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Effects of Plant Clinics on Pesticides Usage by Farming Households in Kenya

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Abstract
Plant clinics focus primarily on diagnosis and dissemination of advice on management/control of plant health problems. The advice provided includes cultural, chemical (pesticides) and biological control or any combination of the listed control methods. Use of pesticides is preferred by farmers for the control of crop pests and diseases because of its quick knock down effect although it is also associated with high costs as well as negative environmental and human health effects. This study examined how plant clinics influence the use of pesticides by maize and tomato farmers in Bungoma, West Pokot, Kirinyaga, Embu and Kiambu Counties in Kenya in the 2016/2017 production year. The objectives of the study were to: (i) examine sources of pesticides (ii) assess factors that determine pesticide usage and (iii) establish changes in pesticide usage practices by farmers. Three hundred and forty three farmers, who included 172 plant clinic users and 171 non-plant clinic users, were selected for the study. The selection process took cognizance of gender issues and selection of non-users in areas where there were no plant clinics in the study counties but with similar agro-ecological conditions and farming systems involving maize and tomato production. Data were collected on socioeconomic variables, pesticide use, costs of production, crop output, per unit price of output and attendance of plant clinics. Data were analysed using descriptive statistics, multiple linear and logistic regression models. The study established that farmer knowledge of pesticides improved following the use of plant clinics. Farmer access to information on pesticides improved with regard to sources of pesticides and the types of pesticides to use. There was also an increase in safe use of pesticides. For both men and women there was a positive and statistically significant relationship between wearing of protective clothing and visit to the plant clinic ($p<0.05$). Plant clinic users had access to more options for pest and disease management. Sixty three percent (63%) of male headed households compared to 70% female headed households used personal protective equipment (PPEs) while spraying before visiting plant clinics. After visiting plant clinics the proportion of male headed households wearing PPEs increased to 75%, while the female headed households increased to 82%. Additionally, awareness of pre-harvest interval increased from 15% to 29% for plant clinic users. There was an increase in knowledge of re-entry interval from 33% to 74% as a result of plant clinic visits. There was also an increase in efficiency of pesticide usage and access to information on management of pests. This suggests the need for improving farmer access to plant clinics for necessary information coupled with advice on pest and disease management practices.
Keywords: pesticides, plant clinics, awareness, safe use, gender, pests, Kenya

1.0 Introduction

Plant clinics are establishments in public access areas such as markets and produce delivery sheds where farmers take plant samples affected and/or infected by different pests and diseases for diagnosis and recommendations on appropriate control measures. Plant clinics were started in Kenya in 2010 by the Plantwise Programme. The key components of the programme are plant clinics, Plantwise knowledge bank (KB) and plant health rallies (PHRs). The purpose of the programme is to increase food security and improve rural livelihoods by reducing crop losses.

This is achieved by establishing a network of plant clinics, similar to those for human health, where farmers can find advice to prevent and manage crop health problems. In so doing, the programme works in collaboration with other plant health service providers such as the Ministry of Agriculture. Plant clinics are operated by plant doctors who are specially trained persons with skills in plant protection and good agricultural practices (GAPs). Most of the plant doctors are agricultural extension officers of the Ministry of Agriculture (Scheidegger and Graf, 2013; Idah Mugambi *et. al*. 2016)

Currently there are 134 plant clinics in 14 counties of Kenya. Plant clinics are a key component of the plant health system of Plantwise programme (PW), which aims at strengthening the links between research, extension, regulation and input supply (Scheidegger and Graf, 2013). In practice, plant clinics focus primarily on diagnosis and disseminating advice on how to deal with plant health problems (Brubaker *et al*., 2013). The service is demand driven since farmers solely determine the need for advice. Plant clinics are set up in public access areas such as markets and produce delivery sheds where farmers take plant samples that are affected and/or infected by different pests and diseases for diagnosis and recommendations on appropriate control measures. These measures can be cultural, chemical, biological or different combinations of the listed methods.

The expected outcome of plant clinic services is improved plant health and consequently increased crop productivity. The key aspects that lead to increased crop productivity are judicious and efficient use of agricultural productivity enhancing inputs such as fertilizer, improved seed, pesticides and advisory services. Efficient use of the factors of production can also lead to environmental protection. A key resource that has many implications to the environment, human health and crop productivity is pesticides (Fikre *et al.* 2016; Frank *et al.* 2015; Shiekh *et al*. 2011). Pesticides are widely used and represent an important ingredient in agriculture (Bond *et al* 2006; Guy *et al* 2017). Insecticides are the most popular pesticides (Bond *et al* 2006). Pesticides are often used to manage pests and diseases to enhance agricultural productivity. However, pesticides have negative impacts on human and animal health as well as on the environment if not properly used and handled (Fikre *et al*. 2016). This study examined how plant clinics influenced the utilization of pesticides by maize and tomato farmers in selected counties in Kenya during the 2016 /2017 production year. The objectives of the study were to: (i) examine sources of pesticides, (ii) assess factors that determine pesticide usage and (iii) examine changes in pesticide usage practices by farmers.

2.0 Materials and methods

The study was conducted in areas with plant clinics and areas without plant clinics. This was in order to get a distinct understanding of the contributions of plant clinics to effective usage of pesticides in Kenyan agriculture. A survey research design was used in the implementation of the study, with a focus on maize and tomato, among users and non-users of plant clinics. The household survey was combined with key informant interviews (KIIs). This was meant to obtain an understanding of the study subject from a cross-section of respondents.

Five counties were purposively selected from 14 counties where the Plantwise Program is implemented in Kenya. The study counties were Bungoma, Embu, Kiambu, Kirinyaga and West Pokot, which represent approximately 30% of all the counties with plant clinics in Kenya. The basis for selection of the counties was their involvement in production of both maize and tomatoes, which were the target crops for the study, as well as having the most queries on the Plantwise Online Management System (POMS) database. From each of the counties one district was selected where there was established production of maize and tomatoes. In addition, plant clinic sites were selected, avoiding sites where the PW random control trial (RCT) impact assessment by the American Institutes for Research (AIR) had been conducted.

The non-users, who were the comparison sample of farmers, were selected from the same counties as the plant clinic users based on target crops, similarity in agro-ecological conditions and farming systems, but in areas without plant clinics. Plant clinic users were selected from lists of participants in the POMS database. Non-plant clinic users were selected from lists of farmers maintained by the agricultural extension officers in the comparison sites. A total of 343 farmers were randomly selected from the listing of users and non-users of plant clinics to participate in the study. The selection process included gender considerations of male and female farmers that was proportional to size, as is the case in the POMS database.

The distribution of respondents disaggregated by county and gender is provided in Table 1. In addition to the farmers, 11 key informants (KIIs) were also purposively selected to participate in the study in order to provide expert opinion and specialized information. These were: 1 crops officer in each of the study counties (giving a total of 5), 5 representatives of agro-input dealers and 1 representative of the Agrochemical Association of Kenya (AAK).

Table 2: Numbers of farm households selected for the study

County	Male headed	Female headed	All households
Embu	49	35	**84**
Kirinyaga	54	7	**61**
Kiambu	45	17	**62**
Bungoma	40	24	**64**
West Pokot	45	27	**72**
All counties	**233**	**110**	**343**

Data was collected using a structured questionnaire for individual farmers and interview guides for the key informants. The farmer questionnaire was digitized for use on tablets on the open data kit (ODK) platform. Data collection tools were developed guided by key variables of the investigation and the analysis procedure. The variables involved in the investigation included socio economic characteristics, types, quantities and costs of inputs used in maize and tomato production, credit use, quantity produced and prices of maize and tomatoes, quantity and cost of pesticides used, sources of information on pesticides and crop protection information.

Quantitative data collected was analysed using means, frequencies, standard errors, cross tabulations, Chi-Square tests and t-tests. Multiple linear regression was used to establish the factors that affect use of pesticides on tomatoes. A binary logistic regression model was used to determine factors that influence the use of pesticides by farmers on maize. The analyses were conducted according to gender categories and use or non-use of plant clinics in order to establish the effect of the plant clinics initiative. Qualitative data, from key informants was analysed using thematic analysis.

3.0 Results and discussions

3.1 Sources of advice on pesticide usage

Sources of advice varied depending on whether a farmer was a plant clinic user or not. Farmers obtained information from several sources at the same time. The three most common sources of advice on pesticides among households were plant clinics, government extension workers and agro-input dealers (Table 2). Majority of farmers who used pesticides on tomatoes obtained pesticide advice from plant clinics (37%). The next most important source of advice on pesticide use on tomatoes was the agro-input dealers. Maize farmers who used pesticides obtained information majorly from plant clinics (33%). Other major sources of advice on pesticide use for maize farmers were agro-input dealers (27%) and government extension workers (21%). Plant clinics and agro-input dealers are good sources of information about pesticides but on average plant clinics are better possibly because they are managed by personnel who are trained and qualified in plant health sciences. This means that there should be sharing of information between plant doctors and agro-input dealers to enhance effectiveness and efficiency of pesticide use. This would also ensure that farmers who do not use plant clinics would get expert opinion from agro-input dealers based on information shared by plant doctors.

Table 2: Sources of advice on pesticide used on maize and tomatoes (%)

Source of information on pesticide use	Maize farmers		Tomato farmers	
	Non-clinic user	Clinic user	Non-clinic user	Clinic user
Plant clinic	0	33	0	37
Government extension worker	21	21	19	22
Agro-input dealer	27	16	29	18
Family /Friends /neighbours	18	7	14	6
Radio /TV	15	10	14	6
Farmer group	3	2	0	2
NGO extension worker	4	3	5	5
Own knowledge/experience	9	4	10	1
Agrochemical company	2	2	6	2
Shows /Exhibitions	1	0	0	1
KARLO	1	0	1	0
Private produce buyer	0	0	0	0
Internet	0	0	0	0
NCPB	0	0	0	1

Note: percentages are based on responses

Male headed households obtained advice on pesticides mainly from agro-input dealers (15.5%), plant clinics (14.2%) and government extension worker (13.7%), as shown in Table 3. For female headed households the major sources of advice were government extension workers (7.0%), plant clinics (6.1%) and agro-input dealers (5.3%). There were no significant differences between men and women regarding sources of advice on pesticides but results indicate that men obtain more advice compared to their female counterparts. This suggests a need for targeted efforts to improve women's access to advice on pesticides.

Table 3: Distribution of source of advice based on gender (%)

Source of information on pesticide use	Gender of Household head	
	Female; N=110	Male; N=233
Agro-input dealer	5.3	15.5
Plant clinic	6.1	14.2
Government extension worker	7.0	13.7
Family /Friends /neighbours	3.6	7.5
Radio /TV	4.0	7.7
Own knowledge/experience	1.4	4.0
NGO extension worker	1.2	2.8
Agrochemical company	0.5	1.7
Farmer group	0.8	1.4
Shows /Exhibitions	0.1	0.5
Private produce buyer	0.0	0.2
NCPB	0.0	0.2
Internet	0.0	0.1
KALRO	0.3	0.0

Note: Percentages are based on responses

Among the plant clinic users, plant clinics were the most common source of advice on pesticide use (34%), followed by government extension workers (21%) and agro-input dealers (17%). For the non-users, the agro-input dealer was the most common source of advice on pesticide use (27%), followed by government extension workers (21%) and the category comprising of family, friends and neighbours (17%), as demonstrated in Table 4. For the non-plant clinic users, radio /TV and own knowledge, also featured among the common sources of advice on pesticide use. According to the key informants (KIIs), the main source of information/advice on pesticide use was agro-input dealers and the government extension officers. It is therefore important to link agro-input dealers with plant doctors for cross checking of information delivered and for improved efficiency in the use of pesticides. The preference for plant clinics as sources of information by the plant clinic users suggests that they have great potential in increasing the reach of information. Availability of plant doctors to provide verbal explanations and complementary materials enhances the reach of information. Increasing the number of plant clinics where possible would enhance and encourage farmers to open up and seek information.

Table 4: Source of pesticide advice for users and non-users of clinics

Source of Information on Pesticide use	Non-clinic user		Clinic user	
	N	%	N	%
Plant clinic	0	0	200	34
Family /Friends /neighbours	68	17	41	7
Farmer group	9	2	13	2
Government extension worker	82	21	122	21
NGO extension worker	17	4	23	4
Agro-input dealer	108	27	97	17
Private produce buyer	1	0	1	0
Radio /TV	61	15	54	9
Internet	1	0	0	0
NCPB	0	0	2	0
agrochemical company	11	3	11	2
Own knowledge/experience	36	9	17	3
Shows /Exhibitions	3	1	3	1
KARLO	3	1	0	0

3.2. Pesticide purchase points for households

The main purchase point of pesticides for both male and female headed households was a licensed agrovet (98%), followed by a shop in the local market (4%) and Kenya Farmers Association (KFA) shops at 1% (Table 5). Ninety eight percent (98%) of the maize farmers and 99% of the tomato farmers, respectively, purchased pesticides from a licensed agrovet. About 99% and 98% of plant clinic users and non-users purchased pesticides from agro-vets. Five percent (5%) of the non-plant clinic users, compared to three percent (3%) of the plant clinic users purchased pesticides from a shop in the local market. Information from plant clinic visits enlightened farmers on the right place from which to purchase pesticides. This is important given that most agrovets have at least basic knowledge on pesticide uses and side effects. As a consequence they can provide advice compared to ordinary shop owners.

Table 5: Pesticide purchase points by farmers (%)

Purchase points for chemicals	Female headed households	Male headed households	Non-clinic user	Clinic user	Maize Farmers	Tomato farmers	All Farmers
Licensed agrovet	96	98	96	99	98	99	98
A shop in the local market	3	4	5	3	4	2	4
Salespersons on a van /motorbike	1	0	1	0	0	0	0
Neighbours /fellow farmers	1	0	0	0	0	0	0
KFA	2	1	2	0	1	1	1
One acre fund	0	0	1	0	0	0	0

Note: Percentages and totals are based on respondents

3.3 Use of pesticides by farm households

Distribution of households with regard to use of pesticide on maize and tomato per county are as shown in Table 6. Overall, 64% of the maize farmers used pesticides while 36% did not use pesticides. Kirinyaga, Bungoma and Embu had majority of farmers using pesticides on maize compared to non-users, with percentages of 88%, 80, and 79%, respectively. However in Kiambu and West Pokot majority of maize farmers had not used pesticides constituting 72% and 65%, respectively. Majority (96%) of tomato farmers in all counties used pesticides. These results are consistent with the fact that pesticides are widely used for agricultural production (Guy *et al* 2017).

Table 6: Use of pesticides on maize and tomato in different counties (%)

County	Maize farmers: User of pesticides; N=206	Maize farmers: Non-user of pesticides; N=118	Tomato farmers: User of pesticides; N=87	Tomato farmers: Non-user of pesticides; N=4
Embu	79	21	93	7
Kirinyaga	88	12	100	0
Kiambu	28	72	100	0
Bungoma	80	20	100	0
West Pokot	35	65	85	15
All counties	**64**	**36**	**96**	**4**

Pesticide use among households varied between plant clinic users and non-users, as well as between maize and tomato farmers. Among the plant clinic users that produced maize, an average of 78% of the farmers used pesticides, and among the tomato farmers an average of 98% used pesticides (Table 7). On the other hand, among the non-plant clinic users that produced maize, half of the farmers used pesticides while 91% of the tomato farmers used pesticides. This result indicates that pesticide use is higher among farmers that grow tomatoes. According to a Mann Whitney U test there was no significant relationship between pesticide use in tomato and plant clinic user ($p>0.05$). This may be because tomatoes are very susceptible to damage by pests and diseases and the immediate response of the farmers is to use pesticides. For both maize and tomatoes, a Chi-Square test established that there was a statistically significant positive relationship ($p<0.05$) between plant clinic use and pesticide use, which indicates that plant clinic use positively influences farmer perceptions of pesticide use.

Table 7: Use of pesticides by plant clinic users and non-users (%)

Plant clinic use	Gender of household head	Maize farmers: User of pesticides, N=206	Maize farmers: Non-user of pesticides, N=118	Tomato farmers: User of pesticides, N=87	Tomato farmers: Non-user of pesticides, N=4
Plant clinic User	Female	75	25	94	6
	Male	79	21	100	0
	Both male & female	78	22	98	2
Non-plant clinic user	Female	44	56	86	14
	Male	53	47	93	7
	Both male & female	50	50	91	9
Both users and non-users	Female	59	41	91	9
	Male	66	34	97	3
	Both male & female	64	36	96	4

An estimated 97% of the male headed households used pesticides on tomatoes compared to 91% of the female headed households. Male-headed households producing maize using pesticides were 66% compared to 59% of their female counterparts. A Chi-square test result indicated that there was no statistically significant relationship between usage of pesticides and the gender of the household head ($p>0.05$) for both users and non-users of plant clinics. This suggests that improving farmer use of plant clinics would improve pesticide use efficiency for both men and women farmers.

3.4 Wearing of Personal protective Equipment by farmers while applying pesticides

Sixty three percent (63%) of male headed households compared to 70% female headed households used personal protective equipment (PPEs) while spraying before visiting plant clinics. For both men and women the proportion that used PPEs before visiting plant clinics was 65%. After visiting a plant clinic, the proportion of male headed households wearing PPEs increased to 75%, while the female headed households increased to 82%. There was no statistically significant difference ($p>0.05$) between male and female farmers with respect to wearing PPE. There was a positive statistically significant relationship ($p<0.05$) between wearing of protective clothing and visit to the plant clinic ($p<0.05$). These results show that plant clinic attendance and advice encourages farmers to use PPEs. This indicates that plant clinics have improved awareness of farmers and also improved safe use of pesticides, particularly for plant clinic users. This is because the absence of personal protective equipment plays a key role in the extent of body exposure to pesticide effects (Guy *et al* 2017). Information from plant clinics enhances farmer understanding of health risks associated with the use of pesticides thereby improving safe use of pesticides by farmers.

The PPEs worn while spraying included, overalls, gumboots, masks, gloves, hats or caps and goggles (Table 8). The PPEs that were mostly used by the farmers before a visit to the plant clinic were the overalls and gumboots in equal proportions (90%), followed by a mask (86%) and gloves (80%). The least used PPE was the goggles (40%). This pattern was similar after the farmers visited a plant clinic. Overalls and gumboots were used by 85% of the farmers while masks were used by 81% of the farmers after plant clinic visits and the number of farmers using different PPEs increased.

Table 8: Protective equipment worn by farmers while applying pesticides (%)

Protective equipment	Before Plant clinic visit; N=77	After plant clinic visit; N=151
Overall	90	85
Mask	86	81
Gumboots	90	85
Gloves	80	68
Cap /hat	58	48
Goggles	40	33

3.5 Knowledge of pre-harvest interval and re-entry interval by farmers

An assessment of whether farmers knew that they had to wait for some time before harvesting their crop after spraying revealed that there were differences depending on use and non-use of plant clinics. Awareness of pre-harvest interval increased from 15% to 29% for plant clinic users (Table 9). Male headed households were more aware of pre-harvest interval both before and after visiting plant clinics, compared to female headed households. Female headed households that were aware of pre-harvest interval before plant clinic visit were 13%, which increased to 21% after visiting a plant clinic. A Chi-Square test indicated that there was no significant difference between male headed and female headed households on awareness of pre-harvest interval after plant clinic visit ($p>0.05$). Visiting plant clinics increased the awareness of pre-harvest intervals of both men and women farmers.

There was an increase in knowledge of re-entry interval amongst the plant clinic users. Before visiting a plant clinic 33% of the households were aware of re-entry intervals but after visiting the plant clinics this proportion more than doubled to 74% (Table 9). Among plant clinic users, the percentage of awareness before plant clinic visit for male headed households was 34%, while for female headed households was 32%. After plant clinic visits 79% of male headed households became aware compared to 64% of the female headed households. A Chi-Square test showed there was no significant difference between male headed and female headed households regarding awareness of re-entry interval after plant clinic visit ($p>0.05$).

Table 9: Farmer awareness of pre-harvest interval and re-entry interval

Awareness	After plant clinic visit			Before plant clinic visit		
	Female headed household n=56	Male headed household n=116	Total plant clinic user n=172	Female headed household n=56	Male headed household n=116	Total plant clinic user n=172
Aware of pre-harvest interval	12(21%)	37(32%)	49 (29%)	7(13%)	19(16%)	26 (15%)
Aware of re-entry interval	36(64%)	92(79%)	128(74%)	18(32%)	39(34%)	57(33%)

3.6 Storage of pesticides by clinic users and non-users

There were variations regarding where pesticides were stored but more than half of the farmers interviewed reported that they kept pesticides in a store designated for pesticides. According to key informants; storage of pesticides improved after plant clinic visit occasioned by receipt of information regarding risks associated with misuse of pesticides coupled with knowledge on safe use of pesticides. There was a tendency for plant clinic users to keep pesticides in a store designed for pesticides. Majority (67%) of the farmers stored pesticides in a separate store, while 30% stored them inside the house (Table 10). Ninety three percent (93%) of the plant clinic users in Kirinyaga County store pesticides in a designated store compared to 42% in Bungoma County. Close to two thirds of non-users in Bungoma County store pesticides inside the house compared to less than a quarter of non-clinic users in Kirinyaga County. Differences exist between counties regarding pesticide storage areas. Communication should prioritise areas with less use of designated stores to avert pesticide related problems such as poisoning.

Table 10: Main storage of pesticides per county (%)

County	Clinic use	Inside the house	Dedicated store	Outside house	Bury in the farm	Buy and use same day
	Non-clinic user	37	60	2	0	0
Embu	Clinic user	19	70	2	8	2
	Both user & non-user	27	66	2	4	1
	Non-clinic user	22	73	0	2	2
Kirinyaga	Clinic user	7	93	0	0	0
	Both user & non-user	14	83	0	1	1
	Non-clinic user	42	58	0	0	0
Kiambu	Clinic user	16	84	0	0	0
	Both user & non-user	28	72	0	0	0
	Non-clinic user	73	23	0	3	0
Bungoma	Clinic user	58	42	0	0	0
	Both user & non-user	65	34	0	1	0
	Non-clinic user	33	67	0	0	0
West Pokot	Clinic user	16	84	0	0	0
	Both user & non-user	26	74	0	0	0
	Non-clinic user	39	59	1	1	1
All Counties	Clinic user	22	75	0	2	0
	Both user & non-user	30	67	0	2	1

Majority of male headed households (65%) stored pesticides outside the house, while 31% store them inside the house. Other male headed households (27%) keep pesticides inside a dedicated store while 2% buy and use them within the same day. Fifty six (56) percent of the female headed households stored pesticides in a dedicated store, 36% stored pesticides inside the house and 4% store them outside the house. Female headed farmers preferred to keep pesticides in a dedicated store irrespective of whether they used plant clinics or not. This means that those involved in disseminating plant clinic information relating to storage practices should give more emphasis to male farmers.

3.7 Disposal of empty pesticide containers

Before plant clinic visits most (25%) of those who later visited clinics used burning, burying and pit latrine as major disposal methods. Other methods of disposal before plant clinic visits were throwing the containers away. According to key informants, disposal of empty pesticide containers has been mainly by throwing them away along with regular household garbage or throwing them into pit latrines. There has been a change amongst the clinic users. After plant clinic visits majority (35%) of farmers used pit latrines and burying (29%). Other methods used for disposal was recycling of containers constituting 2% of households (Table 11).

Before plant clinic visits 31% of female headed households threw away the pesticide containers, while 38% of male headed households disposed pesticide containers by burying them (Table 11). After visiting a plant clinic, 50% of female headed households disposed pesticide containers in pit latrines. A majority (26%) of male headed households disposed through burning.

Table 11: Disposal of empty pesticide containers by plant clinic user (%)

Disposal method	Before plant clinic use			After plant clinic use		
	Male	Female	Both male & female(n=172)	Male	Female	Both male & female (n=172)
Burning	36	28	25	26	15	23
Threw away	14	31	21	8	11	8
Cleaned & stored	1	7	4	2	4	3
Burying	38	21	25	24	19	29
Pit latrine	12	14	25	23	50	35
Recycling	0	0	0	7	0	2

The Agrochemical Association of Kenya (AAK) is currently piloting a “pesticide containers’ retrieval scheme” in 10 counties in Kenya. Once collected the containers are destroyed (by incineration) or recycled for other uses such as, energy or power generation. Discussions with key informants revealed that this initiative is better appreciated by plant clinic users. This demonstrates improved knowledge and skills amongst the plant clinic users. In some counties the Pesticide Control Products Board (PCPB) has provided bins for disposal of pesticide containers as a pilot project but in most cases farmers do not use the bins. This calls for more awareness creation on disposal of used pesticide containers.

3.8 Knowledge of spraying time by pesticide users before and after plant clinic visit

Before visiting a plant clinic 94% of the clinic users had knowledge of the appropriate time of the day for spraying pesticides. After plant clinic visits almost all (99%) of the plant clinic users had knowledege of the appropriate time for spraying. A Chi-Square test showed that there was no significant difference between users and non-users on knowledge of spraying time after plant clinic visits ($p>0.05$). This demonstrates that with or without plant clinics, farmers are aware of the appropriate times to apply pesticides. Before a plant clinic visit, 72% of plant clinic users sprayed their crops in the morning before 9 am. Those that sprayed after 4 pm were 14%, while the rest sprayed between 9 am and 4 pm. After plant clinic visit 80% sprayed in the morning before 9 am and those that sprayed at 4 pm were 15%. The remaining 15% sprayed between 9 am to 4 pm (Table 12).

Before visiting a plant clinic 77% of female headed households sprayed chemicals in the morning before 9 am and 15 % past 4 pm. After visiting plant clinics, 68% of female headed households sprayed their crops in the morning before 9 am while 27% sprayed after 4 pm. Before visiting plant clinics 73% of the male headed households (73%) sprayed in the morning before 9am while 14% sprayed past 4 pm. After plant clinic visits majority (85%) of male headed households spayed in the morning before 9am while 10% sprayed past 4 pm. The differences in spraying time between men and women was however not statistically significant irrespective of the period before and after plant clinic visits.

Table 12: Time of day sprayed pesticides before and after plant clinic visit (%)

Time of day sprayed	Before plant clinic visit			After plant clinic visit		
	Male	Female	Both male & female	Male	Female	Both male & female
Morning before 9 am	73	77	72	85	68	80
Between 9 am- 4 pm	12	6	10	5	6	5
Past 4 pm	14	15	14	10	26	15

3.8 Factors affecting pesticide use on maize

A Binary logistic regression model was used to assess the joint effect of factors affecting pesticide use. The likelihood ratio Chi-square of 44.64 with $p<0.05$ showed that the model fits significantly well. The marginal effects measuring the actual effect of a unit change in each of the explanatory variables on farmers’ choice of use of pesticides are indicated in Table 13.

Table 13: Marginal effects of factors affecting choice of pesticide use in maize

Independent variables	dy/dx	Std. Err.	z	P>z
Gross margin (KES) /acre	0.0000	0.0000	1.1000	0.2730
Area under maize (acres)	-0.0447	0.0218	-2.0500	0.0400
Land (acres) owned by household	-0.0101	0.0053	-1.9200	0.0550
Land (acres) cultivated by household	0.0559	0.0185	3.0200	0.0030
Cost (KES) of maize production /acre	0.0000	0.0000	0.9600	0.3370
Age of household head	0.0046	0.0022	2.0700	0.0380
Household used improved seed	-0.0582	0.1829	-0.3200	0.7500
Head completed primary education	0.0613	0.0751	0.8200	0.4140
Head completed Secondary education	0.1592	0.0718	2.2200	0.0270
Plant clinic user	0.2429	0.0553	4.3900	0.0000
Household head is female	-0.1589	0.0774	-2.0500	0.0400
Household head is farm decision maker	-0.2308	0.0930	-2.4800	0.0130
Head and spouse make farm decision jointly	-0.1690	0.1097	-1.5400	0.1240

Total input cost has a positive effect on the probability of a household using pesticides. Land area (acres) under maize decreases the probability of a household using pesticide. A household being male headed is more likely to use pesticide. The age of household head has a positive influence on using pesticides implying that as the household head gets older, the likelihood of using pesticide increases. Completion of secondary education by a household head is also significantly associated with pesticide use. Thus, having completed secondary education increased the probability of a household using pesticides. The household head as a key decision maker in farming is significantly associated with pesticides use. Thus a household where the key decision maker is the head increases the likelihood of a household using pesticide. Plant clinic users compared to non-plant clinic users have a significantly positive association with pesticide use, thus being a plant clinic user increases the probability of using pesticides. Similarly, as indicated elsewhere in this paper there is more rational use of pesticides amongst plant clinic users. This demonstrates that plant clinic users have more information about the various types of pesticides as well as conditions requiring specific pesticides and could use the recommended pesticides based on their capacity.

3.9 Factors affecting pesticide use on tomato

A multiple linear regression model was used to assess the factors affecting pesticide use on tomato. In this case pesticide use on tomatoes is operationalized as expenditure on pesticides. Information is provided on the coefficients, their standard errors and associated p-values at the 95% confidence interval (Table 14). There is a positive and statistically significant relationship between pesticide use and land area under tomatoes. This is as expected because tomatoes are very sensitive to pests and diseases infestation/infection. Consequently, as land under tomatoes is increased more pesticides are used to control pests and diseases. Where household heads are the key decision makers there is tendency to increase pesticide use on tomatoes. In the study area being a household head is associated with financial control and hence allocation of funds to different functions, including purchase of pesticides to be used on tomatoes. The decision to purchase and use pesticides was easily implemented where the household head was the decision maker. Use of pesticides was influenced by the level of education. Relatively more leaned farmers spend more on pesticides. This is possibly because they appreciate more the importance of pesticides in controlling pests and disease on tomatoes. Plant clinic attendance has positive influence on pesticide use though not statistically significant. This in practice means that plant clinic users have more information and understand better the importance of using pesticides for controlling pests and diseases.

Table 14: Factors affecting pesticide use on tomato

Independent variables	Coefficient	Std. Error	t	P>t
Area under tomato (acres)	11235.19	2347.13	4.79	0.000
Head completed Secondary education	5139.714	2780.038	1.85	0.068
Head completed Tertiary education	3480.022	3373.153	1.03	0.305
Household head is farm decision maker	5053.749	2478.908	2.04	0.045
Plant clinic user	113.6194	2652.634	0.04	0.966
_cons	-4966.44	3013.425	-1.65	0.103

4.0 Conclusion

Plant clinics increase the level of awareness among farmers regarding sources of pesticides and safe use of pesticides. There has been a shift towards a more preventive approach to pest and disease management, as opposed to curative measures which were mainly employed prior to clinic visits. Most farmers now only purchase pesticides upon prescription by the plant doctors.

Agro-input dealers are an important source of information on pesticides and their use. Those that interact with plant doctors have improved knowledge on diagnosis of particular plant pests and diseases. This suggests the need for linking agro-input dealers with plant doctors for cross checking of information delivered and for improved efficiency in the use of pesticides.

Due to lack of awareness, some farmers do not wear protective gear while spraying, or only just partially protecting themselves (say with gumboots or facial masks only). This has been associated with some cases of pesticide poisoning reported by key informants. Pesticide handling behaviour and perceptions of pesticide risks has improved for farmers who are plant clinic users. More awareness creation about the side effects of pesticides in the event of improper use can be effected through greater use of plant clinic services.

Farmers who are plant clinic users are more likely to practice safe use of pesticides such as correct timing, proper disposal and use of protective clothing compared to non-clinic users. According to key informants disposal of empty pesticide containers has been mainly by throwing them away along with regular household garbage or throwing into pit latrines but the trend is changing because of exposure provided in the plant clinics. There was an increase in knowledge of pre-harvest and re-entry interval amongst the plant clinic users. Before visiting a plant clinic 33% of the households were aware of re-entry intervals. After visiting the plant clinics awareness increased to 74%. There was a positive and statistically significant relationship between wearing of protective clothing and visit to the plant clinic ($p<0.01$). These results reconfirm that plant clinic attendance and advice has direct correlation with the use of protective clothing and by implication safe use of pesticides. Farmers have a favourable intention towards pesticide use as occasioned by information obtained from plant clinics.

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