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Influence of plant health clinic training services on potato production: Evidence from smallholder farmers in molo sub-county, Kenya

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As compared to other African countries, Kenya continues to depend on agriculture as source of food and for economic development. Horticulture forms the bulk of agriculture with potato being ranked first in the vegetable category in terms of production and value. It is a lucrative cash and food crop grown in many parts of Kenya. Molo Sub County being one of the regions where the crop is grown enjoys economic value in terms of income generation and food provision. Given the importance of the crop agricultural extension such as plant health clinic training services has a key role in enhancing production through training farmers in innovations on potato protection measures and production improvement. This study thus established the influence of plant health clinic training services on potato production among smallholder farmers in Molo Sub-County, Kenya. Through simple random sampling techniques and purposive sampling, 152 smallholder potato farmers and 10 key informants respectively were selected for the study. Data were collected using structured questionnaires and interviews. The data was analyzed using descriptive statistics and inferential statistics. The type of training access, the relevance of training services, frequency of receiving training, modes of training, and use of training services were found as significant predictors variable influencing potato production at 0.05 significant level (p = 0.000, p = 0.000, p = 0.009, p = 0.000 and p = 0.000, respectively). The study recommends that adequate plant health clinic training services should be provided in potato production.

Key Words: Potato production, plant health clinic training services, multiple regression.

INTRODUCTION

Globally the agricultural sector is important not only for its supply of food but also for its income generation and economic development in many countries (Norton and Alwang, 2020). The potential of agriculture for providing

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food, income, reducing poverty and promoting food security differs according to the comparative importance of it in the livelihoods of the smallholder farmers and the potential of the sector to grow in a way that increases returns to the farmers. Therefore, to achieve potential production will rely mainly on the production capacity of smallholder who manage nearly 500 million farms across the globe and contribute a substantial portion of agricultural production as well as poverty alleviation in many regions of the world (Giordano et al., 2019). Among the key crops in agricultural sectors dominated by smallholder farmers is potato (Devaux et al., 2020). Potato is a worthwhile cash and food crop grown in more than 158 countries in temperate, subtropical, and tropical agro-ecologies (Momčilović, 2019). In terms of ranking, potato is ranked as the number four principal food crop in terms of production after maize, rice, wheat and therefore the largest non-cereal food crop cultivated in the world (FAO, 2019). In Africa potato production is estimated at 25 million metric tons and yield per hectare of 13,215.4 kg/ha and contribute to income and food security in the region (FAOSTAT, 2019).

Kenya is among the top potato producers in Africa where the crop is grown by approximately 800,000 farmers, mainly smallholder farmers, on over 120,000 ha with an average yield of 6 to 10 tons per hectare (National Potato Council of Kenya [NPCK], 2021). About 29.8% of the country's potato production comes from Nyandarua County, 18.9% from Nakuru County, 16.2%, from Elgeyo Marakwet (Ruto, 2018) and according to Maingi and Mbuvi (2020). Molo Sub-County is the main potato growing Sub-County in Nakuru County and is ranked as second leading producer in Kenya. Production of potatoes similarly is an important enterprise for smallholder farmers in Molo Sub-County (Kamau, 2019). It is almost impossible to talk about the livelihood of the people of Molo Sub-County without mentioning potato. Being the key cash crop and source of food and income to the community, money gotten from the sales is used on household needs and care for other basic needs of the farmers in the region (International Potato Center [CIP], 2020). Therefore, a need to carry out study that will establish factors that contribute to the production in Molo Sub-County was important. The focus of the study was the influence of plant health clinic training services on potato production among smallholder farmers.

Agricultural extension services promoting agricultural production

Food production requirements will rise by almost 50% in the year 2050 for the people in the world to feed who are anticipated to reach 9.7 billion by the same year (Bahar et al., 2020). In sight of the above, it seems essential to increase agricultural production by an estimate of 60% to provide food for the global population in 2050 (FAOSTAT, 2019). This would only be realized by improving the agricultural sector which is important for food supply and also in income generation and economic development of many countries (Norton and Alwang, 2020)). Kenya's agriculture segment contributes over 50% of Kenya's GDP and provides employment for over 60% of people and exportations (World Bank, 2018). Smallholder production cultivating on land less than 5 ha are the majority in agricultural sector and therefore they account for over 70% of total agricultural production and marketable production (Amwata, 2020).

The agricultural GDP in Kenya is driven by cash crops and horticulture crops such as potato (Kenya National Bureau of Statistics [KNBS], 2018). Production is of substances for improving the live of the people through increasing income from agriculture in the country. Among the agricultural sectors, potato production is among those playing a crucial role in the livelihoods of the people (Onditi et al., 2021). Potato has been acknowledged as an important food crop in Kenya, with production volumes only second to maize (CIP, 2020). Additionally, potato industry employs over 3 million people along the value chain (Bolt et al., 2019). There is a growing apprehension in Kenya that potato production can meaningfully contribute to apprehending the state objectives of vision 2030 by creating employment, enhancing food and nutritional security and elevating incomes (Devaux et al., 2020).

In spite of the importance of the crop, outdated schemes to produce, inadequate eminence seeds, infertility, poor agronomic practices, an unsystematic marketing system, inadequate access to information and innovations, climate change, escalating prevalence of pests and diseases infestation, poor packaging policy, meager technology transmission and little use of value agro-inputs threatens the quality and quantity of production (Gebru et al., 2017). As revealed by studies conducted by CABI (2020), Chamedjeu (2018) and Kamau (2019), escalating occurrence of pests and diseases infestation contribute an estimated 80% reduction in production therefore threatening overall potato yields. Therefore, access to effective, reliable, and practical extension services on a regular basis, more so those that enable smallholder farmers to address the threats of high pests and diseases infestation is required (Mburu et al., 2018). Agricultural extension services act as fundamental in supporting farmers to deal with existing and new challenges in agricultural production (Bourne et al., 2017). From its definition, agricultural extension is a provision or scheme assisting farmers by means of informative actions in enhancing farming practices, growing production efficacy, revenue, enhancing livelihoods (Kingiri, 2020).

As stipulated by a study carried out by Bourne et al. (2017), agricultural extension offer practical training on agriculture to farmers, provides essential inputs and facilities to sustenance agricultural production; its further

train farmers on new-fangled concepts established by agricultural research station. Therefore, operative agricultural extension service is required to train farmers on novel technology for access and implementation of enhanced production practices towards growth of production and income (Mburu et al., 2018). As it is clearly stated by Kalimba and Culas (2020), for sustainable agricultural development, the tactic in agricultural extension service conveyance, access and use is important. The use of a demand-driven approach in which farmers take initiative of approaching extension agents and expressing their needs have shown significant evidence in contributing to agricultural production (Kingiri, 2020).

On support of the role of demand-driven extension services, Umar et al. (2015) on their study highlighted that they are categorized by answerability of service providers to the users who are the farmers, and by the capability of farmers to select freely amid service providers. Plant health clinic training services are such extension services using a demand-driven approach on a similar method to human health clinic to reach farmers and offering training to them (Musebe et al., 2018). The plant health clinic training services benefit farmers in terms of enabling them obtain knowledge and skills on handling crop health problems, production and hence boost production, therefore transforming to livelihoods improvement (Silvestri, 2019).

Otieno (2019) on his study stated that to be able to succeed in pests and diseases constraints management by farmers it is necessary to select fields and planting materials free of pests and diseases at early stages of production. Therefore, receiving training services from plant health clinic equip farmers with knowledge and skills that promote crop protection consequently helping them reduce and minimize pests and diseases incidence, hence increase their crop production, income, and improve their livelihoods (Rajkumar and Anabel, 2018). Plant health clinic training services is thus indispensable and it offers more package trainings such as training on improved quality seed varieties, improved fertilizer, chemicals use, climate smart agriculture practices, harvesting and storage techologies all aiming to mitigate pest and disease infestation and subsequently improve production (Danielsen and Matsiko, 2016).

Studies in Kenya have also shown the key role plant health clinic training services play in educating farmers on various pests and diseases signs as well as symptoms. According to Kansiime et al. (2020), through plant health clinic training services farmers are trained on how to carry out control, management and monitor occurrence of pests and diseases through packages such as chemicals use, harvesting techologies, improved quality seed varieties and storage techologies. Jowi (2018) also pointed out that farmers receive training on how to relate pests and diseases damages and monitor their emergence. As a result of the important role plant health clinic training services play in achieving rural and agricultural development, it was necessary to conduct a study in order to determine the influence of plant health clinic training services on potato production Molo Sub-County has been selected for the implementation of this research, because it is an agricultural area and an important potato producing Sub-County (Maingi et al., 2020).

MATERIALS AND METHODS

Research design

A cross-sectional survey design was used. The research design was fitting because data were collected at each spot without any repetition. Mugenda and Mugenda (2003) contended that cross-sectional survey design comprises a one-time contact with clusters of persons during data collection.

Study site

The research study took place in Molo Sub-County of Nakuru County, Kenya. Molo Sub County has four wards, that is, Mariashoni, Elburgon, Turi and Molo. It covers a total area of 478.79 km^2 and a population of 156,732. Molo is in the Rift Valley along the Mau Forest and situated at 0.25° South latitude, 35.73° East longitude and 2534 m above sea level. The average temperatures are 14.1°C with an average rainfall of 1131 mm (Kenya National Bureau of Statistics [KNBS], 2019). Its topographical location makes it an appropriate place for growing potatoes (Kamau et al., 2020b).

Sampling and samples

The study targeted 6000 smallholder potato farmers in Molo Sub-County. Moreover, 10 key informants were also considered. Molo Sub-County was purposively selected based on the magnitude of potato production. The four wards, Molo, Turi, Elburgon and Mariashoni where the sample was distributed among the four wards proportionately (Table 1). Simple random sampling procedure was used to select respondents from each ward for the study.

The sample size for the smallholder potato farmers was determined using the formula recommended by Nassiuma (2000). The formula is given by:

$$n = \frac{NC^2}{C^2 + (N-1)e^2}$$

Where: n= is the required sample size, N=is the population within the study area, C= is the Coefficient of variation, e=is the Standard error value.

Nassiuma (2000) asserts that in most surveys or experiments, a coefficient of variation is ≤ 30% and standard error is ≤ 5%. Thus, a coefficient of variation of 25% and standard error of 2% was used for this study. N was 6,000 smallholder potato farmers, C =25% and e =2%.

$$n = \frac{NC^2}{C^2 + (N-1)e^2}$$

Table 1. Sample sizes per ward.

Ward	Number of potato farmers	Proportion (%)	Sample size
Elburgon	1000	16.67	25
Mariashoni	2500	41.67	63
Molo	500	8.33	13
Turi	2,000	33.33	51
Total	6,000	100	152

Sources: Field data, 2022.

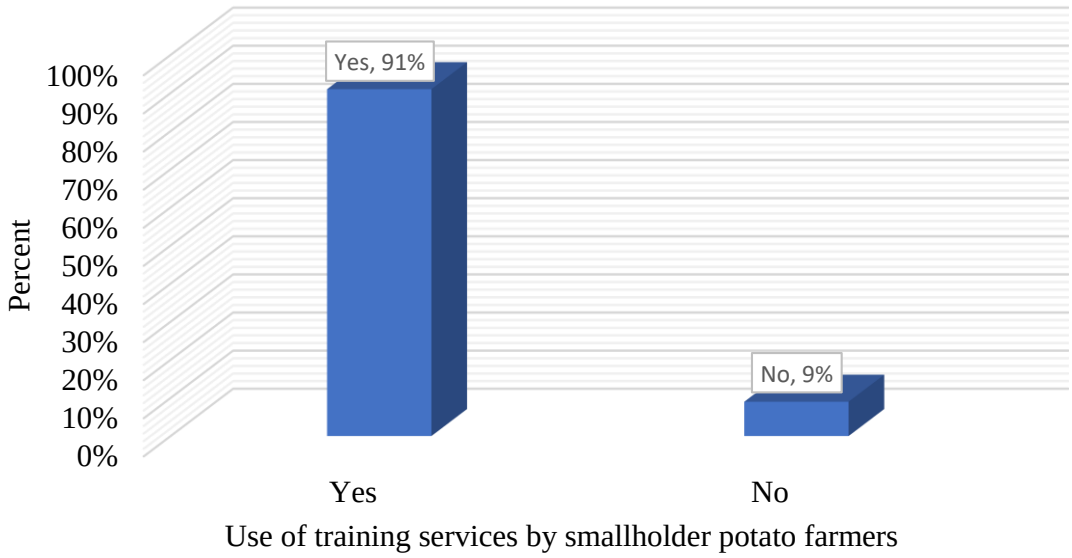

Figure 1. Use of training services by the respondents.
Sources: Field data, 2022.

$$n = \frac{6000 \times (0.25)^2}{(0.25)^2 + (6000-1)(0.02)^2} = 152$$

Purposive sampling was used to select the 10 key informants who included expert in the study area. Mugenda and Mugenda (2003) declared that purposive sampling technique helps the researcher to interview a group of people believed to be experts in their field. Key informants therefore provided information on potato production, and plant health clinic training services in the study area.

Data collection procedures and data analysis

An introductory letter was obtained from the Board of Post Graduate Studies of Egerton University, which facilitated application for a license to carry out research from the National Commission for Science, Technology, and Innovation (NACOSTI). Prior to data collection, a preliminary study was done to map out smallholder potato farmers, brief and familiarize with the local administration and obtain permission to collect data. Appointments for visits were made with the respondents in advance. The researcher used a questionnaire to collect data from the smallholder potato farmers and interview schedules were administered to the key informants. The data were analyzed using *SPSS* version 22. Descriptive and inferential statistics were used to analyze data.

RESULTS AND DISCUSSION

Use of training services by the smallholder potato farmers

Data analysis in Figure 1 reveals that 91% of the smallholder potato farmers use training services from plant health clinic, whereas 9% of the smallholder potato farmers did not use the training services. This means that the smallholder potato farmers were able to use the plant health clinic training services in potato production hence access efficient and effective solutions on crop health problems which enable them to have a greater array of information about intervention options. Key informants provided the information that the use of plant health clinic training services offers pests and diseases

Table 2. Frequency of receiving training by the respondents.

Number of times	Percent
None	9
Once	32
Twice	30
Thrice	10
Four	8
More than 5 times	11
Total	100

Sources: Field data, 2022.

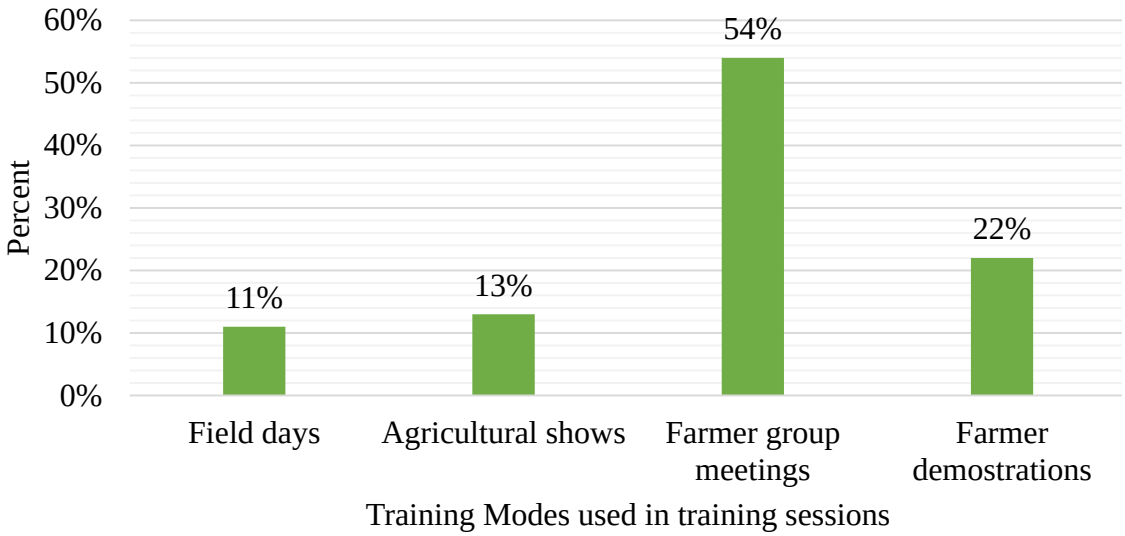

Figure 2. Training modes used in training sessions.
Sources: Field data, 2022.

recommendations practices, integrated pest management promotion and pest and disease surveillance to smallholder potato farmers which are important and innovative solutions to farmers' problems on improving potato production. The findings are in line with those of Silvestri (2019) which noted that farmers training in the new approaches are essential as they equip farmers with skills and knowledge on disease symptom recognition and management, pest management, record keeping and better practical to resolve challenges in crop production.

Frequency of receiving training on potato production

Results in Table 2 reveals that 32% of smallholder potato farmers received training once, as the highest followed by 30% who received it twice. Implying that the smallholder potato farmers received plant health clinic training services once in the previous one year they had planted potato which was very low compared to the much attention required by the potato crop as it is susceptible to pests and diseases. As documented by Kumar (2014), the success in handling and managing disease depends on disease identification and management and are achieved through frequently receiving training services. Key informants' interviews further reinforced the fact that most farmers receive training once or twice per annual potato production.

Modes of training

Figure 2 reveals that 54% of the smallholder potato farmers indicated that the mode of training used was farmer group meetings, 22% indicated farmer demonstrations while a low proportion (13%) and (11%) of the smallholder potato farmers indicated agricultural shows and field days. From this finding, it could be concluded that plant doctors use different modes to offer plant health clinic training services. From the key

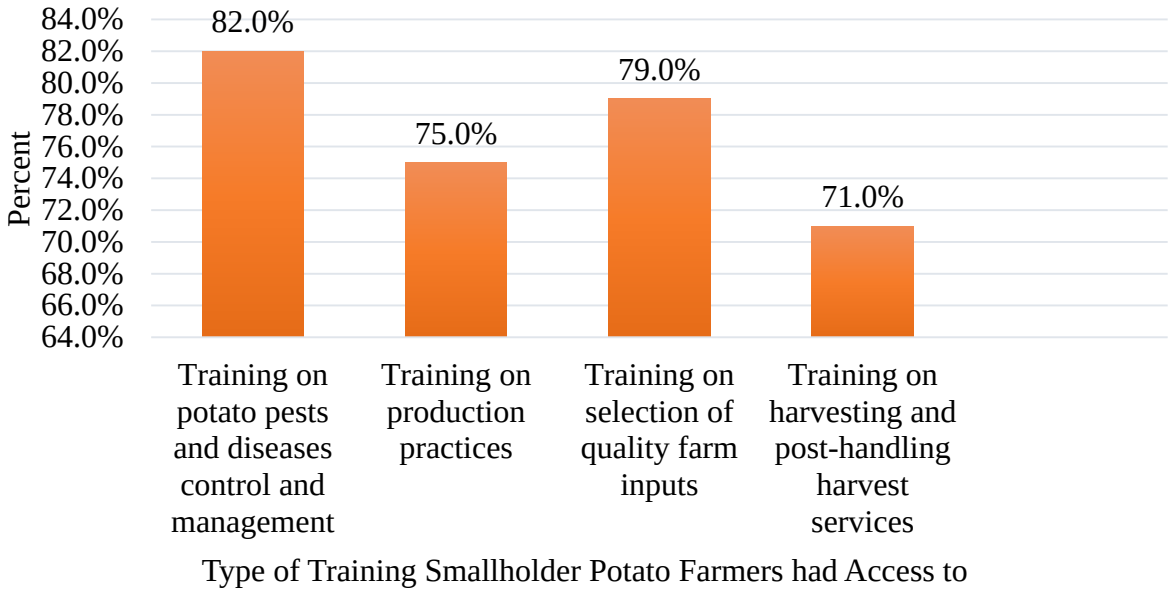

Figure 3. Type of trainings access by the respondents.
Sources: Field data, 2022.

Table 3. Relevance of the training services.

Response	Percent
Not relevant	9
Moderate	3
Relevant	5
Very relevant	83
Total	100

Sources: Field data, 2022

informants' interviews, it was clarified that farmers mostly utilized plant health clinic services through their farmer groups forums. The smallholder potato farmers are therefore able to acquire skills and knowledge on how to handle problems arising from plant health which affects their farm production output (Otieno, 2019). Establishing the mostly used mode for delivering the plant health training services to the respondents were important findings for the Sub-County when planning how future delivery of these services can be made.

Type of trainings access

Figure 3 shows that over 70% of smallholder potato farmers had access to training on potato pests and diseases control and management, production practices, selection of quality farm and harvesting and post-harvest handling services. This implies that many respondents have access to various type(s) of training on potato production which enables smallholder potato farmer to acquire skills and knowledge on how to handle potato health issues to boost potato production. Information gathered from key informants' interviews revealed that the majority of smallholder potato farmers had access to training on various crop protection practices, potato production practices, quality farm inputs and further on how to do harvesting and handle potato after harvesting. Ghiasi et al. (2017) found similar results in their study and concurred with this finding.

Relevance of training services on improving potato production

The findings from Table 3 shows that the majority (83%) of the smallholder potato farmers designated that the plant health clinic training services are very relevant, whereas 5% showed that they are relevant, 3% indicated that they are moderate, while 9% indicated that they are

Table 4. Coefficient of determination for the relationship between plant health clinic training services and potato production.

Model	R	R Square	Adjusted R square	Std. error of the estimate	Change statistics				
					R square change	F Change	df1	df2	Sig. F change
1	0.893[a]	0.797	0.781	0.7321	0.797	86.85	5	146	0.000

[q]Predictors: (Constant), frequency of receiving training, type of training access, mode training, relevance of training services, and use of training services.
Sources: Field data, 2022.

Table 5. Analysis of variance between plant health clinic training services and potato production.

Model		Sum of squares	Df	Mean square	F	Sig.
1	Regression	1230.415	5	246.083	86.85	0.000[b]
	Residual	413.721	146	2.8336		
	Total	1644.136	151			

Sources: Field data, 2022.

Table 6. Multiple regression between plant health clinic training services and potato production.

Model	Unstandardized coefficients		Standardized coefficients	T	Sig.
	B	Std. error	Beta		
(Constant)	2.351	0.500		3.120	0.000
Type of training access	0.156	0.124	0.093	1.403	0.000
Relevance of training services	2.742	0.300	0.593	10.370	0.000
Frequency of receiving training	0.121	0.124	0.035	0.332	0.009
Modes of training	0.342	0.037	0.381	7.201	0.000
Use of training services	0.153	0.461	0.014	0.311	0.000

Sources: Field data, 2022.

not relevant implying that plant health clinic training services are relevant to the majority of smallholder potato farmers in potato production and irrelevant to a very few farmers. These findings agree with those of Nsabimana et al (2015) who steered a study on the analysis of farmers relevance of plant health clinics training services and found out that more than 90% of farmers interviewed stated that plant health clinics training services are relevant in agricultural production and referred to plant health clinics as their main source of crop health information. The plant health clinic training services are a suitable strategy to equip farmers with skills and knowledge concerning crop protection measures which when properly positioned can act as a tool for improvement of crop production (Mur et al., 2015). Plant health clinic training services provide quality agricultural information to farmers with the intention of enhancing farmers' ability to increase agricultural output through equipping them with skills and knowledge in addition to innovations that lead to crop protection and improvement of production (Danielsen et al., 2020).

The relationship between plant health clinic training services and potato production

The hypothesis of the study stated that there is no statistically significant influence of plant health clinic training services on potato production among smallholder farmers in Molo Sub-County, Kenya. A stepwise multiple regression was used to test hypothesis. The results findings are presented in Tables 4 to 6.

The results of analysis of variance (ANOVA) in Table 5 show the usefulness of the model. The F (5, 146) = 86.85, P = 0.000 which is less than 0.05 thus the model was statistically significant in predicting how plant health clinic training services could predict potato production.

From the findings in Table 4, R^2 for the relationship between plant health clinic training services and potato production in Molo Sub-County, Kenya was 0.781. This implies that the independent variables that were studied explain 78.1% of dependent variable.

The multiple regression model equation used to show the influence of plant health clinic training services on

potato production is illustrated following:

$Y = b0 + b1X_1 + b2X_2 + b3X_3 + b4X_4 + b5X_5$, hence

$Y = 2.351 + 2.742X_1 + 0.121X_2 + 0.153X_3 + 0.342X_4 + 0.156X_5$

As shown in Table 6, the relevance of training services, use of training services, modes of training, frequency of receiving training and type of training access had a positive contribution on potato production at unstandardized coefficients of 2.742, 0.153, 0.342, 0.121 and 0.156, respectively. This implies that a unit increase in frequency of receiving training will lead to a 0.121 tons per hectare increase in potato production keeping all other variables constant. Type of training access slope $b_5 = 0.156$, indicates that when the type of training is access, then the potato production is increase by 0.156 tons per hectare. Relevance of training $b_1 = 2.742$ conjectures that relevance of training in improving potato production will lead to a 2.742 tons per hectare increase in potato production keeping all other variables constant. For the use of training services $b_3 = 0.153$ designates that when the training services are use, then the potato production is increase by 0.153 tons per hectare, while modes of training $b_4 = 0.342$ will lead to a 0.342 tons per hectare increase in potato production keeping all other variables constant.

The type of training access, relevance of training services, frequency of receiving training, modes of training and use of training services were found as significant predictors variable influencing the potato production at 0.05 significant level ($p = 0.000$, $p = 0.000$, $p = 0.009$, $p = 0.000$ and $p = 0.000$ respectively) as illustrated in Table 6. Thus, the study hypothesis that there was no statistically significant influence of plant health clinic training services on potato production among smallholder farmers in Molo Sub-County, Kenya was rejected. This deduces that plant health clinic training services had statistically significant influence on potato production in Molo Sub-County. These findings concur with those of Adhikari et al. (2020) who found out that frequency of receiving plant health clinic training services result in skills and knowledge enhancement which is likely to increase uptake of recommendations on how to handle issues such as pests and diseases therefore the likelihood of crop production improvement in Nepal. It is expected that since plant health clinic training services offer the type of training services such as management of pests and diseases and production practices farmers which can maximize production through use of acquired skills and knowledge therefore increase yields.

Kansiime et al. (2020) found out that the frequency of training farmers on crop protection measures statistically influenced household crop production in Kenya significantly. The relevance of training services, use of training services and modes of training findings are in agreement with a study by Maina (2014) in Kenya which found out that these variables influence crop production. According to (Ghosh et al., 2019) plant health clinic training services have an impact on protection measures therefore enable to recognize symptoms of pests and diseases thus prevent and manage them before causing damage to crops. Further the result on use of training services also agrees with that of Uzayisenga et al. (2015) who reported a statistically significant relationship between plant health clinic training services use and crop production among maize farmers in provinces of Kigali city, Northern, Southern, and Western of Rwanda. Bentley et al. (2011) argued that due to the most farmers adopting a functional pragmatic combination of cultural and biological controls recommendations and therefore limiting use of insecticide early in the season, thus allowing dramatic increase in production with slight decrease in plant protection costs.

CONCLUSIONS AND RECOMMENDATIONS

Potato production can be fostered in several ways and this study shows that plant health clinic training services are excellent ways of doing so. The five predictor variables; type of training access, perceived relevance of training services, frequency of receiving training, method of training undertaken, and use of training services were found as significant predictors variables influencing the potato production at 0.05 significant level. Therefore, improvement in plant health clinic services, in terms of frequency of receiving training, relevance of training, use of training services, type of training received, and the modes of training would be necessary to help farmers overcome barriers to information and utilization therefore increase their uptake of knowledge and skills through training that boost potato production.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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