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Host status of fruit flies (*Diptera: Tephritidae*) on French beans in Kenya

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Abstract

Production of French bean (*Phaseolus vulgaris* L.) as a vegetable is important as a source of livelihood and income generation to smallholder farmers. However, production of this crop has not been optimal due to various constraints. Among the most important ones is pest and diseases. In Kenya, major pests reported in French beans include the western flower thrips (WFT) (*Frankliniella occidentalis*), Bean fly (*Ophiomyia phaseoli*) aphids (*Aphis fabae*), red spider mites *(Tetranychus* spp.), the African bollworm (*Helicoverpa armigera*), the legume pod borer (*Maruca vitrata*) and white flies (*Bemisia tabaci*). Although Tephritidae flies are major pests of fruits and vegetables in Africa, Kenya included, they are no reports to indicate that they attack French beans. However, a previous pest risk analysis report indicates that the crop is host to some species such as *Dacus ciliatus* and *Bactrocera cucurbitaceae*. In an effort to secure the international market, we conducted a study to assess French beans from Kenya to establish whether they are indeed hosts to fruit flies or not. The study was conducted in Machakos, Meru, Murang'a, Laikipia and Nyeri regions in the year 2020. In each of the study regions, sampling of pods was carried out in private farms that were planting French beans for export. A total of 2375 samples were collected from various locations in the field and from exit point for analysis. Results showed that, none of the developmental stages of fruit flies (Tephritidae) was present in any of the sampled French beans pods (Field and exit point samples). However, bean seed fly (*Delia platura*), bean fly (*Ophiomyia phaseoli*) and one beetle was recorded in some of the samples. From our study we conclude that French beans is not a host to Tephritidae fruit flies. However, we recommend host preference tests in the laboratory and greenhouse to establish the oviposition potential of the fruit flies to French beans.

Key words: Phaseolus, samples, fruit, pods, preference, oviposition

Introduction

French bean production in Kenya

French bean (*Phaseolus vulgaris* L.) is one of the most important vegetable crop produced in Kenya in terms of production and income generation. An estimated 50,000 smallholder farmers produce French beans and almost 100,000 earn direct income and about 500,000 get income indirectly from the production (Seif *et al*., 2001). French beans are grown mainly for export to the European Union markets and accounts for 60% of all vegetable exports and 21% of horticultural exports (Nderitu *et al.,* 2007). Its main markets include U.K., France, Germany, Holland and Belgium. Over 80% of French bean production is carried out by small-scale farmers, who are expected to maintain high quality standards for their produce to retain their share of these markets.

According to HCD report 2020, the area under French bean production in Kenya increased from 7,942 Ha in 2018 to 8,286 Ha in 2019 with an equivalent increase in volume from 66, 765 MT to 68, 905 MT which was valued at 3.9B. Production is primarily done in warm areas such as Machakos, Nakuru, Kirinyaga and Meru which accounted for 29.2%, 15.9%, 12% and 8.4% respectively of the value (HCD, 2020) with the common varieties in the Kenyan market being *Amy*, *Teresa*, *Samantha*, *Serengeti, Julia* and *Paulista*. Other areas producing French beans in Kenya include: Kajiado, Makueni, Muranga, Laikipia, Narok, Kiambu, Nandi, Taita Taveta, Nyeri, Tranzoia and Embu (HCD, 2020). Around the world, China is the main producer followed by Turkey, India, Spain and Egypt. However, in terms of exports, Kenya ranks sixth position after France, USA, Netherlands, Spain and Mexico. The small holder farmers generally use high amounts of inputs to ensure they optimize the production (Nyakundi *et al*., 2010). French beans are grown throughout the year in periods of low rainfall as their growth and productivity are negatively affected by large amounts of rainfall. Water stress on the other hand, causes flower abortion resulting in yield reduction. The farm sizes under French bean production are dependent on capital and availability of labour.

The major constraints in production of French beans are pests and diseases (Nderitu *et al.,* 2007). The major pest of French beans is the western flower thrips (WFT) (*Frankliniella occidentalis*), which inflicts damage to the flowers and pods (Nyasani *et al.,* 2012). Other pests include; Bean fly (*Ophiomyia phaseoli*), aphids (*Aphis fabae*), red spider mites *(Tetranychus* spp.), the African bollworm (*Helicoverpa armigera*), the legume pod borer (*Maruca vitrata*) and white flies (*Bemisia tabaci*) (Nderitu *et al.,* 2007).

Fruit flies of the family Tephritidae are agricultural pests that attack fruits and vegetables, threatening fruit and vegetable production throughout the world (Vargas *et al*., 2015). Among the most important species include the Mediterranean fruit fly or medfly (*Ceratitis capitata*), melon fly (*Bactrocera cucurbitae*), oriental fruit fly (*Bactrocera dorsalis*) and the so-called Malaysian fruit fly or Solanaceous fruit fly (*Bactrocera latifrons*) all of which are invasives infesting more than 400 different host plants (Vargas *et al*., 2008; CABI, 2021). They impact directly on the economy by rendering horticultural produce (Fruits and vegetables) unmarketable as a result of the damage inflicted during the feeding and oviposition. As a result, many fruit-producing countries have imposed quarantine restrictions on import products infested with particular fruit fly species, and/or require that fruits and vegetables undergo quarantine treatment before their importation is allowed (Vargas *et al*., 2015).

Currently, many fruit fly control programmes are geared towards compliance to Phytosanitary requirements of the importing country to enhance market access (Quinlam, 2002). Consequently, several studies have been carried out to access the economic impact of fruit flies and their threat to a county's ability to export (Nugent *et al*., 2001). To ensure harmony in the requirements for similar levels of risks, International Standards of Phytosanitary Measures are developed and applied in trade. Kenya has continued to ensure strict adherence to these Phytosanitary measures to ensure compliance to requirements by the importing countries.

Kenya has been trading globally for a long time. For instance, in USA The main agricultural products that Kenya exports include; Rose cutflowers, Eryngium, Gypsophilla, Agapanthus Hypericum, Ammi, Dried Bark, Assorted planting materials, Dianthus, Hydrangea, Zantedeschia and Delphinium; Processed fruits including pineapple and mango; Assorted spices; Nuts including processed macadamia nuts and Cashew Kernels; Coffee; Tea; Processed avocado oil and Biological control agents. On the other hand, Kenya imports assorted vegetable seed, Grain including sorghum and wheat, Pulses such as lentils, nuts and maize flour among others. Current data shows that, Kenya's exports to USA have been rising from US $ 360 million in 2008 to US $ 686 million in 2019. In addition, Kenya's export to USA trends grew on annual average rate of 4% over the period between 2015 and 2019 (Otieno, 2011).

Earlier studies on host plants of Mediterranean fruit fly (*Ceratitis capitata*) in Hawaii indicated that String beans (*Phaseolus vulgaris*) is a host (Liquido *et al*., 1990; Liquido *et al*., 1998). However, a USDA pest risk assessment from Zambia provided scientific justification for *C. capitata* not following the pathway (CPHST, 2008) thereby proving that it is

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not a threat to the produce. According to CPHST (2008), none of the references cited in Liquido et al. (1998) had any evidence of field or laboratory data on pest infestation in French beans. Although fruit flies have not been known to attack French beans in Kenya, a pest risk analysis carried out by United States of America (APHIS, 2009) indicated that the crop is host to some species of fruit flies such as *Dacus ciliatus* and *Bactrocera cucurbitaceae*. Past studies indicated that there over 50,000 interceptions recorded in the USA from 192 countries every year, of which majority of the interceptions are recovered from fruits, plants and spices brought by either a traveler disembarking from international flights or from cargo (MC Cullough, 2006). However, there are no interceptions due to fruit flies in French beans from these records.

With the APHIS PRA declaration that fruit flies are pests of French beans, a proof of otherwise is essential in order continue accessing markets including the USA. Therefore, this study aimed at evaluating French beans pods in the field and samples of final produce before export to establish whether they are indeed hosts to fruit flies or not to ensure market access of Kenyan French beans to US.

Materials and methods

Study sites

The study was carried out in five regions: Machakos, Muranga, Nyeri, Meru and some parts of Laikipia which are among the major French bean producing areas in Kenya (Fig 1).

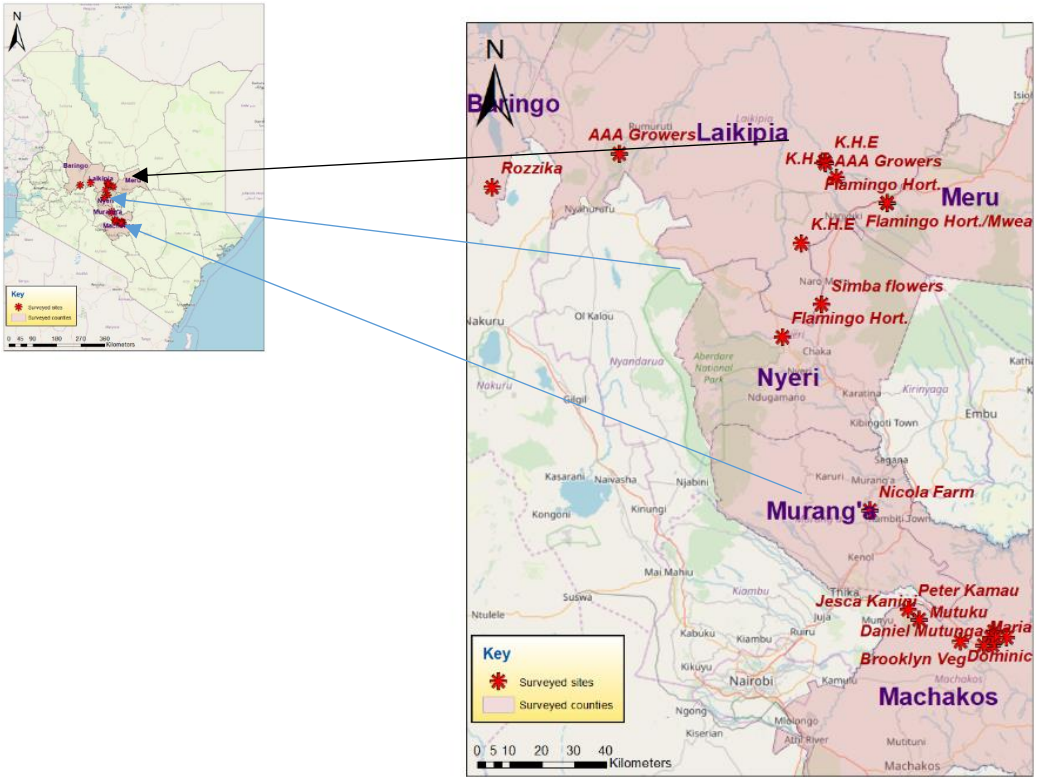

Fig 1. Map of study sites

Sampling method

In each of the five regions visited, two large commercial farms were sampled for data collection purposes except in Machakos where only one was available. In addition, data collection was carried out from eight small scale out-growers located along the Yatta canal in Machakos. The commercial farms visited includes: Flamingo Horticulture, AAA growers, Kenya Horticultural Exporters (KHE), Rozzika farm, Simba fresh, Nicola farm and Brooklyn Veg. At the exit point at the Jomo Kenyatta International Airport (JKIA), French beans pods destined for various market were sampled from various export companies on weekly basis for a period of one year.

Sample collection

In each farm, one kilo of French bean pods ready for export was sampled. The GPS co-ordinates were recorded at each site. First, the pods were checked for pests (eggs or maggots) or signs of stippling. After that, the sample was drawn, placed in sampling bags and taken to KEPHIS-JKIA laboratory for incubation. Additional samples collected weekly from exported produce before they exited the country and taken to the laboratory at JKIA for incubation.

Laboratory analysis

In the laboratory, the pods were placed in large boxes lined with an absorbent paper and covered with a perforated cover lined with fine net to prevent flies from escaping. The boxes were then placed in a laboratory bench to await possible emergencies. Monitoring was done twice weekly and the absorbent paper was changed to reduce excessive wetting of the container. The number of larvae, pupa and adult emergencies of the Tephritid flies collected from the incubated pods was recorded. Data analysis was carried out using Microsoft Excel.

Results

A total of 2167 samples from the field (Table 1) were successfully incubated in the laboratory for one and half months to allow enough time for adult emergence. Out of all the 2167 samples analyzed, no fruit flies (Tephritidae) were recorded (Table 1). However, seven adult bean seed flies (*Delia platura*), three bean flies (*Ophiomyia phaseoli*) and a single beetle (Coleoptera) were recovered from the samples (Table 1).

Table 1. Number of fruit flies and other pests emergence (Tephritidae) recorded from field samples.

Location	No of samples	Tephritid fruitflies	*Ophiomyia phaseoli*	*Delia platura*	*Coleopterans*
Laikipia	319	0	0	0	0
Machakos Central	403	0	*3*	0	0
Machakos East	389	0	*0*	7	0
Meru	400	0	0	0	1
Muranga	213	0	0	0	0
Nyeri	443	0	0	0	0
Total	**2167**	**0**	**3**	**7**	**1**

An additional 208 samples from export consignment at exit point (Table 2) were received and analyzed in the laboratory for a year from Jan 2020 to Dec 2020. In all these consignments only two adult bean seed flies (*Delia platura*), were recorded in February 2020 from a single shipper (Table 2).

Table 2. Number of fruit flies and other pests emergence (Tephritidae) recorded from export consignments.

Month	No of samples	No. of Tephritidae fruitfly pupa	No of Tephritidae fruitfly adults	No of *Delia platura*
January	16	0	0	0
February	21	0	0	2
March	18	0	0	0
April	7	0	0	0
May	26	0	0	0
June	13	0	0	0
July	22	0	0	0
August	9	0	0	0
September	11	0	0	0
October	20	0	0	0
November	19	0	0	0
December	26	0	0	0
Total	**208**	**0**	**0**	**2**

Discussion

Globally, Tephritid fruit flies are the most serious insect pests of both fruits and vegetables (Godefroid *et al*., 2015). In Africa, fruit fly problem was further compounded by the widespread invasion of the alien invasive species *Zeugodacus cucurbitae* (Coquillett) (Diptera:Tephritidae) (formerly known as *Bactrocera cucurbitae*), which most often led to total crop failure (Mwatawala, 2015) as a result of its high reproductive rate and its polyphagous nature. The pest causes direct losses due to damage inflicted by feeding of emerged larvae from the eggs oviposited by the female (Kwasi, 2008; CABI, 2021). In Kenya damage by *Zeugodacus cucurbitae and Dacus sp.* has been reported mainly in cucurbits (Ekesi and Billah, 2007; CABI, 2021), with losses of up to 66.8% reported on bittergourd *Momordica charantia* L. (Cucurbitales: Cucurbitaceae) (Kambura, 2018). *Dacus ciliatus* is a major pest of a wide range of Cucurbitaceae in Africa, Asia and the Middle East. The fly is also a pest in the Indian Ocean (Reunion and Mauritius) and Oriental Asia (Pakistan and India) (CABI, 2021). The melon fruitfly

(*Bactrocera cucurbitaceae*) on the other hand is found in more than 40 countries. In Africa, *it* has been recorded in Curcubits from East and West Africa (Meyer *et al*., 2007).

From our study, there was no evidence of occurrence of *Zeugodacus cucurbitae (Bactrocera curcubitae)* and *Dacus ciliatus* or any other Tephritid flies in French beans of Kenya. Earlier studies by Liquido *et al*. (1990), indicated that although string beans (*P. vulgaris*) was earlier listed as a host to Mediterranean fruit fly (*Ceratitis capitata*), during their 37-year-old research (1949- 1985), the pest was not found infesting the produce. Further, a USDA pest risk assessment from Zambia provided scientific justification for *C. capitata* not following the pathway (CPHST, 2008). According to CPHST (2008), none of the references cited in (Liquido *et al*., 1998) had any evidence of field or laboratory data on pest infestation in French beans. Other studies indicate that fruit fly females may lay eggs in unsuitable hosts usually by mistake (Mayhew, 2001; Larsson and Ekbom, 1995) or due to inconsistences brought about by phylogenetic constraints (Price, 1994) such as size of sensilla that limit the type of fruit or vegetables that they are able to infest (Aluja and Mangan, 2008).

Some of the most important factors that influence fruit fly oviposition behavior and that might lead to a female laying its eggs in a fruit outside its natural host range include size, colour, penetrability and degree of ripeness among other factors (Aluja and Mangan, 2008). In addition, when females are deprived of oviposition opportunities, they accumulate eggs increasing their drive to lay them with reduced preference thresholds (Singer, 2000). Therefore, fruit flies with high egg load such as *Ceratitis capitata* and *Bactocera* spp. will readily oviposit on a fruit or vegetable exposed to, even though they do not infest it under natural conditions (Aluja and Mangan, 2008).

Conclusions and recommendations

From our results, we conclude that French beans are not hosts to Tephritidae fruit flies. Appearance of bean flies in French beans samples investigated in this study, confirms earlier studies in Kenya (Nderitu *et al*., 2007; Seif *et al*., 2001) that indeed they are common pests of the legume in Kenya.

We recommend host preference tests to confirm our findings. Additional field data is also necessary to confirm the results obtained so far.

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