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Adoption of Chemical Fertilizers in Coffee Production in Kikyenkye Sub-County, Ibanda District

David Natukunda, Prof. David Osiru, Doreen Atwongyeire, Ferdinand Aine

Bishop Stuart University,

P.O.BOX 09 Mbarara, Uganda

a.natudavi234@gmail.com

b.dsoosiru@gmail.com

c.atwongyeiredoreen@gmail.com

d.aineferdinand@gmail.com

Faculty of Agriculture, Environmental Sciences and Technology, Bishop Stuart University, Mbarara, Uganda

Email:a: natudavi234@gmail.com, b: dsoosiru@gmail.com, c: atwongyeiredoreen@gmail.com, d: aineferdinand@gmail.com

Abstract

The study focused on assessing the adoption of chemical fertilizers in coffee productionin Kikyenkye Sub-County, Ibanda District. It was limited to; investigating the perceptions and attitudes of farmers on application of chemical fertilizers in coffee, determining the level of awareness of chemical fertilizers use in coffee production, investigating farm-based factors that determine farmers' choice to use chemical fertilizers in coffee production and establishing possible strategies of promoting adoption of chemical fertilizers in coffee production. The study employed a cross-sectional, descriptive research design and primary data was collected from 124 respondents.The study concluded that there is positive perception and attitude of farmers on application of chemical fertilizers where chemical fertilizers use ensure high productivity and yields of coffee, Chemical fertilizers are basically used in high value commercial crops like tea and coffee and that the decisions on chemical fertilizers use is based on access to information and market prices were considered significant at P≤0.05 (P=.019, P=.003 and P=.009) and others like chemical fertilizers applied to in coffee do not provide optimal economic returns to farmers, fertilizers use is influenced by agro-climatic and farm characteristics, chemical fertilizers are not suitable for use in coffee and that chemical fertilizers use that alter the soil properties were non-significant at P-value>0.05(P=.867, P=.706, P=.263 and P=.637).The study further concluded that farmers who had access to training services on the methods of application and easy access to the source of chemical fertilizers had high level of awareness on the use of chemical fertilizers in coffee production. The study also concluded that some farm based factors were significant

for example, small size of land and land fragmentation at p-value ≤ 0.05 (P=0.006 and P=0.008 where as other factors were non-significant like land ownership, coffee-banana intercropping, farm location and long distance in relation to chemical fertilizer distribution channels were non-significant at P-value >0.05(P=0.146, P=0.622, P=0.913, = 0.351). The study finally concluded that possible strategies of promoting adoption of chemical fertilizers in coffee production such as; providing constant training on the value of chemical fertilizers by extension workers was significant at (P=0.000), stabilizing prices for both agricultural inputs and crop outputs without direct government intervention in the market was significant at (P=0.002) while non-significant strategies included; conducting a chemical fertilizer yield response and profitability studies for a range of crops (P=0.938), establishing a fertilizer subsidies program (P=0.766), designing a fertilizer promotion strategy (P=0.273) and considering the potential for public-private partnerships to deliver fertilizer to farmers (P=0.144).The study recommends that there is a need for more education and awareness-raising activities to help farmers make informed decisions about the use of chemical fertilizers, policymakers and agricultural stakeholders to consider the social, economic, and environmental implications of the widespread use of chemical fertilizers in coffee production, governments undertaking awareness-raising campaigns and the need to reduce the cost of chemical fertilizers through subsidies.

Key words.Adoption, chemical fertilizers, coffee production

Introduction

Globally, around 125 million people depend on coffee for their livelihoods through the generated income, and provision of the much-needed rural employment for both men and women in the labour-intensive production and harvesting processes [1]. Global coffee production in 2019/20 was estimated at 169.34 million bags, 2.2% lower than the previous year, as output of Arabica decreased by 5% to 95.99 million bags, while that of Robusta rose by 1.9% to 73.36 million bags. Exports in the first 9 months of coffee year 2019/20 (Oct/19 to Jun/20) have decreased by 5.1% to 95.36 million bags compared to 100.46 million bags in the same period in 2018/19. In the twelve months ending June 2020, exports of Arabica totaled 79 million bags compared to 82.72 million bags the previous year; whereas Robusta exports amounted to 49.35 million bags compared to 48.89 million bags [2].

In Africa, coffee production in year 2014/15 was around 16.9 million bags which was 10% of the estimated world production. Of this, an estimated 10.4 million bags were expected to be produced by just 2 countries that is, Ethiopia and Uganda [2]. Accordingly, the total number of coffee farmers directly involved in production activities in Africa was estimated at 12 million. Although many initiatives have been taken in many African countries to achieve a sustainable coffee sector, moving it

from subsistence to an entrepreneurial one is still a challenge. In fact, productivity is still too low to promote sustainable coffee production in case of long periods of low prices. Farmers need sustainable income generation and long-term security of livelihood. When their income is reduced, small holder farmers are tempted to limit practices that protect soil quality exacerbating the problem. Moreover, given the weak research and extension support, farmers in many countries on the continent have been slow to adopt good practices that could lead to required high coffee quality and productivity (ibid). Ethiopia and Uganda are the leading coffee producing countries and nearly a fifth of the population, depend on it for their livelihood [2].

In Uganda, about 353,907 hectares were under coffee cultivation [3], primarily cultivated by an estimated 1.7 million households. Accordingly, the coffee tree stock under production reached nearly 330 million and there were 112 coffee growing districts out of 134 total districts in Uganda by December 2021. In fact, the national average annual coffee production was 282,000 tons ranking the 8th globally. Despite its value in revenue generation and expansion of land coverage, the level of production has been gradually reducing due to poor harvests acquired at the end of the different seasons due to declining soil fertility in most parts of the country [3].

Similarly, soil has been subjected to severe nutrient deficiency triggered by natural and man-made factors Worldwide as a result of population growth [4]. Therefore, increasing agricultural productivity especially perennial crops where crop rotation would not work effectively, requires a range of measures, including appropriate use of fertilizers, crop protection innovations, and improved seeds [5]. Nowadays, effective soil fertility enhancing strategies and technologies are one of the most essential needs for increasing soil fertility in order to enhance yields of both perennial and annual crops [6]. This is because soil infertility is evolving as a serious problem causing low crop yields, food insecurity and poverty in most households among countries in the world [7].

To increase soil fertility, fertilizers (organic, inorganic, or their integration) are used as the source of plant nutrients [6]. Increasing soil fertility through fertilizer application is the common way of modern agricultural practice [8]. Fertilizers are substances applied to the soil to supply essential nutrients to the plant tissue to increase the growth and yield of the plants [9]. Furthermore, it could be organic or inorganic and natural or synthetic that supplies plants with the necessary nutrients for plant growth and optimum yield [10].

Worldwide, mineral fertilizer consumption is steadily increasing in response to the growing population and increased demand for food crops and nonfood crops [11]. The application of synthetic fertilizers in developing countries is still very low [12]. However, the use of chemical fertilizers is increasing steadily. The major source of fertilizer sales in developing countries has been urea and DAP since the 1960s, and there has been no change in the composition of the use of fertilizers in developing countries' agriculture until 2014/15 cropping season [12]. In every region of the world, the intensification of crop-based agriculture has been associated with a sharp increase in the use of chemical fertilizers. This has been facilitated by farmers getting trainings from different extension agents, non- governmental organizations and projects funded by governments to provide chemical fertilizers on a subsidy[13]. For example, in Uganda the ministry of Agriculture, Animal Industry and Fisheries is implementing the Agriculture Cluster Development Project targeting to motivate farmers to adopt use of chemical fertilizers in coffee production.

Despite different commitments by different non- governmental organization and government agriculture extension workers on training and encouraging farmers to use chemical fertilizers in different enterprises, In Ibanda district, the use of chemical fertilizers is still low due to deficits in perception, knowledge and access to chemical fertilizers by farmers. This low level of knowledge and perceptions among farmers may influence them to use inappropriate types and amounts of fertilizer, or apply them in the wrong way or at the wrong time or not to use them at all. There are many reasons for this: the recommendations are wrong; the subsidized fertilizer arrives late; the right type of fertilizer is not available; the farmer lacks information and skills, or diverts the fertilizer to other, less suitable crops [14].

Despite Kikyenkye Sub-County being one of the highest producers of coffee in Ibanda district, farmers still have unstamped coffee trees in their plantations and the rate of adoption of different coffee management practices especially pruning and soil fertility enhancement is still low and this affects both quality and quantity of coffee produced by farmers in the area hence reduced incomes [15]. To bridge this gap different organizations like Grain Pulse and government programmes like ACDP (Agricultural Community Development Project) have been promoting the use of chemical fertilizers in coffee production but the adoption rate is still low. It is from this background that this research was conducted to assess the adoption of chemical fertilizers use in coffee production in Kikyenkye Sub-County Ibanda District.

The study would help extension workers to focus their efforts on only salient areas in promotion of chemical fertilizers use for increased coffee production. For example, more effort and resources could be directed towards mind set change if attitude and perception were established as limiting factors among others,civil society organizations would get grounds of intervention in promoting the use of chemical fertilizers to increase coffee production and productivity sustainably in the study area and Uganda at large and The study is expected to help policy makers especially in the Ministry of Agriculture Animal Industry and Fisheries to know what affects the adoption of chemical fertilizers in coffee production not only in Kikyenkye Sub-County but also in many other areas in Uganda.

Methodology

Description of the study area

The study was conducted in Kikyenkye Sub-County Ibanda District. Ibanda is located approximately 70 kilometres (43 mi), by road, northwest of Mbarara, the largest city in the Ankole sub-region. This is about 290 kilometres (180 mi), by road, southwest of Kampala, the capital of and largest city in Uganda.The coordinates of the town are 0°08'05.0"S, 30°29'42.0"E (Latitude: -0.134712; Longitude: 30.495000) (UBOS, 2017).Ibanda District is bordered by Kitagwenda district to the west, Kamwenge district to the north, Kiruhura district to the east, Mbarara and Buhweju district to the south, and Rubirizi district to the southwest. KikyenkyeSub- County is located in Ibanda south constituency. It is bordered by KeihangaraSub- County in the south, Igorora town-council in the west, Bufunda Division in the north and Kazo district in the east. Kikyenkye Sub-County is comprised of 3 parishes namely; Irwaniro parish with 8 villages, Kihani parish with 11 villages and Rwengwe parish with 10 villages making a total of 29 villages.

Study design and sampling frame

The study took across-sectional survey design and was descriptive research that assessed the adoption of chemical fertilizers in coffee production in Kikyenkye Sub-County, Ibanda district and the study was conducted between January 2022 to September 2023.Kikyenkye Sub-CountyIbandadistrict was purposively selected for being among the highest coffee producing sub-county in Ibanda district andAnkole region. The district was also selected for the reason that the farmers have started using inorganic fertilizers as advocated by different including technoserve. In order to get an understandingof the adoption of chemical fertilizers in coffee production,coffee farmers were randomly sampled and

data was collected using questionnaire and interview were conducted with 27 key informants who were purposively selected.

Sample selection and sampling technique

To obtain the desired sample,Yamane formula (Yamane, 1967) was used adopted and a sample size of 97 coffee farmers were adopted and 27 key informants were identified since they were the ones responsible for disseminating information on the contributions and adoption of inorganic fertilizers in coffee production.Walks along community routes/roads and household coffee plantation visits were also made in the study areas and observations were made in those communities. A standard structured questionnaire was self administered to a total of 97 respondents who were randomly selected, including all households that had adopted use of inorganic fertilizers in coffee plantations to collect quantitative data.For this purpose, a list of coffee farmers wasprepared in consultation with the sub-county agriculture extension personnel and local leaders of the each respective sub-county and villages and questionnaires were administered to the selected farmers separately.

Data analysis

Qualitative data was obtained through key informants' interviews and observations was organized and meaningfully reduced into themes and contents that were in line with the objectives and the concept of the study according to [17]. Quantitative data was edited, coded, entered in the computer and cleaned to ensure accuracy, consistency, uniformity and completeness. The data was then analyzed using Statistical Package for Social Scientists (SPSS) version 20 to generate descriptive statistics and regression analysis.Analysis of variance (ANOVA) was run to determine significant relationships. Regression analysis was used to examine the relationship between a set of independent variables as factors influencing the adoption of inorganic fertilizers in coffee production.

Results and discussion

Demographic characteristics of respondents

The demographic characteristics of respondents included gender, age, education level and marital status.

Gender of respondents

Respondents during questionnaire survey were asked to identify their gender, responses were captured and presented in figure 1:

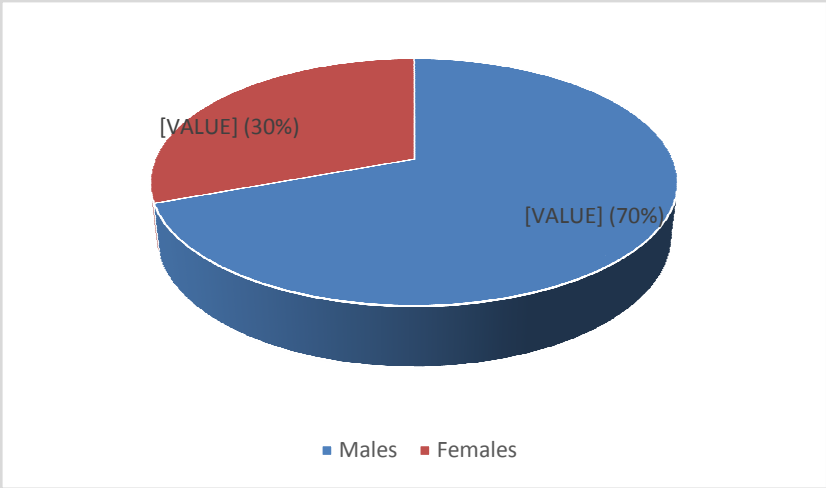

Figure 1: Gender of respondents

Source: Authors" computation from field survey data 2023

The study results revealed that majority of respondents 70% were males compared to females who constituted 30%.There was an observed difference between participants by gender where male dominated the study than female. This perhaps implied that coffee is a laborious crop that requires more of energy especially climbing coffee trees during harvesting. This energy is provided by men than women. To that, men are more associated with profitable enterprises at family level than females.

4.1.2 Age of respondents

Respondents during questionnaire survey were questioned to mention their age, responses were captured and presented in figure 2;

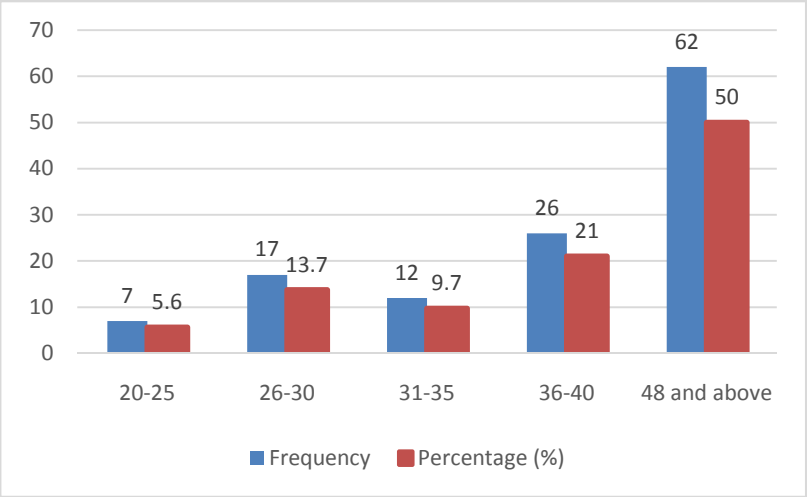

Figure 2: Age of respondents

Source: Authors" computation from field survey data 2023

The study results indicate thatfarmers' age can have positive or negative effects on the adoption of a technology. From Figure 2 above, the majority of the respondents 62 (50%) were aged 40 years and above, 26 (21%) were aged between 36-40 years, 17(13.7%) were aged between 26-30 years, 12 (9.7%) were aged between 31-35 years and 7 (5.6%) were aged between 20-25 years. The dominance of aged respondents implied that the adoption of chemical fertilizer use on coffee production needed those who had spent long period of time in coffee farming and therefore were the ones with enough farming experience. To that, coffee farming requires some reasonable investment for example buying land. It is therefore associated with people with increasing family responsibility which goes with age.

4.1.3 Education level

During questionnaire survey respondents were tasked to mention their level of education, responses were covered and recorded in figure 3 below;

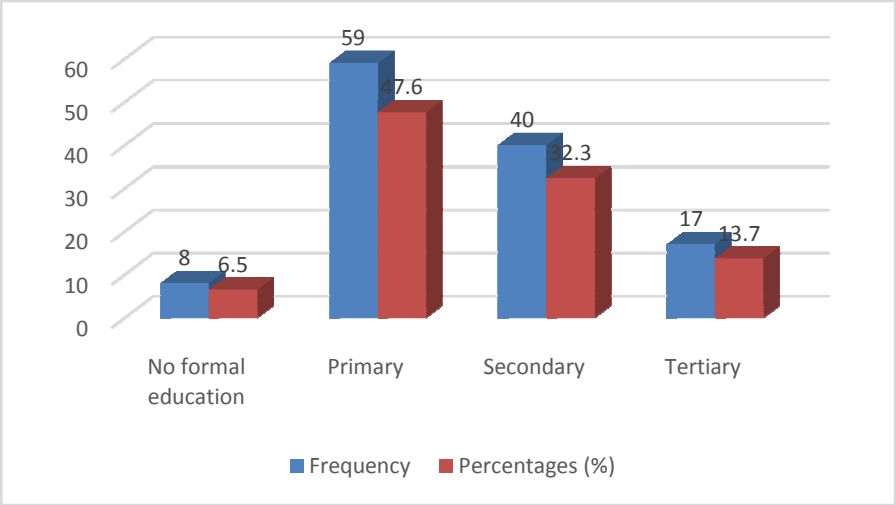

Figure 3: Education level

Source: Authors" computation from field survey data 2023

From Figure 3 above, study results show that 59(47.6%) of the respondents had attained primary level, 40(32.3%) had completed secondary, 17(13.7%) had attained tertiary education and 8(6.5%) had no formal education. The level of education of the farmer indicates the degree at which a farmer can understand and adopt or reject a technology or technologies. However, the dominance of farmers with low level of education implied that most of them lacked school fees to join higher institutions for further studies and this had limited them from adopting the use of chemical fertilizers unlike counterparts who had joined tertiary institutions as this affects coffee production.

4.1.4 Marital status

Respondents during survey were also asked to mention their marital status**,** responses were also captured and indicated in the figure 4 below;

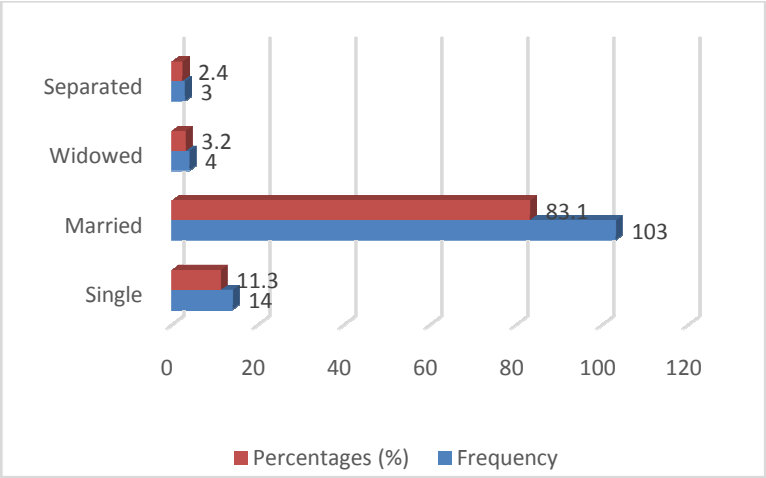

Figure 4: Marital status

Source: Authors" computation from field survey data 2023

The study findings from figure 4 above indicate that 14 (11.3%) of the respondents were single, 103 (83.1%) were married, 4 (3.2%) were widowed and 3 (2.4%) had separated. The majority coffee farmers were married which implied that they had engaged in coffee growing to meet their family needs and basic social services.

Perceptions and attitudes of farmers on application of chemical fertilizers

Coffee farmers have different perceptions and attitudes on the application of chemical fertilizers in their coffee plantations and this depends on the level of training, farmers experience as well as accessibility and availability of such fertilizers in different agro-input shops. Specific questions on the questionnaires were used to measure coffee farmers' perceptions and attitudes towards the use of chemical fertilizers in coffee from their responses.

Farmers' experience in growing coffee (years spent)

The time spent while growing coffee determines the experience of the farmer in using different management practices in their coffee plantations. Respondents were asked about the time spent while growing coffee and their responses were recorded in Table 1 below.

Table 1: Farmers' experience in growing coffee

Time spent while growing coffee	Frequency	Percent
<2 years	6	4.8
2-5 years	9	7.3
5-9 years	38	30.6
10 years and above	71	57.3
Total	**124**	**100.0**

Source: Authors" computation from field survey data 2023

Results from Table 1 above indicate that 71 (57.3%) who were the majority had spent 10 years and above while growing coffee, 38 (30.6%) revealed between 5-9 years, 9 (7.3%) had spent 2-5 years and 6 (4.8%) had spent less than 2 years. This implied that farmers with more years in coffee farming would quickly adopt the use of chemical fertilizers because they already know the realized benefits of applying it unlike farmers with few years in coffee farming. This further enhances the farmer's level of awareness on use of chemical fertilizers.

Number of farmers using chemical fertilizers in coffee

Due to continued soil fertility loss in the coffee plantations, chemical fertilizers have been advocated to be used in coffee plantations. Some of the chemical fertilizers recommended for use in coffee include NPK, DAP, CAN, Urea and Super Phosphates depending on soil conditions (limiting nutrients for coffee in that soil). Respondents were asked whether they were using chemical fertilizers in their coffee plantations and their responses were presented in Table 2 below**.**

Table 2: Number of farmers using chemical fertilizers in coffee

Number of farmers using chemical fertilizers in coffee	Frequency	Percent
Yes	22	17.7
No	102	82.3
Total	**124**	**100.0**

Source: Authors" computation from field survey data 2023

Results from Table 2 above indicate that only 22 (17.7%) farmers had ever used chemical fertilizers in coffee compared to 102 (82.3%) who had never. This clearly shows that the use of chemical fertilizers in coffee is still minimal representing very low adoption of the technology in coffee. This perhaps implied that farmers

either had limited extension training on how best they can use chemical fertilizers to improve production or they clearly never understood how to apply chemical fertilizers due to their low level of education.

Table 3: Model Summary for the relationship between growing coffee and Perceptions and attitudes of farmers on application of chemical fertilizers

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.355[a]	.126	.073	.79481	.629

Source: Authors" computation from field survey data 2023

An R-squared of 12.6 % was obtained. This implied that the simple linear model with farmers' perception and attitude on the use of chemical fertilizers in coffee plantations as the independent variable explained 7.3% of the variations in farmers using chemical fertilizers in coffee production.

Table 4: ANOVA for the relationship between growing coffee and Perceptions and attitudes of farmers on application of chemical fertilizers

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	10.559	7	1.508	2.388	.026[b]
	Residual	73.280	116	.632		
	Total	83.839	123			

A p-value of less than 0.05 (P= 0.026) was obtained. This implies that the use of chemical fertilizers in coffee production would be significantly influenced by the time spent while growing coffee (experience) but this would be achieved effectively when farmers access information on the availability and accessibility of such fertilizers in the locality.

Table 5: Coefficient for the relationship between coffee growing and Perceptions and attitudes of farmers on application of chemical fertilizers

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.743	.800		.929	.355
Chemical fertilizers are basically used in high commercial crops like tea and coffee	.197	.083	.225	2.387	.019
Chemical fertilizers use ensure high productivity and yields of coffee	.500	.444	.215	1.125	.003
Chemical fertilizers applied to in coffee do not provide optimal economic returns to farmers	-.071	.425	-.034	-.168	.867
The decisions on chemical fertilizers use are based on access to information and market prices (cost).	.241	.133	.160	1.814	.009
Fertilizers use is influenced by agro-climatic and farm characteristics	.071	.189	.051	.378	.706
Chemical fertilizers are not suitable for use in coffee.	.340	.127	.350	2.674	.263
Chemical fertilizers use alters the soil properties (both physical and chemical) spoiling the soil.	.100	.212	.048	.473	.637

Source: Authors" computation from field survey data 2023

Results from Table 5 above indicate that respondents had a positive attitude and perception that Chemical fertilizers use ensure high productivity and yields of coffee, Chemical fertilizers are basically used in high value commercial crops like tea and coffee and that the decisions on chemical fertilizers use is based on access to information and market prices (cost) since their p-values were less than 0.05 (P=.019, P=.003 and P=.009). However, results indicated a negative perception and attitude of respondents on the use of chemical fertilizers on premises that; chemical fertilizers applied to in coffee do not provide optimal economic returns to farmers, fertilizers use is influenced by agro-climatic and farm characteristics, chemical fertilizers are not suitable for use in coffee and that chemical fertilizers use alter the soil properties (both physical and chemical) spoiling the soil since their p-values are greater than 0.05 (P=.867, P=.706, P=.263 and P=.637).

Farmers' level of awareness on chemical fertilizers use in coffee production

Awareness is one of the key determinants that shape farmers' choice to embrace or not embrace any technology. Farmers need to know the comparative advantage of a new technology over the traditional ones, the risk associated with undertaking the technology, the cost-benefit relationships among other parameters. They also need to be conversant with the options available, the sources and the comfort of practicing, the required skills to handle the technology, safety issues and sustainability possibilities. Specific questions on the questionnaire were used to measure coffee farmers' awareness level on the use of chemical fertilizers in coffee production.

Coffee farmers were asked on parameters that determine the farmers'levelof awareness on the use of chemical fertilizers in coffee production and their responses are presented in Table 6 below.

Table 6: Parameters that determine farmers' awareness on the use of chemical fertilizers in coffee production.

Parameter	Category	Frequency	Percent
Method of application	Hole placement	2	1.6
	Broadcasting	20	16.1

	Missing value (never used)	102	82.3
	Total	**124**	**100**
Source where farmers acquired chemical fertilizers	Farmers' associations Input suppliers Missing value (never used)	17 5 102	13.7 4 82.3
	Total	**124**	**100**
Who provided the training to you	Extension workers Input suppliers Fellow farmers	84 20 20	67.8 16.1 16.1
	Total	**124**	**100**
Type of fertilizers used	NPK DAP Missing value (never used)	20 2 102	16.1 1.6 82.3
	Total	**124**	**100**

Source: Authors" computation from field survey data 2023

Research findings indicate that, of the methods used by farmers while applying fertilizers, 20 (16.1%) of the respondents used broadcasting whereas 2 (1.6%) used hole placement.

The study also show that of the 22 coffee farmers that used chemical fertilizers, 17 (13.7%) get it from farmers' associations and 5 (4%) get it from input suppliers.

Results indicate that coffee farmers received trainingonthe use of chemical fertilizers from different organisations as follows; 84 (67.8%) got training from extension workers (both for government and non-government organisation), 20 (16.1%) got training from input suppliers and fellow farmers and none got any kind of training from media platforms.

The type of fertilizers used by the farmer depends on the type of crop, soil and the method of application. The study found out that out of 22 coffee farmers who had ever used chemical fertilizers, 20 (16.1%) used NPK and 2 (1.6%) used DAP. These findings implied that farmers who had access to the source of chemical fertilizers and those who attended trainings on the use of chemical fertilizers had enough knowledge which speeded up their awareness which helped them improve on coffee production.

Farm-based factors that determine farmers' choice to use chemical fertilizers in coffee production

There are different farm-based factors that determine the choice of coffee farmers to use chemical fertilizers and these are basically initiated by different land conditions especially in ownership, access, size, location and control. Regression analysis between farm-based factors that determine farmers' choice to use chemical fertilizers and coffee production is indicated in Table 7 below.

Table 7: The coefficient of the Farm-based factors that determine farmers' choice to use chemical fertilizers in coffee production

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	3.641	1.121		3.249	.002
Land ownership	-.326	.162	-.183	-2.015	.146
Coffee-banana intercropping	.203	.410	.044	.495	.622
Farm location	-.033	.303	-.010	-.110	.913
Small plots of land under coffee production	-.330	.119	-.296	-2.782	.006
Long Plot distance in relation to chemical fertilizer distribution channels	-.110	.118	-.102	-.936	.351
Land fragmentation	.263	.097	.319	2.699	.008

Source: Authors" computation from field survey data 2023

Results from Table 7 above show that, small plots of land under coffee production and land fragmentation as the major significant farm-based factors that determine farmers' choice to use chemical fertilizers in coffee production since their p-value was ≤ 0.05 (P=0.006 and P=0.008). Whereas, land ownership, coffee-banana intercropping, farm location (farms located along better roads would ease access to fertilizers unlike farms located in remote areas) and long distance in relation to chemical fertilizer distribution channels were the non-significant since P-value is >0.05(P=0.146,P=0.622, P=0.913, = 0.351).

Possible strategies for promoting adoption of chemical fertilizers use in coffee production

In order to improve on the adoption of chemical fertilizers use among coffee farmers, different strategies have to be implemented and put in place. The most relevant strategies are those that address farmers' perceptions and attitude towards use of chemical fertilizers. In the same vein, awareness of farmers on the role and use of chemical fertilizers is also key as it promotes farmers' positive attitude and perceptions. Strategies targeting to improve institutional and structural functions are also important in promoting accessibility, affordability, awareness and profitability of using chemical fertilizers. From the study, farmers gave their responses on what they think can be of help in promoting the use chemical fertilizers among coffee farmers. The coefficient of these strategies is presented in Table 8

Table 8: Coefficient of possible strategies of promoting adoption of chemical fertilizers use in coffee production

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	1.134	.295		3.844	.000
Designing a fertilizer promotion strategy	.184	.167	.129	1.102	.273
Knowledge of coffee yield response to chemical fertilizers through a study.	.014	.181	.012	.078	.938

Potential for public-private partnerships to provide fertilizer and trainings to farmers	.283	.193	.242	1.472	.144
Stabilizingcoffeeand chemical fertilizer prices in the market	.259	.101	.230	2.557	.002
Provision of Fertilizer subsidies	.046	.154	.038	.299	.766
Constant training on the value and use of fertilizers by extension workers	.547	.098	.479	5.571	.000

Source: Authors‟ computation from field survey data 2023

Results from Table 8 above show that providing constant trainings on the value and use of chemical fertilizers by extension workers and stabilizing prices of both coffee and chemical fertilizers on the market are the significant strategies for promoting the adoption of chemical fertilizers in coffee production. This is because their p-values were less or equal to 0.05 (P=0.000 and P=0.002). However, Knowledge of coffee yield response to chemical fertilizers and its profitability, providing chemical fertilizer subsidies, designing a fertilizer promotion strategy and considering the potential for public-private partnerships to provide fertilizers and trainings to farmers were not significant. This is because their p-values were≥ 0.05 (P=0.938, P=0.766, P=0.273 and P=.144) respectively.

Discussion of the findings, conclusions and recommendations

Demographic characteristics

Gender of respondents is very important in determining the number of males and females who have adopted different technologies leading to the use of chemical fertilizers. It was found that majority of the respondents 86 (69.4%) were male compared to their female counterparts. This was because most of the coffee plantations were owned and controlled by males in the households and decisions to use different inputs including chemical fertilizers were majorly determined by men except for women headed households. This is a common practice where men want to control high value and profitable family enterprises that generate income. They

want to control family finances as a sign of power and authority. Coffee is one of such projects in the study area.Women only did other management practices like weeding, harvesting and part of processing. The study findings also indicate that there was difference between gender in adopting the chemical fertilizers as the percentage of males was bigger than that one of females. This is because women are more constrained to accumulate assets, and have limited access to productive resources such as credit and land and hence, their access to improved technologies including using chemical fertilizers is negatively affected than men. However, women readily reserve time for trainings and related meetings hence tend to be more informed. If they would be empowered to have a decision and access to resources and credit, adoption of chemical fertilizers use in coffee would be higher in the study area. These findings agree with Nakazi, *et al.,*(2017) who in his study reported that females are more constrained to access agricultural credit to fund coffee production innovations that improve agricultural production than males because they lack control over economic andproductive resources and the nature of their economic activity. Therefore, it is hypothesized that female smallholder farmers are more constrained to access agricultural credit than their male counterparts.

The farmers' age can have positive or negative effects on the adoption of a technology. Farmers age determine the level of experience of the farmer in the management of a certain enterprise. The majority of the respondents 62 (50%) were aged 40 years and above and this implies that most coffee plantations were owned by adults since most of them were owning land by hereditary means and accumulatedwealth compared to young ones.Older farmers had more experience and knowledge about traditional farming methods and may have a stronger connection to the land and the coffee plants. It was also found that older farmers had an advantage in terms of access to financing and land ownership, but were also facing the challenges in terms of succession planning and passing on their farms to the next generation.

The study findings indicate that the majority of the respondents 103 (83.1%) were married.There were also more widows with coffee plantations than single mother families. This is largely because coffee enterprises are taken to be masculine as it is basically income generating, while as females are mostly associated with food production enterprises. The high occurrence of widows was found to be that such projects were initiated before the demise of their husbands and widows would then adapt and continue due to family income needs. Shared interest and responsibility is another reason why most married couples had coffee projectsas a means of generating family income. However, single individuals, on the other hand, least owned coffee farms as it is always expensive and time-consuming.It was found out that gender roles impact coffee ownership and use of

chemical fertilizers. For example, it was clear that men were the primary coffee growers and decision-makers regarding to fertilizer use, regardless of their marital status.

The level of education of the farmer indicates the degree to which a farmer can adopt a technology or technologies. This is because a good level of education enables the farmer to adopt different technologies used in a certain enterprise because they understand the technology. It was found that almost all the respondents had acquired a certain level of education hence they were able to understand the procedures of using chemical fertilizers and their dangers to the environment. This is because education can raise awareness about the potential risks associated with the overuse of chemical fertilizers. For example, excessive use of chemical fertilizers can lead to soil degradation, which can reduce crop yields over time. It can also result in water pollution and other negative environmental impacts. By understanding these risks, coffee farmers may be more likely to adopt sustainable farming practices and follow instructions for safe and proper use of chemical fertilizers.

5.2 Perception and attitude of farmers on application of chemical fertilizers

The perception and attitude of farmers towards the application of chemical fertilizers in coffee growing can vary depending on a range of factors, including their level of education, cultural background, and economic circumstances. Some farmers viewed the use of chemical fertilizers as a necessary and effective way to improve crop yields and maintain the health of their coffee plants but lacked knowledge and skills of applying chemical fertilizers

Results from Table 5 indicate that respondents had a positive attitude and perception on opinions that;use of Chemical fertilizers ensure high productivity and yields of coffee, Chemical fertilizers are basically used in high value commercial crops like tea and coffee and that the decisions on chemical fertilizers use is based on access to information and market prices (cost) since their p-values were less than 0.05 (P=.019, P=.003 and P=.009).However, results indicateinsignificant results on opinions that Chemical fertilizers applied in coffee do not provide optimal economic returns to farmers, fertilizers use is influenced by agro-climatic and farm characteristics, chemical fertilizers are not suitable for use in coffee and that chemical fertilizers use alter the soil properties (both physical and chemical) spoiling the soil since their p-values are greater than 0.05 (P=.867, P=.706, P=.263 and P=.637) respectively. This still means that coffee farmers are opposed to these negative opinions on chemical fertilizers use in coffee which is indicative of their positive perception and attitude.

A p-value ≤ 0.05 (P=0.019) was obtained when time spent while growing coffee (farmers' experience) was regressed with the statement that chemical fertilizers use ensure high productivity and yields of coffee (Table 5). This implies that farmers had a positive perception and attitude that the use of chemical fertilizers would ensure high productivity and yields of coffee. This is because farmers had seen or heard of other farmers who had successfully used chemical fertilizers to increase their yields, and this reinforced their perception that these fertilizers are effective. In the study area, it was observed that coffee fields where chemical fertilizers were used had healthy plants with high berry bearing, more drought and disease tolerant and higher yields than fields where chemical fertilizers were not used. Furthermore, agricultural extension services, agricultural input dealers, and other sources of agricultural information were promoting the use of chemical fertilizers as a means to increase coffee yields.

During an interview one of the local leaders had this to say;

"*Farmers perceive that the use of chemical fertilizers will result in higher crop yields because these fertilizers provide a readily available source of essential nutrients for plants, such as nitrogen, phosphorus, and potassium. Chemical fertilizers are formulated to deliver these nutrients in precise amounts and in a form that plants can easily absorb, which can lead to faster growth and higher yields. However, despite the perceived benefits of chemical fertilizers, the adoption of these inputs may be low for several reasons. For example, some farmers may lack the knowledge or resources to properly apply chemical fertilizers, leading to reduced yields or even crop damage. Affordability and access to quality chemical fertilizers are yet other factors that may be limiting its use by coffee farmers*"

This can be compared with [19] who noted that fertilizer is not only scarce but also information related to its use and the potential increases in productivity that it could bring about are unknown, thereby reducing the incentive for its use by farmers.

A p- value less than 0.05 (P=.003) was obtained when time spent while growing coffee was regressed with the statement that chemical fertilizers are basically used in high value commercial crops like tea and coffee. This implies that farmers perceived the use of chemical fertilizers to be for commercial crops and commercial farmers than smallholder farmers. Although farmers positively perceived chemical fertilizers to be used in commercial crops including coffee, the majority were not using it since they were smallholder farmers.While as the size of coffee plantations should not be a determinant factor to using chemical fertilizers, the majority of coffee farmers who used chemical fertilizers in coffee in the study area were found to have large coffee

plantations.This is because commercial farmers had greater access to information and resources related to modern farming practices, including the use of chemical fertilizers. Smallholder farmers, on the other hand, have limited access to such resources due to factors such as lack of education, language barriers, and limited access to technology and credit services. The most important of these limiting factors are lack of education and low access to friendly credit. They therefore tend to produce coffee on subsistence practices.

An interview with one of the agriculture extension workers confirmed this when he said;

"*Chemical fertilizers are often cheaper and more readily available in larger quantities, making them a more affordable option for commercial farmers who may have larger plots of land to cultivate. Similarly, Commercial coffee farmers may be catering for a different market that places more emphasis on yield and consistency in flavor, rather than organic or sustainable farming practices*".

This is in line with [20] who pointed out that the demand for fertilizer technology depends on the contribution to the value of output. One of the factors that determine the adoption of fertilizer technology is the technical relationship between fertilizers use and the quantity of output and the additional output derived from additional units of fertilizer application. This means that for farmers to use chemical fertilizers, they need to be sure of the profit as a result of using them, considering the cost of fertilizers used, the additional yield as a result of using chemical fertilizers, the market price of coffee and the overall income returns in terms of profit.

A p-value less than 0.05 (P=0.009) was obtained when time spent while growing coffee was regressed with the statement that the decisions to use chemical fertilizers is based on access to information and market prices (cost).The use of chemical fertilizers in coffee production is often perceived as a decision that is based on access to information and market prices because farmers need to weigh the benefits and costs of using fertilizers in their coffee fields. Therefore, access to information about the benefits and drawbacks of using fertilizers, as well as information on the specific nutrient needs of coffee plants, can influence farmers' decisions on whether or not to use chemical fertilizers. For example, farmers may be more likely to use fertilizers if they are aware of the potential yield benefits and understand the proper application rates and timing. During an interview one of the local leaders confirmed this when he revealed that;

"*Market prices for coffee can also influence farmers' decisions on fertilizer use. If coffee prices are high, farmers may be more willing to invest in fertilizers to increase their yields and potentially earn more income. On the other hand, if coffee prices are low, farmers may be more hesitant to invest in expensive fertilizers that may not provide a significant return on investment*"

This can be compared with [21] who pointed out that farmer' attitudes and perceptions towards fertilizer quality have led to an increase in the use of fertilizer in cropping fields. Most farmers who still use chemicals believe that those chemicals in the market are of low quality and therefore need to apply more and more ending up overusing them. This becomes costly and less profitable. Once they are assured of high quality fertilizers, they will increase their use sure of increased returns on the investment.

In the same line, high fertilizer prices (cost) on the market reduces profit margin on investment and therefore discourage coffee farmers especially small holders from using them. For example it is on record that in Uganda and Ibanda as well, agro-chemicals market prices have gone up substantially since 2020 where one kilogram of NPK fertilizer shot from 3,000= up to more than 5,000= and a 50kg bag rose from 120,000= to 200,000= in the same period. Despite efforts to promote chemical fertilizers use in coffee, the cost factor can be a big setback to such efforts. This is in agreement with Savci (2012) who asserts that fertilizer utilization by farmers is highly dependent on prevailing fertilizer prices on the market.

The study findings showed that respondents perceiving that chemical fertilizers applied to coffee do not provide optimal economic returns to farmers was not significant since p-value was greater than 0.05 (P=0.867). Since the majority were small scale coffee farmers, they revealed that adoption of chemical fertilizers would not bring optimal economic returns since the average yields from such small portions of land would not cover up all the costs involved in the management of different enterprises. This is why farmers normally opt to use organic fertilizers which they can make using locally available resources. This can be compared with [22] who pointed out that the use of fertilizers is not always profitable. Firstly, it is an expensive investment, which means increased costs. Secondly, if it is not handled properly, fertilizers will have a negative impact on the nature and can be harmful for both animals and human's health when not used carefully.

The study findings also indicated that fertilizers use being influenced by agro-climatic and farm characteristics was not significant since the p-value was greater than 0.05 (P=.706). Fertilizers can be used in different agro climatic zones depending on the level of nitrogen flush hence some farmers lack knowledge on which type of fertilizers should be applied in the soil to improve on its fertility. This can be compared with [23] who pointed out that in most agro-ecological zones, extension workers recommend the use of organic manure and/or triple super phosphate (TSP), calcium phosphate (CAP) or rock phosphate, but not di-ammonium phosphate (DAP), which is soil acidifying being nitrogenous. However, DAP makes up about one

half of all the fertilizer used among the 12 types availablebecause of its adaptability to the environment as well as enhancing quick coffee plant growth. This negative perception is a limitation to the use of chemical fertilizers by coffee farmers due to limited knowledge.

Farmers' level of awareness on chemical fertilizers use in coffee production

The type of fertilizers used by the farmer depends on the type of crop, soil and the method of application. Respondents were asked about the type of fertilizers commonly used; 20 (16.1%) mentioned NPK, 2 (1.6%) mentioned DAP and 102 (82.3%) had never used chemical fertilizers. Majority of the respondents who were using chemical fertilizers in coffee revealed that they were using NPK because it was the most available fertilizer typethey had access to, from different agro- input outlets compared to other fertilizers. Still, most organizations (farmers'organizations) were promoting it to be adopted by coffee farmers. NPK is deemed appropriate in an event that the farmer has no access to soil testing kits to find out which essential nutrients are limiting coffee on the farm. This is because NPK supplies the three primary essential nutrients that is, Nitrogen, Phosphorus and Potassium which are commonly limiting coffee production in most agro-ecological zones. The fact that 102 (82.3%) respondents had never used chemical fertilizers in coffee production is evidence that the use of chemical fertilizers in coffee production in the study area is very low.

The study findings showed that 84 (67.8%) of the respondents were receiving training from extension workers (both for government and non-government organisations) and 20 (16.1%) were receiving from fellow farmers and input suppliers. Although farmers were acquiring trainings from extension workers because agriculture extension services are often the most accessible source of information and training for farmers, particularly those in rural areas, the nature and mode did not favour new users venturing into its adoption. This is because trainings were largely theoretical and not consistent with chemical fertilizers use in coffee,in addition to lack of practical support services. The theoretical mode of these trainings by extension workers is largelyattributed to lack of demonstration farms in addition to low extension worker-farmer ratio (1:5000) which is overwhelming. This partly makes it difficult to make follow ups after training.Extension services have offices in most regions and are staffed by trained professionals who can provide information in the local language and understand the specific needs and challenges of local farmers.However, the facilities are limited and the extension worker-farmer ratios are overwhelming the reason why their trainings do not make significant impact on diffusion of technologies.During an interview one of the local leaders had this to say;

"*Most farmers get trainings on fertilizers use from agriculture extension workers especially of different non-government organization promoting the use of fertilizers in coffee like TECHNO SERVE*). *However, these trainings are not always hands-on and regular and always lack follow up. This is one of the important reasons why it's not effective in winning more coffee farmers to adopt the technology"*

This can be compared with [24] who pointed out those agriculture extension workers are one of the major actors in changing the perception of farmers towards the use of chemical fertilizers in coffee and this can be achieved through constant trainings.

The study also found that farmers were getting chemical fertilizers they used in coffee mainly from two sources namely; 17 (13.7%) got fromfarmers' associations and 5 (4%) from input suppliers whereas 102 (82.3%) were not using chemical fertilizers. Majority were accessing chemical fertilizers from farmers' associations and agriculture cooperatives because the organisations would provide the fertilizers to the farmers on credit basis and on a subsidised price hence some of the farmers would access them on credit basis. This is because most of the farmers reported that the low level of fertilizer use was due to their high prices. During an interview, one of the farmers confirmed this when she said that;

"*I acquired the fertilizer I used from farmer associations since the organisation was giving it to us on credit than buying it from agro-input dealers. This helped me in improving my production hence acquiring high revenues*".

This can be compared with[11] who pointed out that fertilizer is not only scarce but also information related to its use and the potential increases in productivity that it could bring about are unknown, thereby reducing the incentive for its use by farmers. Alongside this is a severe lack of research results on the profitability of the different soil-crop-fertilizer combinations that could be employed in the different parts of the country.

The study findings indicate that 20 (16.1%) of the respondents were using broadcasting method of application and 2 (1.6%) were using hole placement. Broadcasting fertilizers allows for an even distribution of the nutrients across the soil surface, which ensures that all the coffee plants receive the required amount of nutrients for healthy growth although it is irregular. This method also saves time and labor costs, as farmers can apply the fertilizer quickly over a large area.However, hole placement has an advantage of concentrating measured amounts of fertilizers around the root region of each tree. This promotes efficiency and reduces

wastage that could be used by weeds. So, hole placement is more recommended but farmers lacked knowledge of this comparative advantage of hole placement over broadcasting.

Farm based factors that determine farmers' choice to use chemical fertilizers in coffee production

There are different farm-based factors that determine farmers' choice to use chemical fertilizers in coffee production.

The study findings show small plots of land under coffee production as the most significant farm-based factor that determine coffee farmers' choice to use chemical fertilizers since the p-value was less than 0.05 (P=0.006).Chemical fertilizers can be expensive, and small coffee farm owners may not have the financial resources to purchase large quantities of fertilizers. It was observed that all coffee farmers who had coffee plots less than one acre were not using chemical fertilizers. However, using chemical fertilizers is not profitable for only large scale coffee farmers but for small holder coffee farmers as well. The amount of chemical fertilizers applied is always directly proportional to the size of the coffee farm. This is because, chemical fertilizer is capable of increasing yield evenly per tree holding other factors constant, and the quantity applied is equally dependent on the number of coffee trees. This means a small holder farmer applies comparatively less overall quantities of fertilizer over their small farm and it is still profitable. During an interview, one of the local leaders had this to say;

"*Most coffee farmers are operating on small plots and this discourages them from using chemical fertilizers since they are considered to be profitable for commercial farmers"*

This can be compared with[25] who pointed out that small plot of coffee discourage farmers from use of chemical fertilizers hence they opt to continue using organic fertilizers or leaving coffee plantations to subsist. While as [26] observes that small scale producers would be more inclined to adopt improved practices, in practice they always fear risks and uncertainties that come with extra financial investment on their adoption which badly affects their operations in case it proves not to be profitable.

From farmers' view, the study findings indicate land ownership (rights to own and use land) among the non-significant farm-based factors that determine farmers' choice to use chemical fertilizers in coffee since the p-value was greater than 0.05 (0.146). Insecure land ownership rights can discourage farmers from investing in their land or making long-term improvements, including the use of chemical fertilizers. If farmers are unsure whether they will be able to keep their land, they may be less likely to make investments that could increase

yields or improve soil quality.However, in the study area, it was evident that most coffee farmers had coffee plantations on land which they either inherited from their parents or they bought which ownership guaranteed them full rights and decision to use the land. Cases of hiring land or owning land communally which would render them insecure in land use rights were not common. All coffee farmers who were not using chemical fertilizers had secure tenure rights. This means, this factor is not among those ones at play for low chemical fertilizers use in coffee production in the study area but other factors have a bigger impact. It may have significant effect in areas where it applies.

During an interview one of the agriculture extension workers had this to say;

"*Without secure land rights, farmers may have difficulty accessing credit to purchase the necessary inputs, including chemical fertilizers. Lenders may be hesitant to lend money to farmers who don't have clear title to their land or who are at risk of being evicted, but as for farmers in this area, land is commonly acquired through inheritance or buying and therefore individually owned by households.*"

This is in line with [27] who pointed out that secure land tenure has been widely demonstrated to play a critical role in influencing farmers' willingness to invest in soil conservation practices.

The study findings also established land fragmentation among the significant farm-based factors that determine coffee farmers' choice to use chemical fertilizers since its p-value was less than 0.05 (P=0.008). When land is fragmented, farmers may have smaller plots of land to work with. This can make it difficult to access chemical fertilizers as they may be sold in large quantities that are not affordable for small-scale farmers. In addition, transportation costs to reach the plots of land in different locations may be high, further limiting access to inputs. In the study area, land fragmentation was real. Most coffee farmers had small scattered plots of land/ coffee fields sometimes across different villages. Accordingly, this is part of the negative incentives for reasonable investment including the use of chemical fertilizers. During an interview one of the local leaders confirmed this when he said that;

"*Fragmentation of land result in increased labor costs as farmers need to manage multiple plots of land instead of a single larger plot. This can make the use of chemical fertilizers uneconomical, as the cost of inputs and labor may exceed the benefits of increased yields*"

This is in line with [27] who pointed out that land fragmentation is an indicator of productive inefficiency. On the other hand, opponents of land consolidation programs note the benefits of fragmented land holding to reduce risk and encouraging more diversified production.

The study findings also indicate that distance in relation to chemical fertilizer distribution channels was insignificant farm-based factor that determine farmers' choice to use chemical fertilizers in coffee production since the p-value was greater than 0.05 (P=0.351).The distance between the distribution channels and the coffee farms can also impact the availability of different types of fertilizers. For example, some areas may have limited access to certain types of fertilizers due to the distance to the nearest distribution channel. This may limit the options available to farmers and result in the use of less effective or inappropriate fertilizers. The geographical location puts the study area at a long distance from the common main distribution centres of chemical fertilizers mainly bigger commercial centres and towns for it is in a remote area of the region. Since the majority of coffee farmers here were found not using chemical fertilizers, it is an indicator that long distance may have reasonable level of influence on farmers' decision to use chemical fertilizers in coffee, although it does in combination with other factors.

In an interview with one of the local leaders, he pointed out that;

"*If the distance between the distribution channels and the coffee farms is too far, it can result in delays in the delivery of the fertilizers. This delay can affect the timing of the fertilizer application, which may lead to reduced effectiveness of the fertilizers. Additionally, if the distance is too great, it may increase the cost of transportation, which can make the fertilizers more expensive for farmers to purchase and use*"

This is in line with [28] who pointed out that Plot distance can have its own impact on the likelihood of fertilizer adoption & the level of fertilizer use that is distant plots (further away from their homesteads) received less fertilizer.

Research findings still show that geographical location of the farm was among the insignificant farm-based factors since the p-value was greater than 0.05 (P=0.913).Some regions may have soil types that are not well-suited for the use of certain types of chemical fertilizers. For example, acidic soils may require different types of fertilizers than alkaline soils, and the wrong fertilizer can lead to reduced effectiveness or even damage to the soil and crops.

During an interview one of the agriculture extension workers had this to say;

"*Some regions have limited access to water resources, which can make it difficult to effectively use chemical fertilizers. Many chemical fertilizers require adequate water resources to dissolve and move through the soil*

to reach plant roots. In areas with limited water resources, the use of chemical fertilizers may not be a viable option, or farmers may need to invest in expensive irrigation systems to support their use"

This can be compared with [27] who pointed out that the geographical location of the farm determines the land potential and thus the expected returns from a given technology. Prevailing agro-ecological conditions capture the potential risk of crop failure associated with rainfall dependency and soil quality, which affects adoption decisions. Researchers have shown that households located in zones where rainfall is low and erratic are less likely to use fertilizers than those in zones with more reliable rainfall.

Research findings also indicate that coffee-banana inter-planting was not among the significant farm-based factors that determine farmers' choice to use chemical fertilizers in coffee since the p-value obtained was greater than 0.05 (P=0.622). In the study area, most farmers grow bananas as a main food crop and coffee as a main cash crop. It is a common practice to find coffee farmers integrating banana plantation with coffee or other arable crops in this area. It was observed that more than 50% coffee farmers had it integrated with bananas or other arable crops commonly beans, ground nuts and other trees. This makes it difficult for such farmers to commit a decision to apply chemical fertilizers for the benefit of coffee since their cropping interests are divergent. In addition, many leguminous crops and trees, such as beans and acacia, can fix nitrogen from the air and make it available to plants in the soil. When these crops are integrated into coffee farming systems, they can help supply nitrogen to coffee plants, reducing the need for synthetic nitrogen fertilizers. Though not significant, intercrop system used by coffee farmers has some level of potential in determining their choice to use chemical fertilizers.

This can be compared with [29] who pointed out that introducing other crops into coffee farming systems can help break pest and disease cycles that can build up in monoculture coffee plantations. This can reduce the need for synthetic pesticides and fungicides. Use of chemical fertilizers follows not a different trend.

Possible strategies of promoting adoption of chemical fertilizers in coffee production

The study findings suggestproviding constant training on the value of chemical fertilizers by extension workers as the most important strategy of promoting adoption of chemical fertilizers use in coffee production since the p-value was less than 0.05 (P=0.00).This is because Extension workers can help coffee farmers gain a better understanding of the benefits of chemical fertilizers in coffee production, such as increased yields, improved coffee quality, and enhanced soil fertility. This increased understanding can help farmers make

informed decisions about the use of chemical fertilizers in their coffee farms. From the findings, most coffee farmers were not conversant with information relating to profitability, methods of application, formulation options and types available for use in coffee and application rates among other basic information. This is an indicator that if such knowledge and skills relating to effective and efficient chemical fertilizer use in coffee was practically availed to farmers through constant trainings, the trend would significantly change. During an interview one of the local leaders confirmed this when he said that;

"*In some cases, coffee farmers may have misconceptions or negative attitudes towards chemical fertilizers. Extension workers can address these misconceptions and provide accurate information about the benefits of chemical fertilizers, helping to overcome any resistance to their use".*

This is in agreement with [8] who pointed out that extension workers can monitor the use of chemical fertilizers in coffee production and provide feedback to coffee farmers on their effectiveness. This can help coffee farmers see the direct impact of using chemical fertilizers on their coffee plants and soil fertility, which can motivate them to continue using them in the future.

The study findings also suggest stabilizing prices for both chemical fertilizers and coffee in the market among the major strategies of promoting adoption of chemical fertilizers use in coffee production since the p-value was less than 0.05 (P=0.012).Stabilizing prices for both agricultural inputs and crop outputs without direct government intervention in the market can create a more predictable business environment for farmers, which in turn can improve the adoption of chemical fertilizers in coffee production. Currently, coffee prices fluctuate a lot on the market while prices of chemical fertilizers keep on steady increase. This brings a lot of uncertainty on the profitability of using these fertilizers. If this situation can be reversed by relevant policy interventions, farmers can be more willing to venture into using the technology assured of increased yield as well as returns on investment.

During an interview one of the local leaders had this to say'

"*When prices for inputs such as fertilizers are unstable, farmers may hesitate to invest in them, as they cannot be sure they will be able to recoup the cost of the investment. Conversely, when prices for crop outputs are unstable, farmers may be hesitant to invest in fertilizers and other inputs, as they cannot be sure they will be able to sell their crops at a price that will allow them to cover the cost of their investments*".

This can be compared with [6] who pointed out that by creating a more stable business environment, farmers may be more willing to invest in chemical fertilizers, which can increase crop yields and improve the quality of their coffee beans. This, in turn, can lead to higher profits for farmers, which can incentivize them to continue using fertilizers in future crop cycles.

The study findings indicated that providing fertilizer subsidies one of the possible strategies for promoting adoption of chemical fertilizers use in coffee production though was not significant since the p-value obtained was greater than 0.05 (P=0.766).These chemical fertilizer subsidy programs can take various forms, such as direct cash transfers, vouchers, or in-kind support, where the government provides fertilizers at a reduced price or for free to farmers. By reducing the cost of fertilizers, these programs can incentivize farmers to invest in them and use them to improve the productivity and quality of their coffee crops. Currently, there are no robust efforts in the coffee sector aiming at subsidizing chemical fertilizer prices for coffee farmers, one of the reasons why its adoption is very low.

During an interview one of the agriculture extension workers had this to say;

"*Fertilizer subsidy programs can improve the adoption of chemical fertilizers in coffee production by making them more affordable and accessible to farmers, especially smallholder farmers who may have limited resources to invest in inputs*"

This is in agreement with [10] who pointed out that fertilizer subsidy programs can have positive spillover effects on the entire coffee value chain. By increasing coffee yields and quality, these programs can increase the supply of coffee beans, leading to lower prices for consumers and increased exports for the country.

The study findings show that designing a fertilizer promotion strategy is another possible strategy of promoting adoption of chemical fertilizers use in coffee production though it was not significant since the p-value obtained was greater than 0.05 (P=0.273). A fertilizer promotion strategy can educate farmers about the benefits of chemical fertilizers and how they can improve coffee yields. By demonstrating the positive impact that fertilizers can have on coffee yield on demonstration farms or giving samples to coffee farmers to test its impact on increasing coffee yield tremendously, farmers are more likely to adopt these products and use them full board on their coffee plantations.

In an interview one of the local leaders had this to say;

"*Incentives can be used to encourage farmers to adopt chemical fertilizers. For example, a fertilizer promotion strategy might offer discounts on fertilizer purchases or provide free samples to encourage farmers to try the products*"

This can be compared with [8] who pointed out that a fertilizer promotion strategy can showcase success stories from farmers who have adopted chemical fertilizers and seen improvements in their coffee yields. These success stories can serve as powerful examples for other farmers who may be hesitant to adopt new practices.

The study findings alsoindicate that considering the potentialof public-private partnerships to provide chemical fertilizers and trainings to farmers is among the possible strategies of promoting adoption of chemical fertilizers use in coffee production though insignificant since the p-value obtained was greater than 0.05 (P=.144). Public-private partnerships (PPPs) can play an important role in improving the adoption of chemical fertilizers among farmers through complementary advocacy, training, access, supplying and mitigating constraints in accessing affordable credit by coffee farmers. By bringing together the strengths and resources of both the public and private sectors, PPPs can help overcome the barriers that have hindered the widespread adoption of chemical fertilizers by farmers, such as lack of access to markets, inadequate infrastructure, and limited technical knowledge.

This is in line with [6] who pointed out that PPPs can improve the adoption of chemical fertilizers is by providing technical assistance and training to farmers. Many farmers lack the technical knowledge needed to make the best use of chemical fertilizers, such as understanding how to apply them effectively and how to minimize negative environmental impacts. By partnering with public extension services and private companies, governments can help provide farmers with the knowledge and skills they need to make the most of chemical fertilizers.

Conclusions

The study concluded in accordance with study objectives as summarised below;

The study concluded that there is positive perception and attitude of farmers on application of chemical fertilizers where chemical fertilizers use ensure high productivity and yields of coffee, Chemical fertilizers are basically used in high value commercial crops like tea and coffee and that the decisions on chemical fertilizers use is based on access to information and market prices were considered significant at $P \leq 0.05$ (P=.019, P=.003 and P=.009) and others like chemical fertilizers applied to in coffee do not provide optimal economic

returns to farmers, fertilizers use is influenced by agro-climatic and farm characteristics, chemical fertilizers are not suitable for use in coffee and that chemical fertilizers use alter the soil properties spoiling the soil were non-significant at P-value>0.005(P=.867, P=.706, P=.263 and P=.637).

The study further concluded that farmers who had access to training services on the methods of application and easy access to the source of chemical fertilizers had high level of awareness on the use of chemical fertilizers in coffee production.

The study also concluded that some farm based factors were significant like, small plots of land and land fragmentation at p-value was $\leq$ 0.05 (P=0.006 and P=0.008 where as other factors were non-significant like land ownership, coffee-banana intercropping, farm location and long distance in relation to chemical fertilizer distribution channels were non-significant astheir P-value was>0.05(P=0.146, P=0.622, P=0.913, P= 0.351).

The study finally concluded that possible strategies of promoting adoption of chemical fertilizers in coffee production such as; providing constant training on the value of chemical fertilizers by extension workers was significant at (P=0.000), stabilizing prices for both agricultural inputs and crop outputs without direct government intervention in the market was significant at (P=0.002) while non-significant strategies included; conducting a chemical fertilizer yield response and profitability studies for a range of crops (P=0.938), establishing a fertilizer subsidies program (P=0.766), designing a fertilizer promotion strategy (P=0.273) and considering the potential for public-private partnerships to deliver fertilizer to farmers (P=0.144).

Recommendations

There is a need for more education and awareness-raising activities to help farmers make informed decisions about the use of chemical fertilizers. This could include training on proper application rates, the selection of appropriate fertilizer blends, and the use of integrated pest management practices. Such trainings should be regular, practical and supported by demonstrations.

There is a need for policymakers and agricultural stakeholders to consider the social, economic, and environmental implications of the widespread use of chemical fertilizers in coffee production. This could include the development of policies and regulations to promote the sustainable use of chemical fertilizers, as well as the promotion of alternative approaches such as agroforestry and organic farming.

Governments should undertake legal reforms to recognize and protect the rights of vulnerable groups to own and use land. They should also put in place mechanisms to ensure that the law is enforced.

There is a need to reduce the cost of chemical fertilizers through subsidies and other support mechanisms for smallholder farmers. This will make these inputs more affordable and accessible to farmers in the region.

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