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# Assessment of the Usage of Liquid Fertilizer Technology in Dry Season Vegetable Production in Nigeria

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**Abstract**

The use of liquid fertilizer as an alternate means of improving soil fertility has the possibility of adding to the quality and quantity of food crops. Specifically, this study was designed to examine the level, intensity and determinants of usage of liquid fertilizer among dry season vegetable farmers in Nigeria. Data were collected from 309 farmers using a pre-tested interview schedule. Descriptive statistics and multinomial logistic regression were used for data analysis. The study revealed that only 28.1% of vegetable farmers used liquid fertilizer. Farm size, quantity of water, membership of vegetable association and mode of irrigation increased the likelihood that the farmers would use sole liquid fertilizer relative to solenon-liquid fertilizer. Amounts of pesticide and water, gender of the farmer, household size and years of education determined the usage of the combination of both liquid and non-liquid fertilizer relative to sole non- liquid fertilizer. The study concluded that there was a low level of usage of liquid fertilizer and therefore recommended the need for more awareness of the existence and usage of liquid fertilizer through improved extension activities.

**Keywords:**
Irrigation, Liquid Fertilizer, Production, Technology, Vegetables

## 1. Introduction

Vegetables are an integral part of the human diet. Some scholars refer to vegetables as "supplementary protective food" (Wolfe, 2013). In Nigeria, most foods are eaten with one form of vegetables either as the main meal or as a side dressing. They are common ingredients in many of our soups, stews, and sauces. At present, vegetable supply in Nigeria is met mainly from local production. While vegetable production in Nigeria occurs during both the rainy and the dry seasons, studies have shown that dry season vegetable production is more profitable than that of the rainy season (Ayoola et al., 2009; Iwuchukwu and Uzoho, 2009; Enete and Okon, 2010). Dry season vegetable production provides an opportunity for diet improvement and a source of income to the farmers. Increased dry season vegetable production can play a significant role in improving the livelihood of small-scale resource-poor farmers, many of whom suffer from the negative consequences of lack of access to meaningful economic activity during the dry season.

The low supply of vegetables in the dry season has been linked to the severely-nutrient-depleted conditions of most soils used in Nigeria for vegetable production (Adenuga et al., 2012). In times past, farmers relied on the fallow system, crop rotation, intercropping as well as mixed farming strategies to improve the nutrient levels of their farmlands (James et al., 2010). However, enormous pressures on land because of population increase, as well as more demand forland for urbanization now force farmers to grow crops including vegetables continuously on the same piece of land. Hence, putting nutrients back into the soil through fertilizer then becomes the only realistic way to maintain the health of the soils which is necessary for sustained vegetable production. Fertilizer usage in Nigeria currently stands at about 13kg/ha (Liverpool-Taise et al., 2014). This is far lower than the recommended rate of 200kg/ha by Food and Agriculture Organization (FAO, 2006). Most studies carried out on vegetable production, however, indicate that scarcity of fertilizers is one of the biggest challenges faced by farmers (AgbuluandIdu, 2008; Sabo and Dia, 2009; Okunlolaand Ofuya, 2010).The government in Nigeria has made several efforts to ensure the availability of fertilizer. Most recently was the decentralization of procurement and distribution of fertilizers under the Growth Enhancement Scheme (GES). Despite all these efforts, fertilizer availability remains a major challenge that calls for a search for alternatives.

Commercial liquid fertilizer was first introduced into the country in 2003 by the Golden Neo-LifeDiamite International (GNLD) Company as an alternative source of fertilizer (Delphine, 2012). Liquid fertilizers provide plants with high concentrations of easily absorbed soluble nutrients. Studies have shown that use of liquid fertilizer results in higher crop yield (Akanbi et al., 2007; Agbulu and Idu, 2008; Sridhar and Rengasamy, 2010; Deore et al., 2010; Criollo et al., 2011). These studies have shown that its use has been associated with superior quality as well as quantities of crops. Hence, its ability to increase the nutritional content of food crops can address the problem of ‘hidden hunger’ that is so prevalent in many developing countries like Nigeria. Thismaybe attributed to the fact that liquid fertilizers, in addition to the macronutrients present in them, have a high content of essential micronutrients needed by plants (Dittmar, 2007). They are also easily absorbed by the plants either via the leaves (foliar fertilizers) or through the roots, which enables them to act fast. There is also the advantage of improved efficiency in the application of liquid fertilizer. This is because it can be done alongside irrigation (drip or sprinkler) and pesticide application thereby saving time and resources (Dittmar, 2007). The growing interest in the use of liquid fertilizer in agriculture, especially in vegetable production, is that most of them are organic thus making them,environment and health friendly (Hunt, 2013).

The study of the usage and adoption of any technology is centered on understanding, a well as predicting how, why and to what extent individuals or organizations adopt these technologies over time (Rogers, 2003; Straub, 2009). Given the importance of liquid fertilizer and the fact that it is a relatively new technology, there is the need to monitor the extent of its usage, and possibly look into factors that may aid or hinder its usage. Even though commercial liquid fertilizers have been around for well over a decade in Nigeria, littleis known about it. There isno information on its usage, especially in Kwara and Niger States. It is known that information on certain farm and farmers’ characteristics of the usage of technology is necessary for the formulation of policies that would aid its usage, as well as measure the likely impact of variation in the economic conditions of the users on their usage of the technology. There is, however, no ready information on the socio-economic factors affecting the decision to use liquid fertilizer among dry season vegetable farmers. These characteristics can sometimes serve as factors that can aid or hinder the usage of the liquid fertilizer. It is against this background that this study, therefore, sought to assess the adoption of liquid fertilizer among dry season vegetable farmers in Nigeria. Specifically, this study aims to (i). Examine the level of usage of liquid fertilizers among the dry season vegetable farmers; (ii). Determine the intensity of usage of liquid fertilizer among the dry season vegetable farmers, and (iii) identify the determinants of liquid fertilizer usage among the dry season vegetable farmers.

**Literature review**

Many researches abound as to how and why individuals or organizations adopt innovations and technologies.

The existing body of knowledge on adoption decision theory identifies five stages of adoption and these are: the knowledge or awareness stage; the persuasion or interest stage; the decision or evaluation stage; the implementation or trial stage; and the confirmation or adoption stage. Innovations must be widely adopted in order to self-sustain. This means that they must be widely known and adopted so that instead of them fading away, they will be improved upon over time (Peres, 2010). Several studies have explored many factors that influence the adoption of innovations (Straub, 2009; Hochbaum, 2011), and these include:

Relative Advantage: This is the degree to which an innovation is seen to be better than the one it replaces. That is, the perceived efficiency and benefits especially in monetary terms that will be gained by the adoption of the innovation relative to the existing one;

Compatibility: This factor examines how consistent the innovation is with values, experiences and needs of the potential adopters;

Complexity: This deals with the difficulty or ease associated with the innovation in terms of understanding and or using it;

Triability: This deals with the extent to which the innovation can be experimented with before a commitment is made to adopt it; and

Observation: This is the extent to which the innovation provides tangible results, i.e., its evaluation based on its potential for reinvention and its observed effects.

According to Hochbaum (2011), these factors interact and are judged as a whole, so that an innovation that maybe complex but very compatible with the target population, still has a high chance of adoption. Apart from understanding the factors that influence the adoption of an innovation, a good understanding of the characteristics of the potential adopters is also a necessary step needed to facilitate adoption (Straub, 2009; Hochbaum, 2011). The adoption of an innovation such as the usage of liquid fertilizer, usually does not occur at the same time among all the farmers; rather, some farmers are more apt to adopt the innovation than others. Five adopter categories have also been established in literature and these are: the innovators; early adopters; early majority; late majority; and the laggards (Rogers, 2003). Therefore, when promoting an innovation, it becomes imperative to understand the characteristics of the target population as this will help or hinder the adoption of the innovation (Hochbaum, 2011). Little agreement has been however reached as to the exact characteristics that can influence adoption. It is against this information that the study includes certain socio-demographic characteristics as well as some farm characteristics of the vegetable farmers in examining the factors that would determine the usage of liquid fertilizer in dry season vegetable production.

## 2. Materials and methods

### 2.1 Study area

This study was carried out in Kwara and Niger States, Nigeria. Kwara and Niger States are locatedin the Southern Guinea savanna zone. It is the most luxuriant of the savanna vegetation belts in Nigeria. The area is characterized by low rainfall andlong dry periods of up to six months. The soils in the zone are low in organic matter and chemical fertility. Dry season vegetable production is an everyday activity and fertilizers including liquid ones are used in the area.

### 2.2 Sampling technique and sample size

The population for the study comprised of all dry season vegetable farmers in the study area. Locations, where dry season vegetable production was predominantly carried out,were identified from the 2012 Crop Area Yield Survey (CAYS) manual from both States' Agricultural Development Project (ADPs). Twenty-five percent of the identified locations in each of the states were randomly selected from the 33 locations identified in Kwara State and 35 identified in Niger State. This gave a total of eight and nine locations in Kwara and Niger states respectively. Next, the different farmer groups in each of the selected locationswere identified. A list of all dry season vegetable farmers was obtained from the leader of each of the groups. From those lists, another list was compiled to give the total number of vegetable farmers in that location irrespective of the group they belong. Thus total population size for the study was 1270. Using the Morgan's Table (Krejcie & Morgan, 1970) at a confidence interval of 95% and a 5% margin of error, 309 farmers were sampled for the study.

### 2.3 Method of data collection

Data for the study were collected between February 2014 and April 2015 using a well-structured interview schedule administered to vegetable farmers. Focus Group Discussion (FGD) was also organized with the local leaders of the vegetable farmer groups to supplement the data obtained from the interview schedule, and pretesting was done with 30 vegetable growers. A Cronbach's alpha value of 0.816 indicated a high level of reliability and consistency for the set of questions included in the interview schedule.

### 2.4 Analytical techniques

Descriptive statistics which include measures of central tendencies such as frequency distribution mean, mode and percentages were used to examine the level of liquid fertilizer usage among the dry season vegetable farmers as well as to determine intensity of usage of liquid fertilizer among the vegetable growers. Based on the dilution instructions on the liquid fertilizers used in the study, 2.4litres/ha of liquid fertilizer was estimated to be the exact recommended quantity for the study area. For this study, farmers whose usage was above 10 percent less than the exact recommended quantity were categorized as low users, while those whose usage was above 10 percent more than the recommended rate were classified as high users. Farmers who used exactly the recommended quantity plus or minus 10 percent were classified as adequate users. This categorization was used to assess the liquid fertilizer usage intensity (Department of Environment and Primary Industry DEPI, 2014).

The Multinomial logistic regression was used to identify the determinants of the use of liquid fertilizer among the vegetable farmers in the study. The multinomial logistic regression is a technique that can predict the outcome of liquid fertilizer usage (which was the dependent variable) that has two or more categories from a set of independent variables.

The model used for this study is expressed explicitly as:

Pij=

$$\frac{\exp \beta_{oj} + \beta_{1j}X_{1i} + \beta_{2j}X_{2i} + \beta_{3j}X_{3i} + \cdots + \beta_{10j}X_{10i} + \beta_{1j}D_{1i} + \beta_{2j}D_{2i} + \beta_{3j}D_{3i}}{1 + \sum_{j=1}^{k-1} \exp(\beta_{oj} + \beta_{1j}X_{1i} + \beta_{2j}X_{2i} + \beta_{3j}X_{3i} + \cdots + \beta_{10j}X_{10i} + \beta_{1j}D_{1i} + \beta_{2j}D_{2i} + \beta_{3j}D_{3i})}$$

(Rahjiet al, 2008)

for j = 1,2,
where
Pij = the probability of being in each of the category 1 and 2 (comparison category)
Xi = continuous independent variables for category 1 and 2
Di = dummy independent variables for category 1 and 2

Pi0=

$$\frac{1}{1 + \sum_{j=1}^{k-1} \exp(\beta_{oj} + \beta_{1j}X_{1i} + \beta_{2j}X_{2i} + \beta_{3j}X_{3i} + \cdots + \beta_{10j}X_{10i} + \beta_{1j}D_{1i} + \beta_{2j}D_{2i} + \beta_{3j}D_{3i})} \quad (2)$$

(Rahji et al., 2008)

for j =0
where
Pi0 = the probability of being in the reference category which was specified as category 0
Xi0 = continuous independent variables for the reference category
Di0 = dummy independent variables for the reference category

The exponentiated value of the generated coefficient estimates for categories one and two (comparison category) gives the Relative Risk Ratio (RRR) of each of the category one and tworelative to that of the reference category.

Thiswas given as:

$$\exp \frac{P_{ij}}{P_{io}}(\beta_0 + \beta_{1j}X_{1i} + \beta_{2j}X_{2i} + \beta_{3j}X_{3i} + \cdots + \beta_{10j}X_{10i} + \beta_{1j}D_{1i} + \beta_{2j}D_{2i} + \beta_{3j}D_{3i}) \; ....(3).$$

The independent variables hypothesized to affect the usage of liquid fertilizer and their apiori signs are as indicated on Table 1.

## 3. Results and discussion

### 3.1 Level of liquid fertilizer usage in dry season vegetable production

The extent of liquid fertilizer usage in dry season vegetable production is discussed in this subsection. The results are presented in Table 2.

Table 2 showed that less than one-third of the vegetable farmers used liquid fertilizer either solely or in combination with non-liquid fertilizer. The users of non-liquid fertilizers accounted for the majority of the sampled vegetable growers. Further analysis revealed that 96 % of users of non-liquid fertilizer used sole conventional chemical fertilizers such as NPK series and urea, while only four percent used both conventional chemical fertilizers and manure (cow dung and or poultry droppings). The low usage of liquid fertilizer may be attributed to lack of information about the product. As revealed in the study 45.5 %of users of non-liquid fertilizer had never heard about liquid fertilizer. In four locations where data were collected, none of the sampled farmers had ever heard about liquid fertilizer. These places seemed to be the ones farthest from the urban areas and city centers.

### 3.2 Sources and types of liquid fertilizer used in dry season vegetable production

This sub-section highlights the different types of liquid fertilizers used in the study as well as the sources of these fertilizers. The results are presented in Table 3.

Table 3 showed that Supergrowas used on more than half of the plots where liquid fertilizer was used. This may be because it was the first liquid fertilizer that was introduced in the study area and had gained popularity among the farmers over time. It may also be because it was the most readily available liquid fertilizer in agro shops in the study area compared to the other liquid fertilizer. About 73 percent of users of Supergro got them from agro-shops, unlike the other liquid fertilizer where availability was almost tied to the presence of sales agents and extension officers.

### 3.3 The quantity of liquid fertilizer used by the vegetable farmers

To further measure the extent of usage of liquid fertilizer, the study assessed the amount of the liquid fertilizers used by the respondents. The results are presented in Table 4.

Table 4 showed that 25 percent of users of sole liquid fertilizers used above the average recorded for that category. For users of a combination of both liquid and non-liquid fertilizers, about 42 percent of them used above the average recorded for the category while 46 percent of total users used above the 3.41 liters/ha which was the average recorded for the study. Dilution rate for all the liquid fertilizers encountered in the study ranged from 1-2ml of liquid fertilizer to 1 liter of water. Two hundred liters of water is required to spray one hectare of land (Department of Environment and Primary Industry DEPI, 2014). This means that at a dilution rate of 2ml/liter of water, 400ml of liquid fertilizer was required per application per hectare. If a maximum of six applications were done (highest number of application recorded for the study) throughout the dry season period, 2.4 liters of liquid fertilizer is required per hectare of land for the application. Based on this analysis, usage intensity showed that farmers who used above 2.64 liters of liquid fertilizers were high users, below 2.16 liters were low users, and 2.16 – 2.64 were adequate/medium users. These results are shown in Table 5.

Table 1. Definition of explanatory variables used in the multinomial logistic regression model

| Variables | Measurement/Value | Expected sign |
|---|---|---|
| Farm size (X1) | hectares | + |
| Total labour (X2) | man-days | - |
| Quantity of seed (X3) | kilograms | - |
| Quantity of pesticides (X4) | litres | - |
| Quantity of irrigation water (X5) | hectare-cm3 | + |
| Age of farmer (X6) | years | - |
| Household size (X7) | number | + |
| Level of education (X8) | Years of successful schooling | + |
| Amount of credit obtained (X9) | naira | + |
| Frequency of extension visit (X10) | number | + |
| Gender of farmer (D1) | I = male, 0 = female | + |
| Member of vegetable association (D2) | 1 = member; 0, otherwise | + |
| Mode of Irrigation (D3) | 1 = motorized pump; 0 manual | + |

Table 2. Distribution of dry season vegetable production based on the level of liquid fertilizer usage

| Categories of fertilizer usage | Frequency | Percentage |
|---|---|---|
| Liquid only | 44 | 14.20 |
| Liquid with non-liquid | 43 | 13.90 |
| Non-liquid only | 222 | 71.90 |
| Total | 309 | 100.00 |

Table 3. Types and sources of liquid fertilizers used in the study

| Names of liquid fertilizer | | Agrolizer | Agyzme | Boostextra | Plantyzme | Supergro |
|---|---|---|---|---|---|---|
| Frequency of usage | | 4 (4.60) | 1(1.14) | 25(28.74) | 6(6.90) | 51(58.62) |
| Sources of the liquid | Agro shops | 0(0.00) | 0(0.00) | 7(28.00) | 2(33.33) | 37(72.55) |
| | Extension agents | 0(0.00) | 0(0.00) | 2(8.00) | 1(16.67) | 8(15.69) |
| | Sales agents | 4(100.00) | 1(100.00) | 16(64.00) | 3(50.00) | 6(11.76) |

Note: Figures in parenthesis are percentages

Table 4. Distribution of vegetable farms according to quantity of liquid fertilizer usage (liters/ha)

| Range of quantity of liquid fertilizer (litres) | Sole users of liquid fertilizer | Users of both liquid and non-liquid fertilizer | Total |
|---|---|---|---|
| 0.1 – 1.0 | 3 (6.82) | 8 (18.60) | 11 (12.64) |
| 1.1 – 2.0 | 11 (25.00) | 9 (20.93) | 20 (23.00) |
| 2.1 – 3.0 | 7 (15.91) | 8 (18.60) | 15 (17.24) |
| 3.1 – 4.0 | 12 (27.27) | 7 (16.29) | 19 (21.84) |
| 4.1 – 5.0 | 3 (6.82) | 11 (25.58) | 14 (16.09) |
| > 5.0 | 8 (18.18) | 0 (0.00) | 8 (9.19) |
| N | 44 | 43 | 87 |
| Mean | 4.02 | 2.96 | 3.41 |
| Standard deviation | 2.53 | 1.55 | 2.08 |
| Minimum | 1.5 | 0.5 | 0.5 |
| Maximum | 10 | 5 | 10 |

Note: Figures in parenthesis are percentages

Table 5. Distribution of vegetable farmers according to usage intensity

| Usage intensity | Sole users of liquid fertilizer | Users of both liquid and non-liquid | Total |
|---|---|---|---|
| Low (< 2.16 litres) | 13 (29.55) | 17 (39.53) | 30 (34.48) |
| Adequate (2.16 – 2.64 litres) | 4 (9.09) | 3 (6.98) | 7 (8.05) |
| High (>2.64 litres) | 27 (61.36) | 23 (53.49) | 50 (57.47) |

Note: Figures in parenthesis are in percentages

Table 6. Determinants of liquid fertilizer (LF) usage among dry season vegetable farmers

| Variables | Usage of sole LF | Usage of both LF and non-LF | Usage of sole non-LF |
|---|---|---|---|
| Farm size ($X_1$) | 1.232** (3.427) | 0.002 (1.002) | -1.234 |
| Quantity labour ($X_2$) | -0.350 (0.704) | 0.272 (1.312) | -0.266 |
| Quantity seed ($X_3$) | -0.076(0.927) | 0.153(0.858) | 0.077 |
| Quantity pesticide ($X_4$) | -0.357(0.700) | 1.139***(3.123) | -0.859 |
| Quantity water ($X_5$) | 0.163*(0.849) | 0.285***(0.752) | -0.448 |
| Age of farmer ($X_6$) | 0.589(1.802) | 0.126 (1.134) | -0.715 |
| Sex of farmer ($d_1$) | 0.162(1.176) | 1.003*** (2.727) | -1.165 |
| Household size ($X_7$) | -0.172(0.842) | -0.783** (0.457) | 0.955 |
| Years of education ($X_8$) | 0.001(1.001) | 0.782* (0.457) | -0.783 |
| Amount of credit ($X_9$) | -0.086(0.917) | -0.024 (1.025) | 0.062 |
| Membership veg assoc. ($d_2$) | 1.021**(0.360) | -0.103 (0.902) | -0.918 |
| Frequency of extension contact ($X_{10}$) | -0.047(0.953) | -0.235 (0.977) | 0.188 |
| Mode of irrigation ($d_3$) | 1.806***(6.084) | -0.423 (1.526) | -1.383 |
| Constant | -1.350 | 0.579 | 0.771 |
| N | 44 | 43 | 222 |
| Log-likelihood ratio (λ) | 103.86*** | | |

*p < 0.1; ** p < 0.05; *** p < 0.01
Note: Figures in parenthesis represents the Relative Risk Ratios (RRR) of the variables

Table 5 showed that the vegetable farmers in the study area were high users given the evidence that the modal class for all the users whether solely or in combination with non-liquid fertilizers was the high usage intensity category. This may be due to the higher dilution rates of up to 5ml of liquid fertilizer/liter of water recorded in the study. From the farmers' point of view, they thought that increasing the potency of the liquid fertilizer solution will lead to higher yields. Thus, the higher dilution rate may have been responsible for the relatively high usage intensity of the liquid fertilizer recorded in the study. Another reason for the higher dilution rates recorded in the study may be attributed to the fact that some of the farmers had no usage instructions for the liquid fertilizers. This was because the farmers mostly bought small sized bottles (200ml) of the liquid fertilizers because of its affordability, and these smaller containers come with no usage instructions. These small sized bottles are usually filled from the one and four-liter containers that come directly from the manufacturers of the liquid fertilizers. Thus, the usage instructions intended to reach the users only come with the one and four-liter containers and not with the smaller ones.

**3.4 Determinants of liquid fertilizer usage in dry season vegetable production**

The factors that influenced liquid fertilizer usage among the dry season vegetable farmers in the study are presented and discussed in this sub-section. The results of the multinomial logistic regression are shown in Table 6.

The results of the multinomial logistic regression established that at least one of the hypothesized variables included in the model was statistically significantly different from zero $\{\lambda = 103.86 > (\chi 2\ 0.05, 26) = 38.885\}$. The value of P2 = 0.001 in this study indicates a good fit for the estimated model.

Positive and significant coefficients were obtained for farm size, the quantity of water used for irrigation, membership of vegetable associations and mode of irrigation for sole usage of liquid fertilizer. As seen in Table 6, the probability of grouping the vegetable farmers into the exclusive usage of liquid fertilizer category, relative to the reference group which is the sole usage of non-liquid fertilizer increases as these variables increase.

The relative risk ratio of farm size also shown in Table 6suggests that a one-unit increase in farm size is expected to increase the relative risk or the relative probability for sole usage of liquid fertilizer relative tosole usage of non-liquid fertilizer by a factor of 3.427 given that all other variables are held constant. This means that if farm size is increased by one hectare, the probability of the farmers remaining in the sole usage of liquid fertilizer category is increased by a factor of 3.427 if, all other variables are held constant. This implies that a reduction in farm size increases the chances of the farmers falling into the reference category compared to the sole usage of liquid fertilizer category. This may be because farmers with larger farm sizes are assumed to be wealthier than those with smaller farm sizes and so can purchase new technologies, and they also have more capacity to bear the risk if the innovation fails.

The relative risk ratio for membership of vegetable association implies that a one unit increase would be expected to increase the relative probability of the farmers belonging to the comparison category compared to the reference category. These results agree with that of Rajendran (2015) who showed that belonging to an association that is directly related to one's field of expertise can positively influence access to information on the latest innovation as well as benefits associated with its usage, thereby, ensuring that maximum benefits are derived from its usage.

The relative risk ratio for the mode of irrigation as seen in Table 5 also suggests that a unit increase in the manner of irrigation is expected to increase the relative probability of the farmers falling into the sole liquid fertilizer usage category compared to the reference category by a factor of 6.084. This may probably be because users of water pumps often use more water for irrigation compared to those who do manual irrigation (Tegegne et al., 2014). Since the usage of liquid fertilizer is advocated with the use of much water, it, therefore, follows that using water pumps increase the probability of using liquid fertilizer. This, therefore,bolsters the positive coefficient of the quantity of water also seen in Table 5. This means that reducing the amount of water used for irrigation reduces the probability of the farmers using liquid fertilizers.

The positive and significant coefficient of theamount of pesticides, the amount of water, sex of the farmer and the highest level of education for usage of both liquid and non-liquid fertilizer indicates that the probability of categorizing the farmers into the comparison group in relation to the reference group increases as these variables increases. The coefficient of the quantities of pesticides suggests that the multinomial log odd of preferring the usage of both liquid and non-liquid fertilizer compared to the usage of sole non-liquid fertilizer is expected to increase by a factor of 3.123 with a unit increase in the quantities of pesticides. An underlying assumption is all the other variables in the model are kept constant.This may be because liquid fertilizer and pesticide application are sometimes done simultaneously as was observed on the field. It may also be because users of liquid fertilizer know the importance of pest reduction in vegetable production and want to reap maximum net benefits by ensuring optimum yields through the application of pesticides to reduce vegetable loss due to pest infestation. It may also be due to the ability of users of liquid fertilizer to purchase additional inputs such as pesticide to ensure maximum output.

The positive and significant coefficient for the quantity of water also implies that increasing this variable increases the probability of the farmers remaining in the usage of both liquid and non-liquid fertilizer category. The positive and greater than one value of the relative risk ratio of the sex of the vegetable farmer suggests that the relative probability of men remaining in the comparison category compared to that of the reference category increases as the variable increases. This means that the male farmers are more likely to use liquid fertilizer. This result agrees with similar studies by Mbanasor and Kalu (2008) and Bempomaa and Acquah (2014), who showed that male farmers have more access to extension services and credit compared to their female counterparts. This affords them more access to information on new technology and probably equips them with the means to purchase these technologies. The multinomial log odd for the highest level of education indicates that a one-unit increase in the unit in the years of schooling increases the probability of the farmers remaining in the comparison category compared to the reference category by a factor of 0.782 assuming all other variables are held constant. This maybe attributed to the fact that farmers with higher years of education can access, comprehend and use information on innovations and technologies such as liquid fertilizer better.

The negative multinomial logit coefficient of household size indicates that if farmers were to increase household size by one person; the relative risk for the use of both liquid and non-liquid fertilizer compared to the usage of sole non-liquid fertilizer would be expected to decrease by a factor of 0.368. This assumes that all the other variables in the model are held constant. In other words, increasing household size increases the chances of the farmer moving to the reference category compared to the comparison group.

## 4. Conclusion and recommendations

This study concluded that there was a low level of usage of liquid fertilizer among the dry season vegetable farmers. The variables that have been identified in this study that are relevant to the dry season vegetable farmer’s decision to use liquid fertilizer may affect the demand for the product. Hence, little progress would be made in popularizing the usage of liquid fertilizer if there are no deliberate efforts at addressing the socio-economic situations and other challenges which surround the farmers and affect their usage of liquid fertilizer. Based on the findings of the study, it was recommended that to create more awareness on the use of liquid fertilizer. There should be a synergy between the major stakeholders including the manufacturers/importers of the liquid fertilizer and the extension officers in the study area on the marketing of the product. This is because extension agents usually serve as the main channels by which agricultural innovations reach rural areas. This can be achieved by giving incentives to the extension officers or commissioning them to market the liquid fertilizer. Also, all agricultural support programmes that are designed to assist farmers with subsidized fertilizer should look into the possibility of including liquid fertilizer in the program to help create more awareness about the product. Also, provision of borehole water through government assisted projects in locations where there is no irrigation water will ensure the availability of water for irrigation which may encourage the use of liquid fertilizer.

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