00 (0.09)***	(1.23 – 1.75)
Farmer to Farmer	0.99	0.73 (0.04)	(0.90 – 1.07)
Agricultural shows	0.51	0.00 (0.30)***	(0.28 – 0.92)
NGOs	1.15	0.23 (0.11)	(0.92 – 1.43)
Demonstrations	0.83	0.59 (0.34)	(0.43 – 1.63)

Reference category for fertilizer use is "None (never used any fertilizer)"
Reference group for each dummy independent variable is "No"
SE is standard error.

Results for Model Two: Multiple linear regression

Table 4. 2: Factors affecting intensity of inorganic fertilizer use in litres per hectares (n=800)

Variable	Coefficient	p value	95% Confidence Interval
How inorganic fertilizer was obtained			
Purchased	0.27	0.59	(-0.70 – 1.20)
Received for free	-0.57	0.28	(-1.61 – 0.41)
Education level			
Nursery/no school	0.79	0.07	(-0.06 – 1.63)
Primary	-0.38	0.10	(-0.84 – 0.08)
Junior	-0.51	0.26	(-1.39 – 0.37)
Source of Information			
Radio	2.37	0.06*	(-0.09 – 4.82)
Telephone	1.23	0.51	(-2.43 – 4.88)
Extension workers	1.45	0.27	(-1.12 – 4.02)
Farmer to Farmer	2.96	0.02**	(0.47 – 6.13)

NGOs	2.67	0.06*	(-0.22 – 5.47)
Television	2.09	0.04*	(-2.43 – 4.88)
Word of mouth/peers	2.12	0.10	(-0.39 – 4.63)
Newspaper	2.09	0.49	(-0.39 – 8.07)
NAADS/Operation Wealth Creation	3.19	0.03*	(0.25 – 6.13)
Marital Status			
Married	0.86	0.00***	(0.24 – 5.06)
Widowed	-0.56	0.42	(-1.94 – 0.82)
Transport type			
Car/pick up	3.54	0.00***	(2.31 – 4.77)
Donkeys	6.65	0.00***	(4.30 – 9.01)
Head/back loading	2.43	0.00***	(1.87 – 2.98)
Lorry	3.28	0.00***	(1.49 – 5.07)
Motorcycle	1.36	0.00***	(0.73 – 1.99)
Oxen	1.92	0.47	(-3.26 – 7.10)
Tractor	2.34	0.01**	(0.71 – 3.97)
Wheelbarrow	2.38	0.01**	(0.49 - 4.27)
Access to Transport type			
Own	2.05	0.00**	(0.75 – 3.35)
Hired	2.65	0.00***	(1.36 – 4.0)
Type of seed used			
Improved	5.12	0.00***	(0.24 – 1.64)
Purchased seed for planting			
Purchase seed	0.70	0.00***	(0.25 – 1.13)

Significance at the 10%, 5%, and 1% levels is indicated by *, **, and *** respectively