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Case Study

Pest Management Practices Prescribed by Frontline Extension Workers in the Smallholder Agricultural Subsector of Kenya

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Abstract

This article examines pest management practices recommended to smallholder farmers by extension agents, and the factors influencing the same. The study focused on plant health clinics, established under the Plantwise program, as primary providers of data. A diverse range of biotic and abiotic stressors was found to hamper crop production in the smallholder agricultural subsector of Kenya. Much as extension workers prescribed Integrated Pest Management (IPM) practices, albeit on a limited scale, management of crop pests was mainly by use of non-IPM practices. In addition, significant associations were observed between the prescribed practice and individual moderators (namely extension officer's gender, age, education level, and location), type of crop and causative agent. The results of the study confirm the need for further investments in the smallholder agricultural subsector of Kenya. In particular, the sector should prioritize capacity-building initiatives for extension agents on ecological and economical sound approaches to pest management.

Key words: extension, smallholder farmer, plant biotic and abiotic stressor, intervention measure, plant health

Agriculture is the most important enterprise in most African countries, with low agricultural productivity exacerbating poverty, food insecurity, and malnutrition (NEPAD 2013, AGRA 2014). Within the continent, the population involved in agriculture stands at 530 million people and is projected to surpass 580 million by 2020 (NEPAD 2013). In Kenya, the agricultural sector generates a quarter of its gross domestic product (GDP), accounts for 18% of formal employment and roughly 60% of informal employment (Njagi et al. 2014). Hence, agriculture not only remains an integral factor of Kenya's economy but also remains crucial as a major source of income for the majority of its population (Wobst 2005, Thurlow et al. 2007).

The sustainability of some agrarian systems in Africa, however, remains threatened by several factors: the effects of climate change, and population increase, which exerts pressure on land resources (NEPAD 2013). Additionally, productivity of crops is at risk due to proliferation of crop pests (Oerke 2006, Guenat 2014), and the unbridled use of pesticides for their management (Bekele et al. 2013). For instance, it has been reported that, half of the smallholder producers in Kenya use more than three times the prescribed volumes of pesticides (Bekele et al. 2013). This unrestricted use of pesticides gives rise to potential health risks to both growers and consumers, and a risk to the environment.

Integral to addressing the aforementioned challenges is the role performed by properly designed and implemented agricultural advisory services (Evenson and Mwabu 1998, Muyanga and Jayne 2006, GoK 2010). By definition, agricultural extension and advisory services are defined as systems that facilitate the access of farmers, their organizations and other value chain and market actors to knowledge, information, and technologies, presented in a systematic, participatory manner, with the objective of improving their production, income and (by implication) quality of life (Muyanga and Jayne 2006, Grange et al. 2010, AGRA 2013).

This article assesses pest management practices recommended to smallholder farmers by extension agents and the factors influencing the same.

Objectives

The objective of this article is to document recommendations given in Kenya to smallholder farmers for the management of crop pests and the factors influencing the same.

Research Question

This article uses a case study of Plantwise to answer the following research questions:

(1) What influence do individual moderators (extension officers' age, gender, education level, and location) have on pest management practices prescribed by frontline agricultural extension officers to smallholder farmers?
(2) What influence do crop type and type of causative agent have on pest management practices prescribed by frontline agricultural extension officers to smallholder farmers?

Materials and Methods

Case Study Overview

Plantwise is a global program led by Centre for Agriculture and Bioscience International (CABI), which works to help farmers lose less of what they grow. The program, working closely with national agricultural advisory services, supports the establishment of networks of community-based plant clinics where farmers can find practical plant health advice.

Plant clinics, working as human health clinics, enhance visibility of rural advisory services to farmers and increase contact between farmers and advisors. Operating as a demand-driven extension tool, plant health clinics run 1 d weekly or fortnightly in locations readily accessible to smallholder farmers. The farmer brings to the plant clinic a sample of the affected crop, discusses the problem with an experienced agricultural extension officer (also referred to as a 'plant doctor') and receives a diagnosis of the plant health problem (including issues relating to soil fertility and plant nutrition) affecting his or her crop. In addition, the farmer receives a written and verbal recommendation for managing the problem. The farmers visiting plant clinics are mostly adult male and adult female small-scale farmers who produce individually or collectively in groups and rely on rainfall for production. Production is both for subsistence and income.

For their training, plant doctors undergo four areas of training and capacity building (offered by Plantwise) to enable them run plant clinics, collect plant health data, develop extension materials and monitor plant clinic operations. These are: *module 1*: focuses on how to do a field diagnosis through observation of diseased/infested plant's symptoms and listening to farmers; *module 2*: focuses on how to give locally relevant plant health management advice to farmers, using available and affordable inputs and how to recognize when to seek expert help; *module 3*: focuses on how to translate plant health management advice and knowledge into simple factsheets that can be understood by farmers; and *module 4*: Focuses on establishing quality assurance to improve clinic services (including data management)

In Kenya, Plantwise was launched in May 2012 after a successful 2-yr piloting phase. The Ministry of Agriculture, Livestock and Fisheries (MoALF) through the Extension and Training Directorate is leading Plantwise implementation in close partnership with relevant players in the plant health system. Among these players include regulatory agencies (Kenya Plant Health Inspectorate Services [KEPHIS] and Pest Control Products Board [PCPB]), agricultural research and learning institutions (Kenya Agricultural and Livestock Research Organization [KALRO], University of Nairobi [UON]), agro-input providers (Agrochemicals Association of Kenya [AAK], Non-Governmental Organizations [NGOs], Community Based Organizations [CBOs] and Private sector). During the piloting phase (2010–2011), 40 plant doctors were trained to run an initial 25 plant clinics. In the course of this period, farmers and extension staff reported that clinics enabled them better address plant health issues and thus have a crucial role to play in increasing food security. Following this positive feedback, MoALF increased the number of plant clinics across the country. By the end of 2013, there were a total of 112 plant doctors manning a total of 58 plant clinics.

Survey Data

This article examined data collected from plant clinics over a 2-yr period (from 2012 to 2013). The 58 locations where the data were collected were distributed in 12 counties in Kenya: Nyeri, Kirinyaga, Embu, Tharaka Nithi, Machakos, Kiambu, Nakuru, Trans Nzoia, Bungoma, Elgeyo Marakwet, Kajiado, and West Pokot. Reflecting on their agricultural importance, the 12 counties account for only 11% of total land in Kenya, but for 23% of arable land.

Data Management System

The plant clinic data collection and management workflow was broken down into stages. Table 1 shows stages in the data management system process and actors involved.

Data Collection

In data recording, plant doctors used the Plantwise prescription form to record details of farmers' queries. In addition to basic details of the plant clinic and the farmer, the plant doctors captured information about the crop, symptoms and diagnosis and pest control tactics. Once completed by the plant doctors at the plant clinics, the prescription forms were collated, and using a courier service, sent to the central repository located at the MoALF–Plant Protection Services Division (PPSD), Kabete. Data entry was carried out using a simple Excel-based form that mimics the layout of the paper prescription form. These data were then entered in the Plantwise Online Management System (POMS)—an access-controlled section within Plantwise knowledge bank that serves as a central resource for managing plant clinic data as well as program monitoring.

Table 1. Stages in the data management system process and actors involved

Data management system category	Data management system step	Actors involved
Data collection	1. Recording	Plant doctors
	2. Transfer	Plant doctors, via data entry hubs
	3. Data entry	Data clerks
Data processing	4. Harmonization	National data manager
	5. Validation	NDV team consisting of technical experts from national-level research institutes, government ministerial representatives and technical-content experts from CABI.
Data use	6. Analysis	Research and government institutes, MOALF, CABI
	7. Sharing	'Plant doctors', research and government institutes, CABI

Data Processing

Data harmonization concerned the cleaning of digitized data (clinic details, plant doctor names, crop names and diagnoses were mandatory fields to harmonize). This was done by the program's national data manager.

Data validation (assessment of quality of diagnoses and advice) was done by a National Data Validation (NDV) team consisting of technical experts from national-level research institutes, government ministerial representatives and technical-content experts from CABI. During this stage, the pest management advices were post-stratified as Integrated Pest Management (IPM) and non-IPM recommendations depending on their adherence to IPM practices. The components of IPM technology that were considered (based on their availability and affordability) were: 1) crop rotation; 2) use of certified seeds/planting material/resistant/tolerant varieties; 3) observation of planting season/appropriate planting time; 4) monitoring in seedling /field stage; 5) field sanitation/removal of volunteers and alternative hosts of pests and diseases/ removal and destruction of affected plant parts; and 6) field application of low-toxicity synthetic pesticides/commercial formulations of botanical pesticides/selective, pest-targeted pesticides/use of biological control agent. An index was developed—taking cognizance of the above mentioned six components—to categorize the pest management practices. Scores were assigned to each component based on the extent of its use: 2 = completely used; 1 = partially used; and 0 = not used at all. Consequently, a recommendation containing all the six components (in their entirety) had a score of 12. Conversely, a recommendation lacking any of the six components had a score of zero. The score 6 was set to delineate the pest management practice as IPM or non-IPM based recommendation. To answer research questions one and two, abiotic causes data were omitted.

Table 2. Frequencies and percentages of biotic and abiotic stressors in the smallholder agricultural subsector of Kenya

Variable	*N*	Percentage
Invertebrate pest		
Aphids	396	22
Stalk borer	155	8
Whiteflies	137	7
Thrips	84	5
Bollworms	74	4
Nematodes	70	4
Red spider mites	70	4
Bean fly	63	3
Leafminer	57	3
Caterpillars	46	3
Others (comprising 100 invertebrate pests)	679	37
Plant diseases		
Bacterial wilt	268	11
Maize lethal necrosis disease	244	10
Powdery mildew	223	9
Late blight	111	5
Maize streak virus	106	4
Fusarium wilt of banana	104	4
Black rot	90	4
Coffee leaf rust	83	3
Anthracnose	80	3
Coffee berry disease	79	3
Others (comprising 133 plant diseases)	993	42
Abiotic causes		
Nitrogen deficiency	66	18
Calcium deficiency	53	14
Phosphorous deficiency	34	9
Water stress	33	9
Others (comprising 77 abiotic causes)	182	49
Vertebrate pests		
Rodents	17	61
Birds	8	29
Others (comprising three vertebrate pests)	3	11
Others		
Phytoplasma	73	62
Weeds	31	26
Others (comprising six problems)	13	11

Plant Doctors Involved in the Study

A total of 70 individual plant doctors (out of a total of 112 plant doctors) were involved in the study intended at answering research questions one and two. The plant doctors considered for this study were those who had submitted more than 20 plant clinic records (pre-determined threshold) during the period under review.

Data Analysis

All analysis was carried out using a statistical program, SPSS, version 18. To determine the relationship between the test variables and the dependent variable, cross-tabulation was used and tested for significance by the Pearson Chi-square test while the magnitude of relationships was measured by Cramer's V statistic. Significance was defined as P value ≤ 0.05. For research question one, the dependent variable was the type of pest management practices prescribed by extension workers while the test variables were plant doctors' age, education level, gender, and location. Similarly, for research question two the dependent variable was type of pest management practices prescribed by extension workers. However, the test variables for

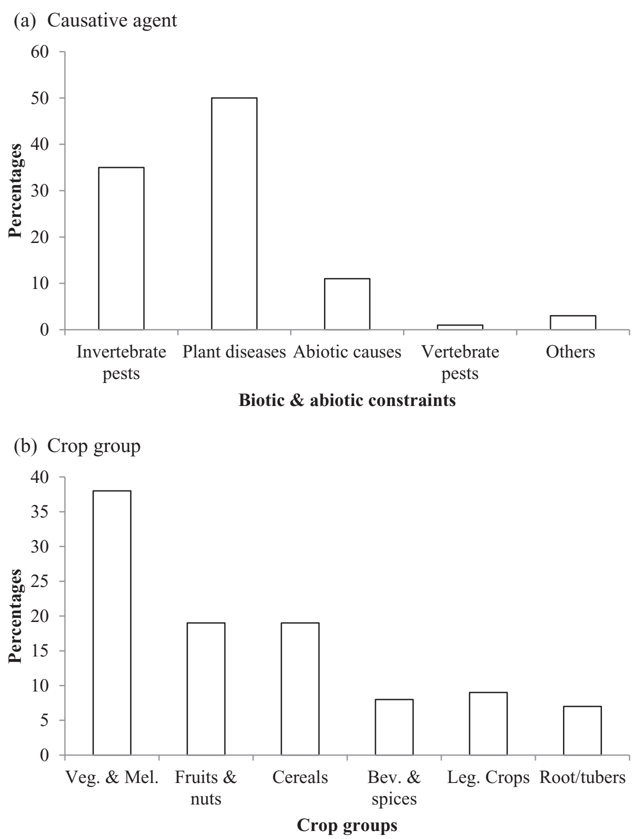

Fig. 1. Percentage distribution of (a) causative agent, and (b) crop group in the smallholder agricultural subsector of Kenya.

research question two were crop type and type of causative agent. In addition to determining the relationship in research questions one and two, cross tabulation was also used and tested for significance by the Pearson Chi-square test when it came to establishing the relationship between incidences of biotic and abiotic stressors and study period, location and crop type. Correspondingly, Cramer's V statistic was also used to measure the magnitude of the relationship in this instance.

Results

Plant Doctors' Demographic and Situational Data

Demographic and situational data for the plant doctors were collected including age, gender, educational level and their location. The 70 plant doctors making up the sample were all under the age of 60, with 11% of them being below 40 yr, 30% between 40 and 50 yr, and 59% over 50 yr. Male plant doctors constituted 64% of the sample while female plant doctors made up 36%. Of the 70 extension officers, only 87% provided information about their highest level of education with 57% having a college certificate and another 43% having a college diploma. Finally, most of the plant doctors (36%) operated plant clinics in Mount Kenya region (Embu, Tharaka Nithi, Kirinyaga and Nyeri counties) while 26% operated plant clinics in Western region (Bungoma, Trans Nzoia, Elgeyo Marakwet and West Pokot counties), 22% in Central rift (Nakuru county) and 11% in Nairobi metropolitan region (Machakos, Kiambu and Kajiado counties).

Table 3. Summary of results of Pearson Chi-square test and Cramer's V statistic for relationship between test variables and incidences of biotic and abiotic stressors

Test variables	*N*	Pearson Chi-square test	df	Cramer's V test	Sig.
Study period	5,584	237.23	4	0.206	<0.001
Location	5,194	85.06	12	0.074	<0.001
Crop type	5,387	526.53	20	0.156	<0.001

Biotic and Abiotic Constraints

A diverse range of biotic and abiotic stressors hamper crop production in the smallholder agricultural subsector of Kenya (Table 2). The main categories of pests and abiotic factors hampering crop production were plant diseases (50%), invertebrate pests (35%), abiotic causes (11%), vertebrate pests (1%), and 'others' (3%) (Fig. 1a). It is more likely that incidences of pests and abiotic stressors were influenced by time, type of crop and location (Table 3). Cross-tabulation for individual moderators is shown in Table 4. Inter-year differences were observed in the incidences of pests and abiotic stressors with more cases of plant diseases and invertebrate pests being recorded in the second year of the study than in the first year. However, unlike plant diseases and invertebrate pests, there were fewer reported cases of abiotic causes in the second year of the study than in the first year (Fig. 2a). Just like in time, differences were also observed among the different crop groups with roots and tubers, for instance, mostly being affected by plant pathogens while leguminous crops were mostly affected by invertebrate pests (Fig. 2b). Finally, variations in incidences of biotic and abiotic stressors were also observed in the different regions with some regions recording higher incidences of attack by certain pests and abiotic causes than others (Fig. 2c).

Research Question 1: Influence of Individual Moderators on Pest Management Practices Prescribed by Frontline Agricultural Extension Officers

Nearly two-thirds of the recommendations were non-IPM practices. On the other hand, only a paltry 21% of the advice was IPM based while the remaining records, accounting for 18%, lacked an actual prescription (either left blank or no concrete management steps was prescribed) (Fig. 3). It is more likely that the type of recommendation prescribed by plant doctors was influenced by plant doctors' individual moderators namely gender, age, level of education and location (Table 6). Cross-tabulation for individual moderators is shown in Table 5. An equal proportion (22%) of records prescribed by male and female plant doctors were IPM based (Fig. 4a). However, there were gender disparities when it came to non-IPM based practices with seemingly a higher proportion of records submitted

Table 4. Cross-tabulation for individual moderators showing frequencies and percentages

Variable	Biotic and abiotic constraints				
	Invertebrate pests	Plant diseases	Abiotic causes	Vertebrate pests	Others
Study period					
Year 1, no. of forms (%)	619 (31)	887 (45)	326 (17)	10 (1)	128 (6)
Year 2, no. of forms (%)	1,316 (36)	1,898 (53)	363 (10)	17 (1)	20 (0)
Location					
Nairobi Metropolitan, no. of forms (%)	598 (43)	615 (45)	148 (11)	10 (1)	7 (0)
Western region, no. of forms (%)	342 (36)	474 (50)	117 (12)	5 (1)	3 (0)
Mount Kenya region, no. of forms (%)	758 (37)	1,058 (52)	210 (10)	9 (0)	10 (1)
Central rift region, no. of forms (%)	225 (27)	529 (64)	69 (8)	2 (0)	5 (1)
Crop group					
Veg. & Mel., no. of forms (%)	856 (42)	924 (45)	219 (11)	2 (0)	51 (2)
Fruits & nuts, no. of forms (%)	254 (25)	610 (60)	120 (12)	7 (1)	21 (2)
Cereals, no. of forms (%)	273 (26)	562 (54)	176 (17)	5 (1)	20 (2)
Bev. & spices, no. of forms (%)	118 (28)	217 (52)	77 (19)	0 (0)	6 (1)
Leg. Crops, no. of forms (%)	316 (61)	110 (22)	57 (11)	0 (0)	32 (6)
Root/tubers, no. of forms (%)	63 (18)	260 (73)	9 (3)	10 (3)	12 (3)

by male plant doctors (62%), relative to their female counterparts (58%), being non-IPM based. Also, compared to records submitted by male plant doctors, a higher proportion of records submitted by female plant doctors lacked an actual prescription or was left blank (Fig. 4a). When it came to influence of plant doctors' age on prescribed pest management practice, there were more IPM-based records submitted by younger plant doctors than older ones (Fig. 4b). Similarly, more IPM-based records were submitted by plant doctors with higher education qualification (25%) than those of 'not-so-high' qualifications (18%) (Fig. 4c). Finally, regional differences were also observed when it came to the number of IPM based records submitted by plant

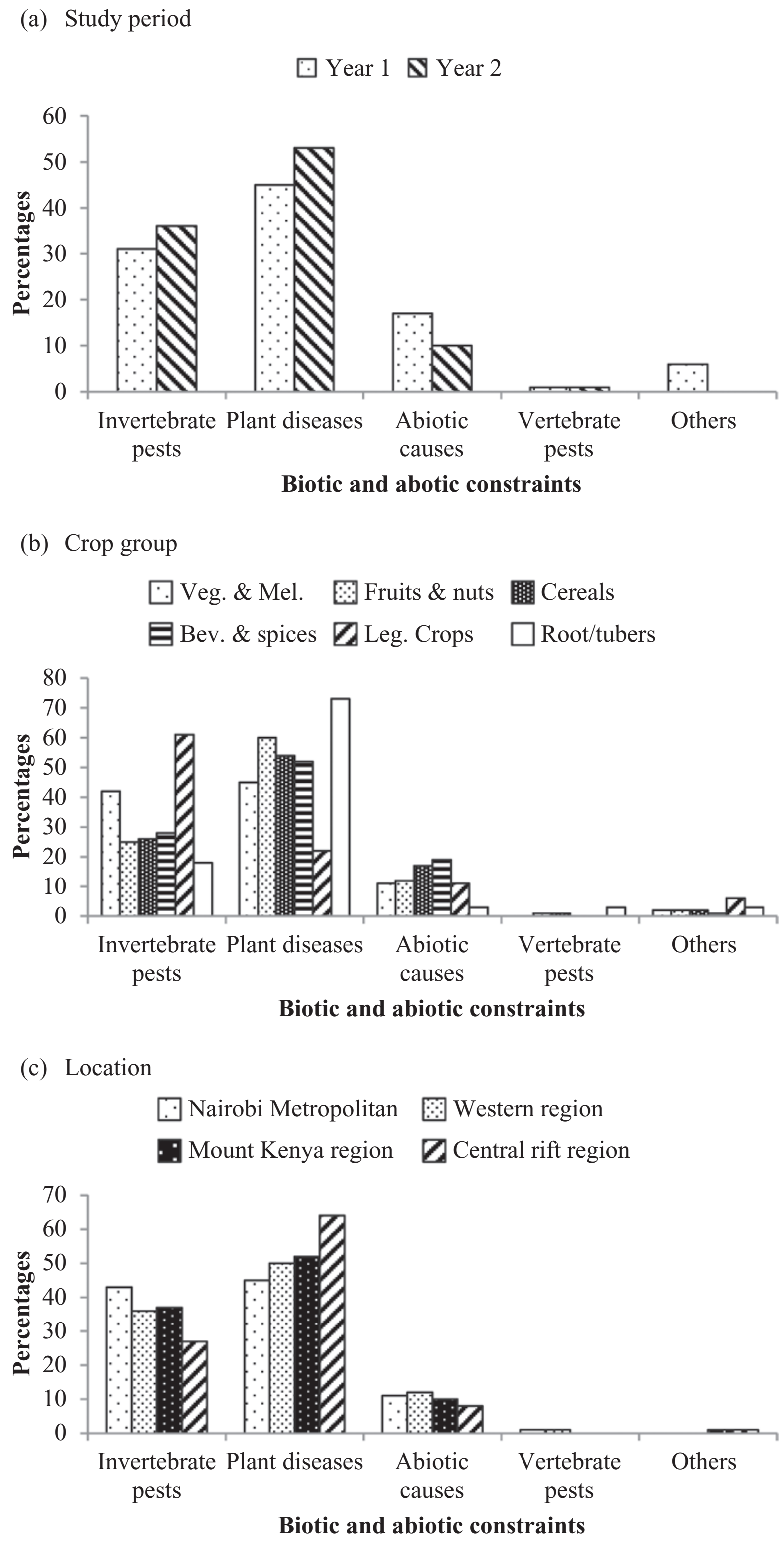

Fig. 2. Percentage distribution of biotic and abiotic stressors over (a) time, (b) crop group, and (c) location.

doctors in the different regions (Fig. 5). In this category, Western region led in the number of IPM-based records (36%) while Mount Kenya region had the least (21%).

Research Question 2: Influence of Crop Type and Causative Agent on Pest Management Practices Prescribed by Frontline Agricultural Extension Officers

It is more likely that the type of recommendation prescribed by plant doctors was also influenced by the type of crop being handled by the plant doctors as well as the type of the causative agent affecting the crops (Table 6). Cross-tabulation for individual moderators is shown in Table 5 while the range of crops produced in the smallholder agricultural subsector of Kenya is shown in Table 7. There were disparities among the different crop groups in the kind of pest management practice prescribed by plant doctors. Four of the crop groups, namely roots/tubers, cereals, vegetables and melons and leguminous crops had more than 20% of the records prescribed by plant doctors on them recommending IPM practices (Fig. 6b). On the other hand, the remaining crop groups, beverages and spices, and fruits and nuts had less than 20% of the records prescribed by plant doctors on them recommending IPM practices. When it came to the influence of type of causative agent on the kind of pest management practice prescribed by plant doctors, similarly, there were observed disparities. Among the different causative agents, the bulk of the records prescribed for the management of plant diseases (27%) were IPM based—the highest proportion in this category (Fig. 6a). On the other hand, the type of causative agent that recorded the highest percentage of non-IPM based practices was invertebrate pests (67%) while the pests categorized as 'others' recorded the highest percentage (88%) of records lacking an actual advice or were left blank by the plant doctors.

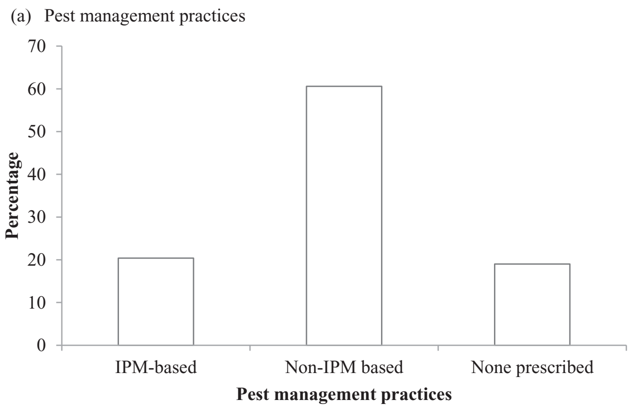

Fig. 3. Percentage distribution of pest management practices in the smallholder agricultural subsector of Kenya.

Discussion

Influence of Individual Moderators on Pest Management Practices Prescribed by Frontline Agricultural Extension Officers

Much as IPM was prescribed to smallholder farmers, albeit on a limited scale, preferred pest management practice was the use of non-IPM technology. The small number of records prescribing IPM-based practices may be argued is the result of, among other things, the propagated notion that in instances of low productivity, the yield saved by IPM compared to 'doing nothing' may be

Table 5. Cross-tabulation for individual moderators showing frequencies and percentages

Variable	Pest management practice		
	IPM-based	Non-IPM based	None prescribed
Gender			
Female, no. of forms (%)	387 (22)	1,001 (58)	351 (20)
Male, no. of forms (%)	514 (22)	1,440 (62)	371 (16)
Age			
<40 yr, no. of forms (%)	127 (27)	250 (53)	95 (20)
40–50 yr, no. of forms (%)	217 (16)	787 (60)	319 (24)
>50 yr, no. of forms (%)	405 (22)	1,190 (63)	285 (15)
Education level			
Cert., no. of forms (%)	420 (18)	1,447 (64)	412 (18)
Dip., no. of forms (%)	302 (25)	698 (57)	221 (18)
Location			
Nairobi Metropolitan, no. of forms (%)	264 (22)	757 (63)	174 (15)
Western region, no. of forms (%)	292 (36)	420 (52)	100 (12)
Mount Kenya region, no. of forms (%)	371 (21)	1,149 (64)	265 (15)
Central rift region, no. of forms (%)	179 (24)	475 (64)	92 (12)
Crop group			
Veg. & Mel., no. of forms (%)	443 (25)	1,087 (61)	264 (15)
Fruits & nuts, no. of forms (%)	164 (19)	558 (64)	147 (17)
Cereals, no. of forms (%)	242 (29)	421 (51)	170 (20)
Bev. & spices, no. of forms (%)	57 (17)	226 (68)	51 (15)
Leg. Crops, no. of forms (%)	87 (20)	272 (61)	87 (20)
Root/tubers, no. of forms (%)	104 (30)	171 (50)	68 (20)
Causative agent			
Inv. Pests, no. of forms (%)	394 (21)	1,280 (67)	239 (13)
Plant dis., no. of forms (%)	721 (27)	1,502 (56)	476 (18)
Vert. pests, no. of forms (%)	6 (22)	17 (63)	4 (15)
Others, no. of forms (%)	0	17 (12)	127 (88)

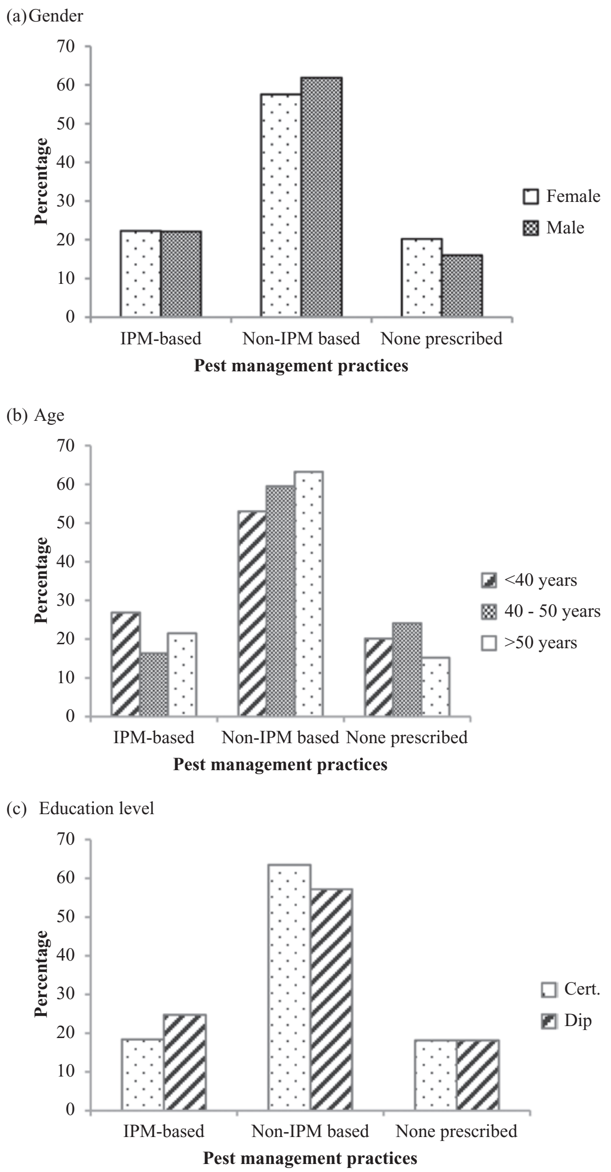

Fig. 4. Percentage distribution of intervention measures based on extension officers' (a) gender, (b) age, and (c) education level.

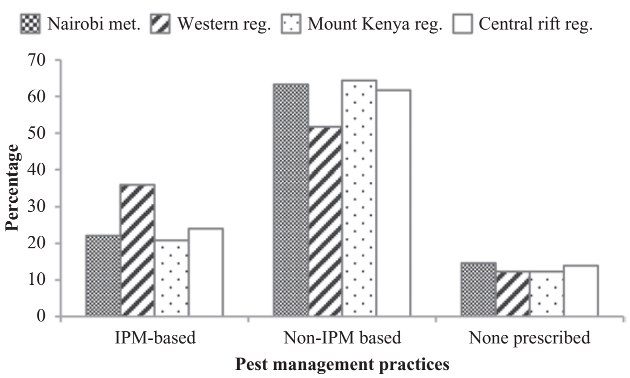

Fig. 5. Percentage distribution of intervention measures based on extension officers' location.

too insignificant to warrant adoption. Based on this reasoning, IPM is viewed to be economically viable only under conditions of high productivity through which the cost of investment will be covered

Table 6. Summary of results of Pearson Chi-square test and Cramer's V statistic for relationship between test variables and pest management practices

Test variables	*N*	Pearson Chi-square test	df	Cramer's V test	Sig.
Age	3,675	61.52	4	0.091	<.001
Edu. level	3,500	20.51	2	0.077	<.001
Gender	4,064	13.18	2	0.057	0.001
Location	4,538	77.22	6	0.092	<.001
Crop category	4,619	74.31	10	0.090	<.001
Causative agent	4,783	566.76	6	0.243	<.001

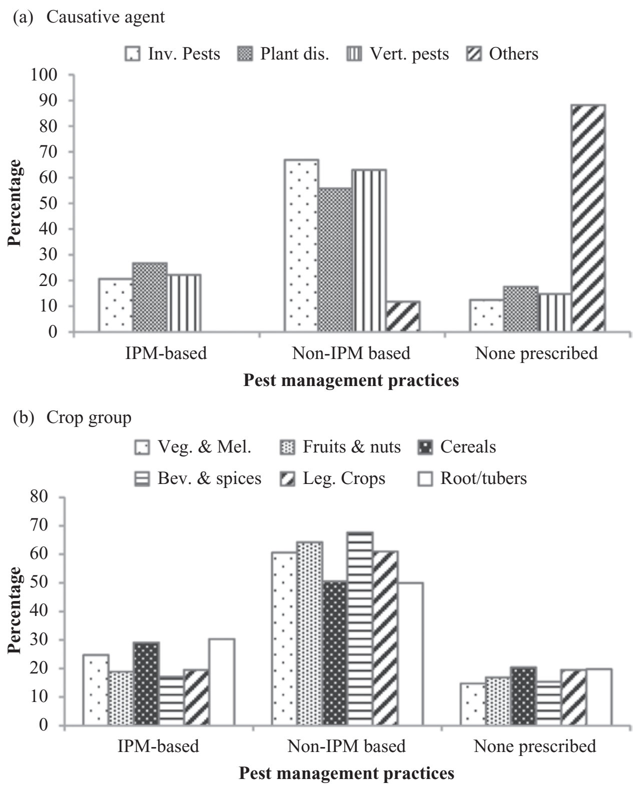

Fig. 6. Percentage distribution of intervention measures based on (a) causative agent, and (b) crop group.

by increased revenue (Parsa et al. 2014). Another possible reason explaining the small number of IPM recommendations, as hypothesized by Parsa et al. (2014), is the belief that IPM requires collective action within a farming community. This belief is anchored on the premise that some pest management decisions are subservient to a collective action dilemma, thus returns from adopting a technology are dependent on whether others adopt it too. Finally, another possible reason explaining this phenomenon is the prominence, over the years, accorded to pesticide-based solutions (Sibanda et al. 2000, Parsa et al. 2014).

Notwithstanding the aforementioned, the choice of prescribed intervention differed significantly depending on the gender, age, education level, and location of the prescribing plant doctor. The small number of records prescribing IPM-based practices by older plant doctors affirms the proposition that individuals with greater experience with existing technologies may be disposed to continue their dependence on existing technologies, and as such there may be a status quo bias (Sharma et al. 2011).

Table 7. Frequencies and percentages of crops brought to plant clinics

Crop	*N* (No. of records submitted)	Percentage
Vegetables and melons		
Tomato	844	41
Kales	450	22
Cabbage	300	15
Spinach	112	5
Capsicum	61	3
Others (comprising 66 crops)	285	14
Fruits and nuts		
Banana	354	35
Mango	232	23
Avocado	162	16
Passion fruit	91	9
Citrus	75	7
Others (comprising three crops)	98	10
Cereals		
Maize	926	89
Rice	110	11
Beverage and spices		
Coffee	418	100
Leguminous crops		
Common bean	316	61
French bean	93	18
Pigeon pea	54	10
Cowpea	40	8
Soya bean	8	2
Others (comprising four crops)	4	1
Root/tuber crops		
Irish potato	259	73
Cassava	43	12
Sweet potato	43	12
Arrowroot	9	3

Likewise, the finding of the study is in agreement with the commonly voiced premise that educated individuals are more likely to take up new technologies and/or are more likely to be early adopters (Nkamleu and Adesina 2000).

Variations across regions in the management practices are probably to be expected considering the mix of cropping systems by location in Kenya, the network effects of the proportion of host crops in the region, and climatic differences varying pest pressures. Also, it may well be that in some regions the quality of crop being cultivated is such that it does not require or justify the use of certain management practices (Sharma et al. 2011).

Gender differences in the prescribed management practices could be an issue of attitude and compliance. It has been reported that women, more than men, are more likely to comply with instructions (Mazman et al. 2009). Through the activities of the technical experts, comprising the NDV team, Plantwise developed Pest Management Decision Guides (PMDGs) and factsheets (reference materials). These reference materials were shared with plant doctors as a practical guide on giving IPM biased recommendations, and it was expected plant doctors would make reference to the guides as part of their routine plant clinic operations. Based on a traffic light system, PMDGs are comprehensive selections of the most appropriate preventative and curative management options for specific pest-crop combinations (Cameron et al. 2016). These information tools act as step-by-step guides for plant doctors to make recommendations for pest management beginning with preventative measures followed by proper pest monitoring before finally considering curative (direct control) measures. Of the direct control measures, priority is accorded to methods that can be applied without restrictions (e.g., no limit on frequency or timing of use) (Cameron et al. 2016).

Influence of Crop Type and Type of Causative Agent on Pest Management Practices Prescribed by Frontline Agricultural Extension Officers

Compared to the other causative agents, it is not surprising that IPM-based practices were mostly prescribed for the management of plant diseases. This is because, the epidemiology of plant diseases, particularly the vectored ones, is complex and often, no single approach will achieve adequate control (Halbert 2008). As it has been established, plant diseases result from a three-way interaction between the host, the pathogen and the environment (McNew 1960, Lucas 1998, Halbert 2008). Seeing an epidemic ensues when all the components in the disease triangle are favorable to disease development, by manipulating one or more of these factors, one is able to render the conditions unsuitable for replication, survival, or infection of the pathogen.

The high number of prescriptions forms recommending non-IPM based practices especially for the management of invertebrate pests confirms the assertion by Munyua et al. (2004) that in Kenya, non-IPM practices are given priority, and often recommended through extension as the main solution to pest problems. Probably this is because, non-IPM practices, particularly the exclusive use of synthetic pesticides, are perceived to work better than softer, less obtrusive materials. Additionally, they can be used to protect crops from anticipated pests, and used against active pest problems. However, there are ecological disruptions and safety problems associated with this high frequency of therapeutic use of synthetic pesticides. The four major problems encountered are pest resistance, pest resurgence, secondary pests, and toxic residues (Lewis et al. 1997).

The results indicating the use of non-IPM practices was the most prescribed form of pest management among the crop groups is consistent with previous findings. Traditionally, farmers have been keen on using non-IPM practices, particularly the exclusive use of synthetic pesticides especially on vegetable crops with one study indicating that 3 out of 10 farmers in Kenya applied pesticide sprays once or twice per season, and another 43% sprayed pesticides more than three times in a season (Munyua et al. 2004).

Seeing the striking similarities between the management options prescribed by 'plant doctors' in this study and the pest management practices adopted by farmers in Munyua et al. (2004) study lends credence to the notion that agricultural extension officers have an immense influence on farmers.

Limitations of the Study

The study includes individual and contextual factors as precursors of prescribed IPM practices by extension workers. While these moderating factors are critical, cultural aspects and organizational factors are not incorporated in the model thus a limitation of the model. Additionally, a comparison was not sought between extension officers within the Plantwise program and those who are not part of the program regarding the kind of pest management advice offered to farmers. It may well be, with the kind of investment made by the Plantwise program to train extension workers on IPM practices, extension workers outside the program may be less equipped, and possibly if they were the ones solely considered for this study the percentage of IPM based recommendations would reduce substantially.

Conclusion

In general, innovations are perceived to be more risky than traditional practices and this notion has received considerable support in literature. At the onset of an innovation, its potential users are usually uncertain of its effectiveness and tend to view its use as experimental. However, that uncertainty declines with learning, therefore inspiring more risk-averse users to adopt an innovation provided it is profitable. In this regard, to raise awareness among extension workers on ecological and economical sound approaches to management of crop pests, there is need for further investments in capacity building initiatives on IPM-based practices. This is essential in strengthening key technical and functional competencies required to drive effective selection and use of management tactics, based on cost/benefit analyses. In addition to the aforementioned initiatives, there is need to also encourage a knowledge transfer program that draws heavily on the expertise of frontline extension workers already prescribing ecological approaches to management of biotic and abiotic stressors. Indeed, communication of information and knowledge among peers is an essential facet of agricultural extension and advisory services, and extension agents must be able to access a continuous stream of new, regionally appropriate information and innovation if they are to be of continuous benefit to farmers.

For stakeholders in the plant health sector, the findings in this study indicate that a divide exists among the different segments of extension workers (based on gender, age, location and education level). Consequently, practitioners are better informed to formulate measures aimed at enhancing the adoption of technology among the various groups of extension workers. For example, IPM training programs for extension workers should be designed in ways that take cognizance of individual factors (gender, age, and education level) and contextual factors (crop types, causative agents and location). In formulating measures aimed at enhancing the adoption of ecological and economical sound approaches to management of biotic and abiotic stressors, practitioners should not restrict themselves only to IPM. Instead, as the study has highlighted, there is also need to build the capacity of extension officers on management of abiotic stressors. This is because abiotic causes also hamper crop production in the smallholder agricultural subsector of Kenya.

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