Plant clinic session in Kikuyu district in Kenya

ECOLOGY | RESEARCH ARTICLE

Farmer participation and motivation for repeat plant clinic use: Implications for delivery of plant health advice in Kenya

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Farmer participation and motivation for repeat plant clinic use: Implications for delivery of plant health advice in Kenya

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Abstract: Plant clinics have been widely established in developing countries as a novel extension approach that provides demand driven plant health advice to smallholder farmers. This paper assesses farmer participation and motivation for repeat plant clinic use, and influence on pest management adoption decisions in Kenya. Cross-sectional farm-level data were collected from 259 farm households categorised as: none, one-time and repeat plant clinic users. Mixed multinomial logistic and multivariate logit regression models were used to jointly analyse farmer participation, and decisions to take-up pest management recommendations. Results showed that participation at plant clinics is motivated by farmers’ perceived value or success of the recommendations given, the main reason given by farmers who repeatedly visited plant clinics. Non-clinic users (33%) lacked awareness, while one-time users (26%) adapted previous advice to other pests/crops thus found no reason to return. Clinic users embraced rational pesticide use and integrated pest management; an impact of plant clinics in terms of pesticide risk reduction, despite the increasing pest burden. More advocacy and farmer awareness are needed to ensure plant clinics turn into well-known institutions providing sustainable plant health advice in the country.

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PUBLIC INTEREST STATEMENT
Smallholder farmers in Kenya are vulnerable to plant pests and diseases, affecting crop yields. CABI-led Plantwise programme and Ministry of Agriculture Livestock and Fisheries established plant clinics to provide plant health advice to farmers. Currently, there are 320 plant clinics spread in 20 counties, though monitoring data shows low utilisation by farmers. This study showed that participation at plant clinics is motivated by farmers’ perceived value or success of the recommendations given, the main reason given by farmers who repeatedly visited plant clinics. Non-clinic users (33%) lacked awareness, while one-time users (26%) adapted previous advice to other pests/crops thus found no reason to return. Clinic users embraced rational pesticide use and integrated pest management; an impact of plant clinics in terms of pesticide risk reduction, despite the increasing pest burden. More advocacy and farmer awareness are needed to ensure plant clinics turn into well-known institutions providing sustainable plant health advice in the country.
one-time users (26%) indicated that they adapted previous advice to other pests/crops thus found no reason to return. Pest management was dominated by pesticide use, which was also the predominant recommendation at plant clinics—considering that farmers mostly presented already diseased plants. At least 34% and 28% of repeat and one-time clinic users, respectively, embraced rational pesticide use and integrated cultural practices for pest control. Model results showed higher likelihood of adoption of a combination of pesticide and cultural practices by repeat clinic users than one-time and non-users, an indication of the impact of plant clinics on pesticide risk reduction through encouraging IPM practices. More advocacy and farmer awareness are needed to ensure plant clinics turn into well-known institutions providing sustainable plant health advice in the country.

Subjects: Environment & Agriculture; Pest Management; Development Communication

Keywords: adoption; integrated pest management; mixed multinomial logistic regression; multivariate logit model; pesticides

1. Introduction

Productivity of crops grown for human consumption is faced with a plethora of risks. Biological and environmental risks have been rated among the most important ones in agriculture, leading to the reduction of crop performance and resulting in a lower yield than the site-specific attainable yield. While environmental factors e.g., lack or excess water in the growth season, extreme temperatures, high or low irradiance can be controlled, biotic stressors (pests, diseases and weeds) have the potential to reduce crop production substantially (Oerke, 2005). Dhaliwal et al. (2007) report that food crops of the world are damaged by more than 10,000 species of insects, 30,000 species of weeds and 100,000 diseases, and 1,000 species of nematodes. On a global scale, Oerke et al. (1994) estimated total losses in principal food and cash crops due to all categories of pests at 42.1%. In Africa, yield losses due to insects are estimated to be between 30% and 60% (Oerke, 2006). In addition, parasitic weeds particularly Striga hermonthica, cause tremendous yield losses to cereal crops such as sorghum, maize, millet, and rice (Rich & Ejeta, 2008). Similarly, crop yield losses due to invasive and migratory pests have been estimated in the range of 20–50% of crop production (Early et al., 2018; Pratt et al., 2017).

Crop losses may be prevented, or reduced, by effective crop protection measures. Several measures have been developed by the scientific community, but principally Integrated Pest Management as the basis for sustainable agriculture intensification (EPA, 2018). It is based on the principle of producing economically, giving priority to ecological safe methods of crop cultivation, minimizing the undesirable side effects and use of crop protection products. However, actual crop protection depends on farmers’ knowledge and attitude towards pest management, and the availability of crop protection methods (McLeod et al., 2015; Oerke, 2006). This underscores the need for farmers to access timely advice and actionable information on pests that affect their crops, including emerging invasive species.

Traditionally, advisory services have been delivered through a public extension system employing a cadre of extension agents undertaking training and visit (T&V) activities. This system is however increasingly being criticised due to multiple resource constraints, high costs of undertaking extension, lack of research and appropriate extension methods, and failure to adapt to meet the needs of smallholder farmers in an era of rapid marketization (Chowa et al., 2013; Davidson & Ahmad, 2003; Moyo & Salawu, 2018). In addition, staff skills and capacity to particularly provide advice on emerging pest problems is limited, amidst lack of (re)training programs. Over the past decade, there has been a general shift in thinking about extension services toward...
supporting pluralistic provision of services that are more responsive to farmer demand (Garforth, 2011).

Plantwise plant clinics are a novel approach that provides demand driven advice to farmers to deal with pests and diseases affecting their crop production. In contrast to most forms of extension where the extension worker initiates interaction with farmers, for plant clinics, farmers usually take initiative and approach the clinics to seek advice (Boa et al., 2016). Plant clinics have been established in many developing countries, are locally owned and based on a similar approach to human health clinics, providing diagnosis and management advice for any problem and any crop (Ghiasi et al., 2017; Bentley et al., 2007). Plant clinics serve as the first interface between the farmer and the extension officer, referred to in this case as the “plant doctor”. Plant doctors are Government or private extension personnel who undergo further tailored training by CABI on how to diagnose plant health problems using visual symptoms and give advice as written recommendations based on integrated pest management (IPM) principles. Since they deal with various crops and problems, advice given at plant clinics is usually diverse (Danielsen et al., 2013). Plant clinics are reinforced by the Plantwise Knowledge bank (https://www.plantwise.org/KnowledgeBank/home.aspx), an interactive website that is available both online and offline, with information on pest diagnosis, pest management, and distribution data for more than 2,500 key pests. At the plant clinic, farmers bring in “sick” plants and a plant doctor diagnoses the problem and gives a recommendation on management. Data regarding the farmer, the problem presented at the clinic, and the recommendation given are entered into either a paper-based prescription form or onto a tablet computer, which details are then fed into a database called Plantwise Online Management Systems (POMS) (Plantwise strategy 2015–2020). Plant clinic data is useful among others in; supporting pest surveillance and alerts, monitoring performance of plant doctors to identify knowledge gaps and training needs, partners and CABI’s internal reporting, identifying extension and research needs and priorities, testing observed indigenous concepts, and monitoring pesticide recommendations by advisory staff.

In Kenya, Plantwise was officially launched in May 2012 after a successful 2-year piloting phase implemented from 2010 to 2011. Currently (March 2020) there are 300 plant clinics spread across 20 counties with more than 550 plant doctors trained to man the clinics. To improve access to information on crop protection, communication amongst actors in plant health services and efficiency in data flow to the Knowledge bank, all plant clinics in Kenya are now equipped with tablet computers. Analysis of POMS data in October 2017 showed that 61,370 queries from 42,283 farmers, for over 50 crops were logged in the system. Results also showed an increasing number of farmers repeatedly using plant clinics, and an equally large number of farmers who only made one visit and did not return to the plant clinic. It is not clear why farmers drop out, and the motivations for repeat plant clinic use/visits. This study therefore assessed; (1) individual farmer participation at plant clinics and motivation for repeat plant clinic use/visits, (2) nature of plant health advice farmers received at plant clinics, and (3) adoption decisions of individual farmers on plant health advice given at plant clinics, in particular sustainable management practices as a key expected outcome of farmer participation at plant clinics. The study contributes to literature on farmer participation in extension programs and adoption of innovations in plant health. The results are also useful for guiding future clinic operations as well as adjustments required for delivery of sustainable plant health advice at the local and national levels.

2. Materials and methods

2.1. Study areas and samples
The study was undertaken in two counties—Nyeri in Central and, Trans Nzoia in Western Kenya. Trans Nzoia County represent a mixed farming system and is a major agricultural area for Kenya. It is covered by three main agro-ecological zones; Upper humid, Upper midland and Tropical alpine zones (GoK, 2019). Rainfall is bimodal with two peaks in April and September. Nyeri on the other
hand, is dominated by cash crop farming (mainly coffee). Rainfall is bimodal, with the long rains expected between March and May, and short rains between October and December (GoK, 2016).

Selection of enumeration areas was based on plant clinic operations and frequency of farmer participation, and pest queries as recorded in the Plantwise Online Management System (POMS). POMS contains data on plant clinic location, farmer participation, pest problems presented at plant clinics and recommendations given to farmers for respective pest problems. Selected study locations had at least 200 farmer records and more than 100 repeat plant clinic users. The study also aimed to capture variation in farming systems, biophysical characteristics and access to markets, which are assumed to affect farmer participation at plant clinics as well as access and utilisation of recommended practices, thus the selection of the two contrasting agro-ecologies.

Respondents comprised farmers who had participated in plant clinic sessions either once or repeatedly. Sample size was to a great extent dictated by the number of farmers in each category according to POMS, though care was taken to ensure a high enough sample for statistical significance. For comparison purposes, farmers who had not participated at all in plant clinics were also sampled. Selection of respondents was facilitated by extension workers and plant doctors in the respective locations. A total of 259 farm households were interviewed in the two counties during October 2017 (Table 1).

2.2. Conceptual underpinning

The contribution of plant clinics is to provide sustainable plant health advice to farmers, contributing in the long run to increased crop production (or reduction in crop losses due to pests) at farm level. This logic is based on the fact that farmers seek advice on crop pest and disease management, which they implement appropriately to reduce losses associated with pests and diseases. Farmers participating at plant clinics at any one time could either be first time or repeat users seeking information to manage crop pests and diseases. Repeat users may present new or recurrent problems on the same crops or different crops. Repeat use of plant clinics by farmers may imply the trust they have in clinic recommendations and are therefore willing to return for advice. This trust may also translate to higher probability of adoption of recommendations given at plant clinics as well as enhanced information sharing within farmer networks. Recurrent problems may imply that recommendations provided earlier were not effective so farmers are seeking alternative recommendations or they did not effectively implement the recommendations due to various other factors e.g., cost, perceived benefit, timing, or opportunity cost of recommendation. On the other hand, one-time users not returning to the plant clinic may imply the perceived relevance of plant clinic advice, or pest problem was solved with recommendation received and the farmer did not need to return, or they may have other support structures e.g., family, neighbours who share the required information. It is important to understand farmers’ motivation to participate in plant clinics and how they make decisions to adopt recommended practices.

| Table 1. Distribution of study respondents (#) |
|---|---|---|---|
| Variable | Category | Trans Nzoia | Nyeri | Total |
| Sub-County | Trans Nzoia East | 74 | 0 | 74 |
| | Trans Nzoia West | 44 | 0 | 44 |
| Clinic user | Mukurweini | 0 | 141 | 141 |
| Gender | Male | 75 | 83 | 158 |
| | Female | 43 | 58 | 101 |
| Total respondents | Total | 118 | 141 | 259 |
2.3. Model specification

Farmers’ decisions to participate in agricultural extension programs and adopt technologies are based on their autonomous motivation (Suvedi et al., 2017). Autonomous motivation relates to an individual’s inherent behaviour or motivation (Ryan et al., 2008). Some studies have explored factors associated with such participation at the grass-roots (Barham et al., 2015; Gido et al., 2015; Meijer et al., 2015; Mwangi & Kariuki, 2015; Ochieng et al., 2017; Suvedi et al., 2017). However, such behaviours vary based on context, nature of technology, and accessibility. This study explores farmers’ motivation to participate at plant clinics and adopt related plant health management practices.

Following Asfaw et al. (2012), this study analyses participation and technology adoption using a random utility framework model. The model is based on the premise that a farmer chooses to participate in a program or use a technology if the utility gained is greater than the utility associated with non-participation or non-adoption. A common modelling framework to analyse program participation under this framework is a binary choice model specification. In this study, participation at plant clinics was grouped into three categories—none (never used plant clinics), one-time (used plant clinic only once) and repeat use (used plant clinic more than once). Given that the dependent variable is nominal with more than two categories, a mixed multinomial logistic (MMNL) regression model that accounts for heterogeneity in individual preferences (Bliemer & Rose, 2010) was estimated. MMNL models comprise multi-equations which allow considerations of several discrete alternatives at the same time. The probability of a farmer’s choice to participate in plant clinics, can be expressed as in Equation (1) (Greene, 2003):

\[ P_{ij} = \frac{e^{\mathbf{X}_i \beta_j}}{\sum_{j=1}^3 e^{\mathbf{X}_i \beta_j}}, \quad \text{for } j = 1 \ldots 3 \]  

(1)

Where \( P_{ij} \) is the probability representing the \( i \)th farmer’s chance of participating at a plant clinic \( j \), \( \mathbf{X}_i \) represents a set of explanatory variables, \( e \) is the natural base of logarithms, and \( \beta_j \) are the parameters to be estimated by maximum likelihood estimator (MLE). The estimated equations provide a set of probabilities for the \( j+1 \) choice for a decision maker with \( \mathbf{X}_i \) characteristics. For identification of the model, there is need to normalize by assuming \( \beta_0 = 0 \). Thus, the probabilities are given by Equations (2) and (3):

\[ \text{Prob. } (Y_i = j | \mathbf{X}_i) = P_{ij} = \frac{e^{\mathbf{X}_i \beta_j}}{\sum_{j=1}^3 e^{\mathbf{X}_i \beta_j}}, \quad \text{for } j > 1 \]  

(2)

\[ \text{Prob. } (Y_i = 1 | \mathbf{X}_i) = P_{1j} = \frac{1}{1 + \sum_{j=2}^3 e^{\mathbf{X}_i \beta_j}}, \quad \text{for } j > 1 \]  

(3)

The marginal effects of explanatory variables on the probabilities are specified as:

\[ \Delta j = \frac{\delta P_{ij}}{\delta \mathbf{X}_i} = P_j \left[ \beta_j - \sum_{j=0} P_j \beta_j \right] = P_j \left[ \beta_j - \beta^* \right] \]  

(4)

In these models the log odds of participation are modelled as a linear combination of the explanatory variables. The analysis assumes independence of the dependent variable, i.e. a farmers’ category of participation at plant clinics—none, once or repeat—is not related to another category. The assumption of independence was tested with the Hausman-McFadden test.

For technology adoption, farmers receive information on various management options, based on crops and pest problems presented at plant clinics. Thus, their adoption decisions are inherently multivariate. In general, past studies of technology adoption have focused on either a single new technology or on a set of new technologies considered as a single unit (e.g., integrated pest management) (Kansiime & Mastenbroek, 2016; Rahmana et al., 2018). Univariate modelling excludes useful economic information contained in inter-dependent and
simultaneous adoption decisions by farmers. The adoption decisions in question relate to pest management techniques employed by various farmers participating or not, at plant clinics. Technology adoption is treated as a discrete decision, resulting in the choice variable being qualitative in nature (although it is recognized that some technologies can be adopted on part of a farmer’s acreage). Thus, farmers’ choice of interrelated pest management practices is modelled using a multivariate logit model.

In general terms, the expected utility, conditional on adoption of a particular technology bundle can be represented by \( U(T_i, z) \) where \( T_i \) denotes the \( i \)th technology bundle and \( z \) is a vector of farm, farmer and market characteristics. The farmer’s choice decision is thus represented as (Equation (5)):

\[
\text{Choose} T_i; T_i = \text{argmax} \{ U(T_i, z) \}, i = 0, 1, \ldots, s
\]

In this study, practice zero will represent adoption of none of the measures; the \( s \)th bundle will represent adoption of all possible crop protection measures. Farmer crop protection measures were largely categorised as; pesticide use and cultural practices. We did not encounter farmers using biological control measures. Pesticides included all instances where farmers used synthetic chemicals e.g., insecticides, fungicides and herbicides for pest control. Cultural practices on the other hand encompass a range of production practices that reduce the likelihood of pest infestation and damage to crops e.g., resistant varieties, field sanitation, early planting, crop rotation etc. Technology bundles were therefore; (i) none (no pest management practice used), (ii) pesticide use only, (iii) cultural practices only, and (iv) pesticide use + cultural practices.

The independent variables included; sex and age of respondent, off farm labour by farm operator, operator education level, size of land (acres) cultivated, access to credit, and perception of pest pressure. We also included variables for participation at the plant clinic which is expected to affect farmers’ knowledge and therefore decision to adopt certain crop protection measures. Selection and narrowing of variables was based on findings from the economic theory of adoption decisions (Feder et al., 1990) and results of previous empirical studies on farmer participation in agricultural programs and adoption (Kansiime & Mastenbroek, 2016; Meijer et al., 2015; Mwangi & Kariuki, 2015; Suvedi et al., 2017). The study did not assess yield levels associated with implementing pest management practices due to a diversity of crops grown by farmers and partial implementation of technologies (technologies being adopted on part of a farmer’s acreage).

2.4. Data collection and analysis

Qualitative and quantitative data were collected using a structured questionnaire. Data collection was done electronically on tablets through face to face interviews. The tablets were pre-loaded with the survey questionnaire designed in open data kit (ODK). The data collection application had in-built range and consistency checks to ensure good quality data. Data collection was facilitated by a team of trained enumerators. Consent was sought from each household head or primary respondent before the interview was conducted.

Farmers were interviewed to assess pest situations, knowledge of pest management practices, information sources on pest management practices, and application of clinic recommendations where applicable. Their participation at plant clinics and motivation for repeat visits, or their lack of participation for those that did not use plant clinics was also assessed. Data were downloaded from ODK as csv files and exported to STATA for analysis. Descriptive analysis was done by calculating frequencies, means, and standard errors. Chi-square tests were used to compare significance of categorical variables between farmer categories by age and gender. Mixed multinomial logistic and multivariate logit regression models were used to simultaneously model factors affecting farmer participation at plant clinics and adoption decisions for various crop protection measures.
3. Results

3.1. Descriptive statistics
Across the study counties, crop farming was the most common activity, and more than 90% of respondents depended on crop farming for their livelihood. Crop farming was dominated by maize cultivation, coffee, banana and vegetables. Respondents were generally old farmers averaging 53 years of age, majority of who were men (60%). More than half of the respondents had secondary education and above. This represents a fairly well-educated farmer population. Average land size in the study area was 4 acres (Table 2). Cultivated land was approximately 2.7 acres, accounting for 68% of land owned by households. On average, interviewed farmers lived within a radius of 2.6 km from the plant clinics. Repeat clinic users had larger farm sizes compared to other farmers.

3.2. Crop pest problems, interventions and source of advice
The majority (93%) of farmers reported having experienced pest problems on their key crops in the previous season. More clinic users (99%) reported pest problems on their crops compared to one-time users (91%) and non-users (88%). The most common pest problems encountered were; caterpillars on the plant, frass outside the fruit or leaves, drying of leaves, and brown patches on leaves (Table 3). Repeat clinic users reported more pest problems (average 2.1) compared to 1.8 and 1.7 for non-clinic and one-time clinic users respectively.

Pest problems were mainly reported for maize, coffee, kales and common bean (Table 4). These represent the most commonly grown crops in the study locations. The most common crops grown by the farmers (maize, coffee and kale) were also among the top six crops presented at the plant clinics according to plant clinic data in POMS. Caterpillars and frass were mainly observed on

| Table 2. Respondent characteristics |
|-------------------------------------|
| None clinic users | One-time clinic users | Repeat clinic users | Combined sample |
|-------------------|----------------------|---------------------|-----------------|
| Sex of respondent (male = 1)      | 0.54 (0.07)          | 0.67 (0.07)         | 0.70 (0.05)     | 0.64 (0.04) |
| Age of respondent (years)         | 50.74 (2.25)         | 55.76 (2.27)        | 53.23 (1.28)    | 53.11 (1.07) |
| No formal education (yes = 1)     | 0.06 (0.03)          | 0.07 (0.04)         | 0.03 (0.02)     | 0.05 (0.02)  |
| Primary education (yes = 1)       | 0.44 (0.07)          | 0.40 (0.07)         | 0.30 (0.05)     | 0.37 (0.04)  |
| Secondary education (yes = 1)     | 0.37 (0.07)          | 0.38 (0.07)         | 0.44 (0.06)     | 0.40 (0.04)  |
| Tertiary education (yes = 1)      | 0.13 (0.05)          | 0.16 (0.05)         | 0.23 (0.05)     | 0.18 (0.03)  |
| Distance to plant clinic (km)      | N/A                  | 2.62 (0.44)         | 2.80 (0.37)     | 2.64 (0.21)  |
| Av. land size (acres)             | 4.22 (0.90)          | 3.38 (0.78)         | 4.23 (0.53)     | 4.01 (0.41)  |
| Cultivated land (acres)           | 2.62 (0.61)          | 1.88 (0.26)         | 3.11 (0.42)     | 2.65 (0.27)  |
| Off farm income (Yes = 1)         | 0.11 (0.04)          | 0.16 (0.05)         | 0.10 (0.04)     | 0.12 (0.02)  |
| Access to credit (yes = 1)        | 0.59 (0.07)          | 0.64 (0.07)         | 0.70 (0.05)     | 0.65 (0.04)  |

Figures in parentheses are standard error.
Table 3. Most common problems encountered by farmers

| Pest/symptom of problem | Non-clinic users | One-time clinic users | Repeat clinic users | Combined sample |
|-------------------------|------------------|-----------------------|---------------------|-----------------|
| Caterpillars on the plant | 49               | 56                    | 72                  | 60              |
| Frass outside the fruit or leaves | 29               | 30                    | 37                  | 32              |
| Drying of leaves/drying of plant | 20               | 19                    | 32                  | 25              |
| Brown patches on leaves | 12               | 15                    | 25                  | 18              |
| Wilting of leaves | 6               | 11                    | 20                  | 14              |
| Leaves curling/shrinking/rolling | 12               | 8                     | 17                  | 14              |
| Fruit abortion | 9               | 11                    | 12                  | 11              |
| Holes on fruits | 3               | 4                     | 17                  | 9               |
| Stunted growth | 6               | 8                     | 5                   | 5               |
| Spider webs | 0               | 0                     | 10                  | 4               |
| Rotting stem | 3               | 4                     | 7                   | 4               |
| Mould under the leaves | 0               | 4                     | 5                   | 2               |
| Transparent marks on the leaves | 3               | 0                     | 0                   | 2               |
| Pest pressure (# of pests reported/season) | 1.8             | 1.7                   | 2.1                 | 1.9             |

Table 4. Common pest problems by crop

| Pest problem | Maize | Coffee | Banana | Kales | Beans | Cabbage | Tomato |
|--------------|-------|--------|--------|-------|-------|---------|--------|
| Caterpillars | 84    | 6      | –      | –     | –     | 4       | 1      |
| Frass on fruit/leaves | 90    | 6      | –      | –     | 3     | –       | –      |
| Drying of leaves | 8     | 43     | –      | 3     | 3     | 8       | 8      |
| Brown patches on leaves | 15    | 25     | 5      | 10    | 10    | 15      | 8      |
| Leaves curling/shrinking/rolling | –     | 17     | –      | 28    | 22    | –       | 6      |
| Wilting of leaves | 15    | 15     | 4      | 8     | –     | 4       | 27     |
| Fruit abortion | –     | 42     | –      | –     | –     | –       | 17     |
| Holes on fruits/grain | 16    | 20     | –      | 4     | 4     | 12      | 8      |
| Stunted growth | 25    | –      | 13     | –     | 13    | 25      | –      |
| Spider webs | –    | 9      | –      | 27    | 36    | –       | 9      |
| Rotting stem | –    | –      | 23     | 15    | 23    | 23      | 8      |
maize, while drying of leaves and patches on leaves symptoms were mainly observed on coffee. These symptoms correspond to the main pest queries in POMS as diagnosed by plant doctors. The main pest queries for maize were fall armyworm, maize lethal necrosis disease and stalk borer, which characteristically represent farmers’ observations of key pest problems/symptoms. Other key pest queries in POMS were; coffee leaf rust and coffee berry disease for coffee; aphids for beans and kales; Fusarium wilt of bananas; and tomato leaf miner (*Tuta absoluta*), bacterial wilt and late blight of tomatoes.

Farmers employed various methods for management of observed pest problems. Pesticide use (67% of farmers) was the most common measure for management of key pests. Cultural practices were also used and included; removal and destruction of crop residues affected by pests, intercropping, planting resistant varieties and application of ash/soil to the maize whorl for control of caterpillars. More repeat clinic users implemented one or more pest management practices compared to one-time and non-clinic users (Figure 1). Proportionately more repeat clinic users reported increasing trend in pesticide use on their farm, compared to one-time and non-users of plant clinics.

Farmers’ sources of pest management advice and other advisory services were varied (Table 5). Plant clinics were reported as the most common source of agricultural information, followed by radio programmes, neighbours/relatives, and government extension agents. Farmers who did not participate in plant clinic sessions relied to a great extent on own experience, and community knowledge exchange. Agricultural trade fairs and demonstration plots were more likely to be attended by repeat clinic users compared to the rest of the farmers.

When asked about their preferred information sources, 86% and 72% of repeat plant clinic users and one-time users respectively mentioned plant clinics as the most preferred source of information. The reasons farmers gave for preferring plant clinics/plant doctor advice were; I trust information from this source (85%), I can ask for further explanation (83%), and information is easy to understand (57%). Other reasons given were; timeliness, and completeness of information given. Non-plant clinic users on the other hand, mentioned government extension as the most preferred of their available information sources, despite the limited reach (36% of the farmers accessed government extension). The reasons for their preference were similar to those given by plant clinic users. It is evident that farmers prefer formal information sources, implying the need to downscale formal extension services.

### 3.3. Farmer participation at plant clinics and motivation for repeat use

This study included three categories of farmers—never used plant clinics, used plant clinics only once, and repeatedly used clinics. One-time users had interacted with the clinics since 2016, an average of 1.6 years, while repeat farmers had more than 3 years’ experience with plant clinics. Not surprising, majority of farmers (87%) who used plant clinics did so when they detected a pest/disease problem on their farms.
Pest management advice obtained from plant clinics was mainly on use of pesticides (64%) (Figure 2). This also corresponds to the practices farmers reported to have applied in the previous season that were dominated by pesticide use. Cultural practices, particularly field sanitation, crop rotation and soil fertility management constituted 36% of recommendations from plant clinics.

When asked if their approach to pest management had changed since they interacted with plant clinics, a majority of farmers indicated that they only used pesticides upon prescription by the plant doctors or a technical person, as opposed to using own knowledge. This is despite the awakened increase in pest pressure due to outbreaks that have contributed to increased pesticide use on field crops. Farmers also mentioned rational use of pesticides and changing the type of...
pesticides to use less harmful chemical ingredients. A small proportion of farmers mentioned use of IPM methods and organic pesticides, including home-made plant extracts. Farmers who participated at plant clinics embraced sustainable pesticide use and integrated pest management practices—34% for repeat farmers and 28% for one-time clinic users (Figure 3).

When asked about motivation for repeat plant clinic use or visit, the main reasons given by farmers were to seek more clarification on certain recommendations (50%) and to bring a different crop/problem following success of a previous recommendation (41%) (Table 6). The main reasons for one-time clinic users were that the recommendation worked and therefore farmer adapted it for other crops, and the farmer did not get the problem again and so did not come back to the clinic. Those who did not use plant clinics, on the other hand, was purely due to lack of awareness of existence of plant clinics.

3.4. Factors affecting farmers’ participation at plant clinics
Regression of factors affecting farmers’ participation at plant clinics is presented in Table 7. The likelihood ratio (LR) chi-square statistics, probability chi-square, and pseudo R-square values indicate that model specification provides a reasonably good fit of the data. From the results, the coefficient for age of respondent is positive and significant for both one time and repeat clinic

![Figure 3. Trend in pest management practices by farmers (PD = Plant doctor).](image-url)

| Clinic participation | Reason                                      | Percent |
|----------------------|---------------------------------------------|---------|
| Repeat use/visit     | To seek more clarification on recommendations | 50      |
|                      | Previous recommendation(s) worked and I brought a different problem | 41      |
|                      | The pest problem is recurrent on my farm     | 4       |
|                      | I did not implement the recommendation(s) the first time | 1       |
| One-time use/visit   | Recommendation worked and I adapted it to other crops | 43      |
|                      | Did not get the pest problem again           | 34      |
|                      | No longer grows the crop for which I had sought advice | 6       |
|                      | Plant clinic is too far                      | 4       |
users in comparison to those who did not use plant clinics. This implies that older farmers were more likely to participate in plant clinics compared to young ones. Lack of formal education also showed significant effect on clinic participation albeit negative. This implies that farmers with no formal education were less likely to participate at plant clinics compared to those with higher education. The results also showed that distance to plant clinic is associated with negative effect on participation for one-time clinic users and not repeat users in comparison to non-participants.

3.5. Farmer adoption decisions of pest management practices

Table 8 shows parameter estimates of the multivariate logit model of adoption of pest management practices. The base category is non-adoption against which results are compared. The model fits the data very well with the Wald test, $\chi^2 = 1246.71$; $P > \chi^2 = 0.000$ implying that the null hypothesis that all the regression coefficients are jointly equal to zero is rejected.

Results show that higher pest pressure was more likely to lead to adoption of cultural pest management practices. Farm size was positively associated with pesticide use, implying that farmers with bigger farms were more likely to use pesticides compared to those with small farms. Off farm income positively predicted adoption of all pest management packages. Sex and age of respondents were negatively associated with probability of adopting pesticides and cultural measures, respectively. This implies that women and older farmers were more likely not to apply any pest management practices compared to other farmer categories.

Model results with respect to clinic participation show that repeat participation at plant clinic was likely to result in adoption of pesticide use for pest control, and a combination of pesticides and cultural practices. This is linked to recommendations obtained from plant clinics that showed higher proportion of recommendations on pesticide use. Plant clinics by their design are expected to give IPM based management practices—both preventive and control—thus it is logical that farmers participating at plant clinics were more likely to implement cultural practices as well, in addition to pesticide use.
4. Discussion

This study assesses farmers’ participation at plant clinics, motivation for repeat use/visits, and effect on pest management adoption decisions. Farmers showed awareness of pest problems on their crops, particularly reported on maize, coffee, and kales, which also represent the most popularly grown crops in the study locations. Farmers described pest problems by symptoms. Comparisons with plant clinic data from the region linked some of the symptom descriptions to certain common pests of the crops—fall armyworm on maize, coffee leaf rust on coffee, aphids and spider mites on kales. Frequent clinic users reported more pest problems compared to one-time and non-clinic users. This may be due to the fact that repeat clinic users were more knowledgeable and could better identify pest problems than the other farmers. Other findings comparing plant clinic users and non-users showed that clinic users were more aware of their pest problems and therefore more likely to act (Musebe et al. 2018).

Pest management was dominated by pesticide use. This corresponds with the advice obtained from plant clinics which was mainly on pesticide use. Considering that farmers typically visit plant clinics when the pest problem has already occurred, it is logical that most of the recommendations given at the time may relate to control as opposed to prevention. However, farmers were also given advice on prevention which may be applicable in the subsequent seasons to reduce pest risk. Increased use of pesticides was also attributed to increased pest problems particularly caterpillars on maize as reported by farmers. These caterpillars were mainly as a result of invasion by the fall armyworm during the study season, against which chemicals were heavily used on maize (Rwomushana et al., 2018), a previously rarely sprayed crop. This may further explain why recommendations at the plant clinics were mainly on pesticide use. However, the inclusion of IPM-based practices and judicious pesticide use, particularly by clinic participants alludes to the value of plant clinics in providing green recommendations to farmers, despite the pressure to respond to pest burdens.

Table 8. Multivariate logit model estimates of adoption of pest management practices

| Independent variable                  | Pesticide | Cultural | Pesticide + cultural |
|---------------------------------------|-----------|----------|----------------------|
|                                       | Coef.     | Std. Err.| Coef.                | Std. Err.| Coef.         | Std. Err. |
| Clinic use/visit (yes = 1)            | 5.667**   | 2.643    | 3.082                | 2.733    | 3.738*        | 2.754     |
| Pest pressure (# of pests observed)   | −0.221    | 0.279    | 0.481*               | 0.293    | 0.328         | 0.288     |
| Area planted (acres)                  | 0.298**   | 0.154    | −0.14                | 0.248    | 0.213         | 0.181     |
| Sex of respondent (male = 1)          | −0.166**  | 0.077    | 0.012                | 0.024    | 0.03          | 0.040     |
| Age of respondent (years)             | −0.025    | 0.018    | −0.057***            | 0.023    | 0.005         | 0.036     |
| Primary activity farming (yes = 1)    | 1.104*    | 0.708    | 1.410                | 1.009    | −1.466        | 1.184     |
| Education (ordinal, none = 0)         | 0.240     | 0.236    | −0.435               | 0.351    | −0.319        | 0.303     |
| Access to credit (yes = 1)            | 0.139     | 0.444    | −0.540               | 0.611    | 0.767         | 0.922     |
| Off farm income (yes = 1)             | 15.697*** | 0.707    | 16.614***            | 0.871    | 1.122*        | 0.694     |
| Constant                              | 0.876     | 1.451    | 1.939                | 1.738    | −1.138        | 3.022     |
| Number of observations                | 176       |          |                      |          |               |           |
| Wald chi²(27)                         | 1246.71   |          |                      |          |               |           |
| Prob>chi²                             | 0.000     |          |                      |          |               |           |
| Pseudo R²                             | 0.276     |          |                      |          |               |           |
| Log pseudo likelihood                 | −133.39   |          |                      |          |               |           |

Base category—Did not apply anything
Significance: ***<0.001, **< 0.05, *< 0.1.
Farmers received plant health advice from various sources. Those who participated at plant clinics rated it as their most preferred source of information, based on trustworthiness of information, clarity of recommendations and availability of an opportunity for further consultation. Repeat plant clinic users were motivated to use plant clinics in order to seek more clarification, and present a new problem following success of previous recommendation. Similarly, Ghiasi et al. (2017) reported that farmers willingness to use the plant clinics was in part based on service relevance, usefulness and familiarity with plant clinic services. Besides, other studies have showed that plant clinics have potential to make large contributions to farmers’ earnings (Bentley et al., 2011), a further motivation for farmers to make repeated visits.

Socio-economic characteristics affecting farmers’ participation at plant clinics included age of farmer, education level and distance to plant clinic. More educated farmers were more likely to participate at plant clinics. This is possibly because more educated farmers can better process information. Similar results were reported by other researchers (Feleke & Zegeye, 2006) suggesting that participation in extension programmes depends on decision maker’s education level. Results also show that older farmers were more likely to participate in plant clinics compared to younger ones. This result is contrary to Suvedi et al. (2017) who shows a reduced likelihood of farmer participation in agricultural extension activities as they get older. On the other hand, distance to plant clinics was associated with negative effect on participation for one-time clinic users, and not repeat users in comparison to those who never used plant clinics at all. Traveling to plant clinics could be associated with the opportunity cost of time, thus discouraging participation at plant clinics. It is however interesting that for repeat farmers, this was not the case. This can be explained by the fact that a number of farmers who recorded repeated use of plant clinics also indicated that they sought advice from plant doctors on phone or plant doctor visiting their farms on request as opposed to the common practice of attending plant clinic sessions. This suggests the need for plant doctors to deliver advisory services within farming communities to increase farmers’ participation. Where repeat plant clinic visits were common despite the long distance, further studies may be needed to assess what the optimal clinic distribution would be. While some studies have shown a higher male to female ratio among plant clinic users (Karubanga et al., 2017), this study shows that men were less likely to participate at plant clinics compared to women. This implies that plant clinics are responsive to farmer needs irrespective of gender, although participation may be constrained by institutional or socio-cultural impediments, similar to studies by Achandi et al. (2018).

Farmer decisions to adopt pest management measures were influenced by various socio-economic characteristics. Farm size was positively associated with pesticide use, implying that farmers with bigger farms were more likely to use pesticides compared to those with small farms. Hu et al. (2019) report similar results, where farmers with larger farm sizes are more likely to spend money on technology and pursuit of knowledge. Farmer perception of pest pressure was associated with high likelihood of adoption of cultural pest management practices. This could be related to economics of pesticide use once there is heavy pest pressure, on small and segmented plots, characteristic of most farming households in the study location. Off farm income positively predicted adoption of all pest management packages. This is contrary to some studies that have shown a negative relationship between off farm activity and technology adoption on farm (Dorfman, 1996). In this case, pest management requires a farmer to invest in technologies that may be costly, thus access to alternative income acts as a buffer against production risks helping a farmer to invest in production. Sex and age of respondents were negatively associated with probability of adopting pesticides and cultural measures, respectively. This implies that women and older farmers were less likely to apply any pest management practices compared to other farmer categories. Participation at plant clinics showed positive effect on adoption of pesticide use, and a combination of pesticides and cultural practices. This implies that farmers participating at plant clinics were more likely to adopt sustainable pest management practices compared to those who did not. Other studies reported contribution of plant clinics to adoption of technologies (Ghiasi et al., 2017; Bentley et al., 2011).
However, considering the fact that within the sampled communities, some farm households had not interacted with plant clinics due to lack of awareness, points to the need for wide spread advertisement of the plant clinics so that they can turn into well-known institutions providing plant health advice in their communities. This study also notes that while the current model of plant clinics is based on farmer demand (as opposed to traditional extension approaches that are supply driven), some scholars have indicated that farmers are not specifically interested in participating (Mosse, 2005). A review of the demand-driven extension system in Uganda showed similar results of poor farmer participation and evasion of ownership (Parkinson, 2009). This may further explain the lack of participation, which calls for long term capacity building of farmers to harness the benefits of plant clinics in providing sustainable demand-driven advice. Lastly, the scope of plant clinics currently focuses on diagnosis and provision of recommendations, based on a diseased plant presented at the clinic. This specificity in service delivery has been linked to high positive impacts (Bentley et al., 2011), though this study finds it limiting in terms of sustainable pest management as most of the recommendations turn out to be curative (addressing an existing problem), rather than preventive. Recommendations given for next season may not always be implemented due to the time lag between seasons. This calls for an adjustment in the scope of plant clinics, as well as in the advertising to emphasise their role in providing integrated pest management advice.

5. Conclusion
This study shows evidence of value of plant clinics to rural farming communities in delivering actionable plant health advice, by comparing farmer participation and uptake of recommendations. Plant clinics are implemented under the Plantwise programme, with an approach that aims to deal with pest and disease problems in all crops, delivered by a cadre of trained extension workers known as plant doctors. Interviewed farmers were aware of pest problems on key crops grown in the study areas, though in most cases described them by symptoms. Comparisons with plant clinic data in POMS from the region linked some of the symptom descriptions to certain common pests—fall armyworm on maize, coffee leaf rust on coffee, aphids and spider mites on kales. Pest management was majorly by use of pesticides—a curative rather than preventive measure that was also commonly recommended at plant clinics—considering that farmers mostly presented already diseased plants. However, it is evident from the results that plant clinic users employed rational use of pesticides and integrated other cultural practices. This is an indication of the impact of plant clinics on pesticide risk reduction through encouraging the use of IPM in pest control, despite the increasing pest burden.

The majority of farmers who participated at plant clinics rated it as their most important information source on plant health. Participation at plant clinics was motivated by farmers' perceived value of the advice and as such those who made repeat visits to plant clinics either sought more clarification or brought new problems following success of previous recommendations. However, within the sampled communities, some households expressed lack of awareness of plant clinics. This calls for wide spread advertisement of the plant clinics so that they can turn into well-known institutions providing sustainable plant health advice in their communities. Farmers with no formal education and those living far from the plant clinic were less likely to participate in plant clinics, implying the need to adjust the approaches to reach such farmers e.g., through community outreach (mobile plant clinics), and improving prescriptions to make them understandable even to less literate farmers. Increasing density of fixed plant clinics can improve farmer participation, but this should be informed by research on optimal clinic distribution.

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