Research Article ISSN: 2770-2928

International Journal of Agriculture and Technology

Enhancing Climate-Smart Agricultural Practices: A Focus on the Production of African Indigenous Vegetables and Pulses in Kenya

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Received: 16 Apr 2023; **Accepted:** 21 May 2024; **Published:** 29 May 2024

Citation: Muthama E, Samita NE, Dharani N, Rebecca Karanja. Enhancing Climate-Smart Agricultural Practices: A Focus on the Production of African Indigenous Vegetables and Pulses in Kenya. Int J Agriculture Technology. 2024; 4(1): 1-11.

ABSTRACT

Pulses and African indigenous vegetables (AIVs) are essential food crops farmed mostly by small-scale farmers in Kenya. Pulses and AIVs are essential in the fight against malnutrition and food insecurity. Additionally, pulses are essential for the nitrogen fixation in the soil. The production of African Indigenous Vegetables and pulses in Kenya is severely affected by climate change and the current surge in insect pest populations. Despite the numerous agricultural methods implemented, increasing soil fertility and controlling pests still pose a significant challenge. The purpose of this study was to evaluate the presence and diversity of AIVs and pulses, their pests' incidences and farmers' pests' management practices in Murang'a County, Kenya. Secondly, the study was conducted to assess the availability and practice of climate-smart agriculture (CSA) practices in AIVs and pulses cultivation. Data were collected using a semi-structured questionnaire from a sample of 226 respondents. Farmers were interviewed in their farms and open-ended questions were used to evaluate practices. Data analysis were performed using statistical software IBM SPSS Version 28. Data were analyzed with descriptive statistics and logistic regression. The findings indicate that farmers have been growing pulses and AIVs for subsistence purposes. Farmers employed a number of climate-smart farming techniques, including the use of organic manure, intercropping, conservation agriculture, the use of cover crops, agroforestry as well as minimal and zero tillage. The AIVs and pulses were significantly present in the study area, and farmers were aware that insect pests were attacking their crops. The logistic regression analysis showed socio-demographic variables such as the level of education, marital status and age had significant positive effect on farmer's knowledge levels on CSAPs and pests control strategies. Cultivation of AIVs and pulse requires easily available and reasonably priced pest control and soil fertility enhancement products. The study recommends that farmers adopt sustainable farming methods that manage pests, safeguards soil fertility and improves on the yield of AIVs and pulses. There is a need for policies that promote and improve sustainable farming methods.

Keywords
Pests management, Soil fertility, Food insecurity, Descriptive statistics and IBM SPSS.

Introduction
Statistics from FAO, Boliko [1], show a progressive global increase in the number of people facing hunger and starvation reaching more than 820 million in 2018. A major issue in Sub-Saharan Africa (SSA) is food instability and inadequate nutrition [2]. African Indigenous Vegetables (AIVs) provide opportunities to expand production systems, improve food nutrition, and raise financial security in many SSA nations in the face of climate change [3]. The ever-changing climate is worsening prevailing vulnerabilities of the deprived people who rely on semi-subsistence agriculture for their survival [4]. A significant portion of the world's food is produced as annual rain fed crops in the tropics, where climate unpredictability has a significant impact on output [5].

Climate-smart agricultural practices (CSAP) involve sustainable water utilization, soil management techniques and biodiversity management. The practices play a crucial role in enhancing resilience, reducing greenhouse gas emissions, increased productivity per unit area and mitigation against environmental degradation [6]. Despite the crucial role played by these smart practices, their adoption by small-scale farmers has been of a lower degree [7]. African Indigenous vegetables and pulses are crucial food crops that offer lasting solutions to food insecurity and nutrition. Pulses and AIVs are naturally dense in nutrients such as vitamins, minerals and micronutrients [8]. However, their production is affected by harsh weather conditions caused by the effects of climate change and insect pests as well as poor agricultural practices undertaken by smallholder farmers. Local communities in Kenya have traditionally made use of AIVs and pulses a key component of their diets. These vegetables and pulses are grown in small kitchen gardens or as intercrops with other food crops such as maize and other cereals. Local trade exists for a wide range of AIVs and pulses throughout the country meaning that they are consumed by a wide range of people in the country both in the urban and rural areas [9,10]. Despite the area allocated to AIV production and the cash earned from AIVs showing a rising tendency, their production is still very low compared to their exotic counterparts [11]. The AIVs and pulses are highly dependent on good farming practices for good yields, Womdim et al. [12], but there has been a huge impact on yields due to poor crop husbandry and attack by insect pests.

Off late, Kenyans have seen an increase in diet related ailments such as diabetes and obesity. Physical activity has many known advantages; however, it might not be the most effective way to stop the obesity problem. The consumption of fatty meals, processed sugars and insufficient intake of vegetables and fruits are the main causes of obesity [13]. Pulses and AIVs are micronutrient dense and could prove a powerful weapon in the fight against obesity, assorted diseases, poverty and malnutrition [14]. Common AIVs include cowpeas (*Vigna unguiculata* L), black nightshade (*Solanum nigrum* L), while commonly consumed pulses include; cowpeas (*Vigna unguiculata*), green grams (*Vigna radiata* L) and pigeon peas (*Cajanus cajan* L) [9,15,16]. Daily consumption of AIVs and pulses in their recommended portions prevents serious diseases and safeguards against food insecurity [17].

Southern part of Murang'a County is a classic example of an Arid and Semi-Arid Land (ASAL), a region with nutrient-deficient soils, lack of water for irrigation purposes, poor crop cultivation practices and serious food shortages leading to the provision of relief foods by the Government of Kenya. Crop cultivation in ASALs is heavily dependent on local weather dynamics, climate, land and water for its ability to thrive, agriculture is particularly vulnerable to natural and environmental disasters [18].

Despite the growing popularity of AIVs and pulses and their health benefits, not much research has been done on their production aspects [19]. Climate Smart Agriculture practices enhance the farmers' ability to deal with harsh weather occurrences, which has an impact on both the yield levels and the unpredictability of production. The availability and stability aspects of food security are important to our study because pulses and AIVs are important food crops in Kenya. This study therefore, was necessary to first assess the presence and diversity of AIVs and pulses in the study area and secondly, assess the availability of climate smart agricultural practices among the smallholder farmers in Murang'a south sub-county.

Materials and Methods

Study Site Description

The research work was carried out in Ithanga Location, Murang'a south sub-County in Murang'a County. Ithanga is a relatively dry region compared to other parts of Murang'a County. Murang'a County is found between latitudes 0^o 34' South and 1 ^{o} 07' South and Longitudes 36^o East and 37^o 27' East. Ithanga Location is located on the eastern part with semi-arid conditions. Long rains fall in March to May while the short rains begin in October and cease in December. Ithanga has average temperatures ranging from 21-35˚C. The study area is characterized by sandy/clay soils with a dense population of averagely 419 people per square km which is significantly higher than the national average of 92 people per square km in Kenya [20].

Sample and Sampling Techniques

The survey works interviewed 226 respondents from five villages in Ithanga location. The target population was smallholder farmers who cultivate AIVs and pulses. Random probability sampling was conducted to select farmers based on the sampling formula by Nassiuma, (2000):

$$n = \frac{105000 * 0.3^2}{0.3^2 + (105000 - 1)0.02^2}$$

Where: n = sample size
N= accessible population of interest
n= Coefficient of variance (set as 30%)
e= standard error (set as 2%).

$$n = \frac{105000 * 0.3^2}{0.3^2 + (105000 - 1)0.02^2}$$

n = 226
Therefore, 226 smallholder farmers participated in this survey.

Statistical Analysis

Demographic data, farmer's perception and knowledge, presence of AIVs and pulses, cropping patterns, crop production practices, insect pests management strategies and the farmers' climate smart agricultural practices was collected using a semi structured questionnaire. For convenience of entry and analysis, responses were coded using figures. The coded responses were entered into Microsoft Excel 2016 and cleaned before being transferred into IBM SPSS Version 28 for analysis. The results are presented in descriptive statistics and logistic regression table.

Results and Discussion

The results from the survey showed that all the smallholder farmers interviewed (226) had cultivated AIVs and pulses.

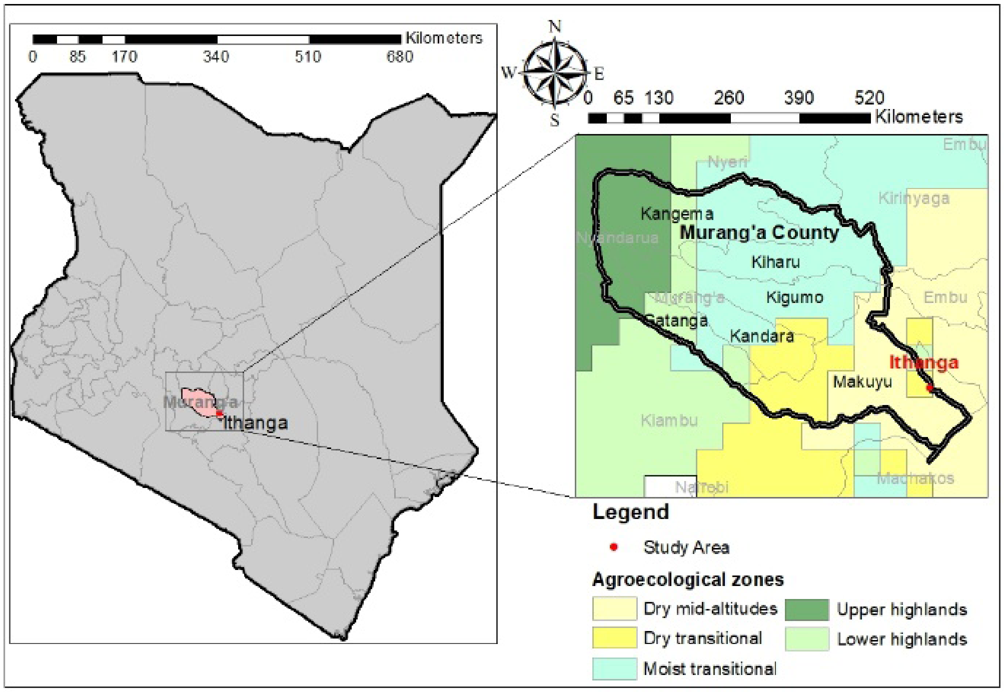

Figure 1: Map of Murang'a County showing Ithanga Location, the study site.

Table 1: Descriptive Statistics–Social-Economic characteristics showing factors affecting cultivation of AIVs and pulses in Ithanga location.

Variables	Parameters	No. of respondents	Percentage %
Gender	Female	144	63.7
	Male	82	36.3
Age	Minimum	23	
	Maximum	85	
	Median	50	
	Range	62	
	Mean	51.11	
Marital status	Single	22	9.73
	Married	165	73
	Windowed	39	17.26
Level of Education	No Formal Education	34	15.04
	Primary School	142	62.83
	Secondary School	42	18.58
	Vocational Training College	8	3.54
Relationship with household head	Self	150	66.37
	Spouse	76	33.63
Cell phone	No	32	14.16
	Yes	194	85.84
Acreage	AIVs	1.12	
	Pulses	1.4	
Number of Years of AIVs/Pulses Cultivation	Minimum Number of years	5	
	Maximum Number of years	60	
Experience in Growing AIVs	Mean Average in Years	21.26	
Experience in Growing Pulses	Mean Average In years	20.38	

Women represented 63.7% of the respondents while men were 36.3% (Table 1). Most respondents were in marriage institutions accounting to 73% married, Single parent households respondents were 9.73% while the rest were widowed representing a 17.26% (Table 1). Education levels varied per respondents as follows, 15.4 % of the respondents had not received any formal education, 62.83% had completed primary basic education, 18.58% had completed secondary school education while 3.54% had completed post-secondary education with the highest been a diploma holder. In every household, an average of 1.12 acres and 1.40 acres were available for AIVs and pulses cultivation respectively (Table 1). From the results, there was a significant land (in acres) allocation dedicated to AIVs and pulses production, meaning that AIVs and pulses are high priority crops to the households. The average farm size cultivated by farmers differed significantly with the national average of 2.5 acres at $P \leq 0.001$ [21]. According to the results, the average age of the farmer respondents was 51.11 years (Table 1). The average age of the respondents was significantly lower than the national average of 61 years at $P \leq 0.001$, meaning that most of the respondents were energetic and able to carry out farming activities without a lot of strain.

From the results, farmers were found to practice intercropping of the AIVs and pulses with other crops such as maize, beans and fruit trees. The study showed that farmers had experience in AIVs and pulses production with a mean average of 21.26 years for AIVs and 20.38 years for pulses (Table 1). The youngest farmers had cultivated AIVs and pulses for a period of 5 years while the most experienced farmer had cultivated the crops for a period of 60 years. AIVs have been cultivated in sub Saharan Africa (SSA) for many generations as part of the food systems [22]. There was a significant positive correlation between the respondents' age and levels of experience in growing pulses at $P \leq 0.01$ (Table 2). This implies that the elderly people had significantly many years cultivating pulses than AIVs cultivation compared to younger respondents. African indigenous vegetables are highly perishable and require intensive handling skills during harvesting and processing. Preparing AIVs for onward cooking and consumption requires some handy skills and patience, which are widespread within young women as opposed to pulses, which are easy to handle during shelling and drying for storage. This probably explains why the elderly people preferred more pulses cultivation as compared to AIVs cultivation.

Further, according to the results there was a significant correlation between the marital status and the acreage of AIVs cultivated at $P \leq 0.05$ (Table 2). Meaning that the respondents in marriage institution were more involved in AIVs cultivation, this is true for especially women who were the majority respondents at 63.7% (n=226) as opposed to Pulses cultivation. In local set ups, indigenous vegetables are readily used as main meal accompaniments. Meals preparation is predominantly a women affair. In addition, AIVs are highly perishable vegetables and need good post-harvest handling skills. The number of acreage under pulses reduced with the respondent's education level at $P \leq 0.05$, this implies that farmers with higher educational levels were cultivating less acreage of pulses compared to farmers with lower education levels who cultivated AIVs. The implication of this is that AIVs could be more economically and nutritionally beneficial to the farmers with higher levels of education as opposed to pulses, which are harvested when dry, shelled and stored for future use.

The study results showed that farmers practiced intercropping of the AIVs and pulses with other crops such as maize, beans and fruit trees. Figure 2 shows the different AIVs cultivated by farmers,17% of the respondents had grown cowpeas, 17% black nightshade (*solanum nigrum*), 17% pumpkin (*Cucurbita maxima*) and 17% amaranths (*Amaranthus roseus*), 15% fig leaves (*Cucurbita ficifolia*) while 13% had spider plants (*Cleome gynandra*). Other type of AIVs grown by respondents included 3% comfrey (*Symphytum officinale*) and 2% grew jute mellow (*Corchorus olitorius*).

Pulses Grown By Farmers in Ithanga

According to the findings, farmers had extensive cultivation of pulses in their farms with 20% cowpeas (*Vigna unguiculata*), 20% green grams (*Vigna radiata*), 20% common beans (*Phaseolus vulgaris*), 20% pigeon peas (*Cajanus cajan*), dolichos (*Lablab purpureus)* and chickpeas (*Cicer arietinum L.*) (Figure 3). Only 6% of farmers grew chickpeas and 14% grew dolichos (Figure 3) making these two crops relatively unpopular choices. Pulses are nutrient rich crops that contain proteins, fiber, micronutrients and vitamins. Pulses have a protein content of about 22-24% representing almost twice the protein content in wheat and thrice that of rice [23]. Pulses can grow in wide range of soils as intercrops with stables, cereals and other crops. Pulses can be planted in farm fields to break disease circle during crop rotation and biologically help in nitrogen fixation in the soil.

Table 2 : Social –demographics correlation matrix.

Correlation Matrix, n=226									
Variables	**Gender**	**Age in Years**	**Marital Status**	**Education Level**	**Cell Phone Possession**	**Experience in Growing AIVs (Y)**	**Acreage under AIVS**	**Acreage Under Pulses**	**Experience in Growing Pulses (y)**
Gender	1								
Age in Years	-0.055	1							
Marital Status	0.039	0.132*	1						
Education Level	-0.104	-.182**	-.159*	1					
Cell Phone Possession	0.010	-0.079	0.010	.485**	1				
Experience in Growing AIVs	0.052	-0.009	0.012	-0.075	-0.044	1			
Acreage under AIVS	-0.056	-0.021	-.162*	0.045	0.023	0.031	1		
Acreage Under Pulses	0.038	0.036	-0.026	-.133*	-0.035	0.089	-0.003	1	
Experience in Growing Pulses	0.057	.305**	0.104	-0.054	-0.046	.628**	-0.008	0.031	1
*. Correlation is significant at the 0.05 level (2-tailed).									
**. Correlation is significant at the 0.01 level (2-tailed).									

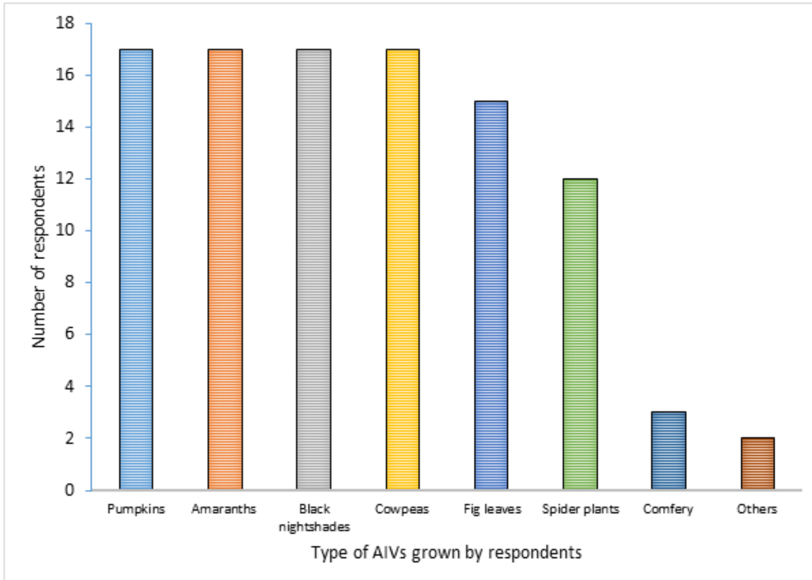

Figure 2: Proportion of respondents who grew different African indigenous vegetables in Ithanga location.

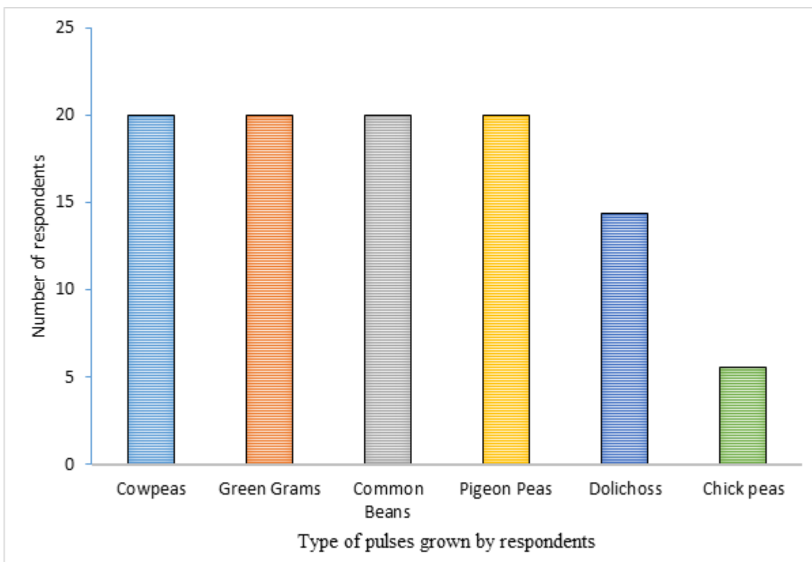

Figure 3: Proportion of respondents who grew different types of pulses in Ithanga location.

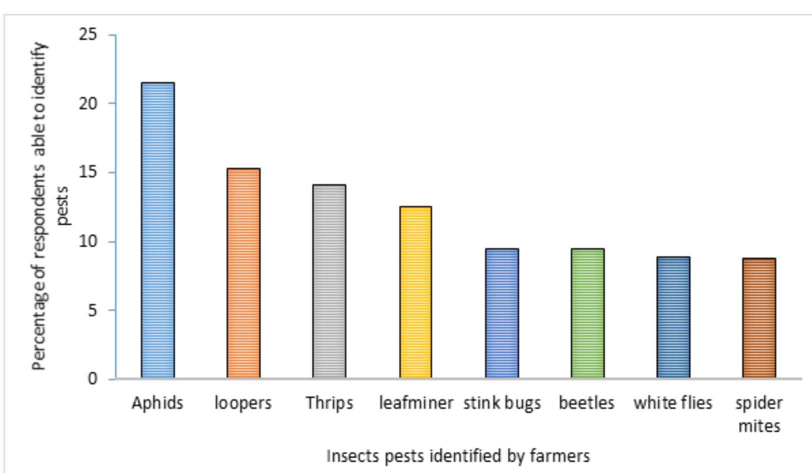

Figure 4: Proportion of insect pests identified by African indigenous vegetables and pulses crop respondents in Ithanga location.

Determining the Constraints Faced by Farmers in the Cultivation of AIVS and Pulses

The study findings showed that 100% of the respondents were aware of insect pests' attack in AIVs and pulses. All farmers stated that pests and disease control was the main challenge in food crops production. Farmers indicated that they could lose up to 100 % of the farm produce if they did not institute control measures against insect pests. Insect pests, are notable constraints on crop production [24]. As depicted in Figure 4, farmers identified the main insect pests that attack their crops. Aphids were the main pests identified by farmers followed by loppers, thrips, leaf miner, stinkbugs, beetles, whiteflies and spider mites. According to Reddy [25], of all insect pests attacking pulses, only 12 species cause considerable economic. The damages caused by insect pests are different and depend on the season, year, country, plant species, variety, cultivars and cropping systems [25].

The study findings revealed a positive correlation at P< 0.01 between the level of education of the respondents and the method of pest control chosen. Pulses and AIVs cultivation has been severely affected by increasing difficulties in managing insect pests and diseases due to resistance development and secondary resurgence due to overreliance on synthetic pesticides [26]. Insect pests such as Aphids are well distributed in the tropics, CABI [26]. In Kenya these pests are distributed all over the country.

Farmers' Knowledge on the Management of Insect Pests Attacking AIVS and Pulses

According to the findings, farmers were knowledgeable on how to check and identify the attack symptoms caused by insect pests. One hundred and seventy nine (179) farmers representing 79% of the respondents used curled and irregular leaves as ways to identify pest attack while 27 farmers knew about presence of natural enemies such as ants and ladybird beetles as indicators of aphids attack on AIVs and pulses. Ladybird beetles and lacewings are common predators for aphids control in AIVs and pulses [27]. Conservation of natural predators to these pests can be achieved by avoiding use of broad-spectrum pesticides

According to the results, other attack symptoms identified include; stunted growth, visual observations, stained leaves/pods, presence of holes in the leaves and presence of insect fecal matter on leaves. Sucking insect pests suck the plant sap from leaves, stem and flowers; affected plants are stunted, turn yellow and wilt [28]. Forty-six, 46% of the farmers presented that they were using synthetic chemicals in the control of insect pests, while 28% used homemade concoctions and 26% of the interviewed farmers had been using cultural ways for pests' control. Farmers identified the local agrovets as the main source of synthetic chemicals. The homemade concoctions were made by mixing plants such red pepper, mexican marigold, lantana, Tithornia, among others. Use of sodium hypo-chloride and washing detergent was also recorded as ways of pest control.

The study findings revealed that the respondent's knowledge levels on climate smart agricultural practices compared against the independent variable of age, gender, education levels, household leadership and cell phone possession (Table 3). From the results shown in table 3 there was a significant difference between the respondent's level of education and the knowledge expressed in the use of IPM pest control strategies at P≤0.03604*. Farmers with higher education levels are able to process information and search for suitable technologies to improve their crop production challenges [29]. Education gives them the ability to recognize, understand and adopt new information and adopt new technologies much faster.

Table 3: Logistic regression table. Respondents' knowledge levels on climate smart agricultural practices at P≤0.05.

Dependent variables and socio-demographic profile	Statistics Likelihood ratio Chi-square	Df	P values
Knowledge of non-pesticide control			
Gender	1.2	1	0.27
Age	7.9	8	0.44
Educational level	9.42	4	0.041*
Household head relationship.	1.98	1	0.16
Cell phone.	0.035	1	0.85
Knowledge IPM			
Gender	1.58	1	0.21
Age	14.14	8	0.07
Educational level	10.27	4	0.036*
Household head relationship	1.44	1	0.22
Cell phone	3.01	1	0.08
Knowledge of conservation agriculture			
Gender	0.07	1	0.78
Age	8.02	8	0.43
Educational level	8.79	4	0.066
Household head relationship	0.46	1	0.49
Cell phone	1.15	1	0.28
Knowledge of CSAPs in AIVs and pulse			
Gender	1.58	1	0.21
Age	14.14	8	0.078
Educational level	10.27	4	0.036*
Household head relationship	1.44	1	0.23
Cell phone	3.01	1	0.08

The study findings depicted in figure 6 shows the pest control methods used by farmers. The product manufacturers' adverts through local radio stations and the quick fix ability of the chemicals to kill the pests in one go contributed to the heavy use of synthetic chemicals. Farmers had little concern for personal safety, effects on non-target organisms and long-term health effects of the chemicals. As documented by Abang et al. [30], farmers do not have the right knowledge on chemical handling and usage. Some of the chemical brands used by farmers include; 'Profile' (Profenols, Cypermethrin), 'Thunder' (Imidacloprid + beta –cyfluthrin), 'Escort' (Emamectin benzoate) and 'Alpha degree' (Cypermethrin). From the results, only 11.5% of the respondents had information about non-pesticide pests control methods. Only 5.3 % of the farmers had information on integrated pest management (IPM) and using its components in their farms. There was a significant difference in knowledge levels expressed by farmers in the use of IPM technologies and their level of education at P ≤ 0.05.

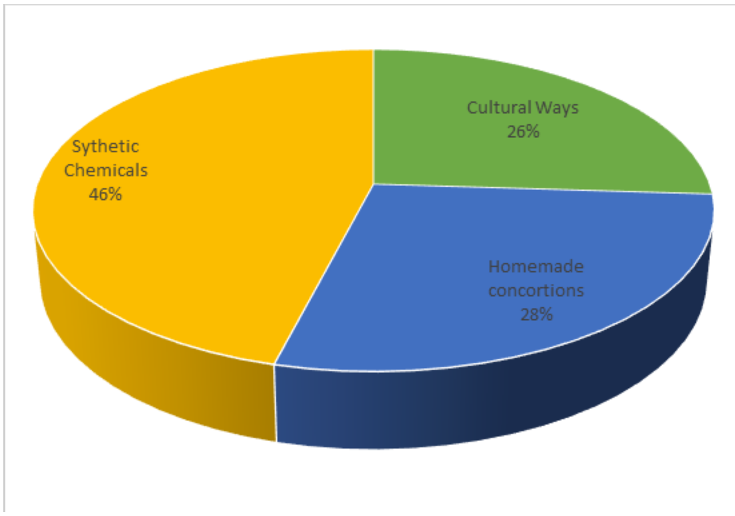

Figure 5: Proportion of AIVs and pulses respondents using pest control methods in Ithanga location.

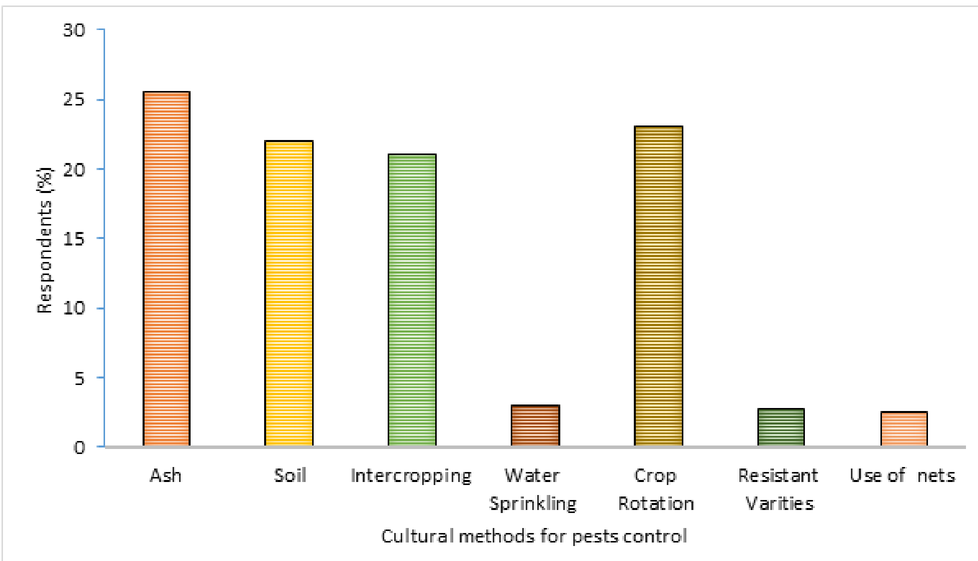

Figure 6: Cultural methods of pests control used by respondents in cultivating AIVs and pulses in Ithanga location.

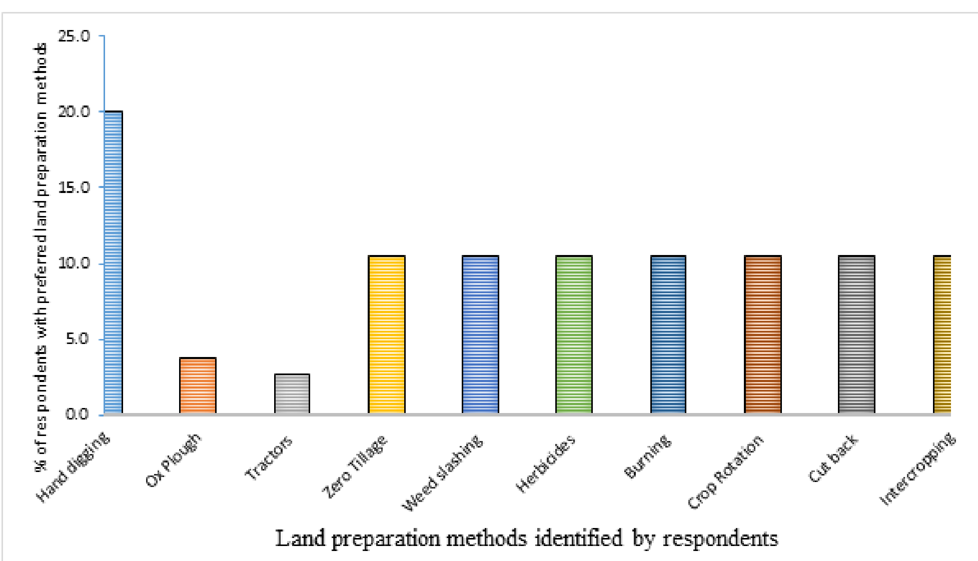

Figure 7: Proportion of respondents who used different land preparation methods in Ithanga location.

Some of the IPM strategies used by farmers included; plant based pesticides, bio pesticides, physical traps, pheromone traps, pruning, soapy water sprays, use of insect nets and water sprinkling on the leaves. Studies done by Srinivasan [31], showed that installation of yellow sticky traps significantly reduces the population of insect pests in cowpeas and green grams. Use of soapy water sprays and raw water sprinkled on the leaves has a mechanical force of washing down the insect pests attacking plants. The occasional rains witnessed in the study site also helps in controlling pest's population by periodically washing down and drowning these pests.

The cultural methods used by farmers for pest control included use of wood ash and Soil applied on the leaves. The study findings revealed that Twenty-five percent of the respondents in this category were using wood ash sprinkled on the leaves and root zones to control pests. Twenty four percent (24%) of the farmers used soil sprinkled on leaves and intercropping as ways of managing insect pests. Other methods mentioned included water sprinkling on crops and crop rotation. Only 2% of the respondents used resistant crop varieties as means of pests control in their AIVs and pulse farms. There was a significant difference between the respondent's level of education and the knowledge expressed in the use of non-pesticide control methods for insect pests at P≤0.041*. High humidity and dry soils provide a conducive breeding environment for insect pests such as aphids. Warm and humid conditions favor many species, including plant pathogens, Hatfield et al. [32], while crops suffering from water stress are more vulnerable to damage by pests [33]. Figure 6 shows the various cultural methods used by farmers for control of pests.

Farmers knowledge on Climate Smart-Agriculture practices

Respondents used several methods of land preparation such as hand digging, weed clearing and burning (Figure 7). The minimal farm mechanization could be explained by the presence of small parcels of land, farm topography and presence of fruit trees in the

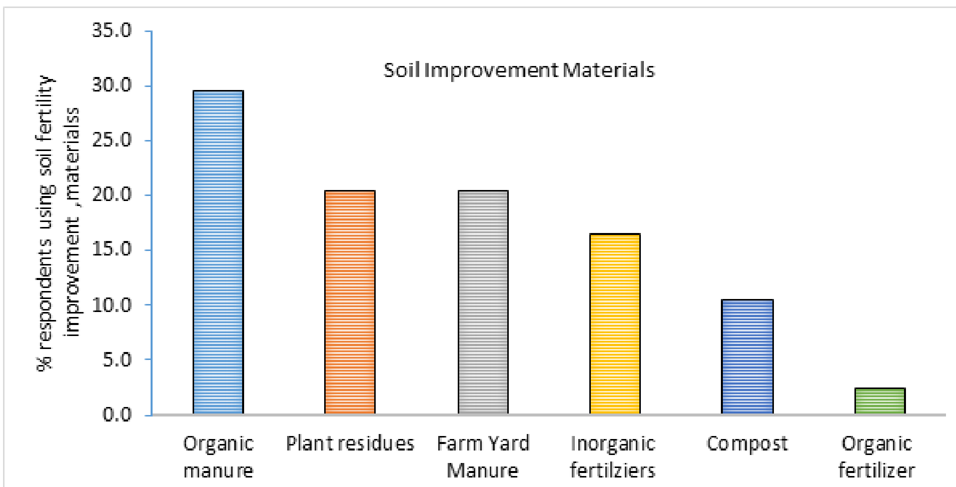

Figure 8: Proportion of respondents who used different soil fertility improvement materials in Ithanga location.

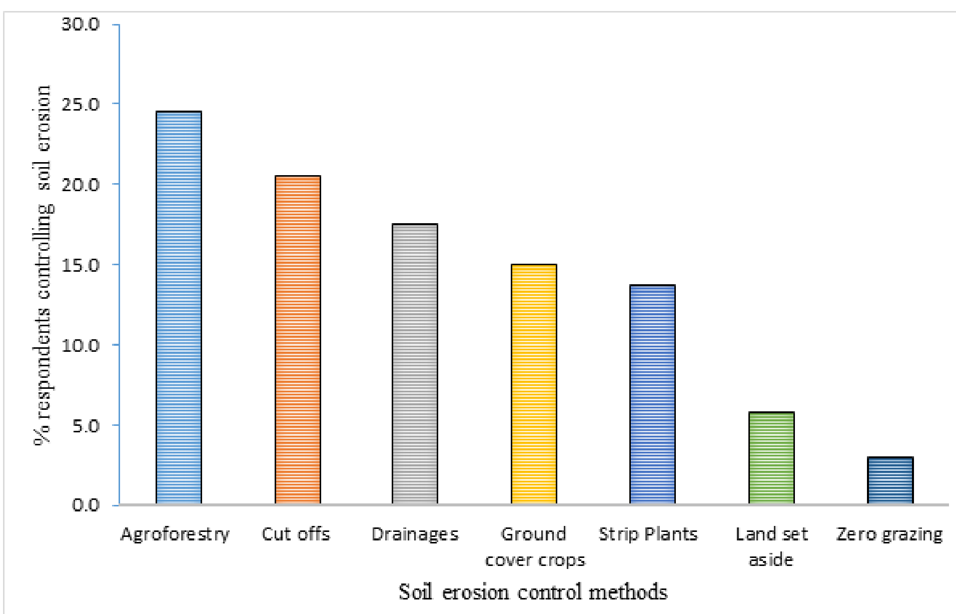

Figure 9: Proportion of respondents with their soil erosion control strategies in Ithanga location.

farm. Only 11% of the respondents used smart practices such as weed slashing, crop rotation, intercropping and herbicides. These aspects of conservation agriculture protects the soil structure by improving soil fertility and maintaining soil moisture levels. According to Campbell B et al. [34], it is anticipated that by 2050, climate change would have a detrimental influence on at least 22% of the land that has been planted with the most important food crops.

The study findings revealed that the study results, farmers knew how to improve soil fertility by use of organic manure, green manure, farmyard manure and inorganic fertilizers. Farmers used mixed soil improvements products at the same time such as animal manure and inorganic fertilizers. Manure is applied during land preparation. According to Zhang et al. [35], use of manure can improve soil water holding capacity and positively impact on crop production [36]. The research findings showed that farmers used various soil improvements products (Figure 8.0). Use of organic manure reduces overreliance on inorganic fertilizers, this is confirming with Svotwa et al. [37], who emphasizes that farmers use organic manure as a less costly practice as opposed to the commercially traded inorganic fertilizers. Farmers purchased inorganic fertilizers from agrovets; however, the other products used in soil fertility improvement were readily available in their homesteads and neighborhoods. Some practices such as early planting can also help in pests' control as documented by Prodhan et al. [38], compared to late planting.

Conservation agriculture (CA) is a farming system that promotes minimum soil disturbance. According to the results, 7.5% of farmers were aware about CA and actively practiced it in their farms, some of the CA practices used by farmers include; minimum tillage intercropping, use of cover crops, Zai pits, herbicides and zero tillage. According to the results about 70% (n=226) of the respondents had experienced soil erosion in their farmers and had installed soil erosion control practices (Figure 9).

Our study findings show that 18% of the farmers (n=226) used some form of irrigation in their farms. According to Slingo et al. [4], crop productivity is significantly impacted by the availability of water for agriculture. Farmers used surface irrigation with water that was ferried to the farm by donkeys or oxen. Only 5% of the farm received intermittent irrigation. Kales and spinach were the only crops receiving irrigation. According to the results, only 5.31% of the respondents were aware of climate smart agriculture (CSA). The 12 farmers identified the CSAs as: biodiversity management, intercropping, use of organic manure, crop rotation, cover crops, certified seed, resistant varieties, bio pesticides and integrated pest management. The results obtained from this study revealed low adoption of climate smart agriculture practices. Our research findings confirms with the similar works done by Twomlow et al. [39], which concluded that farmers lack appropriate land and crop management interventions.

Conclusion and Recommendations

The works carried out in this study sought to first assess the presence and diversity of AIVs and pulses grown by farmers in Ithanga location. The research works also assessed the availability of climate smart agricultural practices among the smallholder farmers in Ithanga location in the Southern part of Murang'a County. According to the study findings; AIVs and pulses were significantly present in the study area. The interviewed farmers were aware that insect pests were destroying their crops. The study further concludes that the Farmers' Socio-demographics such as age, marital status and education level had significant positive effect on farmers' practices in the cultivation of AIVs and pulses. However, cell phone possession and household leadership were not significantly associated with farmer's practices in the cultivation of the two crops. This study showed that the profile of farmers might affect adoption of new technologies in AIVs and pulses production especially on modern pest control methods and use of climate smart agricultural technologies. Despite the efforts made by farmers, crop production was still heavily affected by various factors such as soil erosion, lack of certified seeds; pests control challenges and overreliance on rain fed agriculture.

This study recommends adequate training and capacity building on pulses and AIVs smallholder farmers. Farmers would highly benefit from training on emerging technologies and climate smart agriculture. Key areas for training include soil fertility improvements, conservation agriculture, pests and disease control, water harvesting and climate smart agricultural practices. Despite the setbacks, some farmers, about 5.31 % of the respondents had adopted CSA technologies like IPM, organic manure, minimum and zero tillage, conservation agriculture, mulching, and intercropping, which have shown promising results for the cultivation of AIVs and pulses. Provision of government sponsored services through extension works is needed to build farmers capacity to adapt to the changing climate and improve their crop cultivation practices. At the local level, farmers are encouraged to come together and establish farmer groups. Through the groups, extension of agricultural technologies and support from non-governmental bodies through farmer field schools (FFs) will be possible for building sustainable food production systems and improve on their saving culture through table banking and maintain healthy and beneficial relationship in the neighborhood through group dynamics. The study further recommends that farmers should use sustainable farming practices that control insect pests, preserve soil fertility, and increase AIVs and pulses crop yield and adoption of policies that support and advance sustainable farming practices. Finally, this study recommends the evaluation of the effectiveness of the CSAPs in the context of yield improvements and insect pests' management among smallholder farmers in Murang'a south.

Acknowledgements

This work was made possible by a grant from the DVC –RIO, Kenyatta University. Special gratitude to all farmers for voluntarily taking part in the interviews.

Grant Details

Kenya University DVC-RIO Grant Number VC-RG-095

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