African Phytosanitary Journal http://www.africanphytosanitaryjournal.go.ke
ISSN 2617-1856 (Paper) DOI: 10.52855/WLQV2820
Volume 4, Issue 1, 2024

Farmer perception, knowledge and management of the scale insect pest complex infesting crops and trees in Coastal Kenya

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Abstract

Scale insects and mealybugs (Hemiptera: Sternorrhyncha: Coccomorpha) are serious plant sap-sucking pests affecting a wide range of cultivated crops and tree species. The insects are highly diverse and can have devastating effects on yields due to lack of farmer awareness and inappropriate management practices. Recent alien mealybug invasions in Kenya include among others, papaya mealybug (*Paracoccus marginatus*), a highly invasive pest that is spreading quickly. Farmer experience with diverse crop pests can support development of a successful pest management strategy and contribute to reduced impacts on both crop yields and agro-biodiversity. This socio-economic survey was carried out in three coastal counties of Kenya (Mombasa, Kilifi and Kwale) to establish the impact of scale insect and mealybug pests on farmer livelihoods and to document the perception, knowledge and management practices used by smallholder farmers. Data from oral interviews using ODK were administered to respondents and analysed using Excel and GENSTAT. It emerged that 26% of the respondents were familiar with scale insects and 51% with mealybugs, respectively. Of these, 78.13 % and 94% acknowledged having encountered scale insects and mealybugs, respectively, on their farms. The farmers confirmed that scale insect pests affected a high diversity of crops and trees. About 56% of the respondents used pesticides to control the pests while 25% did not apply any management strategy. The remaining 19% practiced cultural control methods such as field sanitation and intercropping with less susceptible crops. Pesticides were reported to be moderately effective (41-70%) at controlling scale insects and mealybugs. Other management options reported by farmers included farm hygiene, the use of high-pressure water jets, and applications of ash and bio-pesticides such as home-made neem extract. Based on the findings, it is recommended that capacity building for farmers and input providers be undertaken to enhance the knowledge of scale insect and mealybug pest biology, symptoms of crop and tree attack, host ranges and management practices. Additonally, training on the use of low-risk pest control products and innovative control methods should be undertaken to reduce the impact of the pest on crop production and agro-biodiversity.

Keywords: Farmer knowledge, management, mealybugs, scale insects and socio-economic survey.

Introduction

Scale insects (including mealybugs) are pests belonging to Order Hemiptera, superfamily Coccoidea (Gullan and Cook 2007). They are serious pests of several crop and fruit species including cassava (*Manihot esculenta*), papaya/pawpaw (*Carica papaya*), citrus, egg-plant (*Solanum melongena*), soursop (*Annona muricata*) and ornamentals, among others (Franco *et al.* 2009; Mazzeo *et al.* 2014). These pests cause damage by sucking plant fluids from leaves, stems and sometimes roots (e.g. in the case of groundnuts) (Kondo *et al.* 2008). The coffee mealybug (*Planococcus kenyae*) attacks coffee and a large number of wild and cultivated plants including yam (*Dioscorea rotundata*), pigeon pea (*Cajanus cajan*), passion fruit (*Passiflora edulis*), sugarcane (*Saccharum officinarum*) and sweet potato (*Ipomoea batatas*) (Watson and Ouvrard, 2019).

In the last seven years the scale insect population in Kenya has greatly increased, with these pests being reported in most parts of the country, causing serious yield losses in crops and trees including native species. In the coastal region, an invasive mealybug pest, papaya mealybug, *Paracoccus marginatus* Williams & Granara de Willink, was first reported on papaya in 2016 (Macharia *et al*., 2018). However, the problem has since escalated to affect other crops and fruit trees in other areas. Yield losses of affected crops have been estimated to be as high as 91% and it is feared that the percentage may increase after recent identification of 66 more potential scale insect pest species new to Kenya, most of them non-native (Watson *et al*., 2021; Macharia *et al.,* 2021).

In Africa, a number of farmers still depend on indigenous methods to manage pest problems (Abate *et al*., 2000). However, in Coastal Kenya majority of the farmers were reported to use pesticides as their only method to control scale insects and mealybugs since they had inadequate knowledge of any other form of pest control (CABI, 2020). However, there are several impediments to the successful management of these pests. Scale insects have a waterproof layer of wax coating their bodies which repels aqueous contact pesticides and their habit of feeding on leaf undersides and

in other cryptic sites can make them unreachable by regular pesticide application techniques (Ouvrard *et al.*, 2013). Unfortunately, most farmers are not aware of these pest characteristics making it difficult for them to apply pesticides effectively. Understanding of these challenges could help farmers in future management of the pests. Therefore, this survey was carried out to understand how farmers perceive and understand the pests especially in management perspective.

A socio-economic survey was carried out in three coastal counties (Mombasa, Kilifi and Kwale) to establish the perception and knowledge of scale insects including mealybugs by smallholder farmers and the impact on their livelihoods. Information on farmers' current perceptions of scale insect control practices and available resources may provide essential data on acquired skills and indigenous knowledge for the successful development of pest management strategies and contribute to rural development at the county level.

Kilifi and Kwale counties are the main farming areas in the coastal region of Kenya due to the availability of sufficient land and a larger workforce (Okutoyi, 2021). Earlier studies in the area by Wekesa *et al.* (2017) observed that farming activities have been declining over time. This is mainly due to unpredictable rainfall and increased problems with weeds, insect pests and diseases, making the people to turn to alternative sources of livelihood. Presence of new pests such as scale insects exacerbates the problem further. In Mombasa, most of the areas is mainly residential with the major economic activity being fishing and ecotourism. Farming though present, occupies a small percentage. There is lack of information on whether the farmers at the coastal region are aware of these insect pests and actions that they undertake to deal with them.

Methodology

Study sites

The study was carried out in three different coastal Counties: Mombasa, Kwale and Kilifi (Figure 1), in mid-2019. In all the three Counties data was collected from 12 sub-counties. Farmers were selected randomly with the guidance of the county agriculture extension officers.

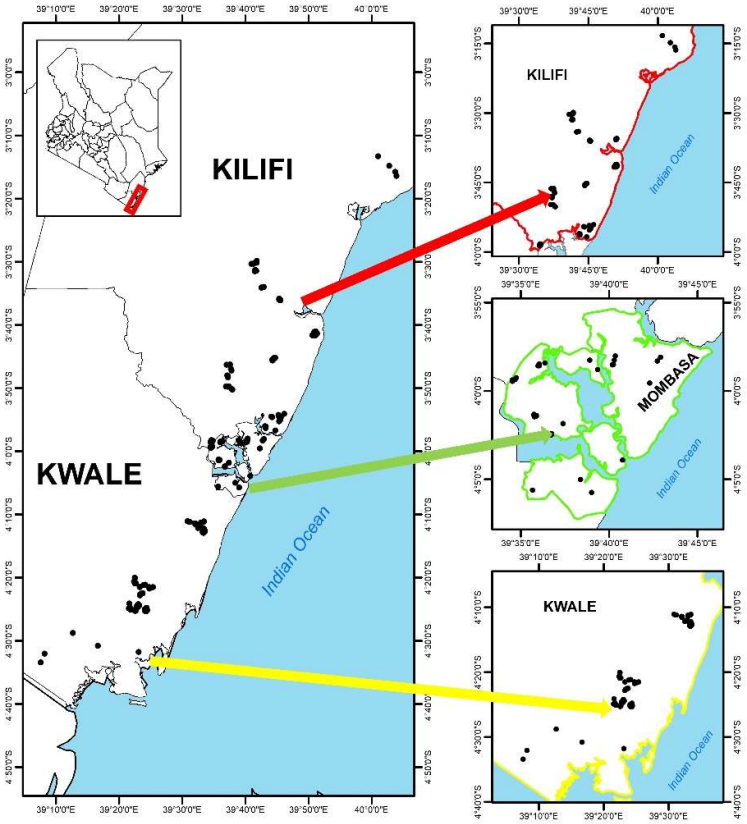


Figure 1. Map of the study sites

Study design and data collection

A formal structured questionnaire was developed on ODK (Open Data Kit) collect v 1.30.1 for recording the data. The questionnaire was jointly developed by all seven partner institutions of the Darwin Initiative project (Kenya Agricultural and Livestock Research Organization (KALRO), Kenya Plant Health Inspectorate Service (KEPHIS), Kenya Forestry Research Institute (KEFRI), Centre for Agriculture and Biosciences International (CABI), National Museums of Kenya (NMK), University of Nairobi (UoN) and Natural History Museum, U.K. (NHM)) and covered aspects of both agriculture and forestry. The study was carried out using face-to-face oral interviews, where enumerators engaged the respondents to capture appropriate responses to target questions. This allowed the use of multiple languages, with English as the basic language used

to design the questionnaire and train enumerators, and a general-purpose language for communication. However, Kiswahili as the native language in the coastal region, was used in case-to-case interviews as warranted.

Enumerators were trained prior to data collection to standardize responses and minimize skewness. During this period, areas of enumeration and team leadership aspects were agreed upon. The questionnaire was translated onto the ODK system so that enumeration was paperless, with immediate submissions after enumeration and discussion with team leaders to confirm that all aspects were captured. A target of 250 respondents was set before the enumeration process across the three Counties. The parameters captured included: age, gender, crop production constraints, pest infestation and management. Data was extracted from the ODK server and converted to MS Excel for curation. The results were shown as Excel spreadsheets and GENSTAT was used for basic analyses.

Results and discussion

Details of the respondents

In all the three Counties, a total of 238 respondents were interviewed: 41% from Kwale County, 39% from Kilifi and 20% from Mombasa (the smallest and most urbanised county). There was cross-gender representation in all the counties, although the majority of respondents were male. The study by Wekesa *et al*. (2017) established that participation of women in decision-making in the coastal regions of Kenya was limited, as they required consent from the men. An additional youth representation in Kilifi (24%), Kwale (20%) and Mombasa (13%) was recorded (Figure 2).

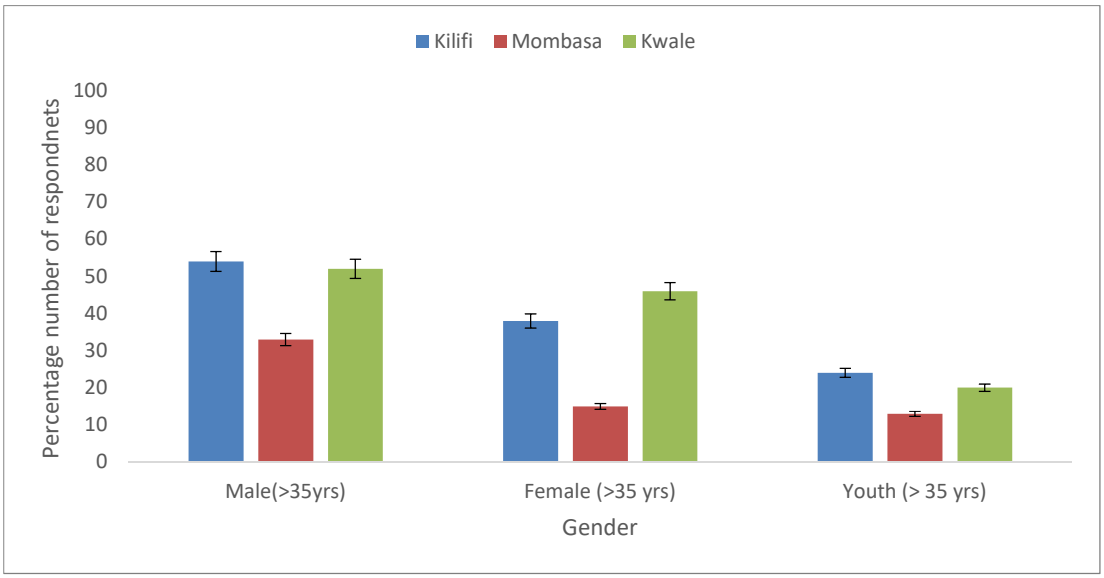


Figure 2. Gender representation from the respondents

The major constraints of crop production were found to be insect pests (45%), diseases (21%), drought (20%) and climate (5%). Other constraints included insuficient farm inputs, lack of markets and low yields (together accounting for 7%) (Figure 3). Scale insects and mealybugs were among the pests reported to have caused challenges to crop production in the area. However, out of the 238 farmers interviewed, only 26% (n=62) were familiar with scale insects and 51% (n=121) were familiar with mealybugs. Of those who were aware of scale insects 78.13% and 94.3% could correctly distinguish scale insects and mealybugs respectively, from a group of other insects. Some soft scale insects (family Coccidae) have a barnacle-like appearance and are covered with a waxy coating that hides and protects the adult and its eggs, making it difficult to recognize it as an insect (*Shorthouse, 2003).* In contrast, mealybugs have no hardened covering but a white cottony/powdery wax coating with wax extensions (filaments) around the margins of the small, soft body (Held, 2019); the colonies look like clusters of cotton wool on the above-ground portion of plants, making them more visible to the naked eye. This probably explains why more respondents indicated that they identified the mealy bugs more than the scale insects.

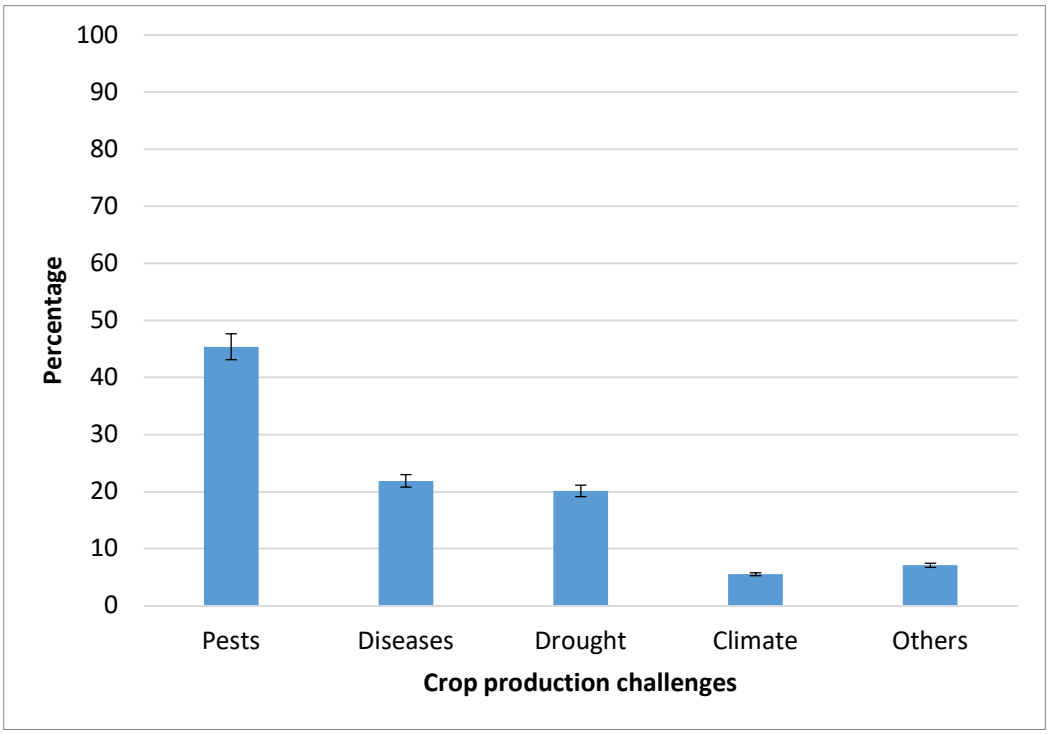


Figure 3. Crop production constraints

Amongst the host plants investigated, papaya was the most infested by both mealybugs and other scale insects, followed by cassava and citrus (Figure 4); both were reported to cause a lot of damage to the host plants recorded. However, it was noted that damage caused by presence of both pests was much more than what was caused by occurrence of each pest individually (Figure 5). The most common symptoms were leaf withering, leaf yellowing, stunted growth, drying of tissues and defoliation. Compared to other types of scale insects, mealybugs caused the most damage (Figure 5). A previous study in coastal Kenya indicated that an alien invasive species, papaya mealybug (*Paracoccus marginatus*) was introduced in 2016 (Macharia *et al.,* 2018). More recent survey conducted in the area identified additional seventeen alien scale insects and mealybug species in Kenya (Macharia *et al*., 2021), feeding on many crop species including cassava, sugarcane and egg-plant, among others thus adding to the burden of crop pests already experienced by farmers in this region.

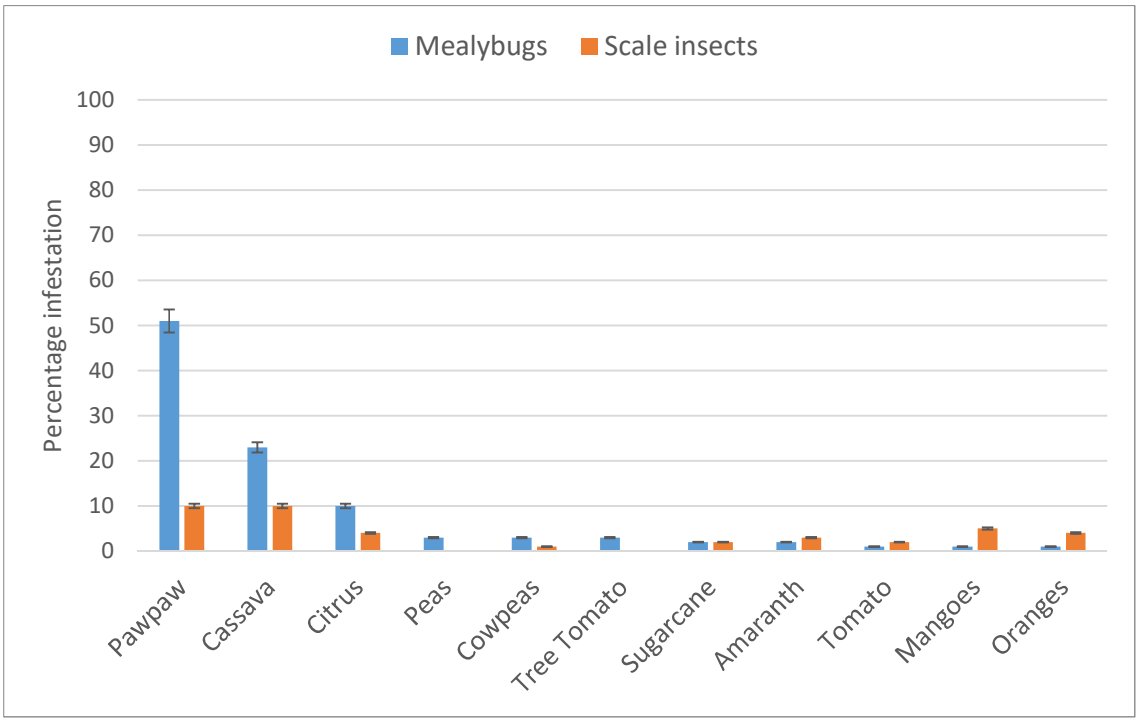


Figure 4. Percentage of plants infested with mealybugs and scale insects

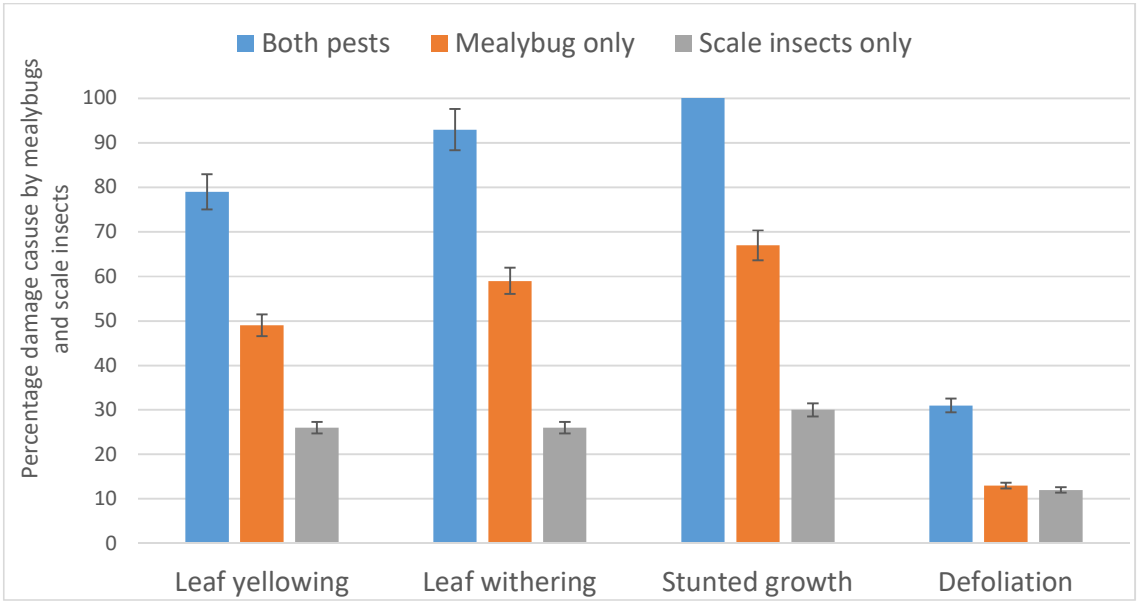
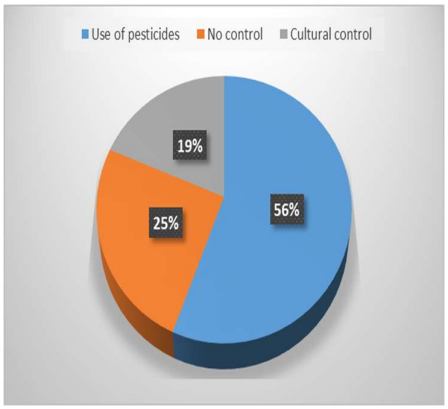


Figure 5. Percentage damage due to mealybug and scale insect infestations

Although over half of respondents (56%) indicated that they mainly used insecticides to target all insect pests on the farm, a considerable number (25%) did not use any control method (Figure 6a). Most of those using insecticides (39%) intended to kill fall armyworm; only 6% targeted other species of caterpillars. Although other insect pests were also targeted, the number of instances was generally very low (Figure 6b).



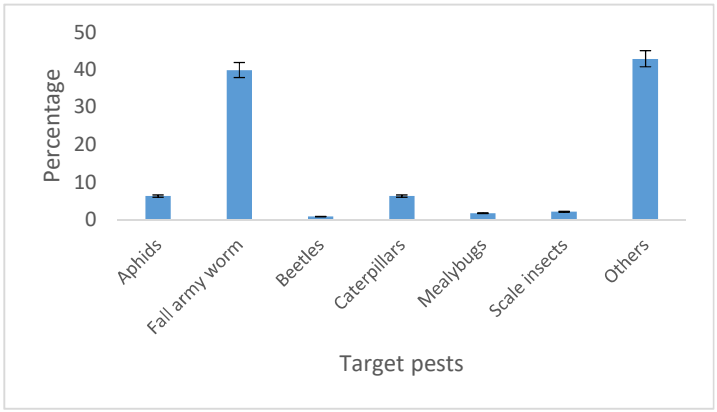


Figure 6a. Pest control methods employed

Figure 6b. Target pests for control

Pesticides play a significant role in food production by protecting crops from pest attack, increasing yields and can determine the number of times per year a crop can be grown on the same land particularly for countries that face food shortages. Earlier studies in Kenya (Abong'o *et al.*, 2014) indicated that the rapid expansion of agriculture due to population growth has resulted in increased demand for agro-chemicals which have become an integral part of plant, livestock and public health protection. Unfortunately, majority of farmers use broad-spectrum pesticides. This increases the risk of selection for resistance to pesticides in non-target insect pests, due to sub-optimal dosages. On the other hand, some farmers are known to use non-chemical methods of pest control because of the risk of toxic effects of pesticides and their high cost (Marete *et al.*, 2021).

Majority of the respondents indicated that agrovets (29%) and extension officers (27%) were their main sources of information on pesticide use. Others

depended on their own experience and advice from neighbours. Unfortunately, very few (3.55%) of them read pesticide labels (Figure 7), hence were not able to follow proper guidelines for safe application and effective use with reference to target pests. Previous studies in Kenya reported that farmers relied on several sources of pesticide information, which to some extent resulted in malpractice (Marete *et al.,* 2021). Earlier studies in Africa and other developing countries (Damalas and Eleftherohorinos, 2011; Lalah *et al.*, 2018) indicated that there is a lack of knowledge and qualified agricultural extension workers to help explain to farmers how to safely handle pesticides. Farmers who received proper information were able to apply pesticides in the right way and use host-specific pesticides hence reducing the toxic effects of pesticide exposure (Marete *et al.*, 2021).

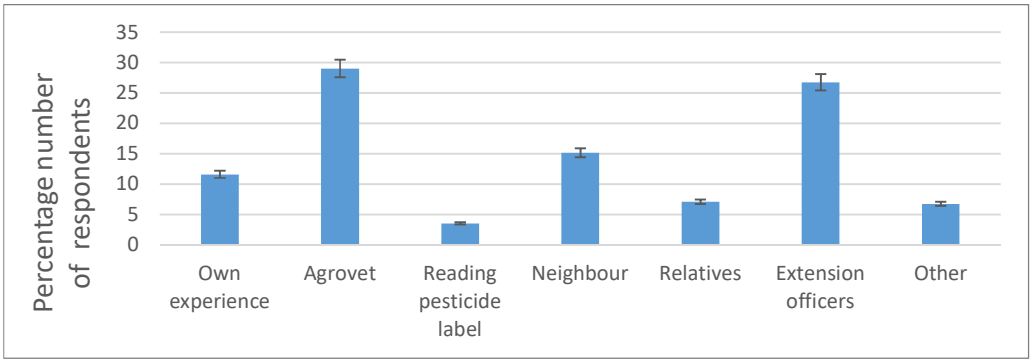


Figure 7. Source of information for pesticide use

Conclusion

A diversity of crops (both cultivated and uncultivated) are affected by scale insects and mealybugs, hence posing serious threat to the livelihood of most households in the coastal counties. Farmers rely on pesticides to manage these pests although in most cases broad spectrum insecticides are used to maximize management of other pests in the farm. Farmers in these counties access information about pests from various sources which is a good sign that they are kept informed especially on pest management issues. However, failure to read the pesticide labels was recorded as a challenge that may lead to unsafe use of pest control products. The survey showed that farmers in

coastal counties of Kenya had a major challenge in identification of scale insects and mealybugs. Some farmers may not be able to manage these pests appropriately because they may not even be aware they exist. This has been documented as a major challenge in early detection and management of scale insects in the counties.

Recommendations

Based on the findings from this study, it is recommended that the capacity of extension officers and other information providers in the coastal counties on the identification and proper management of scale insects and mealybugs be built. Factsheets, manuals and other relevant documents should be developed, published and distributed to various strategic areas for visual recognition of the target pests and how they occur on the farms, to enhance awareness of these pests. National institutions should work with the identified county governments to develop effective management practices for the target pests. Further to this, parasitoids, predators and other natural enemies of scale insects and mealybugs should be identified and practices that enhance the population of the natural enemies should be developed and encourged to enable sustainable control. There is need to train affected farmers on use of specific insecticides for specific target pests, to avoid misuse of chemicals on the farm.

Acknowledgements

The study was made possible by funding provided by the United Kingdom's Darwin Initiative scheme project 25–032, supported by Department for Environment Food & Rural Affairs (Defra), Department for International Development (DFID) and the Foreign, Commonwealth and Development Office (FCDO).

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