Crop Protection 28 (2009) 477–488

Contents lists available at ScienceDirect

Crop Protection

journal homepage: www.elsevier.com/locate/cropro

Correlation of fruit fly (Diptera Tephritidae) infestation of major mango cultivars in Borgou (Benin) with abiotic and biotic factors and assessment of damage

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ARTICLE INFO

Article history:
Received 8 October 2008
Received in revised form
20 January 2009
Accepted 20 January 2009

Keywords:
Bactrocera invadens
Ceratitis cosyra
Climatic factors
Population dynamics
Mangifera indica
Loss assessment

ABSTRACT

Fruit flies associated with mango trees were monitored in two orchards in Benin using traps baited with methyl eugenol, terpinyl acetate and *Torula* during 2005–2006. Population fluctuations were analysed with respect to environmental factors including air temperature, relative humidity and rainfall in relation to different mango cultivars. Mangoes were sampled every two weeks during the two crop years, to assess the damage caused by these quarantine pests on ten main cultivars. Three native species of *Ceratitis* and a recently described new exotic species, *Bactrocera invadens* made up the complex of economically significant fruit flies associated with the mango tree in Borgou. *Ceratitis* species occurred during the dry season and the main species, *Ceratitis cosyra*, reached a peak at the end of the dry season. *B. invadens* populations were scarce during the dry season, but increased steadily from the end of April to reach a peak at the end of June during the rainy season. Regression analyses indicated that minimum–maximum temperature, relative humidity and rainfall were the major climatic factors influencing fly populations. Daily rainfall was the factor showing the strongest positive correlation with *B. invadens* populations. Host plant was another essential factor influencing the population fluctuations. Trapping and rearing data indicated that *Ceratitis quinaria* and *Ceratitis silvestrii*, were abundant only in the dry season, causing damage only to early cultivars. *C. cosyra*, also common during the dry season, attacked both early cultivars or mid season cultivars. A consistent population increase of *B. invadens* in the early rainy season caused considerable damage to mid season and late cultivars. The seasonal increase of the *B. invadens* population coincided with the fruiting period of the main mango cultivars in this Northern Guinean savannah, but mango availability influenced the population of this new invasive species only when the rains had arrived. Mean damage on mangoes for the two seasons and two studied orchards increased from 17% in early April to 73% at mid June.

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1. Introduction

Mango (*Mangifera indica* L.) is an important tropical fruit for Sub-Saharan African economies since it represents (i) a fundamental source of nutrition for rural populations living in the Soudano-Sahelian regions of West Africa, (ii) a basic production in reducing poverty, (iii) a potential export product (Vayssières et al., 2008). Mango producers in Benin are confronted with three problems that are closely connected (i) deterioration of fruit quality due to fruit flies, (ii) inadequacy of post harvest control methods, and (iii) a saturation of the national market leading to wastage and lower prices. There are several studies on species associated with the mango tree in East Africa (De Meyer, 2001; Lux et al., 2003a; Mwatawala et al., 2006) and South Africa (Labuschagne et al., 1996; Grové, 2001), but there is very little on the subject in West Africa, especially concerning the qualitative and quantitative losses that they cause in mango production.

In Benin, twelve species of fruit fly associated with mangoes had been identified, four of which are economically important: *Ceratitis cosyra* (Walker), *Ceratitis silvestrii* Bezzi, *Ceratitis quinaria* (Bezzi), and *Bactrocera invadens* Drew Tsuruta & White (Vayssières et al., 2005). A new species was described in 2005 (Drew et al., 2005) and is presently known as *B. invadens*. This invasive species, probably originating from Sri Lanka, was found for the first time in Africa in Kenya in 2003 (Lux et al., 2003b) and then in Tanzania (Mwatawala et al., 2004). This new threat has also been reported in 2004 in Sudan (Luckman, 2004), Cameroon (Ndzana Abanda et al., 2008) and Senegal (Vayssières, 2004). However, both timing and precise pathway of the invasion by *B. invadens* into Africa, especially West

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0261-2194/$ – see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.cropro.2009.01.010

Africa, are not really known. Many reasons can cause accidental introductions of invasive species. This has implications not only for interspecific competition (Duyck et al., 2004, 2006), but also for the expected erosion of biodiversity. Such biological invasions are now considered as a major component of global change (Vitousek et al., 1996).

B. invadens, recently described, needs to be studied because it is a new species and is presently considered as the most important tephritid species of commercially grown fruits in West Africa. In addition to its host range and trapping methods, many other topics need to be studied, as adult populations of *B. invadens* and *C. cosyra* exhibit strong fluctuations throughout the year. The causes for such high variability are poorly understood, although some preliminary observations on the influence of abiotic and biotic factors on these population fluctuations have been made.

The aims of the study during 2005–2006 were threefold, namely to (i) monitor the fluctuations in these tephritid populations of economic significance, (ii) determine the potential correlation of population fluctuations with abiotic and biotic parameters, and (iii) determine the damage caused to different commercially important cultivars.

2. Material and methods

2.1. Study area

The most numerous and largest orchards (75% of Beninese mango orchards), with the most plant diversity, are in the Northern Guinean savannah of Benin, more specifically in Borgou. This experiment included two mango orchards among the six in which we studied during 2005–2006. They had (i) an area of at least 8 ha of grafted, fruit-bearing mango trees, (ii) more than five commercially important cultivars per orchard, (iii) regular spacing between the mango trees, (iv) availability of technical supervision to ensure no pesticide application, and (v) absence of any nearby crop (cotton etc.) requiring the use of pesticides. The two orchards received no crop protection during this study. Localities and coordinates of the two orchards are Korobourou (09.38750N; 002.71335E) and Komiguea (09.43590N; 002.62385E) which are located very close to Parakou.

The two orchards were chosen because (i) all the mango cultivars were identified, (ii) they were just near to the Asecna meteorological station, (iii) both are representative of many other orchards, (iv) they are better established and managed with data recording.

The homogeneous mango orchard in Korobourou comprised 100% mango trees. The mixed Komiguea orchard predominantly also contained plum bush (Anacardiaceae), several species of citrus (Rutaceae), guavas (Myrtaceae) and several species of annonas (Annonaceae). The ten cultivars in this study matured at different times, thus, Gouverneur (=Amélie) is an early season cultivar, Eldon, Ifac 3, Améliorée du Cameroun, Dabshar, Kent are mid season cultivars and Smith, Alphonse, Keitt and Brooks are late season cultivars. We identified a total of 29 cultivars in all orchards surveyed from 2004 to 2006 (Vayssières et al., 2008) in central and northern Benin. All these grafted cultivars are attacked by fruit flies and are therefore likely to host their larvae. Fruits of non-grafted mango trees are also attacked.

2.2. Placement and service of traps

Methyl eugenol (4-allyl-1,2-dimethoxybenzene-carboxylate) and terpinyl acetate (acetic acid terpinyl ester) are highly attractive parapheromones (White and Elson-Harris, 1992) for males of the mango fruit fly species of economic significance in this area, so insecticide baited methyl eugenol traps were used to monitor population densities and periods of peak activity of *B. invadens*, while insecticide baited terpinyl acetate traps were used for the three main *Ceratitis* species (*C. cosyra*, *C. quinaria*, *C. silvestrii*). These attractants were used as solid cylindrical substrates or plugs (from IPS Ltd – England), as this type of formulation makes it possible to have homogeneous doses of the parapheromones to facilitate comparison of results. In each orchard, there were 8 Tephri-traps (from Sorygar SL – Spain), four with terpinyl acetate and four with methyl eugenol. One cube of DDV insecticide was used per trap.

Three McPhail (from Chemtica Int – Costa Rica) traps baited with *Torula* yeast (3 tablets for 300 ml of water per trap) were also in each orchard and these mostly captured females but also a few sexually immature males.

The capacity of the Tephri-trap is 450 cc. Its dimensions are (i) total height 142 mm, (ii) yellow base diameter 110 mm, (iii) height of top 40 mm, (iv) holes diameter 22 mm, (v) invaginated hole diameter 26 mm. The attractant was set up on a support in the upper part of the trap and the insecticide (DDVP) in the lower part. The capacity of the McPhail trap is 500 cc. Its dimensions are (i) total height 198 mm, (ii) yellow base diameter 130 mm, (iii) height of transparent top 150 mm, (iiii) invaginated hole 54 mm.

Traps were suspended on mango branches in the lower third of the foliage. The central coil of wire holding the trap was coated with thick grease in order to prevent any predatory activity by weaver ants (*Oecophylla longinoda*) on dead adult flies in the bottom of the trap. Parapheromone cylinders and insecticide were changed every month. *Torula* pellets were changed each week after careful washing of the McPhail traps. All the traps used were rotated on a weekly basis in all the mango orchards. There were two traps per hectare irrespective of the attractant. Data on other attractants (Trimedlure and Cuelure) used in and around orchards are not reported here.

2.3. Abiotic factors recorded

Temperature (minimum–maximum), relative humidity (RH), precipitation and wind speed were provided by the Asecna meteorological station in Parakou, located three kilometres from the orchards where the correlations between population fluctuations and abiotic factors were studied. Rain gauges were also installed in the two orchards and precipitation was regularly recorded after every rainfall event.

2.4. Fruit sampling

In general, the mango season starts in the first week of April and lasts 10–12 weeks based on the quantity of the produce and the harvest dates chosen by the farmers. Generally, planters in Borgou have the habit of harvesting early in order to reduce the effects of tephritids on fruit damage. During two years, assessment of losses caused by tephritids was carried out from the beginning of April to mid June in these two orchards on 8 cultivars common to both orchards: Gouverneur, Eldon, Ifac 3, Dabshar, Kent, Smith, Alphonse de Goa and Brooks. Furthermore, in Korobourou fruits of Keitt were also sampled while in Komiguea fruits of Améliorée du Cameroun were sampled.

Every two weeks, 50 fruits of each cultivar were sampled at each site. The fruits were sampled at pre-ripening time and ripening time, the main period of attack, so all the ten cultivars were not collected together during the whole mango season because of their different ripening time. Mangoes belonging to different cultivars and different sites were kept separately in shaded rooms to allow the number of puparia per kg of fruits to be measured, using a technique developed in Mali (Vayssières et al., 2007). The number

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