Assessment of Information Dissemination Channels for the Adoption of Integrated Pest Management Among Large-Scale Farmers in Uasin Gishu, Kenya

*Cherotich N. & Mireri C.
Department of Spatial and Environmental Planning, Kenyatta University, Nairobi, Kenya
*Corresponding author: neliycherotich54@gmail.com
Phone number: +254712312616

Received: 20/05/2024 **Revised: 26/05/2024** **Accepted: 30/05/2024**

Integrated pest management (IPM) is a long-term management practice involving cultural, biological, and physical methods. Chemical control is only applied where other techniques are ineffective and pesticides that only kill the target organisms are selected to minimize environmental pollution. This paper examines the different IPM practices adopted and information dissemination channels for the adoption of these practices among large-scale farmers in Soy sub-county. The study surveyed a total of 155 large-scale farmers from 13 locations in Soy sub-county. The study employed a survey research design and collected data through household questionnaires and a focus group discussion schedule with the farmers association. Descriptive statistics was used to analyze data where tables, graphs, and pie charts were used in presenting the quantitative data. Data from the focus group discussion schedule was analyzed using qualitative content analysis. The findings showed that natural IPM methods adopted were cultural, physical, and biological practices. The chemical methods adopted were herbicides, insecticides, and fertilizers. The respondents obtained information on IPM practices through farmer-to-farmer training, field exhibitions, farmer field days, television, radio, and extension officers. As a result, there was inadequate information on complex practices of natural IPM practices as they required proper training hence the main dependence on chemical control methods due to their quick and guaranteed results in crop yields. The pesticides used were glyphosates, carbamates, and organophosphates which are mainly non-selective, highly toxic, and carcinogenic some of which are counterfeit products contributing to environmental pollution, animal, and human health risks.

Keywords: Integrated pest management, dissemination channels, synthetic pesticides, adoption, large-scale farmers, maize production, Kenya

https://dx.doi.org/10.4314/etsj.v15i1.16

INTRODUCTION

Pesticide use is of great significance in modern agriculture as it protects crops against pests and diseases and increases agricultural productivity (Hashimi *et al*., 2020). However, its intense use among farmers contributes to ecosystem contamination due to high toxicity (Balmford *et al.*, 2018). Unregistered and prohibited pesticides are extensively made available in the East African market where environmental pollution, the risk to human health, food contamination, and loss of biodiversity are associated with the overuse of these pesticides (Biswas *et al*., 2014; Nicolopoulou-stamati, 2016).To minimize these negative impacts, registration of pesticides that are less harmful and advocating for natural methods including Integrated Pest Management (IPM) is vital for green cultivation and Sustainable Development Goals (SDGs).

In 1970, there was a move to reduce pesticide reliance due to growing concern about their resultant effect on both the environment and human health which led to the introduction of organic standards by the International Federation of Organic Agriculture Movements (IFOAM) (Seufert e*t al*., 2017). The movement influenced governmental agencies such as EU regulations of organic agriculture and principles by limiting overdependence on agrochemicals and Genetically Modified Organisms (GMOs) and encouraging organic agriculture through the use of traditional and biological methods (Luttikholt, 2020). The movement ensured that knowledge on organic standards was widely spread by providing communication and dissemination channels such as farmer field schools to enhance organic farming and its adoption (Meemken & Qaim, 2018; Seufert *et al*., 2017).

The knowledge and information on IPM technology are key to contributing to the awareness of the existence of this technology and its benefits (Heller *et al*., 2020; Horgan, 2017; Murray *et al*., 2020).The information dissemination is greatly influenced by the availability of advisory channels such as extension officers which bring a good collaboration with the farmers hence fostering the adoption of good agricultural techniques (Malekani & Mubofu, 2020). These communication channels can be used to convey both natural and chemical IPM information (Deguine *et al*., 2021). To achieve this, the IPM strategy requires an adequate understanding of farmers' knowledge of agricultural production and practices in managing and controlling pests and diseases. This information will help to

incorporate a strategy that helps farmers successfully adopt IPM practices (Dara, 2019).

The low IPM adoption in developed countries is attributed to inadequate knowledge among the farmers and IPM dissemination channels such as extension officers and IPM experts. In Kenya, Uasin Gishu County is the leading producer of maize which is mainly practiced in large-scale farms of 50 Ha and above, and pesticide use by farmers in this county is therefore critical in crop production. Soy sub-county was chosen as the area of study as it is the largest sub-county with a higher concentration of large-scale farmers who practice maize farming (MoALF, 2017).

IPM is a lasting approach that controls and prevents crop pests with little negative impacts on the environment, and biodiversity and ensures safe and healthy food for human consumption (Khanal *et al*., 2020). However, little is known about these IPM practices and their adoption, particularly among large-scale farmers, and how it has contributed to enhancing crop yields as well as the protection of non-target species and biodiversity within the environment. In addition, studies have discussed how pesticide use has been widely adopted across many developing countries. It's not clear yet whether large-scale farmers are aware of natural IPM practices such as cultural, physical, and biological methods as alternatives to chemical control methods. This paper, therefore, sought to assess the dissemination channels used for spreading information on IPM practices and adoption among large-scale farmers.

LITERATURE REVIEW

Integrated pest management began in the early 19th century where crops were protected from pests and diseases in every aspect of production (Seufert e*t al*., 2017). As the years passed by, the increase in human population led to a high demand for food which encouraged the invention of synthetic pesticides. Crop yields began to increase since 1940's to 1970's through technology advancement and the development of pesticides in different varieties (Khanal *et al.,* 2021) . Many African countries began to improve crop quality and quantity by educating farmers on pesticide use and providing extension services which boosted crop production. Subsidies on pesticides encouraged many farmers to depend on pesticides which later turned to over-use since they lacked knowledge on proper application (Alwang *et al*., 2019).

From then on, the pesticides were found to cause environmental pollution and ecosystem imbalance due to their toxicity (Balmford *et al.*, 2018). It led to the invention of IPM which was an environmentally friendly approach and appropriate for crop production. Integrated pest management (IPM) is a long-term management practice involving cultural, biological, and physical methods (Khanal *et al.,* 2021). Chemical control methods can only be applied when other techniques are ineffective and pesticides that only kill the target organisms are selected to minimize environmental pollution (Samiee *et al.,* 2014). It is a long-term approach that helps in safeguarding the biodiversity through the prevention and control of crop pests and diseases (Khanal *et al.,* 2021).

Cultural methods are reported to interrupt insect pests' life cycle by providing hostile environmental conditions that prevent them from spreading for example through pruning away the infected crop parts, disinfecting farm tools, and proper plowing to expose any breeding larvae in the soil (Dara, 2019). Intercropping, crop rotation, and adjusting planting seasons and dates promote the reduction of soil nematodes and other disease-causing mechanisms as well as reducing pest infestations by destroying their breeding habitats (Dara, 2019). A study in Pakistan found that the push-pull method through intercropping different crop species has helped in luring harmful pests particularly stemborers from damaging crops and eliminating weeds as well as improving soil texture and fertility (Ali *et al*., 2021).

Physical and mechanical methods are treatments, barriers, equipment, or high temperatures used to control weeds and insect pests where physical methods involve manual removal of pests and weeds through hand picking, weeding, and trapping insect pests to prevent them from attacking the crops (Khan *et al*., 2021). Mechanical methods use hot water for steaming and sterilization to destroy and kill weeds as well as using nets as a barrier to prevent insect pests (Dara, 2019; Humayun & Ruslan, 2014).

Biological methods involve the introduction of natural enemies such as predators and parasites to attack or suppress the insect pests affecting the crops (Khan *et al*., 2021). It is a natural and target-specific way of controlling pests and weeds in a crop farm in which plant extracts containing insecticidal properties (botanicals) are used to destroy or repel insect pests and prevent disease infections in crops (Dara, 2019; Mwangi & Kariuki, 2015). Reports have shown that biological methods have been effectively achieved to control pests both in greenhouses and in open fields through the introduction of natural enemies to feed on harmful insect pests (Dara, 2019).

In Kenya, biological control methods are available such as the use of natural enemies in crop protection. However, suppliers mainly put their focus on farmers doing crop production for export as many farmers on the other hand lack technical knowledge in breeding these natural enemies. This makes it difficult for its widespread adoption as there is no support for the registration and adoption of non-exotic biological methods.

Behavioral control methods confuse insects during their mating seasons through the use of insect pheromones

and poisonous attractants that trap or attract them into toxic baits (Dara, 2019; Karamidehkordi, 2014; Kughur, 2020). Infertile male insects can also be released to reduce the insect population by preventing them from reproducing (Khan *et al.,* 2021). Chemical control methods are only applied when needed and not for preventive measures where selective and non-persistent pesticides are preferred since they only act on target organisms or species and remain active in the environment for a short while (Karamidehkordi, 2014). Many farmers regard the use of synthetic pesticides to control crop pests as the only reliable method (Khan & Damalas, 2015), where about 95% of Kenyan farmers are reported to be depending on pesticides in controlling pests such as T. absoluta (Mwenda *et al*., 2023).

The availability of knowledge enables farmers to adopt sustainable agricultural practices (Gütschow *et al*., 2021) .This knowledge can be achieved through various advisory channels and demonstrations which is crucial for IPM adoption (Gütschow *et al*., 2021). Dissemination methods through field exhibitions, agricultural extension officers, Farmer Field Schools (FFS), electronic media, and village gatherings spread information on farming innovations (Nyagwansa *et al.,* 2021). A recent study from Punjab, Pakistan, pointed out that the accessibility of knowledge has promoted pesticide hazard awareness and encouraged the implementation of IPM, especially through Farmer Field Schools where the educated farmers adopted the organic methods of pest control (Khan *et al.,* 2021).

Studies have shown that mass media and farmer field days are cheaper methods of information dissemination as they enhance the adoption of simpler practices compared to farmer field schools which are expensive and require more time to learn complex practices in detail and put them into practice such as biological methods (Dorothy *et al*., 2019; Kughur, 2020; Pretty & Bharucha, 2015). However, the farmer field schools have achieved results by training farmers intensively (Alwang *et al*., 2019). A small group of farmers trained on complex practices through learning every IPM practice and putting them into practice repeatedly has been shown as an effective way to IPM adoption (Alwang *et al.,* 2019; Dara, 2019; Deguine *et al.,* 2021). Agricultural extension services provide the farmers with information on safe agricultural practices and also build the farmers' knowledge which is important in developing new methods of agricultural production. The education level of farmers influences information dissemination through various advisory channels (Khan, 2020). The effectiveness of the information channels is subject to the farmers reached and their readiness to adopt new technology. The advisory channel is considered effective when the information is relayed in the preferred language that suits the needs of the user (Nyagwansa *et al.,* 2021).Studies explained that farmers mainly relied on farmer-to-farmer training approach, agro-vet dealers, and pesticide sales representatives to obtain information on pest control and management (Mwenda *et al*., 2023).Therefore, a farmer with practical knowledge can organize field exhibitions and educate other farmers on good agricultural practices and adoption (Deguine *et al.,* 2021).

Agrovet dealers and suppliers also play a significant task in providing instruction to farmers on pesticide handling hence a quick advisory channel that disseminates knowledge because of their closeness to farmers (Parsa *et al*., 2014). According to a recent study to identify the advisory channels used for safe agrochemical use in Kisii County, the agricultural extension officers were most useful to farmers in channeling the information (Ndimbwa, 2021). Farmers relied on effective pesticide sellers and farmer trainers which were most effective as they would reach a large and wide area of targeted farmers (Nyagwansa *et al.,* 2021).

MATERIALS AND METHODS

Method of Measurement

IPM adoption was the outcome/dependent variable for this study that is influenced by the availability of information sources. In this case, IPM adoption was categorized into; cultural, physical, biological, and chemical methods. The information channels are the driving forces (independent variables) that influenced IPM adoption which includes farmer-to-farmer training, field exhibitions, farmer field days, radio, television, and extension officers.

Study Area

Uasin Gishu County borders Trans Nzoia to the north, Kakamega to the northwest, Kericho to the south, Elgeyo Marakwet to the east, Nandi to the southwest, and Baringo to the southeast (Akenga *et al.,* 2017). The county receives a high and reliable amount of rainfall of between 900 to 1,200 mm annually with a height of 1800 m above sea level (Akenga *et al.,* 2017). The county has red loam and clay soils which are good for maize and other crop production. The county comprises six sub-counties namely; Soy, Moiben, Turbo, Kapseret, Ainabkoi, and Kesses as shown in Figure 1. Due to the research limitations, the study was conducted in Soy sub-county which lies between longitudes 35°10'East and 35°20'East and latitudes 0°40' North and 0°50' North where large-scale production of maize is predominant.

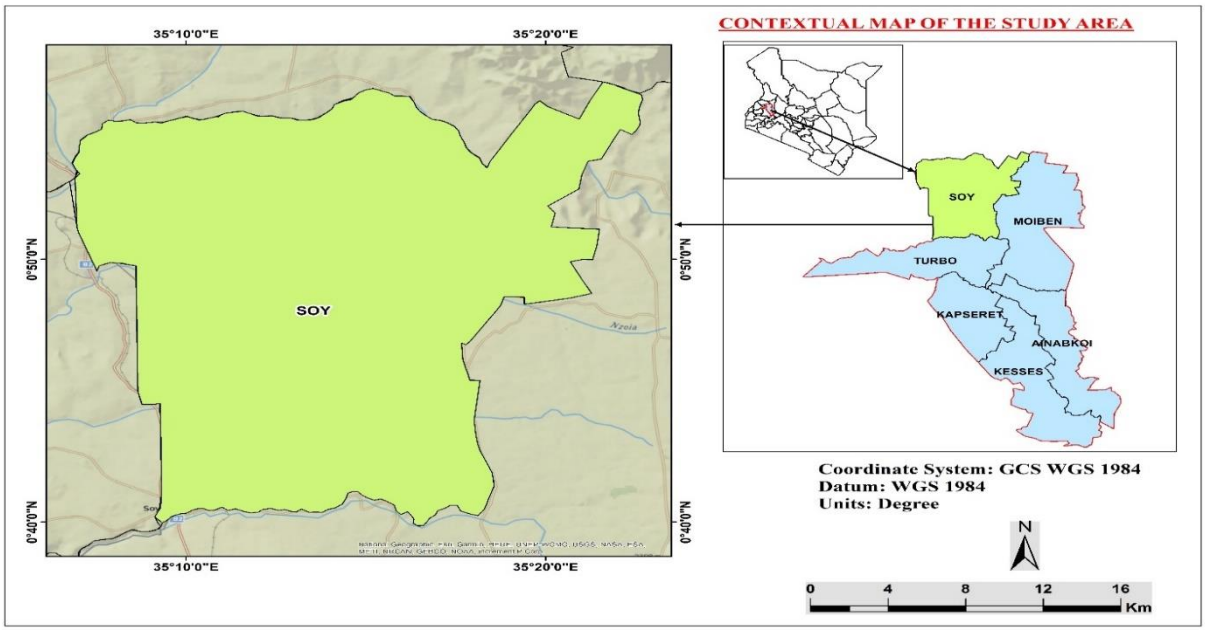

Figure 1: Location of Soy sub-county

Research Design

The study employed a survey research design. The research design allowed the collection of data using different methods such as; questionnaires, and focus group discussions (Costanzo *et al.,* 2012; DuBenske, *et al*., 2014; Ponto *et al.,* 2010). Despite the method being expensive and time-consuming it enabled both qualitative and quantitative data collection which provided a comprehension of the various variables under study and gave reliable information from the data collected (Stern *et al.,* 2014; Van Wyk & Taole, 2015).

Sampling size and sampling procedure

The target population was the large-scale farmers in Soy sub-county. There was a total of 181 large-scale farmers in the sub-county where the sample size was obtained using hypergeometric distribution to calculate the sample size for the small population.

$$\mathbf{n=\frac{NZ^2\,pq}{(E^2(N-1)+Z^2pq}}$$ where;

N=population size (181)

Z= level of confidence value (1.96)

P and q =population proportions (0.5 each)

E= accuracy of the sample (0.03)

$$\mathbf{n=\frac{181*1.96^2*0.5*0.5}{(0.03^2(181-1)+1.96^2*0.5*0.5}}$$

n = 155

Data collection and analysis

A total of 155 large-scale farmers in the sub-county were surveyed from 13 locations which included; Ziwa, Soy, Sirikwa, Segero, Moi's Bridge, Matunda, Kuinet, Kongasis, Koisagat, Kipsomba, Kibulkeny, Kapsang, and Barsombe. The data was obtained using structured questionnaires which were administered to the large-scale farmers and a single focus group discussion schedule with the farmers' association. The single focus group discussion had a total number of 7 members with the moderator (researcher) and the participants (large-scale farmers) which was an effective method to obtain in-depth information that the questionnaire could not gather (Tümen Akyildiz & Ahmed, 2021). It also provided a conducive environment for the participants to express their ideas and feelings. (Tümen Akyildiz & Ahmed, 2021). The focus group discussion schedule took a period of 1 hour where voice recording and note-taking were mainly used to collect the data (O Nyumba *et al*., 2018). Descriptive statistics was used to summarize data through tables, graphs, and pie charts. Qualitative data from a focus group discussion was analyzed using qualitative content analysis where systematic writing of data collected was organized into different categories according to the different information obtained (O Nyumba *et al*., 2018). This was combined with the data obtained from household questionnaires. The reliability scale for the items under the research study was 0.816

Reliability Statistics

Cronbach's Alpha	N of Items
.816	9

Ethical consideration

The respondents were protected from any harm including confidentiality of their individualities so that their details such as professionalism and personal qualities were not mentioned in the results. Privacy and

innominateness were also maintained to avoid psychological harm among the respondents. The permission to conduct the study was granted by the National Commission for Science, Technology, and Innovation (NACOSTI), the county commissioner, the county ministry of education, sub-county assistant commissioners, and the chiefs from the various locations in Soy sub-county.

RESULTS AND DISCUSSION

Demographic Characteristics

About 90.3% of the respondents were male while 9.7% were female. The highest level of education for most respondents was primary level with 46.5% while the least was tertiary level with 1.9% having attended colleges as illustrated in Table 1. The highest number of respondents (66.5%) practiced farming as their main occupation, others were business traders (20%) while the least were employed (13.5%) (Table 1).

Table 1: Demographic characteristics of the large-scale farmers

Demographic information	N	Percentage
Gender		
Male	140	90.3
Female	15	9.7
Education		
No formal education	45	29
Primary level	72	46.5
Secondary level	35	22.6
Tertiary level	3	1.9
Main occupation		
Farming	103	66.5
Employed	21	13.5
Business	31	20

Integrated Pest Management Practices and Adoption

From the survey conducted, IPM practices adopted were both natural methods and chemical control methods. Table 2 shows that out of 155 farmers surveyed, a total of 103 farmers had adopted the natural methods which were cultural, physical, and biological methods. The natural IPM practices were spread across Ziwa (3.88%), Soy (8.74%), Sirikwa (6.80%), Segero (9.71%), Moi's Bridge (11.65%), Matunda (12.62%), Kuinet (13.59%), Kongasis (4.85%), Kipsomba (6.80%), Kibulkeny (8.74%), and Kapsang (12.62%) locations. The respondents from Barsombe and Koisagat locations have been encountering the outbreak of persistent crop pests and diseases which has forced them to mainly depend on chemical control methods as they reported to be more effective.

On the other hand, a total of 138 large-scale farmers had adopted chemical control methods consisting of herbicides, insecticides, and fertilizers. The chemical control methods had higher adopters compared to natural methods and were distributed across all the locations; Ziwa (5.07%), Soy (9.42%), Sirikwa (7.25%), Segero (5.80%), Moi's Bridge (10.14%), Matunda (9.42%), Kuinet (10.14%), Kongasis (3.62%), Koisagat (7.25%), Kipsomba (5.07%), Kibulkeny (7.25%), Kapsang (12.32%) and Barsombe (7.25%) locations (Table 2)

Table 2: Adoption of IPM practices among large-scale farmers

Location	No. of large-scale farmers	Percentage	Natural methods adoption	Percentage	Chemical methods adoption	Percentage
Ziwa	8	5.2	4	3.88	7	5.07
Soy	17	11.0	9	8.74	13	9.42
Sirikwa	10	6.5	7	6.80	10	7.25
Segero	17	11.0	10	9.71	8	5.80
Moi's Bridge	14	9.0	12	11.65	14	10.14
Matunda	13	8.4	13	12.62	13	9.42
Kuinet	14	9.0	14	13.59	14	10.14
Kongasis	5	3.2	5	4.85	5	3.62
Koisagat	10	6.5	0	0	10	7.25
Kipsomba	7	4.5	7	6.80	7	5.07

Kibulkeny	10	6.5	9	8.74	10	7.25
Kapsang	20	12.9	13	12.62	17	12.32
Barsombe	10	6.5	0	0	10	7.25
Total	**155**	**100.0**	**103**	**100**	**138**	**100**

Information Dissemination Channels for IPM Adoption

Figure 2 depicts the main channels that were used to convey information to large-scale farmers on IPM adoption. Farmer-to-farmer training (50.32%), field exhibitions (23.87%), farmer field days (11.61%) radio (6.45%), television (1.94%), and extension officers (5.81%) were the main dissemination channels (Figure 2). The respondents explained that they mainly rely on their fellow farmers to obtain knowledge on IPM adoption similar to a case study carried out in Punjab (Deguine *et al.*, 2021). They were also able to learn the technology through practical examples from experienced fellow farmers in their preferred language during field exhibitions which made it easy for adoption. Field exhibitions were reported to be carried out annually in the University of Eldoret as an agribusiness trade fair while annual field days were usually carried out in Chebororwa ATC. Other respondents reported that they have learned IPM technology by listening to experts from radio stations and television. Despite the few number of extension officers, they would mainly reach out to farmers by disseminating information on chemical control methods, the application time, and procedure.

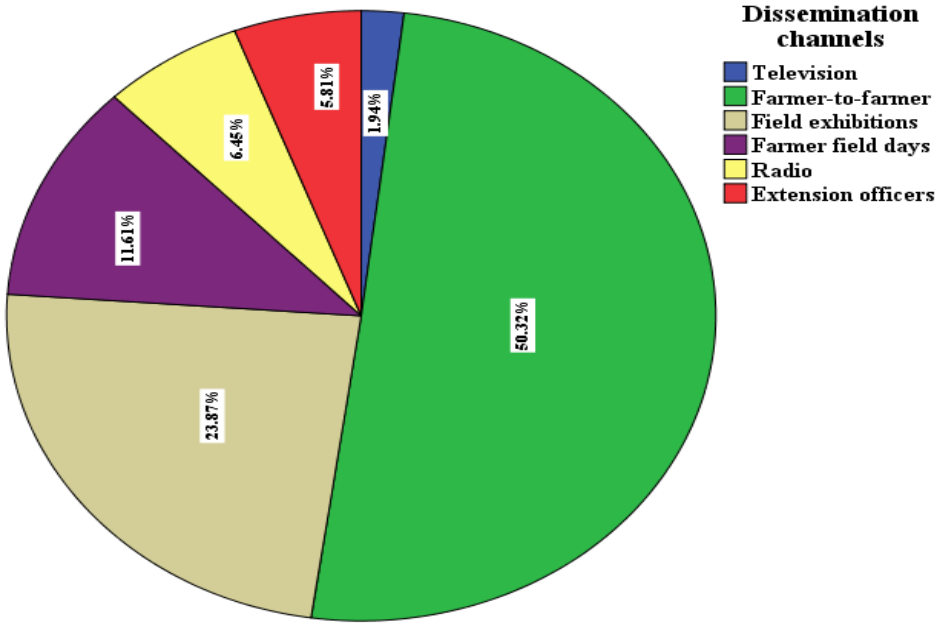

Figure 2: Dissemination channels used to convey information on IPM adoption

Cultural Practice Adoption

From the survey conducted, the cultural practices adoption was evident among the large-scale farmers and have embraced its significance in controlling crop pests and diseases. Figure 3 illustrates that farmer-to-farmer training was the main dissemination channel which led to high adoption (69.31%). The respondents also obtained information on cultural techniques through field exhibitions, farmer field days, and television which yielded its adoption (21.78%, 5.94%, and 2.97%) respectively. The main cultural practices adopted were cleaning and disinfecting farm machinery to prevent the transfer of pest larvae and weeds from one farm to another during plowing and planting.

Intercropping and crop rotation with other crops such as beans, wheat, and sunflower crops as well as adjusting planting dates was also practiced as it helps in enriching the soil with nutrients and reduce pests and disease infestations as per Dara (2019). Farmers also practiced the push-pull method where maize is intercropped with desmodium or nappier grass to repel stalk borers and stem borers. This is similar to a study carried out in Pakistan where cultural techniques through the push-pull method were found to be effective in destroying harmful pests particularly stemborers from damaging crops (Ali *et al*., 2021).

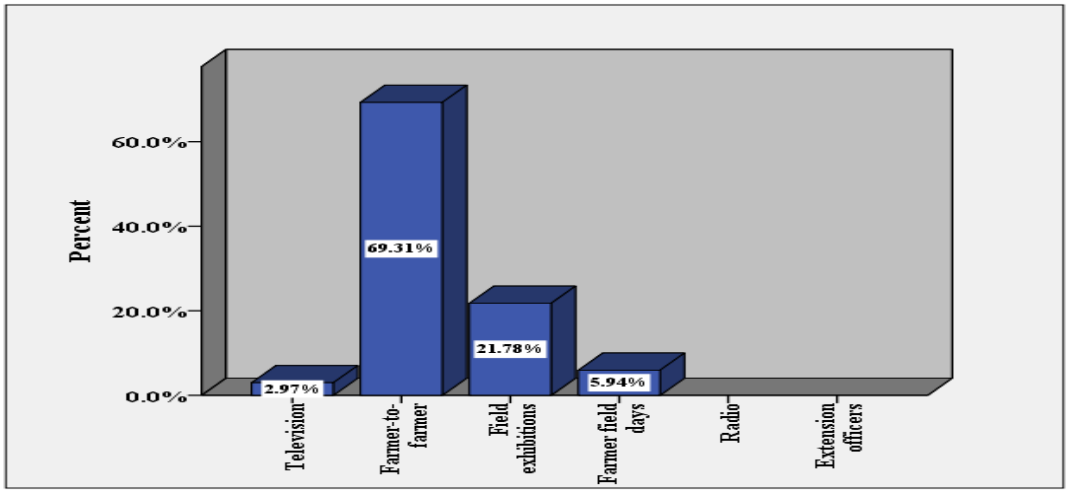

Figure 3: Dissemination channels for the cultural practice adoption

Physical Practice Adoption

The physical practices adoption was evident among the respondents. Figure 4 shows that the main dissemination channel that contributed to its adoption was farmer-to-farmer training (77.11%). Field exhibitions, farmer field days, and television also provided information that led to its adoption (20.48%), 1.20%, and 1.20% respectively. The cultural practices adopted were hand weeding and manual uprooting of weeds which were alternatives to the use of synthetic herbicides. Others have used insect traps and scarecrows to scare away birds and other insects from attacking the crop field which is similar to Khan *et al*. (2021) study on the physical methods of IPM. Despite the practice being significant in protecting the environment against pollution from pesticides, the majority of large-scale farmers still rely on pesticides to control weeds and insect pests. They explained that physical methods such as manual weeding are labor intensive, time-consuming, and may not be effective due to the re-emergence of some weeds and insect pests hence opting for synthetic herbicides and insecticides.

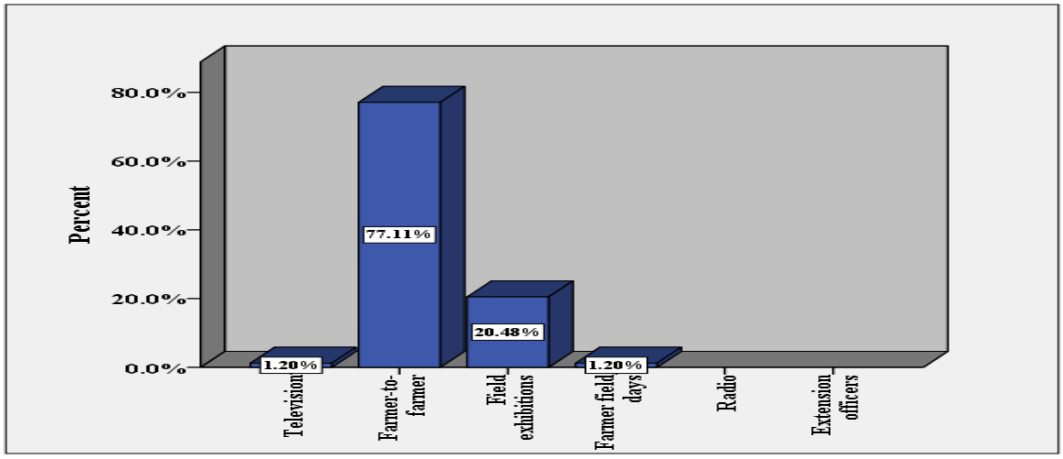

Figure 4: Dissemination channels for physical practice adoption

Biological Practice Adoption

From the survey, the respondents explained that there is a group of farmers who discovered the idea of obtaining plant extracts from red pepper, tobacco, and neem and found its effectiveness in controlling fall armyworms and stalk borers in maize production. According to Figure 5, the spread of the technique among large-scale farmers mainly through farmer-to-farmer training led to its adoption (74.07%). Respondents who have attended field exhibitions and farmer field days also learned the technique that led to its adoption (20.37% and 3.70%) respectively. Other respondents obtained the information through television programs hence adoption (1.85%). They reported that fall armyworms and stalk borers have developed resistance to synthetic pesticides which has caused much damage to their maize crops hence preferring biological practice as an alternative pest control method. The biological methods adopted coincide with the study on using botanicals to suppress

harmful pests (Dara, 2019; Mwangi & Kariuki, 2015). However, its adoption among large-scale farmers is still low as they reported that the few extracts obtained do not cover a large farm hence the practice requires adequate resources for implementation. Farmers also lacked adequate knowledge of the complex biological practices and their implementation process as they required proper training.

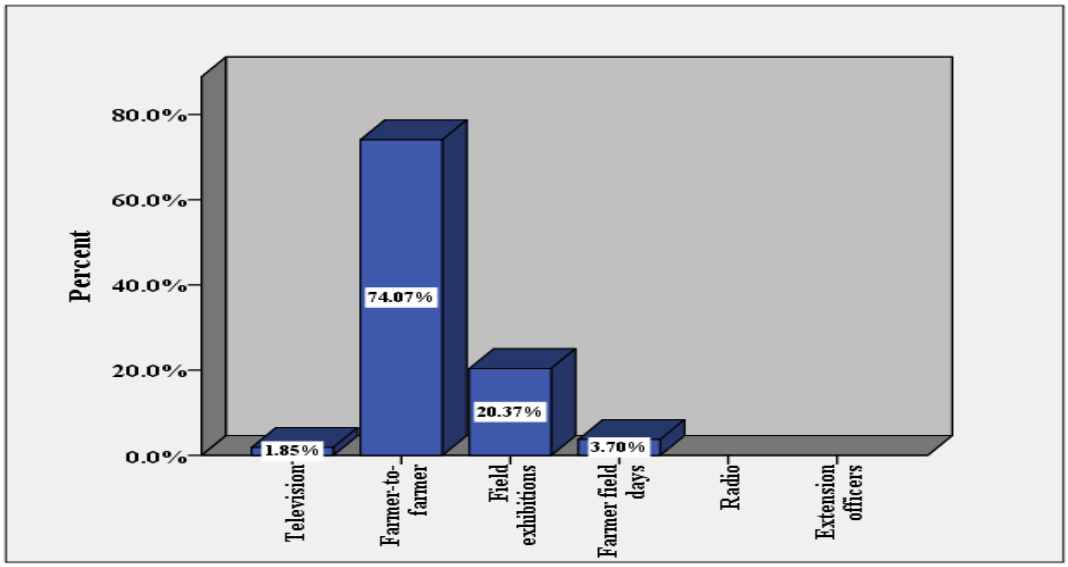

Figure 5: Dissemination channels for biological practice adoption

Chemical Control Methods and their Adoption

Out of 155 respondents, a total of 138 farmers had adopted chemical methods as the main control methods to boost maize production. Table 3 illustrates that the pesticides adopted were herbicides (100%), fertilizers (99.28%), and insecticides (76.81%). Glyphosates, metolachlor, and atrazine such as round-up, lumax, and primagram gold were mainly used as herbicides to kill weeds in the maize farm. Carbamates and organophosphates such as malathion,emamectin benzoate, and carbofuran were mainly used as insecticides. Synthetic fertilizers such as nitrogen phosphorous and potassium (NPK), Diammonium phosphate (DAP), Calcium ammonium nitrate (CAN), and Urea were mainly used to increase crop quality and quantity. The majority of these pesticides used among the respondents have been proven to be highly toxic and carcinogenic some of which are counterfeit products and therefore exposing animal and human health to risks as per the research done by Hashimi *et al.* (2020).

Table 3: Chemical control methods and their adoption

Location	Herbicides adoption	Percentage	Fertilizers adoption	Percentage	Insecticides adoption	Percentage
Ziwa	7	5.07	7	5.11	0	0.00
Soy	13	9.42	12	8.76	8	7.55
Sirikwa	10	7.27	10	7.30	10	9.43
Segero	8	5.80	8	5.84	7	6.60
Moi's Bridge	14	10.14	14	10.22	14	13.21
Matunda	13	9.42	13	9.49	12	11.32
Kuinet	14	10.14	14	10.22	11	10.38
Kongasis	5	3.62	5	3.65	2	1.89
Koisagat	10	7.25	10	7.30	10	9.43
Kipsomba	7	5.07	7	5.11	6	5.66
Kibulkeny	10	7.25	10	7.30	7	6.60
Kapsang	17	12.32	17	12.41	9	8.49
Barsombe	10	7.25	10	7.30	10	9.43
Total	**138 (100%)**	**100**	**137(99.28%)**	**100**	**106 (76.81%)**	**100**

According to Figure 6, farmer-to-farmer training was the main channel for conveying information on various pesticides and their effectiveness in maize production which led to their adoption (55.47%). Respondents who attended farmer field days and field exhibitions led to adoption (10.95% and 21.17%) respectively as they were able to learn new pesticide products from various pesticide companies and their mode of action. Radio and television encouraged the adoption of pesticides (3.65% and 2.19%) respectively since they provided farmers with information on modern commercial farming and farm inputs. Extension officers have also encouraged the adoption of pesticide usage (6.57%) as they mainly reach out to farmers particularly when there is a new pesticide product in the market, educate them on the importance of the pesticide, and train them on the application process.

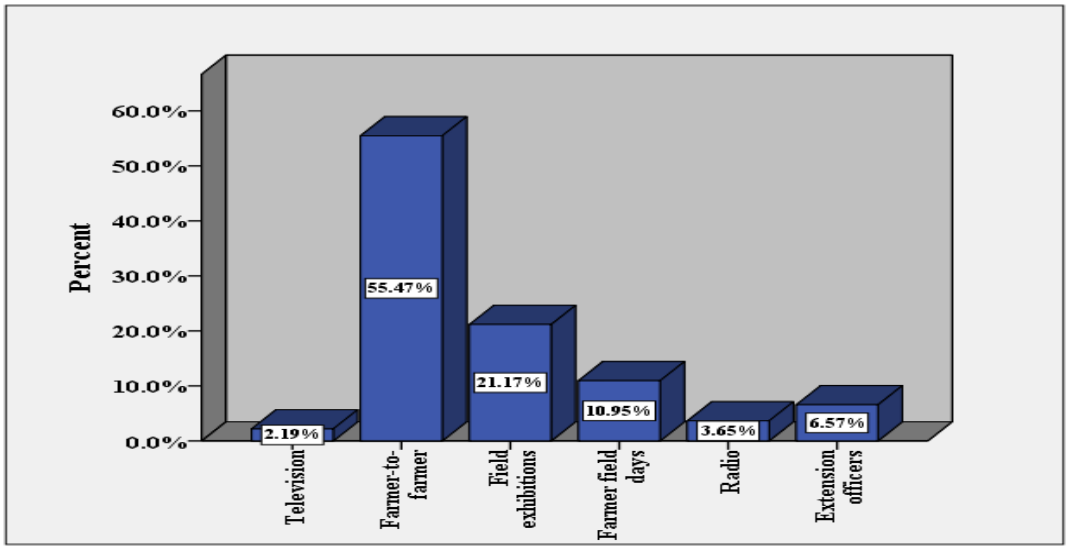

Figure 6: Dissemination channels for the adoption of chemical control methods

CONCLUSION

This study assessed integrated pest management practices and how information channels influence the adoption of these practices among large-scale farmers in maize production. The findings show that large-scale farmers have adopted both natural methods and chemical control methods where high dependence on chemical control methods was evident among the respondents. Information on IPM practices was mainly obtained through farmer-to-farmer training. Other information channels included field exhibitions, farmer field days, television, radio, and extension officers. Despite the practices being environmentally safe, their adoption among large-scale farmers is still low. These findings suggest that IPM practices are adopted and implemented when there is adequate and availability of dissemination channels. It also showed that IPM techniques are embraced particularly when the information is well relayed especially with more practical examples by the experts to ensure farmers get a clear understanding of the practices and their significance in crop production. Interventions such as setting aside different large farms for growing insecticidal plant extracts as well as setting aside farms for IPM trials will promote natural IPM methods. Removal of subsidies for pesticide products and banning highly hazardous and toxic pesticides while introducing selective and non-persistent pesticides in Kenyan markets will reduce the negative impacts on the environment. The government should also strengthen training programs on IPM practices by introducing farmer field schools and increasing the number of extension officers in the county.

While the study contributed to valuable knowledge, it was limited to the language barrier as the majority of the respondents could not be able to express their ideas fluently due to their illiteracy. Additionally, it was not possible to analyze data using inferential statistics because the nature of the data collected could not meet the assumptions required.

REFERENCES

Akenga, T., Kerich, E. & Sudoi, V. (2017). *A Survey on Use of Agrochemicals in Farms in Uasin Gishu and Homa Bay Counties, Kenya*. *January*. https://doi.org/10.13140/RG.2.2.22050.04805

Alwang, J., Norton, G. & Larochelle, C. (2019). Obstacles to Widespread Diffusion of IPM in Developing Countries: Lessons from the Field. *Journal of Integrated Pest Management*, *10*(1). https://doi.org/10.1093/jipm/pmz008

Balmford, A., Amano, T., Bartlett, H., Chadwick, D.,

Collins, A., Edwards, D., Field, R., Garnsworthy, P., Green, R., Smith, P., Waters, H., Whitmore, A., Broom, D. M., Chara, J., Finch, T., Garnett, E., Gathorne-Hardy, A., Hernandez-Medrano, J., Herrero, M., … Eisner, R. (2018). The environmental costs and benefits of high-yield farming. *Nature Sustainability*, *1*(9), 477–485. https://doi.org/10.1038/s41893-018-0138-5

Biswas, S. K., Rahman, S., Kobir, S. M. A., Ferdous, T. & Banu, N. A. (2014). A Review on Impact of Agrochemicals on Human Health and Environment. *Bangladesh Perspective*. *July*.

Costanzo, E. S., Stawski, R. S., Ryff, C. D., Coe, C. L. & Almeida, D. M. (2012). Cancer survivors' responses to daily stressors: Implications for quality of life. *Health Psychology*, *31*(3), 360–370. https://doi.org/10.1037/a0027018

Dara, S. K. (2019). The New Integrated Pest Management Paradigm for the Modern Age. *Journal of Integrated Pest Management*, *10*(1). https://doi.org/10.1093/jipm/pmz010

Deguine, J. P., Aubertot, J. N., Flor, R. J., Lescourret, F., Wyckhuys, K. A. G. & Ratnadass, A. (2021). Integrated pest management: good intentions, hard realities. A review. *Agronomy for Sustainable Development*, *41*(3). https://doi.org/10.1007/s13593-021-00689-w

Dorothy, G., W, M. B. & Owuor, G. (2019). *Willingness to pay for an Integrated Pest Management Strategy for Suppression of Citrus Infesting False Codling Moth , African Citrus Trioza and Greening Disease Among Citrus Producers in Kenya*. *10*(2), 44–53. https://doi.org/10.7176/JESD

DuBenske, L. L., Gustafson, D. H., Namkoong, K. H., Atwood, R. P., Brown, R. L., Chih, M. Y.,…& Cleary, J. (2014). CHESS Improves Cancer Caregivers' Burden and Mood: Results of an eHealth RCT. *Bone*, *23*(1), 1–7. https://doi.org/10.1037/a0034216.CHESS

Gütschow, M., Bartkowski, B. & Felipe-Lucia, M. R. (2021). Farmers' action space to adopt sustainable practices: a study of arable farming in Saxony. *Regional Environmental Change*, *21*(4). https://doi.org/10.1007/s10113-021-01848-1

Hashimi, M. H., Hashimi, R. & Ryan, Q. (2020). *Toxic Effects of Pesticides on Humans , Plants , Animals , Pollinators and Toxic Effects of Pesticides on Humans , Plants , Animals , Pollinators and Beneficial Organisms*. *5(4)*(August), 37–47. https://doi.org/10.9734/APRJ/2020/v5i430114

Heller, S., Joshi, N. K., Chen, J., Rajotte, E. G., Mullin, C. & Biddinger, D. J. (2020). Pollinator exposure to systemic insecticides and fungicides applied in the previous fall and pre-bloom period in apple orchards. *Environmental Pollution*, *265*, 114589. https://doi.org/10.1016/j.envpol.2020.114589

Horgan, F. G. (2017). *Integrated pest management for sustainable rice cultivation: a holistic approach*. 309–342. https://doi.org/10.19103/as.2016.0003.23

Humayun, M. & Ruslan, K. (2014). *Adoption and intensity of integrated pest management (IPM) vegetable farming in Bangladesh : an approach to sustainable agricultural development*. https://doi.org/10.1007/s10668-014-9613-y

Karamidehkordi, E. (2014). Farmers ' knowledge of integrated pest management : a case f armers ' knowledge of integrated pest management : a case study in the Z Anjan. May.

Khan, A. (2020). Effect of Extension-Farmers Contact on Farmers' Knowledge of Different Pest Management Practices in the Rain-Fed Districts of Khyber Pakhtunkhwa, Pakistan. *Sarhad Journal of Agriculture*, *35(2)*(January 2019), 602–609. https://doi.org/10.17582/journal.sja/2019/35.2.602.609

Khan, F. Z. A., Manzoor, S. A., Gul, H. T. & Ali, M. (2021). Drivers of farmers ' intention to adopt integrated pest management : a case study of vegetable farmers in Pakistan Drivers of farmers ' intention to adopt integrated pest management : a case study of vegetable farmers in Pakistan. October. https://doi.org/10.1002/ecs2.3812

Khan, F. Z. A., Manzoor, S. A., Gul, H. T., Ali, M., Bashir, M. A., Akmal, M., Haseeb, M., Imran, M. U., Taqi, M., Manzoor, S. A., Lukac, M. & Joseph, S. V. (2021). Drivers of farmers' intention to adopt integrated pest management: a case study of vegetable farmers in Pakistan. *Ecosphere*, *12*(10). https://doi.org/10.1002/ecs2.3812

Khanal, A., Regmi, P. P., Kc, G. B. & Kc, D. B. (2021). *Determination on the level of adoption of IPM Technology in western Nepal*. *January*. https://doi.org/10.22161/ijeab.56.18

Khanal, A., Regmi, P. P., Kc, G. B., Kc, D. B. & Dahal, K. C. (2020). *Determination on the level of adoption of IPM Technology in western Nepal*. *5*(6), 1541–1550. https://doi.org/10.22161/ijeab.56.18

Kughur, G. P. (2020). *Assessment of Adoption of Integrated Pest Management Practices among Cowpea Farmers in Okpokwu Local Government Area of Benue State , Nigeria Assessment of Adoption of Integrated Pest Management Practices among Cowpea Farmers in Okpokwu Local Government A*. *August*.

Luttikholt, L. (2020). *Principles of organic agriculture as formulated by the International Federation of*

Organic Agriculture Movements Principles of organic agriculture as formulated by the International Federation of Organic Agriculture Movements. *5214*(December 2007). https://doi.org/10.1016/S1573-5214(07)80008-X

Malekani, A. & Mubofu, C. (2020). DigitalCommons @ University of Nebraska - Lincoln Agricultural information sources , channels and strategies for sharing agricultural research findings among farmers in Iringa district in Tanzania. *Library Philosophy and Practice*.

Meemken, E. & Qaim, M. (2018). Organic Agriculture , Food Security , and the Environment. *Annual Review OfResource Economic*, *10*(2018), 39–63.

The Ministry of Agriculture Livestock and Fisheries (MoALF, 2017). Climate Risk Profile for Uasin Gishu County. Kenya County Climate Risk Profile Series. *Kenya County Climate Risk Profile Series.*, 1–22. https://reliefweb.int/sites/reliefweb.int/files/resources/Uasin Gishu_Climate_Risk_Profile_Final.pdf

Murray, K., Jepson, P., Bouska, C., Scherr, M. & Walenta, D. (2020). Integrated pest management summit reveals barriers, needs, and goals for agricultural extension. *Journal of Extension*, *58*(3), 1–9.

Mwangi, M. & Kariuki, S. (2015). Factors Determining Adoption of New Agricultural Technology by Smallholder Farmers in Developing Countries. *Issn*, *6*(5), 2222–1700. www.iiste.org

Mwenda, E., Muange, E. N., Ngigi, M. W. & Kosgei, A. (2023). Impact of ICT-based pest information services on tomato pest management practices in the Central Highlands of Kenya. *Sustainable Technology and Entrepreneurship*, *2*(2), 100036. https://doi.org/10.1016/j.stae.2022.100036

Ndimbwa, T. (2021). *Channels used to deliver agricultural information and knowledge to smallholder farmers*. *47*(2), 153–167. https://doi.org/10.1177/0340035220951828

Nicolopoulou-stamati, P. (2016). *Chemical Pesticides and Human Health : The Urgent Need for a New Concept in Agriculture*. *4*(July), 1–8. https://doi.org/10.3389/fpubh.2016.00148

Nyagwansa, R., Ochola, W., Odhiambo, J., Bunyatta, D. & Omweno, J. O. (2021). Effectiveness of Selected Advisory Channels on Safe Use of Pesticides among the Small Holder Kale Farmers , A case of Kisii County , Kenya. *East African Scholars Journal of Agriculture and Life Sciences*, *4*(6), 151–156. https://doi.org/10.36349/easjals.2021.v04i06.003

O Nyumba, T., Wilson, K., Derrick, C. J. & Mukherjee, N. (2018). The use of focus group discussion methodology: Insights from two decades of application in conservation. *Methods in Ecology and Evolution*, *9*(1), 20–32. https://doi.org/10.1111/2041-210X.12860

Parsa, S., Morse, S., Bonifacio, A., Chancellor, T. C. B. & Condori, B. (2014). *Obstacles to integrated pest management adoption in developing countries*. *111*(10), 3889–3894. https://doi.org/10.1073/pnas.1312693111

Ponto, J. A., Ellington, L., Mellon, S. & Beck, S. L. (2010). Predictors of adjustment and growth in women with recurrent ovarian cancer. *Oncology Nursing Forum*, *37*(3), 357–364. https://doi.org/10.1188/10.ONF.357-364

Pretty, J. & Bharucha, Z. P. (2015). Integrated pest management for sustainable intensification of agriculture in Asia and Africa. *Insects*, *6*(1), 152–182. https://doi.org/10.3390/insects6010152

Samiee, A., Rezvanfar, A. & Faham, E. (2014). *Factors influencing the adoption of integrated pest management (IPM) by wheat growers in Varamin County , Iran*. *June*.

Seufert, V., Ramankutty, N. & Mayerhofer, T. (2017). What is this thing called organic ? - How organic farming is codified in regulations. *Food Policy*, *68*, 10–20. https://doi.org/10.1371/journal.pbio.0050018

Stern, M. J., Bilgen, I. & Dillman, D. A. (2014). The State of Survey Methodology: Challenges, Dilemmas, and New Frontiers in the Era of the Tailored Design. *Field Methods*, *26*(3), 284–301. https://doi.org/10.1177/1525822X13519561

Tümen Akyildiz, S. & Ahmed, K. H. (2021). An Overview of Qualitative Research and Focus Group Discussion. *International Journal of Academic Research in Education*, *7*(1), 1–15. https://doi.org/10.17985/ijare.866762

Van Wyk, M. & Taole, M. (2015). Planning , Designing and Conducting Education Learning Research. *Educational Research*, 164–185.