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*Research Article*

# Farmers' Knowledge and Perceptions of Fruit Fly Pests and Their Management in Northern Ghana

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**ABSTRACT**

**Farmer-level knowledge is an important component of the action plan of the fruit fly committee of Ghana. A survey was conducted among 188 fruit growers in 20 districts in northern Ghana between February and May, 2012, to assess their knowledge, perceptions and practices (KPP) regarding fruit fly pests. Semi-structured questions designed in an open- and closed-ended fashion were used to assess farmers' KPP about the pests. Majority (90 %) of the farmers were already aware of the fruit fly problem in the country with 55.3% perceiving it to be very serious. Majority (80.9%) of farmers however, demonstrated poor knowledge in identifying the fruit fly species of economic importance, especially the new African invader fruit fly, *Bactrocera invadens*. Farmers were more conversant with the economic impact of fruit flies than their direct damage symptoms on host fruits. A total of 39% growers took no action to control fruit flies in their farms. Recommended fruit fly control strategies such as pheromone trapping, bait application, soil inoculation and biological control were either unknown or inaccessible to growers. A total of (72%) 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 farmers' field schools appropriate for helping them acquire basic knowledge of fruit fly pests and their control, and enable the most receptive farmers to reach a level of independent decision-makers.**

## INTRODUCTION

The horticultural industry in sub-Saharan Africa is confronted with several constraints including the incidence of pests and diseases (Norman, 2003). The fruit and vegetable production sector in particular is threatened with infestation by fruit fly pests (Lux *et al*., 2003a). Tephritid fruit flies are considered to be of greatest concern owing to their extensive damage and economic losses to major fruit and vegetable crops, coupled with their quarantine status (White and Elson-Harris, 1992; Ishida *et al*., 2005; De Meyer *et al*., 2007; USDA-APHIS, 2008). Economically important fruit fly pests in Africa belong to the genera *Bactrocera*, *Ceratitis*, *Dacus* and *Trirhithrum* (De Mayer *et al*., 2007). Most of these fruit fly species are highly polyphagous, attacking several cultivated and wild fruits and vegetable crops (De Mayer *et al*., 2007; Rwomushana *et al*., 2008; COLEACP-CIRAD, 2010). In Ghana, the earlier fruit flies observed to be of major concern were *C. capitata* (Wiedman) which attack citrus (Afreh-Nuamah, 1999), and *C. cosyra* (Walker) which attacked mango (Lux *et al*., 2003a). However, the arrival of the African invader fly, *B. invadens* (Drew et al.,2005) has jeopardized the situation in the fruit and vegetable production sector (Lux *et al*., 2003b; Mwatawala *et al*., 2004; Vayssieres *et al*., 2005; Drew *et al*., 2005; Billah *et al*., 2006). In the northern part of Ghana in particular, production of major fruit and vegetable crops such as mango, water melons, tomato, peppers and the cucurbits has been severely hit with heavy losses from fruit fly attack.

Since 2010, the National Fruit Fly Committee (NFFC) of Ghana has been established to set standards of public-private sector partnerships for protecting the horticulture industry from fruit flies and other invasive pests in the country (PPRSD-MoFA, 2010; COLEACP-CIRAD, 2010). In its action plan, the committee seeks to, among other things, intensify stakeholder awareness of fruit fly pests in all parts of the country. To this regard, the issue of farmer training has been identified as a pressing need for achieving effective fruit fly awareness creation in the country. An important component of this is to obtain an insight into the needs of fruit producers, as acceptance of any pest management innovation must meet the needs of the customer (Mumford and Norton, 1993).

Ochou *et al*. (1998) 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 (Madisa *et al*., 2010). It is widely acceptable that innovation communication on fruit fly research would be more robust when more farmers' knowledge, perceptions and practices are taken into consideration (Heong *et al*., 2002). There has been increasing interest in incorporation of farmers' indigenous knowledge into research and development programmes for finding workable solutions to agricultural problems (Isin and Yildirim, 2007; Obopile *et al*., 2008). Abdullahi *et al*. (2011) assessed the perceptions of mango farmers on the pest status and management for *B. invadens* in two districts within southern Ghana. In line with the action plan of NFFC of Ghana, this survey study sought to determine the key features associated with the knowledge, perceptions and practices of fruit producers regarding fruit fly pests and their management practices in the northern sector of Ghana. The specific objectives were to:

1. describe the demographic profile of fruit growers
2. determine the knowledge and perceptions of fruit growers regarding fruit fly pests, and
3. assess their fruit fly control efforts and the way forward to addressing the fruit fly menace.

## MATERIALS AND METHODS

### Study Area

The geographical focus of the study was northern Ghana which comprises the Northern, Upper West and Upper East administrative regions of the country (Figure 1).

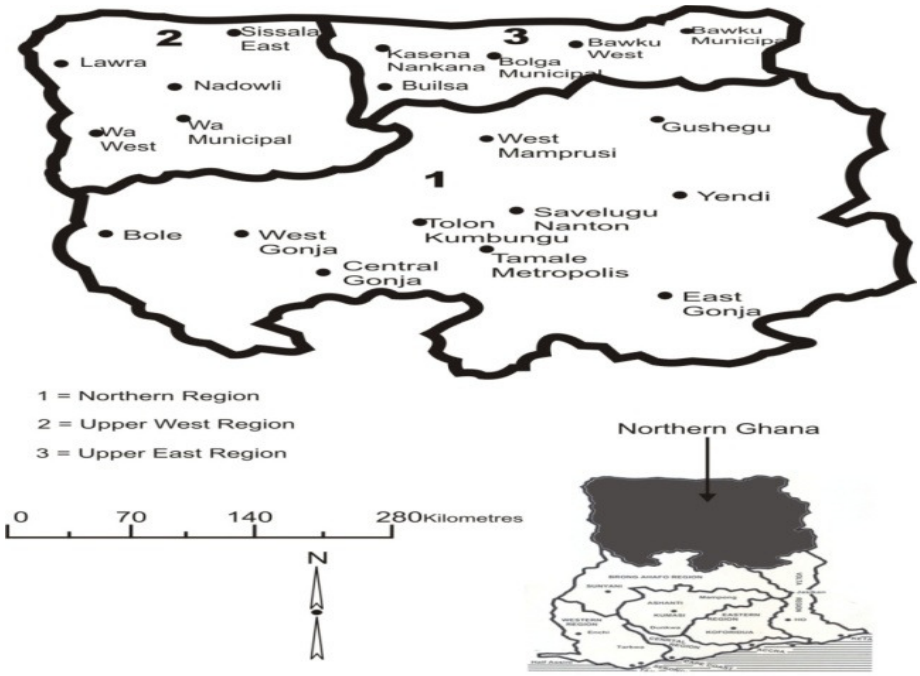


Figure 1: Map of northern Ghana showing study districts.

It is located on lat. 9° 30'N and long. 1° 25'W of the equator. It occupies a land area of about 98,000 km² which is about 41% of the total land area of Ghana. The area is bounded by the Brong-Ahafo and Volta regions to the south, the Republic of Togo to the east, the Republic of Cote'd'Ivoire to the west and the Republic of Burkina Faso to the north (MoFA-GTZ, 2006).

**Survey Methods**

The study was a questionnaire survey involving fruit growers from the three administrative regions of northern Ghana, namely, Northern, Upper East and Upper West. The 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 total of 20 districts, consisting of 12 from the Northern Region, and five each from the Upper West and Upper East Regions, were selected through the assistance of the Regional Directorates of Crops Services. Lists of fruit crop producers in the selected districts were obtained from the various District Agricultural Development Units of the Ministry of Food and 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, and that the fruits produced were the preferred host plants to the fruit fly pests present in the ecology. Ten farmers were selected from each district to answer questionnaire, thus, giving an overall total of 200 respondents from the three regions (Table1). Selected farmers were contacted through the assistance of their respective Agricultural Extension Agents.

The methods and tools for data collection were based on procedures for analyzing agricultural problems and assessing farmers' knowledge, perceptions and practices (KPP) as documented by Werner (1993), Munford and Norton (1993), and Mutsaers *et al*. (1997). Semi-structured questionnaire designed in a closed- and open-ended fashion were used to assess the KPP of fruit producers regarding fruit fly pests and their management. The questions were developed on the following key aspects: farmer's demographic information; knowledge of fruit fly pests, fruit fly damage and economic impact; fruit fly management strategies, and way forward to addressing the fruit fly menace in the area. 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 to help verify farmers' ability to identify the fruit fly pests of economic importance in the area.

Content and face validity were established by a panel of experts consisting of researchers from the Department of Agricultural Extension Education of the University for Development Studies (UDS), and a group of professionals in entomology at the Savanna Agricultural Research Institute, Ghana. A pilot test was conducted with 20 fruit 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 February to May, 2012. Interviews were conducted by members of the research team together with some Research Assistants from the UDS, using English or

appropriate local languages (for farmers who were illiterates). Each interview lasted on average, 40 mins. Data were analyzed using appropriate statistical procedures for description (frequencies, percentages, means and standard deviations). Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS for Windows version 16.0).

## RESULTS

### Background of Fruit Growers

Out of the 200 fruit growers involved in the survey, a total of 188 respondents, representing 94% completed the questionnaire (Table 1).

Table 1: Study districts and number of fruit growers interviewed.

| Regions | Districts | No. fruit growers interviewed |
|---|---|---|
| Northern | Tamale Metropolis | 10 |
| | Savelugu-Nanton | 10 |
| | West Mamprusi | 10 |
| | Yendi | 9 |
| | East Gonja | 9 |
| | Tolon-Kumbungu | 10 |
| | Central Gonja | 10 |
| | West Gonja | 10 |
| | Bole | 10 |
| | Gushiegu | 8 |
| Upper West | Wa Municipality | 10 |
| | Wa West | 7 |
| | Nadowli | 10 |
| | Lawra | 10 |
| | Sissala East | 9 |
| Upper East | Bolga Municipality | 10 |
| | Bawku Municipality | 10 |
| | Bawku West | 8 |
| | Kasina-Nankani | 9 |
| | Builsa | 8 |
| Total | | 188 |

The demographic information of the fruit growers who participated in the interview, is presented in Table 2. The sex distribution indicated that 179 (95.2%) were males while 9(4.8%) of them were females. Their ages ranged from 16 to 55 years. Farmers with ages ranging 31-40 and 41-50 were 70 (37.2%) and 42 (22.3%), respectively. Only 11 (5.8%) farmers were above 50 years of age.

The educational background of the framers showed that more than half, 95 (50.5%) of them were illiterates with non-formal education. A total of 46 (24.5%) of them had basic education (to the upper primary, middle or junior high school levels). The proportion of farmers with secondary or technical education background was 38 (20.2%) while only 9 (4.7%) farmers were educated to tertiary level (which encompassed training college, polytechnic or university education). Fruit growers were also asked whether they belonged to any farmer based association in their localities. A total of 81 (43.0%) of them said they were members of various established farmer organizations under the auspices of the Ministry of Food and Agriculture (MoFA) , Integrated Tamale Fruit Company (ITFC), German Technical Co-operation (GIZ), Millennium Development Authority (MiDA) and other agriculture-oriented organizations. However, majority, 107 (57.0%) of the producers said they did not belong to any farmer association (Table 2).

Table 2: Demographic information of fruit growers, northern Ghana, 2012.

| Factors | Frequency | % |
|---|---|---|

| | | |
|---|---|---|
| Sex | | |
| Male | 179 | 95.2 |
| Female | 9 | 4.8 |
| Age range (years) | | |
| 10-20 | 7 | 3.7 |
| 21-30 | 58 | 30.8 |
| 31-40 | 70 | 37.2 |
| 41-50 | 42 | 22.3 |
| >50 | 11 | 5.8 |
| Educational level | | |
| Non-formal | 95 | 50.5 |
| Basic | 46 | 24.5 |
| Secondary | 38 | 20.2 |
| Tertiary | 9 | 4.7 |
| Membership to farmer-based association? | | |
| Members | 81 | 43.0 |
| Non-members | 107 | 57.0 |

**Fruit Production Profile of Farmers**

Table 3 presents the fruit production profile of the respondents. Various types of fruit and vegetable crops were cultivated by the farmers interviewed. Mango was the dominant fruit crop cultivated by majority (51.5%) of the farmers. Watermelon and yellow melon were produced by 36.1% and 11.1% of the farmers, respectively while other fruit crops such as pawpaw, citrus and banana were grown only as minor crops under small scale backyard conditions. Among the vegetable crops produced by farmers included tomato (41.5%), chilli pepper (28.7%), cucumber (26.6%), pumpkin (24.5%), hot pepper (22.8%), garden eggs (17.0%) and okro (11.2%). In many situations an individual farmer may be found cultivating 2 or more of the above crops.

Table 3: Fruit production profile of farmers, northern Ghana, 2012.

| Factor (N = 188) | Frequency | % |
|---|---|---|

| | | |
|---|---|---|
| Fruit crops grown | | |
| Mango | 97 | 51.5 |
| Water melon | 68 | 36.1 |
| Yellow melon | 21 | 11.1 |
| Pawpaw | 8 | 4.2 |
| Oranges | 4 | 2.1 |
| Banana | 3 | 1.5 |
| Tomato | 78 | 41.5 |
| Chilli pepper | 54 | 28.7 |
| Hot pepper | 43 | 22.8 |
| Cucumber | 50 | 26.6 |
| Pumpkin | 46 | 24.5 |
| Garden eggs | 32 | 17.0 |
| Okro | 21 | 11.2 |
| Years in fruit crop production | | |
| 1-10 | 58 | 30.8 |
| 11-20 | 42 | 22.3 |
| 21-30 | 51 | 27.1 |
| 31-40 | 22 | 11.7 |
| >40 | 15 | 7.9 |
| [1]Scale of production | | |
| Small scale | 103 | 54.8 |
| Medium scale | 56 | 29.7 |
| Large scale | 29 | 15.4 |
| Cropping system | | |
| Organic mono crop | 15 | 7.9 |
| Organic mixed crop | 22 | 11.7 |
| Inorganic mono crop | 73 | 38.8 |
| Inorganic mixed crop | 78 | 41.5 |

[1]For plantation crops, large scale = >10 ha; medium scale = 2-9 ha; small scale = <2 ha. For vegetable crops, large scale = >10 acres; medium scale = 2-9 acres; small scale = <2 acres.

Data on the fruit production experience of the framers indicated that 58 (30.8%) farmers had been in the fruit and vegetable crop production business for 1-10 years while 42(22.3%) had grown them for 11-20 years. Farmers producing fruit crops for 21-30 years and 31-40 years were 51(27.1%) and 22 (11.7%), respectively. Only 15 (7.9%) of farmers had been in production for over 40 years. Also, majority, 103 (54.8%) of the producers were small- scale peasant farmers while a total of 56 (29.7%) were medium- scale producers. Farmers producing fruit and vegetable crops in commercial/large scale were 29 (15.4%). Inorganic farming was the dominant practice of farmers, in which 78 (41.5%) and 73 (38.8%) use synthetic pesticides in production under mixed crop and mono cropping systems, respectively. However, farmers producing fruit and vegetable crops under organic mixed cropping systems were 22 (11.7%) while 15 (7.9%) of them practiced organic farming in monocrop systems.

**Awareness of the Fruit Flies and Pest Identification**

In order to determine their levels of awareness of the fruit fly problem in the area, farmers were first asked whether they have ever heard of fruit fly pests. A total of 169 (90%) responded in affirmative while 19 (10.0%) of them said they had never heard of the pests. The 169 respondents further indicated that they received information on fruit fly pests from various sources, including their own experiences (10.6%), fellow farmers (37.2%), fruit traders (13.0%), agricultural extension agents (36.6), researchers (5.3%), radio/television (25.4%) and others such friends and relatives (4.7%) (Table 4). The farmers were then asked to indicate their self-perceived nature of the fruit fly pest situation in the area. Majority of the respondents (55.3%) indicated that the fruit fly problem was very serious while 54 (28.7%) said that the fruit fly problem was serious. The proportion of farmers who said the fruit fly problem was not serious was 10 (5.3%) while 20 (10.6%) had no opinion about the nature of the fruit fly pests situation in their localities.

Table 4: Descriptive statistics summarizing farmers' knowledge of fruit fly damage and economic impact, northern Ghana, 2012.

| Rank | Responses | Frequency[1] | % | Mean[2] | Std. dev. |
|---|---|---|---|---|---|
| 1 | Fruit fly infestation reduces farmers' income | 155 | 91.7 | 4.1 | 1.0 |
| 2 | Fruit flies are a threat to horticulture industry | 153 | 90.5 | 4.1 | 1.0 |
| 3 | Infested fruits usually attract poor market | 146 | 86.3 | 4.0 | 0.9 |
| 4 | Adult flies create punctures on fruits | 130 | 76.9 | 3.9 | 0.8 |
| 5 | Fruit fly damage reduces fruit quality | 119 | 70.4 | 3.8 | 1.0 |
| 6 | Infested fruits usually get rotten | 98 | 57.9 | 3.7 | 1.1 |
| 7 | Infested fruits may fall off the plant prematurely | 97 | 57.4 | 3.7 | 1.1 |
| 8 | Fruit fly infestation reduces cost production cost | 82 | 48.5 | 3.6 | 1.2 |
| 9 | Fruit fly pests are a quarantine problem | 81 | 47.9 | 3.6 | 1.2 |
| 10 | Infested fruits usually contain maggots | 76 | 44.9 | 3.5 | 1.3 |
| 11 | Fruit fly maggots feed on the fruit | 57 | 33.7 | 3.4 | 1.4 |
| 12 | Fruit fly eggs are laid inside the fruit | 52 | 30.7 | 3.3 | 1.5 |
| 12 | Adult fruit flies do not feed on fruits | 52 | 30.7 | 3.3 | 1.5 |

[1]Number of agree and strongly agree responses

[2]Scale: 1 = strongly disagree; 2 = disagree; 3 = no opinion; 4 = agree; 5 = strongly agree

Those farmers who showed awareness of the fruit fly problem were further tested for their ability to identify true fruit fly pests. The results showed that 8 (4.7%) and 14 (8.2%) of the farmers wrongly referred to *Apis malifera* and *Musca domestica*, respectively as true fruit fly pests. Also, 18 (10.6%) farmers wrongly considered *Drosophila melanogaster* as a true fruit fly pest. The proportion of farmers correctly identifying *C. capitata*, *C. cosyra*, *B. invadens* and *D. vertebratus* as true fruit fly pests were 40 (23.6%), 102 (60.3%), 66 (39.0%) and 54 (31.9%), respectively. Meanwhile, 21 (13.0%) of them said they had no idea as to which of the insects were true fruit fly pests. With respect to their ability to identify the new African invasive fruit fly pest from the insects provided, 37 (21.9%) correctly identified *B. invadens* while 50 (29.5%) were wrong. Majority, 87 (51.4%) of the farmers said they had no idea about the new invasive fruit fly pest (Table 3).

Table 3: Awareness of fruit flies and pest identification by farmers, northern Ghana, 2012.

| Factor | Frequency | % |
|---|---|---|
| Have you heard of fruit fly pests before? (N = 188) | | |
| Yes | 169 | 90.0 |
| No | 19 | 10.0 |
| Sources of information on fruit fly pests? (N=169) | | |
| Own experience | 18 | 10.6 |
| Fellow farmers | 63 | 37.2 |
| Fruit traders | 22 | 13.0 |
| Agric officers | 62 | 36.6 |
| Researchers | 9 | 5.3 |
| Radio/TV | 34 | 25.4 |
| [a]Others | 8 | 4.7 |
| Self-perceived nature of fruit fly problem (N = 188) | | |
| Very serious | 104 | 55.3 |
| Serious | 54 | 28.7 |
| Not serious | 10 | 5.3 |
| No opinion | 20 | 10.6 |
| [b]Insect species identified as true fruit fly pests (N=169) | | |
| *Apis malifera* | 8 | 4.7 |
| *Musca domestica* | 14 | 8.2 |
| *Drosophila melanogaster* | 18 | 10.6 |
| *Ceratitis capitata*[1] | 40 | 23.6 |
| *Ceratitis cosyra*[1] | 102 | 60.3 |
| *Bactrocera invadens*[1,2] | 66 | 39.0 |
| *Dacus vertebratus*[1] | 54 | 31.9 |
| No idea | 21 | 13.0 |
| Identity of the new invasive fruit fly (N=169) | | |
| Correct | 37 | 21.9 |
| Incorrect | 50 | 29.5 |
| No idea | 87 | 51.4 |

[a]Others may include respondent's relatives and friends; [b]Colour photographs of insects (without their names) were provided for the identification; [1]True fruit fly pests; [2]The new African invader fruit fly.

**Fruit fly Damage and Economic Impact**

Table 4 summarizes the knowledge status of the farmers regarding the damage and economic impact of fruit fly pests in the area. The mean value of the overall (summated across the 13 items) knowledge of farmers about fruit fly damage and economic impact was 3.7; the standard deviation (SD) was 1.1. 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 rank 3. All the 3 statements addressed the economic effect of fruit fly pests in agricultural production. The third highest item mean value (3.9; SD=0.8) was reported for statement in rank 4, that addressed the external fruit damage caused by fruit flies, which may seemed easily recognizable by the farmers. The lowest item mean value (3.3; SD=1.5) was reported for 2 statements in the 12$^{th}$ rank. Both statements concerned the internal fruit damage by the pest which might not be easily recognized by the farmers. In general, farmers seemed to be more conversant with the resultant effects of fruit fly infestation than their damage mechanisms/symptoms on host fruits.

**Fruit Fly Pest Management Practices and Way Forward**

The various efforts made by fruit growers in control of the fruit fly pests encountered in their farms are presented in Figure 2. The results showed that pheromone trapping, spraying with synthetic chemicals, disposal of infested fruits, regular weeding and prompt harvesting of fruits were the fruit fly control practices common among the farmers.

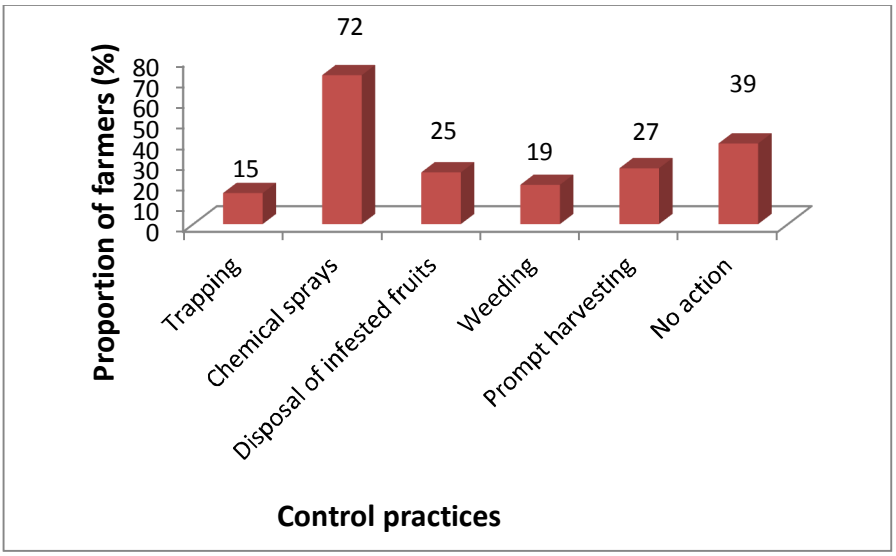


Figure 2: Practices adopted by farmers in control of fruit fly pests, northern Ghana, 2012.

Majority (72%) of the farmers applied synthetic chemical insecticides, mostly belonging to the organochlorine and organophosphate groups for the control of fruit fly pests. The proportion of farmers who said they practiced prompt harvesting, disposal of infested fruits, and weeding as means of fruit fly control were 27%, 25% and 19% respectively. Only 15% farmers (especially, mango growers) said they set pheromone traps (using methyl eugenol or terpinyl acetate) in their farms to catch the flies. Thirty-nine (39) percent of the farmers however indicated that they had not taken any action to control fruit fly pests in their farms. The farmers were further interviewed to determine the recommended fruit fly management strategies already known to them. Control techniques such as farm sanitation, prompt harvesting of fruits, and use of pheromone traps were known to at least, 30% of the farmers. Only 15%, 7% and 4% farmers knew of biological control, bait application technique, and soil inoculation with biopesticides, respectively. Other control strategies such as sterile insect technique, irradiation of fruits, wrapping /bagging of fruit as well as cold and heat treatment procedures were virtually unknown to the farmers (Figure 3).

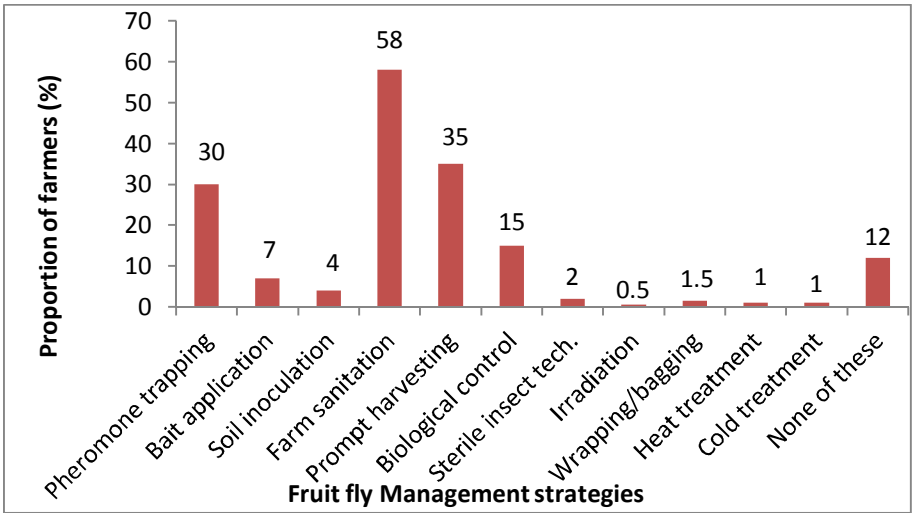


Figure 3: Farmers' knowledge of fruit fly management strategies, northern Ghana, 2012.

Meanwhile, 12% respondents indicated that they did not have any idea about any of the control method mentioned to them.

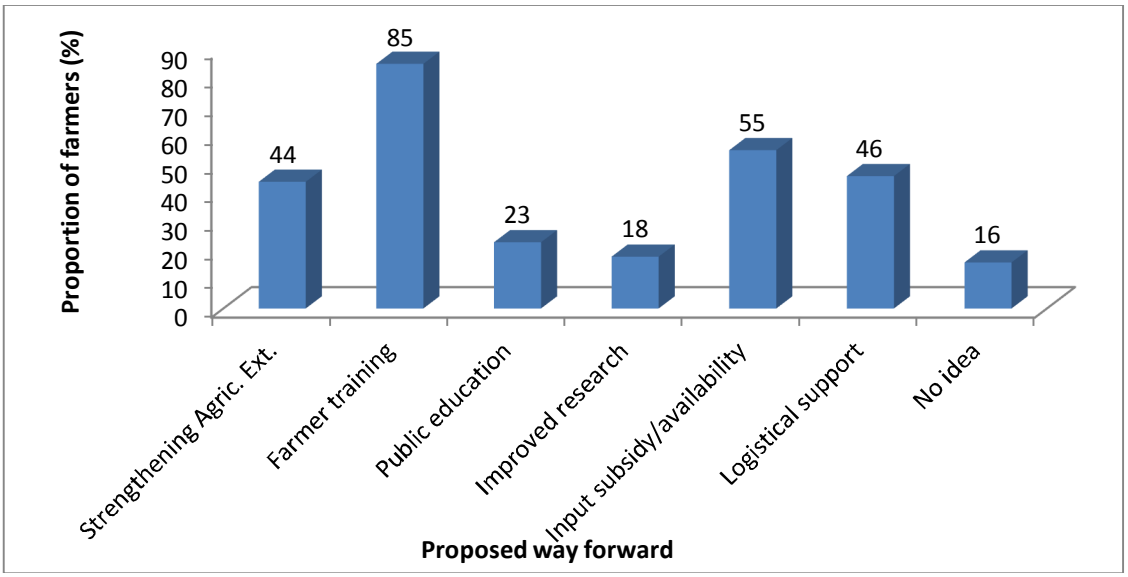


Figure 4: Way forward to addressing the fruit fly menace as proposed by farmers, northern Ghana, 2012.

Figure 4 presents the various opinions expressed by the farmers as the sustainable ways to addressing the fruit fly problem in the area. Among them included strengthening agricultural extension, farmer training, public education, input availability/subsidy and logistical support. More than half (85%) of the respondents indicated the need to train fruit growers on fruit fly pests and their management, as a way to addressing the menace. About 55% suggested the availability/subsidy of recommended inputs (chemicals and equipment) for controlling the pests, while 46% said that logistical support to farmers and extension staff in terms of transportation and training facilities was a possible remedy. Also, 44% 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 education and improved research were 23% and 18%, respectively. However, 16% of the farmers could not propose any practical way for addressing the fruit fly problem in their localities.

## DISCUSSION

### Demographic and Production Profile of Farmers

The results of this study indicated that fruit and vegetable production in northern Ghana is a male dominated business with females represented by only 18.4% of the respondents. This situation is particularly worrisome in an area where a large percentage of the population is female and several homes are headed by single female parents. Females are known to be equally efficient fruit producers as their male counterparts. It is therefore important to encourage their involvement in fruit and vegetable production to promote food security and poverty alleviation. Analysis of the educational background indicated that most of the fruit growers were illiterates. Existing literature shows that improved crop production requires high level of expertise from farmers in order to implement effectively the recommended practices (Crosby *et al*., 2000). Madisa *et al*. (2010) observed that educated farmers are generally more open to innovative ideas and new technologies that promote positive change. Trend in the age distributions implied that majority of the farmers were in their active age. Higher rate of young farmers involved in fruit crop production is a good sign for the horticulture industry in Ghana. Increased and sustainable fruit crop production can therefore be enhanced if many of these young farmers would become members of the functional farmer-based associations in the area.

Fruit crop production in northern Ghana was predominantly a stallholder business. Mango and water melon were the major fruit crops produced in large scale in the area. Among the vegetable crops, tomato, peppers and the cucurbits featured prominently. All these fruit crops have been recognized as major hosts of both the invasive and native fruit fly species. Fruit flies are polyphagous causing extensive losses to both cultivated and wild fruit crops (Drew *et al*., 2005; IITA-CIRAD, 2008; COLEACP-CIRAD, 2009). Mango has been the most preferred host of the new African invader fly, *B. invadens* (Lux *et al*., 2003a; Vayssieres *et al*., 2005) but it is also attacked by the native *Ceratitis* species (Mwatawala *et al*., 2004). Water melons, tomato, peppers and the cucurbits also suffer infestation and damage by a wide range of fruit fly species (White and Elson-Harris, 1992; Ekesi *et al*., 2006; De Mayer *et al*., 2007; IITA-CIRAD, 2008). In most situations, mixed cropping was a traditional practice of the farmers. Unfortunately, however, this practice has the tendency to modify the microclimate in many fruit crop farms to favour multiplication of insect pests (Kilaro *et al*., 2009).

**Fruit Fly Identification, Damage and Economic Impact**

Farmers need to improve their knowledge of economically important fruit fly species, especially for *B. invadens*. This pest was first reported from eastern Africa in 2003 (Lux *et al*., 2003b; Mwatawala *et al*., 2004). It was later reported in other parts of the continent (Drew *et al*., 2005) including Ghana in 2005 (Billah *et al*., 2006). Knowledge of the presence of *B. invadens* and other 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 strategies to combat the menace (Abdullahi *et al*., 2011).

Farmers generally demonstrated fair knowledge of the damage and economic impact of fruit fly pests on crop production. Farmers seemed to be more conversant with the effect (economic impact) of fruit fly infestation than their damage symptoms (internal and external). In any case, however, their level of knowledge basically implied that farmers were aware that tephritid fruit flies cause serious damage to their crops with detrimental consequences on their earnings. Fruit fly damage and economic losses have been reported to have great impact on the local economy. Smallholder farmers elsewhere have bemoaned the effects of fruit flies on their fruit production (Mwatawala *et al*., 2004; Yaya-Toure, 2007). Previous studies have identified the presence of fruit flies in a wide variety of hosts and their wide infestation rates on commercial fruits like mango (Vayssieres *et al*., 2005; Rwomushana *et al*., 2008). *Bactrocera invadens* in particular, is currently considered as the major fruit pest in Africa. Its polyphagous nature, presence in certain hosts and rapid spread throughout the continent makes it a devastating pest and thus, calling for its easy recognition among all pest-conscious fruit growers (Mwatawala *et al*., 2009; Abdullahi *et al*., 2011).

**Fruit Fly Management Strategies and Way Forward**

The results of the study further indicated that many fruit growers take no measures to control fruit fly pests in their farms. Recommended control methods such as pheromone trapping, bait application, soil inoculation and biological control were known to some farmers but were not in use, probably due to their unavailability or unaffordability. Among the efforts made to control fruit flies, synthetic chemical sprays dominated the practices. The type of chemicals used revealed that farmers did not know the recommended chemicals for controlling the pest. Many extension programmes in the area encouraged the use of pesticides without proper consideration of their environmental and health risks. Farmers' decisions on what and how pesticides are used did not have a bearing on human health and environmental safety. These concerns cannot be isolated due to the fact that indiscriminate pesticide use results not only on actual yield loss, but also leads to the extinction of natural enemies of fruit flies and the development of resistance of these and other pests (Banjo *et al*., 2010). It is, however, evident that farmers adopted a number of multiple efforts to minimize fruit fly infestation in an IPM fashion (Figure 2).

There is therefore the need to carefully study how these practices can be improved upon, where necessary to enhance their effectiveness in fruit fly suppression (Ekesi and Billah, 2006).

On the way forward to addressing the fruit fly menace in the area, majority of the growers proposed the need for farmer training to help improve their capacities. Consideration needs to be given to comprehensive educational materials illustrated by simple texts and colour photographs of pest species, biology, damage and control. There is the clear need to select Agricultural Extension Agents, and train fruit growers using the farmers' field schools (FFS) approach. The trained AEAs would undertake the training of literate farmers. The most receptive literate farmers would provide, in appropriate local languages, illiterate farmers with the basic knowledge of fruit fly pests in such a way that they can be truly independent decision-makers at the farm level.

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