# Do farmers adopt advice on good pesticide practices? A case study of plant doctor recommended pesticide use in maize and tomato production

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## Summary

Pesticides are now widely used to manage the recent outbreak of crop pests such as fall armyworm (*Spodoptera frugiperda*, FAW) and *Phthorimaea absoluta* (syn. *Tuta absoluta*). However, reports on farmers' pesticide use practices are often insufficient. Hence, this study aimed to assess how Kenyan maize and tomato farmers' use of pesticides aligns with plant doctor recommendations. We collected data from 600 randomly selected maize and tomato farmers (clinic users and non-clinic users) using a pre-tested structured questionnaire and key informant interviews with plant doctors and extension officers. Results suggest farmer practices matched plant doctor recommendations in over 80% of clinic users' cases. However, there were significant differences in recommended pesticide use and actual practices between

plant clinic users and non-plant clinic users. Although plant clinic users were significantly more likely to wear Personal Protective Equipment (PPE) while working with pesticides, we observed inadequate PPE use among most farmers. This contributed to reported incidences of dizziness, headaches, and other acute pesticide health symptoms. Occasionally farmer practice does not match plant doctor recommendations due to the high cost of inputs, and lack of money to purchase the recommended inputs. Overall, this study shows that plant clinic participation resulted in more judicious use of pesticides and PPE wearing by farmers. The divergence in views means that there is a need to reconcile farmer actions and ideal situations through seminars, farmer field schools, barazas, and other information dissemination methods.

## Key highlights

- Farmers follow plant doctor recommendations in over 80% of cases. Where they do not, it is mostly due to a lack of money to purchase recommended inputs.
- While farmers apply suitable pesticides, they sometimes increase the strength or frequency of application, because they think this will lead to quicker pest control.
- More than 85% of plant clinic users apply pesticides at the right time of the day, compared to only about 55% of non-clinic users.
- 80% of farmers are not aware of pre-harvest intervals, and harvest and sell when the crop is in high demand. By contrast, farmers that attend plant clinics are aware of re-entry intervals and observe them.
- There were significant differences in the methods used to dispose of empty pesticide containers by plant clinic users and non-plant clinic users, and non-users tended to throw them away where they were mixing, in pit latrines, in holes dug in the farms, and by burning. This may be due to the lack of a proper mechanism to ensure farmers take empty containers to a designated place.
- The only PPE used by most farmers is gumboots. While more maize farmers who attend plant clinics use PPE, compared to those not attending them, for tomato farmers attendance at plant clinics makes no difference to PPE use.

## Context

Agriculture is essential to Kenya's economy, accounting for 60% of its foreign exchange earnings and central to food security, poverty reduction, and economic growth (Abong'o et al., 2014). Pests are a major limiting factor of agricultural productivity growth globally and in sub-Saharan Africa, in particular, where crop losses due to pests are predicted to be between 30% to 60% (Oerke, 2006; Savary et al., 2012). They contribute to considerable pre-and post-harvest losses, leading to reduced yields and incomes, threatening food security, and poverty reduction strategies (MoALFC, 2018; Pretty et al., 2015). Thus, Kenyan smallholders, particularly maize and tomato farmers, rely heavily on chemical pesticides to tackle for example, the recent outbreak of *S. frugiperda* and *P. absoluta* ravaging their farms. However, pesticide use can create non-negligible risks and hazards to the environment, and human and

animal health (Musebe et al., 2018; Ocho et al., 2016; Eyhorn et al., 2015; Maroni et al., 2006; Carvalho, 2006), often due to incorrect usage, such as using banned pesticides (Van Hoi, et al., 2009), limited use of PPE (Stadlinger et al., 2011), lack of adequate knowledge and education among farmers (Ocho et al., 2016), over-spraying (Grovermann et al., 2013), and improper handling of pesticide containers (Damalas et al., 2008), and incorrect pesticide storage.

Access to information and knowledge creation are critical drivers to achieving efficient adoption of technologies and pesticide use (Manfre et al., 2013). In agriculture, new information and knowledge fuel innovation and increase productivity and competitiveness. Farmers currently access information through a complex web of social networks that include other farmers, family members, extension agents, and input supply dealers. In Kenya, one key source of information is CABI-supported 'plant clinics', where farmers receive advice from plant doctors on appropriate control measures that are in line with integrated pest management principles (Bentley et al., 2018) based on their own demand. There are 320 plant clinics in Kenya, spread across 20 counties, with more than 550 plant doctors trained to operate the clinics (POMS, 2020). It is expected that the advice leads to more judicious use of pesticides by farmers. However, there has been little research exploring if farmers' actual practices align with plant doctors' recommendations on pesticide use.

# What we did

The objective of the study was to assess how actual farmer practices in maize and tomato production align with the recommendations on pesticide use given by plant doctors. It sought to do this by answering a number of research questions, including the following:

- What are plant doctors recommending for the management of fall armyworm (FAW) on maize and *P. absoluta* on tomato?
- Do farmers' practices match plant doctors' recommendations? If not, why not? What happens instead?
- What chemicals are being used (in particular any red-list chemicals)?
- Do farmers use the recommended pesticide dose, time of application, frequency of application, and number and type of pesticide for each cropping season, etc.?
- Do farmers use the recommended PPE?
- Does the use of plant clinic advice result in the more judicious use of pesticides by farmers?

### Data collection

Data collection took place from October to December 2020 in and around eight purposively selected counties, based on their involvement in maize and tomato production (Embu, Nakuru, Kiambu, Machakos, Trans Nzoia, Kirinyaga, Nyeri, and Bungoma). A household survey using a structured questionnaire was conducted with 600 farmers, including both plant clinic users and non-users. Only maize farmers that experienced FAW and tomato farmers that had *P. absoluta* were surveyed. Plant clinic users were randomly selected based on their records in

the Plantwise Online Management System (POMS), which records data on plant clinic attendees and the problems brought to the clinic, as well as plant doctors' diagnoses and recommendations for tackling problems. Non-users were randomly selected from farmer lists from nearby areas with similar agro-ecological zones to the plant clinics selected in each county.

In addition, 16 plant doctors and extension officers were interviewed on the pesticide-related information they provide to clinic users beyond those indicated in the clinics' prescription forms. POMS data were analysed to compare plant doctor recommendations and on-farm practice.

The study achieved a reasonable response rate of over 80%, allowing for statistical inferences to be drawn. There was a near equal representation of men and women with respect to receipt of plant clinic services and participation in the production of maize and tomato (Table 1).

**Table 1: Study sample**

| Plant clinic user (maize) | | Plant clinic user (tomato) | | Non-plant clinic user (maize) | | Non-plant clinic user (tomato) | |
|---|---|---|---|---|---|---|---|
| 178 | | 88 | | 155 | | 115 | |
| **Female** | **Male** | **Female** | **Male** | **Female** | **Male** | **Female** | **Male** |
| 91 | 87 | 35 | 53 | 71 | 84 | 49 | 66 |

### Analysis

Quantitative data collected was analysed using descriptive statistics, including chi-square tests and t-tests. Regression analysis was used to determine factors that caused a variance between the recommended application methods and farmers' actual practices. All analyses were conducted based on different gender categories of pesticide users for both plant clinic attendees and non-plant clinic attendees. The qualitative data from the interviews with plant doctors and extension officers were analysed using thematic and content analysis.

# Study findings

## Plant doctor recommendations

### Fall armyworm management on maize

Plant clinic doctors recommend various ways to manage the pest, including chemical (pesticides), cultural, mechanical and biological control methods. A wide variety of chemical pesticides were recommended. Control methods included the application of soil, ash, hot pepper, sawdust or soap solution to the whorl to suffocate pests, avoiding staggered planting, timely planting (early land preparation and planting), thorough weeding (keeping fields weed-free), planting certified seeds, fertilizer application, avoiding planting off-season crops, crop rotation, and intercropping maize with crops that are not susceptible to FAW (e.g. cassava). Mechanical control measures recommended include physically crushing, handpicking, rogueing, or pouring hot water on caterpillars. The use of pheromone traps is also recommended, based on farmer capacity.

### *P. absoluta* management on tomatoes

As a prelude to any recommendation, farmers are first advised to conduct regular monitoring. Control methods recommended include uprooting affected plants, physically crushing the larva with one's hands, using tutasan traps, using black sticky traps, and burying infested fruits, as well as the use of chemical pesticides and pheromone traps.

Plant doctors provide advice on proper pesticide application methods for both pests, the right timing and application rates, and when to use the chemical in regard to the crop stage and infestation level. Plant doctors also provide extra information beyond that included on the prescription forms provided to farmers. This includes information on the importance of soil testing and where to have soil tested, soil fertility management through fertilizer application, how to reduce mineral deficiencies in crops, the use of indigenous technical knowledge, and how to follow instructions on labels. Importantly, the study found that plant doctors advise that chemical control should be a last resort, and they inform farmers about hazardous pesticides and why they should not be used, and how to use pesticides safely.

## Farmer practices

### Fall armyworm management on maize

Farmers use a combination of methods for FAW control on maize. These include cultural and mechanical practices, and the use of chemicals (Silvestri et al., 2019). Practices include use of soil, ash, chilli, sand or tobacco at the maize whorl, dry planting, destroying maize leftovers, early land preparation, avoiding off-season planting of maize, crop rotation, intercropping maize with different crops that are not susceptible to FAW, proper weed control, early planting, fertiliser application. Farmers' mechanical methods include regular scouting and crushing the worms, handpicking the larvae/egg masses, and crushing them. Mass trapping by use of pheromone traps is also carried out. The use of chemical pesticides was limited by financial requirements. Other pesticide application prerequisites such as pre-harvest and re-entry intervals and use of PPE were adhered to minimally. Knowledge of the negative human and environmental effects was not widespread among the farming community.

### *P. absoluta* management on tomatoes

Farmers employ a combination of different cultural methods such as the use of clean seedlings, crop rotation with non-host crops, field hygiene (burning of debris and rogueing the infected plants), watering/mulching to prevent water loss, planting of certified seeds, regular monitoring, and field sanitation. Other methods include the use traps, physically crushing the larva, burying infested fruits, and scout regularly for timely effective control. Biological methods are the use of pheromone traps and use of black sticky traps.

## Use of recommended pesticide application practices

Through farm visits/follow-ups, plant doctors engage in observation and discussions to ascertain what farmers actually do following the receipt of advice, with farmer practices matching plant doctor recommendations in over 80% of the cases. The study found no significant difference in the degree to which plant doctor advice is implemented based on gender of the household head.

Sometimes, farmers' practices do not match plant doctors' recommendations due to the high cost of inputs, a lack of money to purchase the recommended inputs, and a perceived mismatch between recommended practices and farm size (with some farmers claiming their farm size is too small to implement the recommended practices – e.g. crop rotation). When they do not follow the recommended practices, farmers use what they have to hand, or what they can afford. Sometimes this includes indigenous technical knowledge and other traditional practices, some of which work positively. On the other hand, sometimes farmers incur a high production cost when they use practices other than those recommended by plant doctors.

Over 85% of farmers use alternate chemicals to avoid the development of resistance. This is mainly due to information received from plant doctors and extension officers. Plant doctors advise farmers to check on pesticide active ingredients and not the company/trade name or ask them if not sure. If farmers do not alternate chemicals, it is because they use the only pesticides they know, or the alternatives are too expensive, or not available.

### Quantity of pesticide applied

Most (80%) of the farmers interviewed stated that they apply pesticides' recommended doses, and while most plant doctors reported that farmers were applying suitable pesticides, they reported that farmers did not always apply the recommended amount. Over 87% of farmers interviewed reported that they mix chemicals correctly. Agro-dealers supply measuring equipment, from the chemical companies, to farmers. The equipment are usually marked for specific pesticides, and farmers are advised to read the labels. Failure to mix chemicals correctly is due to ignorance/negligence, and wanting to use less chemicals, as they are expensive. Some farmers doubt the recommended dosage and want the pesticide to work faster, thereby mixing it incorrectly. Other reasons for incorrect mixing are that calibrations are not clear and straightforward on the label, and measuring equipment is not provided.

### Number and frequency of applications

Half of the plant doctors interviewed reported that farmers are adopting the correct application frequency but do not use the recommended number of doses. Reasons given for incorrect application frequency or dosage included, lack of knowledge, a dependence on the weather, the status of the crop or the pest in the field, and the high cost of inputs. Plant doctors reported that once pests can no longer be seen easily, most farmers cease applying pesticides.

### Timing of application

More than 85% of plant clinic users apply pesticides at the right time of the day, compared to only about 55% of non-clinic users. The main reasons reported for farmers not applying pesticides at the right time are: they do not scout for pests (poor scouting makes it challenging to determine when pests and diseases attack the crop, and hence, farmers apply the pesticides when it is too late); they do not have the necessary pesticides due to the high input cost; and they only apply pesticides when they actually see pests on the crops.

### Pre-harvest and re-entry intervals

80% of farmers (both those who did and those who did not visit plant clinics) were not aware of pre-harvest intervals and never observed them if pesticides were applied. The reasons given for this included a desire to harvest and sell when the crop is in high demand, without caring about the time they sprayed pesticides, as well as not reading the label well, or simply ignoring it.

All farmers that attended plant clinics were aware of re-entry intervals and always observed them. This was in contrast to those that that did not attend plant clinics, some of whom were unaware of them and did not observe them. The reasons for this failure included negligence, lack of regular farm visits, and some farmers' not keeping a record of when they sprayed last. Some farmers ignore the safety measures and assume chemicals are not poisonous. Others do not have adequate knowledge of the safe and effective use of pesticides.

### Disposal of pesticide containers

The study found that farmers who attended plant clinics understood the need to safely dispose of empty pesticide containers, and were aware of the health and environmental risks associated with improper disposal. The study observed significant differences in the disposal methods of plant clinic users and non-plant clinic users, and with more plant clinic users burying empty containers away than non-users, and more non-users disposing of the containers in pit latrines. All farmers also tended to burn the containers and throw them away with regular household waste. However, it was found that there is no proper mechanism to ensure farmers take empty containers to a designated place, with limited measures to enforce safe disposal. The regulatory authority for the collection and proper disposal of used pesticide containers is not active.

## Use of PPE, and health effects of pesticide use

While 80% of farmers reported using PPE, this referred mainly to gumboots, which do not offer protection against pesticide risks. A few farmers use gloves, overalls, masks, headgear, mouth-respirator, eye goggles, and aprons. The high cost of recommended PPEs made it difficult for farmers to purchase and use them. There were statistically significant differences concerning the use of PPEs by the different farmer categories (Pearson $\chi 2$ (3)=9.915, p=0.019). More maize farmers attending plant clinics use PPEs compared to those who do not attend plant clinics. The proportion of tomato farmers using PPEs was nearly the same for plant clinic users and non-plant clinic users. Compared to maize farmers, there is a relatively higher level of use of PPEs by tomato farmers, possibly because pesticide use on tomato crops is higher than in maize.

A few farmers reported health complications after pesticide application and the plant doctors interviewed also indicated a few cases of farmers' health being affected after using pesticides. This included allergic reactions, difficulty breathing, sneezing, congestion of the respiratory system, skin irritation, severe headaches, and stomach problems. Affected farmers were advised to use full PPE.

## Contribution of plant clinic advice to judicious pesticide use by farmers

The farmers surveyed and the plant doctors interviewed argued that the use of plant clinic advice resulted in more reasonable/correct use of pesticides by farmers. Plant doctors inform farmers about proper application methods, timings, and application rates, as well as pre-harvest and re-entry intervals. It was reported that plant clinic advice enables farmers to avoid underuse and overuse of chemicals, leading to greater effectiveness and reducing wastage of chemicals.

## The way forward

The study found that farmer attendance at plant clinics results in a more judicious use of pesticides and better rates of PPE use by farmers. Farmer perceptions and knowledge about pesticides have improved in terms of types of pesticides to use, quantities, timeliness re-entry, and pre-harvest intervals. The tendency to use pesticides hastily is precluded by crop monitoring, allowing timely and effective control of pesticides that assure pests' reasonable control. Information on pesticide use is improved by regular interaction with plant doctors who can easily access other information not within the farmers' domain.

However, even where farmers attend plant clinics, they do not always follow plant doctor recommendations. This implies a need for further engagement to ensure farmer actions match the recommended practices. Policymakers could play a role here, by implementing seminars, farmer field schools, barazas, and other information dissemination methods to encourage farmers to take up the practices advised by plant clinics. The study also found that safe pesticide disposal is rarely observed, with most farmers throwing away empty pesticide containers in an unsafe manner. Policymakers can support safer disposal by providing a physical structure for disposal of empty pesticide containers and by ensuring the regulatory authority for the collection and proper disposal of used pesticide containers is active.

The results of this study can be used to help guide future plant clinic operations and to provide additional information and training to farmers on pesticide use and pesticide safety to ensure farmers use pesticides in the most judicious manner possible.

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