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Farmers' Perspective on Insect Pests that Affect Vegetables in Protected Structures with Emphasis to *Tuta absoluta* (Meyrick) in Lesotho

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Authors' contributions

This work was carried out in collaboration with all authors. Author MMS designed the study, collected data, and wrote the first draft of the manuscript. Authors MS and PVM managed the analysis of the study. All authors read and approved the final manuscript.

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ABSTRACT

Protected farming is one of the innovations used by farmers to control pests and climatic conditions and therefore improve yield of vegetables. However, these structures also provide an ideal environment for biotic factors such as insect pests and diseases. In this study, a survey of 60 farmers was conducted to determine the types of vegetables cultivated under protected structures, insect pests and management practices employed by farmers using structured questionnaires. Data was analysed through descriptive statistics using Statistical Package for Social Sciences (SPSS). The results showed that most farmers grew tomato, cabbage, swiss chard, rape and peppers. Farmers considered insect pests as the major constraint to vegetable production. The most important insect pests found infesting farmers' vegetables were aphids (*Aphis gossypii*), tomato leafminer (*Tuta absoluta*), bagrada bug (*Bagrada hilaris*) and cutworm (*Agrotis ipsilon*). To manage these pests, farmers relied heavily on chemical pesticides which are dangerous to them and to the environment. It is therefore important to develop an integrated pest management plan that farmers can use to reduce use of pesticides.

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1. INTRODUCTION

Vegetable production in Lesotho accounts for about 13.5% of land planted to crops, with fruit adding a further 1.5 percent [1]. The 2009/2010 agricultural census showed that out of the total area planted with vegetables (5817 ha), spinach and rape occupy the highest area of 25.2 % each and cabbage followed with 22.1 %; with tomato only occupying about 3% [2].

The government of Lesotho in collaboration with development partners is upscaling vegetable farming by providing high tunnels and shade nets as well as initial basic training on protected farming. Programs that support this initiative include the World Bank's Smallholder Agriculture Development Project (SADP) and the World Trade Organization's Enhanced Integrated Framework (EIF) project [3]. These programs have provided grants to about 400 farmers for production of vegetables such as tomatoes, cucumbers, pepper and cabbage [4].

Protected vegetable production plays an important role in world food supply and the role is expanding with time [5]. These structures are aimed at modifying the crop environment through the use of soil covers and/or plant covers to control pests and climatic conditions [6]. They create a favorable environment for the sustained growth of the plant to realize its maximum potential even in adverse climatic conditions [7]. However, presence of warm, humid conditions and abundant food under protected structures provide a stable environment and habitat for pest development [8]. Increased air temperature within the high tunnels may cause an increase in insect populations, which may affect crop production; some of these insect species may also lead to an increase in insect-vectored diseases [9]. Normally, the natural enemies that control pests in open fields are lacking under protected environment [8]. According to Johnson et al. [10] pest pressure is often greater on crops grown in protected structures such as high tunnels when compared with open-field plots. Ingwell et al., [11] indicated that greenhouse pests, like aphids and whiteflies were more prevalent in high tunnels, compared to field plots. Desneux et al. [12] also added that tomato leafminer, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae), is a key pest of both open field and protected crops such as tomatoes, which results in 100% yield loss at high population density. Leafminer was first recorded in Africa in 2008 [13], and in the neighboring country, South Africa, it was recorded in 2016 [14]. However, in Lesotho reports about this pest are insufficient, lacking its distribution and population dynamics.

In Lesotho protected structures, such as tunnels and shade nets, have not been evaluated for their impact on insect pests' infestations on vegetables production. Therefore this study was conducted to determine types of crops cultivated, insects infestations on crops grown under farmers management practices.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted in four districts of Lesotho on selected Agricultural Resource Centre (ARC), based on accessibility and high production capacity. These ARCs are namely; Leribe (Hlotse, Peka and Maputsoe), Berea (Sefikeng, Teyateyaneng, Maqhaka, Pilot and Mapoteng;), Maseru (Roma and Masianokeng) and Mafeteng (Matelile, Ha Mosala, Kolo, Ramokoatsi, Ribaneng, Thabana-morena and Tšakholo). The ARCs are strategically placed in different localities of the districts to serve farmers with similar farming activities. The ARCs offer technical backstopping and communicate government policies to farmers.

2.2 Data Collection

The data was collected from 1st October 2019 to 28th February 2020 through individual farmers' interviews. A survey of 60 farmers was conducted by use of a structured questionnaire. Farmers were selected on the basis of vegetable production under protected structures and were chosen with the assistance of Smallholder Agriculture Development Project (SADP).

Farmers were interviewed individually using both close-and open-ended questions. The questions were centred on the type of vegetables cultivated under protected structures; constraints of vegetable production such as different insect pests and their control methods; including pesticides application. Pilot questionnaires were also administered with only five farmers from

Mafeteng, and corrections were made accordingly on the questionnaire.

2.3 Data Analysis

The Statistical Package for Social Sciences (SPSS) 20 was used to capture, clean and analyse data on farmers' profile, vegetables produced by farmers, insect pests encountered by farmers. All tables and graphs were drawn using Microsoft excel.

3. RESULTS

3.1 Farmers Profile

The characteristics of farmers interviewed are reflected in Table 1. Male farmers were the most dominant producers with 70% farmers and only 30% female farmers. Farmers (28.3%) in the age group of 40-50 were the most active farmers in vegetable production followed by the age group of 30-40 with 26.7% farmers. Most farmers had higher education at 38.3% ranging from Tertiary Certificate, Diploma, Degree, Post-graduate Diploma and Master's Degree. About 35% of farmers had 1 – 3 years' experience in vegetable production.

3.2 Types of Vegetables Produced Under Protected Structures

Table 2 shows the farmers response on the vegetables grown under high tunnels and shade nets. Tomato was the most grown vegetable under high tunnel with 78.3% of farmers cultivating it, followed by cabbage which was cultivated by 48.3% of the farmers. Cabbage was the most cultivated vegetable in the shade net (21.7%) followed by tomato and green pepper at 18.3% and 16.7% respectively. Other vegetables grown included; carrots, water melon, cucumber, onion, chillis, Okra, gooseberry, potatoes, and green beans.

Table 1. Summary of the characteristics of farmers in the study areas

Profile of farmers	Characteristics	Frequency (%)
Gender	Male	70.0
	Female	30.0
Age group	less than 20	1.7
	20-30	16.7
	30-40	26.7
	40-50	28.3
	50-60	20.0
	above 60	6.7
Educational background	Primary level	15.0
	Secondary level	21.7
	High school level	21.7
	Tertiary level	38.3
Farmers experience in vegetable production	1 – 3 years	35.0
	4 – 6 years	28.3
	7 – 9 years	1.7
	10 – 12 years	13.3
	13 – 15 years	20.0

Table 2. Major vegetables produced under protected structures in Lesotho

Name of a crop	Frequency under High tunnel (%)	Frequency under Shade net (%)
Tomato	78.3	18.3
Rape / English giant	23.3	6.7
Spinach / Swizz chard	35.0	6.7
Cabbage	48.3	21.7
Lettuce	10.0	0.0
Beetroot	8.3	1.7
Green pepper	18.3	16.7
Others	25.0	16.7

3.3 Farmers' Perspective on Insect Pests that Affected their Vegetables

Vegetable crops were affected by pre- and post-harvest insects that had an impact on yield. Farmers regularly monitored their fields to identify insects and assess population density to employ proper integrated control methods before pest damage can affect yield and quality of the produce. Field inspection and scouting for insects was done regularly by most farmers (83%). Others did inspection on a weekly interval (10%) or fortnightly basis (2%) while some indicated that they performed field scouting only when the plants showed symptoms of stress (2%).

Table 3 shows insect pests that affected farmers' crops. Aphids were the most problematic insect pest under both high tunnel and shade nets with 65% and 23.3% respectively. The second most aggressive insect that affected farmers' vegetables was tomato leafminer which was most dominant under high tunnels with 61.7% of farmers affected as opposed to 10% of farmers under shade nets affected. When comparing the two structures, the incidence of insects encountered by farmers was high under the high tunnels than in the shade nets.

Table 3. Major insect pests encountered by farmers under protected structures

Insect pests	Frequency under High tunnel (%)	Frequency under Shade net (%)
Tomato leafminer	61.7	10.0
Aphids	65.0	23.3
Bugrada bug	40.0	20.0
Cutworm	31.7	6.7
White fly	15.0	1.7
Red spider mites	13.3	1.7
Leaf eating ladybird beetles	10.0	6.7
Locust	10.0	8.3
Others (Fruit fly, millipede, snail & Slug, grasshopper, nematodes, earth worms)	16.7	3.3

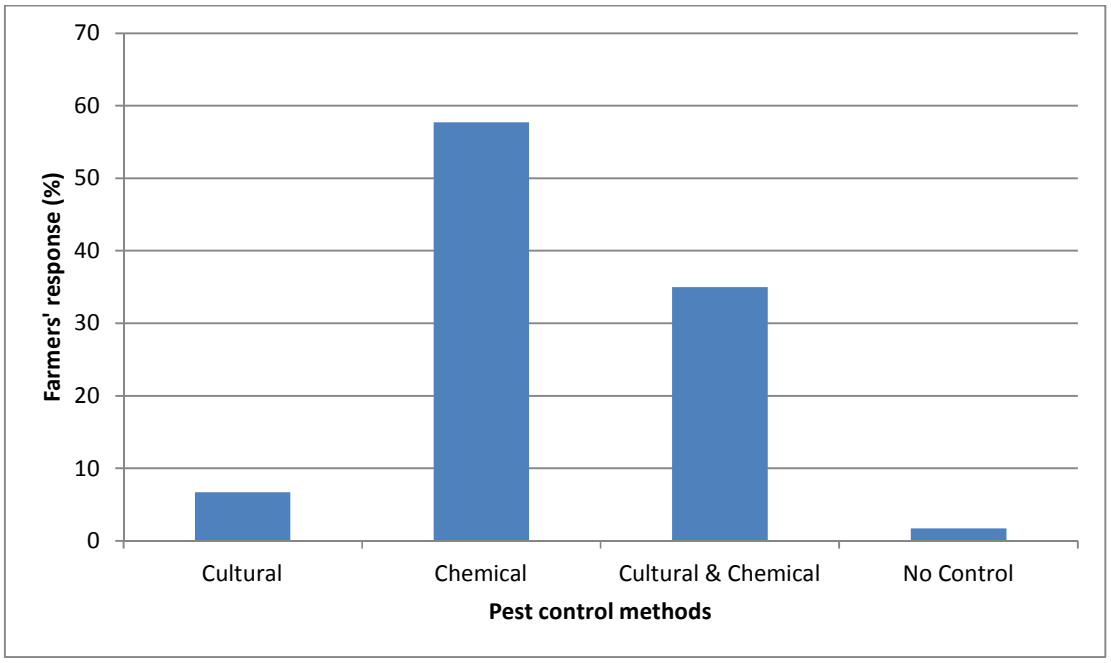

Fig 1. General insect management practice used by farmers

Farmers undertook a range of control measures for insect pests affecting their crops (Fig. 1).

Most farmers (57.7%) used pesticides to control insects, while about 35% integrated both cultural and chemical methods to control the insect pests. In cultural methods farmers removed the affected plants or plant parts and some even burnt them especially when it was tomato leafminer affecting their crops. Very few farmers, 1.7% did not apply any control measures.

3.3.1 *Tuta absoluta* as the most destructive pest of vegetables under high tunnels and shade nets

Farmers were severely affected by tomato leafminer which was very destructive and resulted in substantial yield losses. This pest forced some farmers (6.7%) to stop tomato production under high tunnels due to lack of effective control measures. Fig. 2 shows the crop production years that the farmers were first affected by tomato leafminer. The first encounter was in 2016 where 5% of the farmers interviewed reported this insect. Some farmers, 28.3%, did not have the incidence of this pest in their vegetables and 8.3% of the farmers had the cases of tomato leafminer but they did not recall the exact year that this pest infested their crops.

The management practices used for control of tomato leafminer are reflected in Table 4. Farmers (13%) used Steward to control this pest and it was effective in managing it. Some farmers

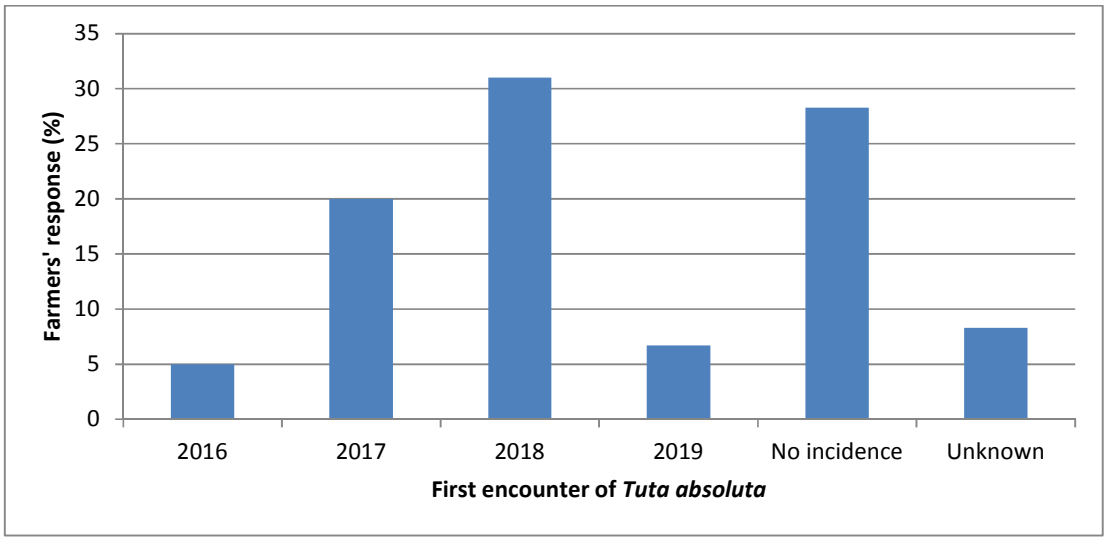

Fig. 2. First encounter of *T. absoluta* by farmers in selected districts of Lesotho

Table 4. Management of tomato leafminer by farmers

Management practice for tomato leafminer	Active ingredients	Farmers' response (%)
Steward	Indoxacarb	13.3
Attacke	Lambda Cyhalothrin	6.7
Carogen	Chlorantraniliprole	3.3
Belt	Flubendiamide	3.3
Other chemicals (Malathion, aphicides, deltamethrin, altha-thrin 100SC, hunter, lamdex, lamda EC, methomex and cypermethrin)	Malathion, Dimethoate, Deltamethrin, Alpha-cypermethrin, chlorfenapyr (pyrrole), Lambda Cyhalothrin 50 EC, Methomyl (carbamate) and Cypermethrin	15.0
Cultural methods; (Uproot the affected plants, burning the affected plants, Home-made traps)		15.0
Pheromone traps		1.7
No control		15.0

used cultural practices like making home-made traps (using a light bulb to attract adult leafminer then setting a colorful basin below with water so that the adult will fall in it). Other farmers could not afford to buy any pesticides for this pest.

4. DISCUSSION

Male farmers were the most dominant gender group with 70%. Ochilo et al. [15] and Asante et al. [16] also found majority of farmers in vegetable production to be males in Sub-Saharan Africa. Majority of farmers had higher education at tertiary level at 38.3%. These results were not in line with those found by Khapayi and Celliers, [17] who found no heads of households had tertiary education King William's town area in Eastern Cape, South Africa and Asante et al. [16] who only found 3.2% farmers that had tertiary qualifications in a study conducted in Ghana. Majority of farmers (35%) had 1 – 3 years in experience on vegetable production. These results were also not corresponding to those found by Fuad et al. [18] who found majority of farmers with 8 – 19 years of experience in farming in India.

Vegetable production under protected structures has been increasing over the past five years in Lesotho as a result of donor and government support and cultivation of many vegetables in the country is scale neutral and even smallholder farmers with less than a hectare of land can operate at a profit [3]. Under these structures, tomato was the most cultivated vegetable by farmers interviewed (96.6%). Fufa et al. [19] also found that tomato was a major vegetable in sub-Saharan Africa. The second most cultivated crop by farmers was cabbage which was grown by 48.3% and 21.7% farmers under high tunnel and shade net respectively. Cabbage was grown throughout the year, both as a summer and winter crop. However production of these vegetables is not enough to meet the demand of consumers. According to World Bank [3] cabbage is a highly demanded vegetable crop in Lesotho with about 423.76 tonnes of demand in Maseru district only.

Majority of the interviewed farmers (83.3%) performed regular field scouting to monitor the insects that attacked their vegetables. Most farmers interviewed had a high incidence of insects in their high tunnels than in shade nets. Farmers were mostly affected by aphids which attacked mostly cabbage both under high tunnel and shade net with 65% and 23.3% respectively. Kaiser and Ernst [20] also found aphids attacked crops under high tunnels because it provides an ideal environment for such insects.

The second most important pest affecting farmers' crops was tomato leafminer which affected about 65% of the farmers under high tunnels and few farmers (10%) under shade nets. Based on this study, this pest was first detected on the farmers' fields in 2016, which is the same year it was first encountered in South Africa [14]. It affected vegetables such as tomatoes and rape. As indicated by Bawin et al. [21] and Tonnang et al. [22] tomato leafminer, *Tuta absoluta* is a devastating pest of tomato and other Solanaceous crops in many areas of the world causing severe damage and yield losses. Among pests discovered in these protective structures, *T. absoluta* is blamed to eradicate some farmers (6.7%) engaged in tomato production due to their failure to its control and management. According to Chidege et al. [23] and Desneux et al. [12], in the absence of control strategies for this pest, yield losses can reach 80%–100%.

Most farmers used pesticides to control the insect pests attacking their vegetables. For control of *T. absoluta,* which was the most aggressive pest, farmers used insecticides such as Steward, Attacke, Coragen and Belt. Only farmers using Steward indicated that it was effective against tomato leafminer. However, farmers claimed that most of other chemicals they used, the insect developed resistance against them. Rwomushana [24] indicated that use of pesticides to control *T. absoluta* is unsustainable and likely to lead to widespread development of resistance due to over-reliance on chemical pesticides. Other insect pests that affected farmers included bugrada bug, cutworm and white fly.

In many sub-Saharan Africa, protected agriculture is not suitable in all climatic conditions and they need to be combined with other methods to ensure adequate pest control [6]. In Lesotho, there are areas that have high rainfall capacity such as Leribe and other areas such as Mafeteng which can be considered as low rainfall areas of the country. Therefore, the study on the suitability of high tunnels and shade nets in the agro-ecological zones of the country should be conducted. And also determine the suitable relative shading capacity of shade nets under Lesotho's conditions.

Researchers and extension workers also need to work with farmers in developing integrated pest management strategies under protected structures that will reduce heavy reliance on pesticides by farmers as this poses risks on individual farmers and the environment.

5. CONCLUSION

There is a potential increase in vegetable production as a result of protected structures in Lesotho. Majority of farmers were males, however, most of the farmers had limited years of experience in vegetable production under these structures. Tomatoes were the most cultivated vegetable crop under high tunnels, while cabbage was the most produced crop under shade nets. Under these structures, vegetable production was hindered by insect pests. The most problematic insect pests were aphids and tomato leafminer, followed by bugrada bug and cutworm under high tunnels. Under shade nets the highest incidences of pest were aphids and bugrada bug followed by tomato leafminer and locust. Tomato leafminer devastated farmers vegetables and resulted in severe yield loss at the beginning of its infestation, and some farmers eventually stopped tomato production altogether. For management of these insect pests farmers relied heavily on insecticides. Few farmers used pheromone traps and cultural methods, which included burning the affected plants.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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