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Perceptions of Sierra Leonean Mango Farmers on the Pest Status and Current Management Practices for the Control of Fruit Fly in Sierra Leone

Paul Borbor Brewah, Alusaine Edward Samura, Abu James Sundufu*, Vandi Amara, Raymonda Adeline Bernadette Johnson

Crop Protection Department, School of Agriculture and Food Science, Njala University, Moyamba, Sierra Leone
Email: paulbobir@gmail.com, alusaine.samura@njala.edu.sl, *abuj.sundufu@njala.edu.sl, vandiamara66@gmail.com, raymonda.johnson@yahoo.com

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Abstract

Tephritid fruit flies are considered one of the world's most notorious pests of horticultural crops, including mango (*Mangefera indica* L.) in Sierra Leone, causing extensive direct and indirect damage. A survey was conducted among 60 mango farmers in 7 districts in Sierra Leone between June and August, 2022, to assess their perceptions regarding fruit fly pest status and the current management options adopted for the control of this pest. Semi-structured questions designed in an open and closed-ended fashion were used for the study. The majority (83%) of the farmers were already aware of the fruit fly problem in the country with 62% perceiving it to be very severe. The majority (60%) of farmers, however, demonstrated poor knowledge of identifying fruit fly species, especially *Bactrocera dorsalis*, *Ceratitis capitata*, and *Ceratitis cosyra*. Farmers were more conversant about the direct damage symptoms to host fruits and the economic impact of fruit flies. A total of 32% of growers took no action to control fruit flies on their farms. Sixty-nine percent (69%) of the farmers adopted cultural control measures, like practicing prompt harvesting, collection and disposal of infested fruits, and weeding to maintain better sanitary conditions on their farms. Recommended fruit fly management strategies such as the use of botanicals and resistant varieties were either unknown or inaccessible to growers. A total of 52% applied chemicals that were not recommended for the control of fruit flies without considering their environmental and health risks. It is important to train fruit growers to improve their capabilities for fruit fly management through extension agents that are appropriate for helping them acquire basic knowledge of fruit fly pests and their management.

Keywords

Fruit Growers, Fruit Fly Pests, Knowledge, Perceptions, Sierra Leone

1. Introduction

Although growth in the horticulture sub-sector presents many opportunities for improving food and nutritional security and growing the rural economies and livelihoods of the poor populace, it faces threats from insect pests. For instance, tephritid fruit flies impact the entire horticultural sector in the countries of Western Africa, destroying 50% to 80% of fruit production [1], and are known to cause extensive economic losses to horticultural crops throughout Africa as a whole [2]-[10].

Sub-Saharan Africa (SSA) alone is home to 915 fruit fly species from 148 genera, out of which 400 species develop in either wild or cultivated fruits or both. They belong mainly to three genera: *Ceratitis, Dacus* and *Trirhithrum*, which cause between 25% (*Ceratitis* and *Trirhithrum*) and 62% (*Dacus*) damage to fruits and vegetables [11]-[14].

Mango (*Mangifera indica* L.) is the most widely cultivated fruit tree in the Sahel and one of the most important tree crops in the tropics [15]. It is a highly prized exotic fruit on the European market and one of the important fruit crops grown in tropical and sub-tropical regions [16]. The damage by *B. dorsalis* to mango, for instance, is estimated to vary from 40% to 90% depending on the location, the cultivar and the seasons in Eastern, Central, Southern and Western Africa [17] [18], while in Northern Africa, Medfly *Ceratitis capitata* (Wied.) is wreaking havoc [19]-[21]. In addition, indirect losses attributed to the quarantine restrictions imposed by importing countries to prevent the entry and establishment of fruit flies are estimated at $2 billion annually in Africa [13]. The direct and indirect damage continue to have wide-reaching socio-economic implications, including the loss of jobs, income and trade for millions of rural and urban populations involved in the horticulture value chains across Africa.

Ochou *et al.* [22] noted that the prospect of enhancing the farmer's role as an independent decision maker requires a realistic assessment of their on-farm crop protection practices and an understanding of the major constraints which may inhibit efforts to improve the pest management system. Reliable information needs to be obtained to appreciate fruit producers' practices and to assess opportunities and constraints for decision making at the farm level so that appropriate fruit fly control decision tools and tactics can be designed to meet the needs of fruit producers. It is thus, necessary to conduct surveys that can provide farmers' alternative view point on the crop protection constraints facing them in their efforts to increase and sustain fruit and vegetable crop production [23]. There has been increasing interest in the incorporation of farmers' indigenous knowledge into research and development programmes for finding workable solutions to

agricultural problems [24] [25]. Abdullahi *et al.* [26] and Benjamin *et al.* [27] assessed the perceptions of mango farmers on the pest status and management for *B. invadens* in two districts within southern and northern Ghana, respectively.

In 2006, the interception of mangoes at the borders of the European Union (EU) caused a loss of around 9 million euros for exporters in the region, or more than a third of the total value of exports of that year [28]. The pressure of fruit flies on horticultural production (yields) has a negative impact on the food, health, social security of populations and the environment (due to the use of pesticides of all kinds); and on the economic security (income, exports, competitiveness) of the mango sector in particular, is very important [28]. To provide a response to the height of the scourge, the Commission of the Economic Community of West African States (ECOWAS) initiated, in November 2014, the support Project to the regional plan of fruit flies control (FFCP), with financial support from the EU and the Agence Française de Development (AFD).

In line with the action plan of ECOWAS, FFCP, and AFD, this survey study sought to assess the perception of mango farmers on the pest status and current management options for the control of this pest. The studies were undertaken in seven districts in the Northern, Southern and Western Regions of Sierra Leone. The objectives of this study were to assess the general perception of mango farmers on the pest status of fruit fly infestations and to study the management practices adopted by the farmers.

2. Materials and Methods

2.1. Study Location

The study was conducted in three regions of Sierra Leone namely, the Northern, Southern and Western, where there are established mango orchards (**Figure 1**). In each region, at least one district was selected; Port Loko, Kambia, Tonkolili, Bombali, Koinadugu (Northern region), Moyamba (Southern region), and Western Rural (Western region).

2.2. Methods

A stratified random sampling procedure was used so that each fruit-producing district represented a stratum (sampling unit). The districts were selected based on the availability of commercial fruit crop producers. A list of fruit crop producers in the selected districts were obtained from the Crop Protection Unit of the Ministry of Agriculture. The target farmers were purposively selected based on the criteria that the farmer has experienced at least, three consecutive harvests from his/her farm. Ten farmers were selected from each district to respond to the questionnaire, thus, giving an overall total of 60 respondents from the survey locations. Selected farmers were contacted with the assistance of their respective Agricultural Extension Agents.

Semi-structured questionnaire designed in a closed- and open-ended fashion were administered to farmers selected at random to assess the perceptions of fruit

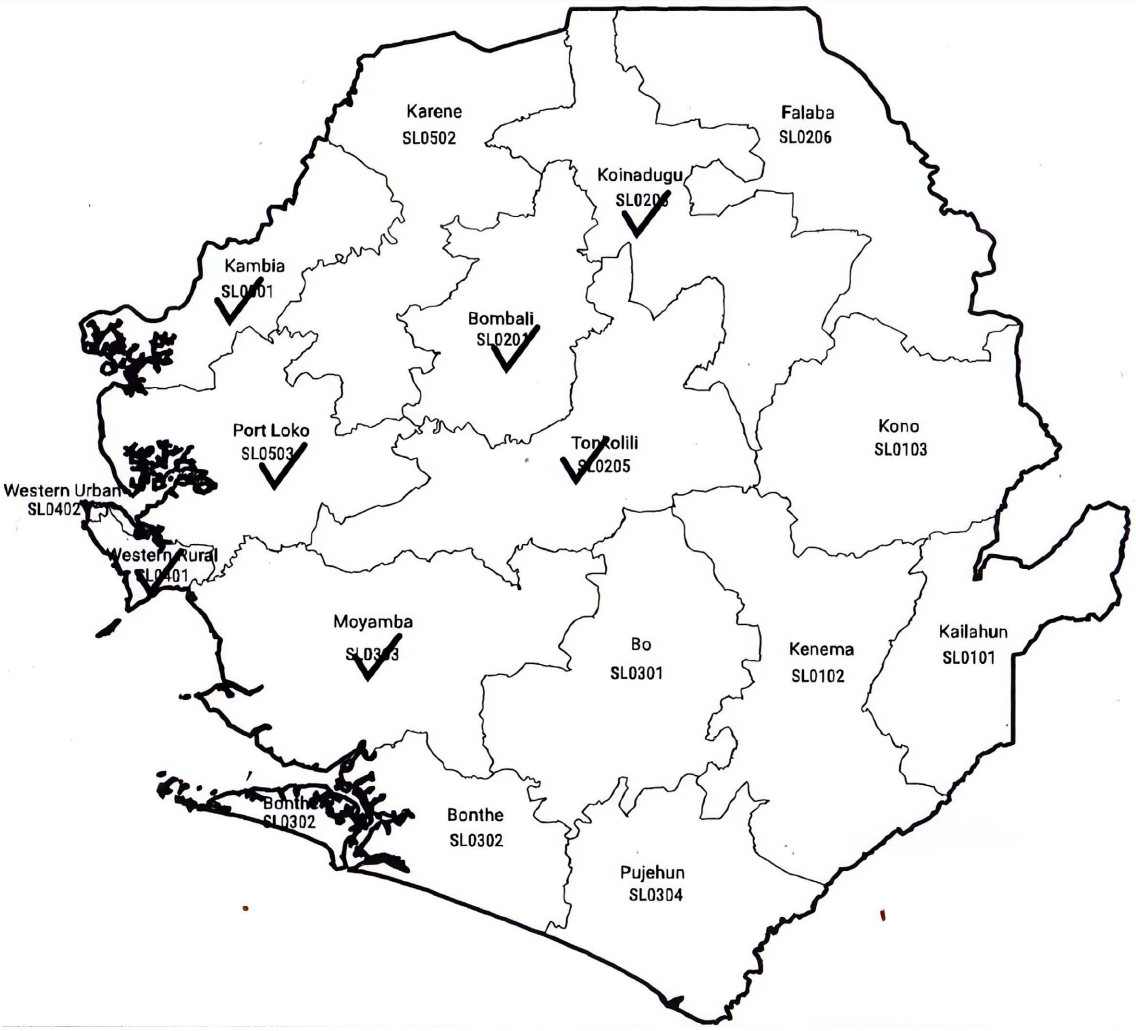

Figure 1. Map of Sierra Leone showing the study area (Port Loko, Kambia, Tonkolili, Bombali, Koinadugu Districts (Northern region), Moyamba District (Southern region), and Western Rural District (Western region) indicated by (√).

producers regarding fruit fly pests and their management. The questions were developed on the following key aspects: knowledge of fruit fly pests, fruit fly damage and economic impact; fruit fly management strategies, and sustainable options to addressing fruit fly damage. Farmers' knowledge of fruit flies was investigated through simple dichotomy statements (*i.e.*, Yes/No), while their perceptions and practices were measured using multiple-point likert rating, or frequency determination statements to indicate the strength of responses to the questions. Colour photographs of the fruit flies, together with other dipteran insect species were provided in a chart (**Figure 1**) to help verify farmers' ability to identify the fruit fly pests in the area.

Content and face validity were established by a panel of experts consisting of Extension Officers and a group of researchers in Crop Protection Department (Entomology) at the School of Agriculture and Food Sciences, Njala University, Sierra Leone. A pilot test was conducted with 20 mango growers, not included in

the sample, three weeks before the study. After the pilot test, minor changes were made in the expression of the questions.

Data were collected using face-to-face interview combined with field observations, from the month of June to August, 2022; using English and/or appropriate local languages (for farmers who were illiterates). Each interview lasted on average of 40 minutes.

2.3. Data Analysis

All data generated from the field survey were analyzed using descriptive statistics (percentages). Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS for Windows version 16.0).

3. Results

3.1. Perception of Mango Farmers on the Pest Status of Fruit Flies

In order to determine their levels of awareness of the fruit fly infestation in their farms, farmers were first asked whether they had ever heard of the insect pest. From the results of the survey, 50 (83%) responded in the affirmative while 10 (17%) of them said they had never heard of the pest. The 50 respondents further indicated that they received information on fruit fly pests from sources including fellow farmers (20%), fruit traders (14%), agricultural extension agents (36.0%), and radio (26.0%) and others such as friends and relatives (4%) (Table 1). The farmers were then asked to indicate their self-perceived nature of the percent damage by fruit flies in their localities. The majority of the respondents 37 (62%) indicated that the fruit fly problem was very severe while 14 (23%) said that the fruit fly problem was moderately severe, while 9 (15%) of farmers said the fruit fly problem was severe (Table 1).

With respect to identification of fruit fly species, those farmers who showed awareness were further tested for their ability to identify true fruit fly pests. The results indicated that 11 (22%) and 7 (14%) of the farmers wrongly referred to Housefly (*Musca domestica*) and Honey Bee (*Apis melifera*), respectively as true fruit fly pests. Also, 12 (24%) farmers wrongly considered *Drosophila melanogaster* as a true fruit fly pest. However, there were farmers who correctly identified *Bactrocera dorsalis* 8 (16%), *Ceratits capitata* 5 (10%), and *C. cosyra* 4 (8%) as true fruit fly pests. Meanwhile, 3 (6%) of them said they had no idea as to which of the insects were true fruit fly pests (Table 1).

3.2. Fruit Fly Damage and Economic Impact

The perceptions of farmers regarding the damage and economic impact of fruit fly pests in the farms are presented in Table 2. The mean value of the overall (summated across the 8 items) knowledge of farmers about fruit fly damage and economic impact was 3.9; the standard deviation (SD) was 1.0. The highest mean value for an item (4.1; SD = 1.0) was reported for 2 statements in ranks 1 and 2. The second highest item mean value (4.0; SD = 0.9) was reported for statement in

Table 1. Awareness of fruit flies and pest identification by farmers.

Variable	No. of respondents	(%)
Heard of the insect pest before? (N = 60)		
Yes	50	83
No	10	17
Sources of information on fruit fly pests? (N = 50)		
Fellow farmers	10	20.0
Fruit traders	7	14.0
Agricultural extension agents	18	36.0
Radio	13	26.0
Friends and relatives	2	4.0
Self-perceived nature of the percent damage by fruit (N = 60)		
Very severe	37	61.5
Moderately severe	14	23.1
Severe	9	15.4
Insect species identified as true fruit fly pests (N = 50)[a]		
Musca domestica	11	22.0
Apis melifera	7	14.0
Drosophila melanogaster	12	24.0
Bactrocera dorsalis[b]	8	16.0
Ceratitis capitata[b]	5	10.0
Ceratitis cosyra[b]	4	8.0
No idea	3	6.0

[a]Colour photographs of insects (without their names) were provided for the identification; [b]True fruit fly pests.

Table 2. Farmers' knowledge of fruit fly damage and economic impact.

Rank	Responses	Frequency[a]	%	Mean[b]	Std. dev.
1	Fruit fly infestation reduces farmers' income	39	78.0	4.1	1.0
2	Fruit flies are a threat to mango industry	38	76.0	4.1	1.0
3	Infested fruits usually causes loss in market value	37	74.0	4.0	0.9
4	Adult flies create punctures on fruits	33	66.0	3.9	0.8
5	Fruit fly damage reduces fruit quality	30	60.0	3.8	1.0
6	Infested fruits usually get rotten	25	50.0	3.7	1.1
7	Infested fruits may fall off the plant prematurely	24	48.0	3.7	1.1
8	Fruit fly infestation increases production cost	21	42.0	3.6	1.2
	Overall average			**3.9**	**1.0**

[a]Number of agree and strongly agree responses; [b]Scale: 1 = strongly disagree; 2 = disagree; 3 = no opinion; 4 = agree; 5 = strongly agree.

rank 3. All the 3 statements addressed the economic effect of fruit fly pests on agricultural production. The third highest item mean value (3.9; SD = 0.8) was reported for a statement in rank 4, that addressed the external fruit damage caused by fruit flies, which may seem easily recognizable by the farmers. In general, farmers mentioned fruit destruction as one of the damage caused by the fruit flies. Farmers believed that, the fruit flies pierced the skin of the fruit, sucked the fruit juice and laid eggs, which changed into larvae (maggots). These caused changes in the colour of the fruits, premature ripening and loss in fruit quality of the fruits. Total loss in yield is the direct effect of the presence of mango fruit flies in mango production and the reduction in farmers' income due to loss of market value.

3.3. Fruit Fly Pest Management Practices Implemented by Sierra Leonean Farmers

The various control measures farmers used to reduce the effects of fruit flies encountered in their farms are presented in Figure 2.

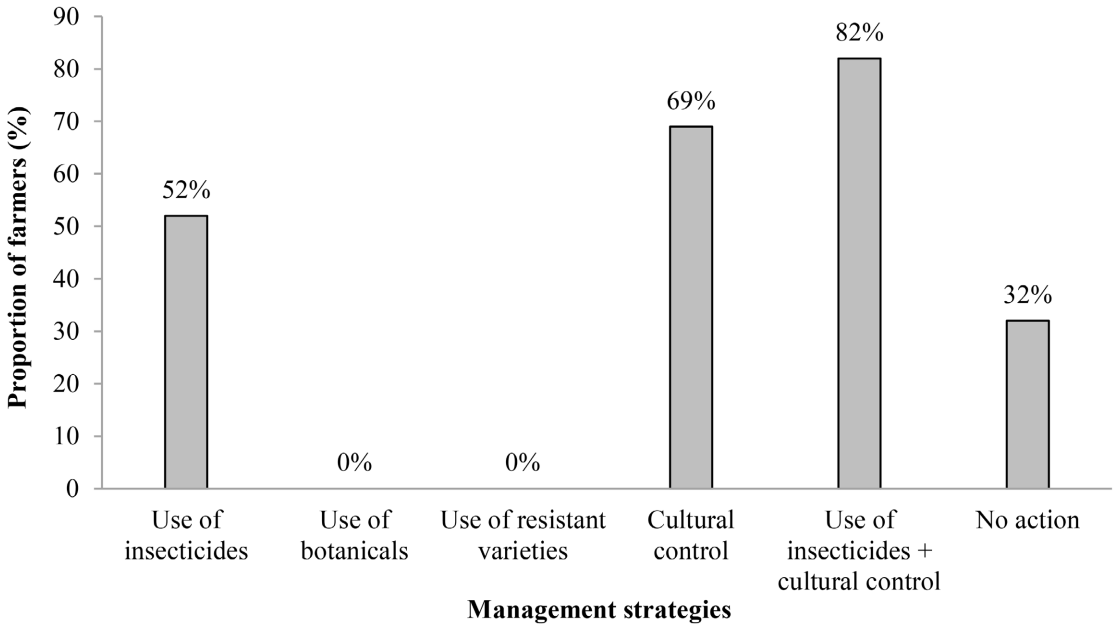

Figure 2. Management strategies adopted by farmers of fruit fly pests in Sierra Leone.

Slightly over 50% of the farmers use synthetic chemical insecticides, applied as either a single control method (52%) or in combination with one or more other control measure(s), indicated by the majority (82%). The farmers applied synthetic chemical insecticides, mostly belonging to the organochlorine and organophosphate groups for the management of fruit flies in their orchards. Besides these two management strategies, 69% of the farmers adopted cultural control measures, like practicing prompt harvesting, collection and disposal of infested fruits, and weeding to maintain better sanitary conditions on their farms. This in essence, has the advantage of reducing the source of infestation. Meanwhile, all the farmers were ignorant of the use of botanicals and resistant varieties for the

management of the fruit flies in Sierra Leone. With respect to the latter, the farmers generally believed that no variety of mango was in any way resistant to the attack of the pest and hence the use of host-plant resistance as means of controlling would be ineffective for all practical commercial purposes. Thirty-two (32) percent of the farmers however indicated that they had not taken any action to manage fruit fly infestation in their farms.

In response to the sustainable options for addressing the fruit fly infestation, the majority (44%) of the respondents indicated the need to train fruit growers on fruit fly pests and their management, as a way to address the pest problems. About 20% suggested the availability/subsidy for recommended inputs (chemicals and equipment) for controlling the pests, while 18% farmers suggested that the capacities of extension agents should be strengthened by empowering them with the appropriate crop protection innovations. The proportion of farmers suggesting the need for public awareness and improved research were 9% and 5%, respectively. However, 4% of the farmers could not propose any practical way to address the fruit fly problem in their localities (Figure 3).

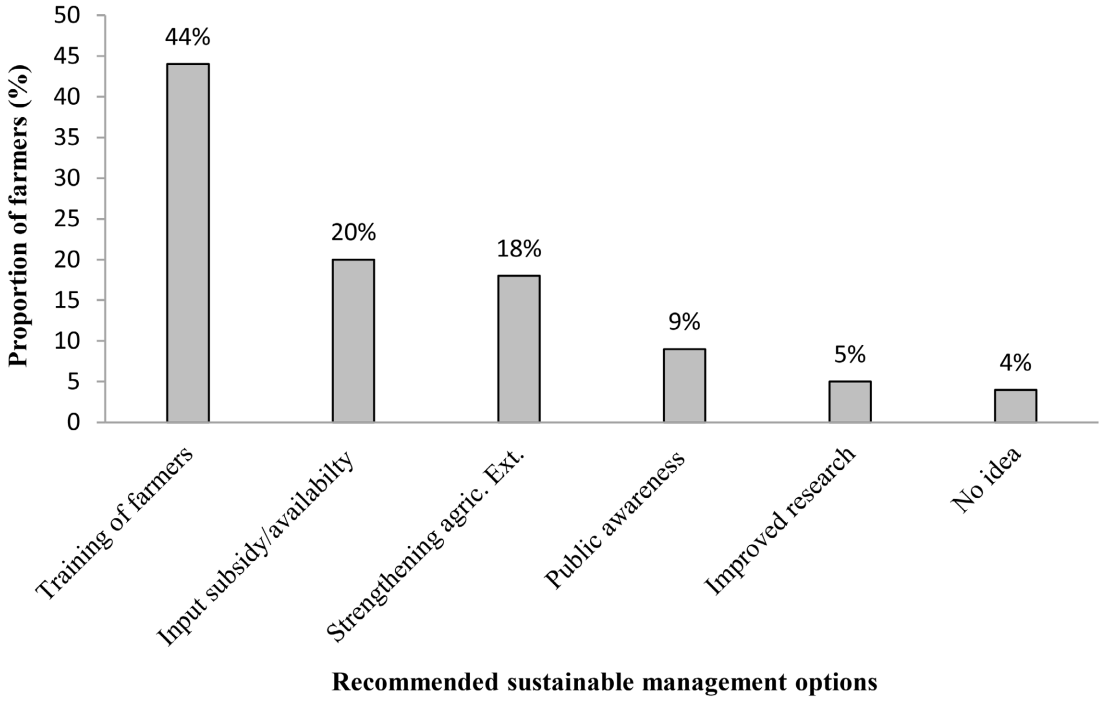

Figure 3. Recommended sustainable management options to addressing the fruit fly menace as proposed by farmers.

4. Discussion

The results of the survey indicated that mango farmers were aware of fruit flies among the major pests of mango in Sierra Leone. However, with respect to the identification of fruit fly species, the majority 30 (60.0%) of farmers demonstrated poor knowledge in identifying the actual fruit fly species, especially *Bactrocera invadens*, *Ceratitis capitata, and Ceratitis cosyra*. This was quite striking. In some

cases, we had to show cards with photos of fruit flies to them so they would understand what the topic was about. This is a fact that makes farmers more vulnerable to misleading management strategies. This confirms Sarango [29]'s observation in Malaysia, where baited methyl eugenol is frequently sold in packaging illustrated with pictures of a female melon fly. This is misleading information due to the fact that attractants do not work on female flies and methyl eugenol does not work to catch Melon flies but Oriental Fruit flies. It is clear that good knowledge of the biology and behavior of the species responsible for the crop damage is required to successfully establish and perfect integrated pest control methods. This necessitated the identification of the actual fruit fly species responsible for mango damage in the orchards in Sierra Leone.

On the effect of fruit flies fruit production, the farmers who did not correctly identified actual fruit flies, were of the opinion that, their fruits were damaged by other arthropod pests associated with mangoes. On the contrary, those that correctly identified the actual fruit flies recognized the fact that, tephritid fruit flies cause severe damage to their crops with detrimental consequences on their earnings. This knowledge could have been gained as a result of curiosity on the part of the farmers trying to know the identity of the flies they see most often or through contact with agriculture extension workers. This confirms Vayssieres *et al.* [1]'s observation that losses caused by fruit flies range from 12% - 50% for mangoes in Benin, depending on the season and management practices adopted. Thus, fruit flies inflict heavy losses on fruits and vegetable crops because of their phytophagous habits [30] [31]. Activities by different fruit fly species lead to these losses and vary between fruit fly species, fruit host involved and among communities. Thus, they are accorded different economic status in different farming systems in the world [17] [26]. The knowledge of the presence of the fruit fly pests is crucial in aiding the development of solutions to minimize their effect and/or farmers' acceptance of new innovations in combating these pests. It also has an advantage of prompting farmers to collaborate with researchers in developing sustainable on-farm environmentally friendly strategies to reduce the losses caused by the pest Abdullahi *et al.* [26].

Several strategies are being adopted by farmers for the control of fruit flies (including *B. dorsalis, Ceratitis capitata, C. cosyra*) in Sierra Leone. These strategies include the use of insecticides, which these farmers admitted, there were satisfied with, and thought that insecticides were an effective control measure. However, effectiveness of the insecticides could be explained by the exaggerated number of applications. Many farmers sprayed their fields more than five times during the growing period without following any quarantine period. Farmers also mentioned cultural control measures, primarily field sanitation. This method focuses on the destruction of all unmarketable and infested fruits and the disposal of crop residues immediately after harvesting. Although, this is a laborious exercise, it can be effective if the fruits are collected twice a week and destroyed throughout the entire growing season [32]. Finally, a combination of insecticides and cultural

practices, which proved to be the most outstanding, to manage fruit flies. It was evident that farmers adopt multiple strategies to minimize the loses due to fruit flies in an IPM fashion outlined by Ekesi and Billah [33] and Obeng-Ofori [34]. However, the recommended sustainable fruit fly management strategies indicated by growers were, training fruit growers through agriculture extension agents about appropriate methods for managing fruit fly damage to mangoes, availability/subsidy for recommended inputs for controlling the pests, and improved research on appropriate crop protection innovations.

5. Conclusion

The perceptions of Sierra Leonean farmers regarding the pest status and current management options for the control of this pest were studied in seven districts in Sierra Leone. The study showed that, although farmers mistakenly identified the actual fruit flies, they are already aware of the tremendous yield and other losses that can be incurred due to the activities of the insect pest. Regarding the management of pest, most of the farmers adopted cultural control measures, like practicing prompt harvesting, collection and disposal of infested fruits, and weeding to maintain better sanitary conditions on their farms. There is the need, therefore, to carefully study how these practices are carried out by farmers and make improvements where necessary to enhance their effectiveness in fruit fly suppression.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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