# Susceptibility of Low-Chill Blueberry Cultivars to Mediterranean Fruit Fly, Oriental Fruit Fly, and Melon Fly (Diptera: Tephritidae)

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**ABSTRACT** No-choice tests were conducted to determine whether fruit of southern highbush blueberry, *Vaccinium corymbosum* L., hybrids are hosts for three invasive tephritid fruit flies in Hawaii. Fruit of various blueberry cultivars was exposed to gravid female flies of *Bactrocera dorsalis* Hendel (oriental fruit fly), *Ceratitis capitata* (Wiedemann) (Mediterranean fruit fly), or *Bactrocera cucurbitae* Coquillet (melon fly) in screen cages outdoors for 6 h and then held on sand in the laboratory for 2 wk for pupal development and adult emergence. Each of the 15 blueberry cultivars tested were infested by oriental fruit fly and Mediterranean fruit fly, confirming that these fruit flies will oviposit on blueberry fruit and that blueberry is a suitable host for fly development. However, there was significant cultivar variation in susceptibility to fruit fly infestation. For oriental fruit fly, 'Sapphire' fruit produced an average of 1.42 puparia per g, twice as high as that of the next most susceptible cultivar 'Emerald' (0.70 puparia per g). 'Legacy', 'Biloxi', and 'Spring High' were least susceptible to infestation, producing only 0.20–0.25 oriental fruit fly puparia per g of fruit. For Mediterranean fruit fly, 'Blue Crisp' produced 0.50 puparia per g of fruit, whereas 'Sharpblue' produced only 0.03 puparia per g of fruit. Blueberry was a marginal host for melon fly. This information will aid in development of pest management recommendations for blueberry cultivars as planting of low-chill cultivars expands to areas with subtropical and tropical fruit flies. Planting of fruit fly resistant cultivars may result in lower infestation levels and less crop loss.

**KEY WORDS** resistance, *Vaccinium* spp., *Ceratitis capitata*, *Bactrocera dorsalis*, *Bactrocera cucurbitae*

Blueberries (*Vaccinium* spp.) have become a major crop worldwide (Strik 2005). North America, South America and Europe are the largest production regions. In North America, which accounts for ≈82% of the world production, the planted area increased 30% from 1992 to 2003 to 97,054 ha (Strik and Yarborough 2005, Brazelton and Strik 2007). Most of the South America production is in Chile, but Argentina is rapidly expanding its planting area. In Europe, Germany and Poland have the largest plantings, followed by France, The Netherlands, Spain, Portugal, Italy, and the United Kingdom. In some countries, such as China, Mexico, Brazil, Uruguay, and Thailand, commercial production is in the early stages (Strik 2007).

Blueberry production is expanding owing to the development of new cultivars better adapted to nontraditional growing areas (Strik 2007). There are three general types of commercial blueberry: northern highbush, southern highbush, and rabbiteye. Northern highbush blueberry, *Vaccinium corymbosum* L. (Ericaceae), is native to the northeastern United States, and cultivars were developed through traditional breeding programs. Southern highbush cultivars involve complex crosses between *Vaccinium corymbosum* L. and *Vaccinium darrowi* Camp (a species native to the southeastern United States) to express the low-chilling trait. Rabbiteye cultivars are derived from *Vaccinium virgatum* L. (formerly known as *V. ashei*), also native to the southeastern United States. Chilling requirement and susceptibility to frost damage determine where these types can be grown. Northern highbush cultivars have a higher chilling requirement (>800 h at 0–7°C) and greater winter cold hardiness than do southern highbush or rabbiteye cultivars (<300 h of chilling) (Strik 2005).

Development of low-chill varieties of southern highbush blueberry mean that blueberries can be grown in increasingly warm climates, such as Hawaii, southern California, Mexico, Italy, Spain, Portugal, and Thailand where they will encounter new pests, including subtropical and tropical fruit flies (Hummer et al. 2007, Follett et al. 2009). If blueberry cultivars show variation in susceptibility to fruit fly attack, growers might selectively plant cultivars to minimize problems of crop loss due to fruit fly infestation. Three economically important invasive fruit fly species are

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established in Hawaii—Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann); oriental fruit fly, *Bactrocera dorsalis* Hendel; and melon fly, *Bactrocera cucurbitae* Coquillett (Diptera: Tephritidae). Mediterranean fruit fly spread from its origin in Africa to Mediterranean Europe and many parts of Central and South America (CABI 1997), and it is among the most destructive pests of >100 species of fruit, such as citrus (*Citrus* spp.), apples (*Malus* spp.), pears (*Pyrus* spp.), mangoes (*Mangifera* spp.), guavas (*Psidium* spp.), and peaches (*Prunus* spp.). Oriental fruit fly and melon fly also are important economic pests of a wide variety of fruits and vegetables throughout southern Asia and several Pacific Islands (CABI 1997). Tephritid fruit flies feed as larvae on the pulp of fruits, causing the development of infection courts for fruit diseases. Also, female fly oviposition holes can cause scarring, which lowers fruit quality.

The objective of this study was to determine the susceptibility of low-chill blueberry cultivars to infestation by Mediterranean fruit fly, oriental fruit fly, and melon fly.

## Materials and Methods

Laboratory cage no-choice experiments were conducted to determine the susceptibility of blueberry to Mediterranean fruit fly, oriental fruit fly, and melon fly. Fruit of 17 southern highbush blueberry cultivars ('Biloxi', 'Blue Crisp', 'Emerald', 'Jewel', 'Jubilee', 'Legacy', 'Misty', 'Millennia', 'O'Neal', 'Sapphire', Sharpblue', 'South Moon', 'Southern Belle', 'Spring High', 'Star, 'Sunshine Blue', and 'Windsor') grown in an experimental planting at Mealani Experiment Station (University of Hawaii, Waimea, HI; elevation, 908 m) were harvested during a 14-wk period from August to December 2009 as ripe fruit became available. The tests used laboratory flies obtained from colonies maintained at the USDA–ARS laboratory in Honolulu, HI, that were reared on standard diets for each species (Vargas 1989, Vargas et al. 1990). In a typical week, four to six cultivars were harvested and exposed to fruit flies. For each fruit fly species and cultivar combination, 50 fruit were spread out in a single layer and were exposed to 50 gravid female flies in 25- by 25- by 25-cm screen cages outdoors (23–26°C) for 6 h in no-choice tests. After the 6 h of exposure, fruit were removed from each cage and placed in a 3.8-liter plastic bucket with a screened lid and sand and held at 20–25°C and a photoperiod of 14:10 (L:D) h in the laboratory for larval development and pupariation. After 2 wk, fruit and sand were inspected for puparia. Puparia were transferred to 120-ml plastic cups for adult emergence. For each fruit fly species, two to four replicate cages were set up for each cultivar (depending on fruit availability) during the harvest period, and data were analyzed as a completely randomized design. On each day that tests were conducted with blueberries, a ripe papaya (*Carica papaya* L. 'Rainbow') was exposed to each fruit fly species in separate cages by using the same methods to demonstrate the oviposition competence of adult female flies and the suitability of the environmental conditions for development and rearing. Ripe papaya is a preferred host for the three fruit fly species.

The number of puparia per gram of fruit was calculated to compare cultivar infestability because fruit size among cultivars varied substantially. Data on the number of puparia per gram fruit weight were first subjected to a two-way analysis of variance (ANOVA) with fruit fly species and cultivar as main effects; because there was a significant interaction effect, each fruit fly species was analyzed separately. For each fruit fly species, log-transformed data on the number of puparia per gram fruit weight, and arcsine-transformed data on percentage adult emergence for each cultivar were subjected to one-way ANOVA. Means separations were done using Tukey's test ($P > 0.05$) (SAS Institute 2002). Data for papaya infestability were analyzed similarly. Several blueberry cultivars were not evaluated for susceptibility to melon fly owing to insufficient fruit and poor replication.

## Results

Fruit size among cultivars varied from ≈1.85 g (Spring High) to 0.25 g (Misty) per fruit. The fruit fly species by cultivar interaction was highly significant for the number of puparia per gram of fruit ($P < 0.001$); therefore, the three fruit fly species were analyzed separately. Linear regression of the number of puparia per gram against the average weight of fruit was not significant for Mediterranean fruit fly ($P = 0.26$) or melon fly ($P = 0.23$) but was significant for oriental fruit fly ($P = 0.05$), with larger fruit tending to produce fewer puparia ($\log[\text{puparia/g}] = -0.40 - 0.27[\text{fruit wt}]$; $R^2 = 0.07$).

For oriental fruit fly, the cultivar effect was significant for the number of puparia per gram of fruit ($F_{15,36} = 2.8$; $P = 0.005$) and percentage adult emergence ($F_{15,36} = 2.7$; $P = 0.006$). Sapphire fruit produced 1.42 oriental fruit fly puparia per g (Table 1), which was twice as many as the next most susceptible Emerald (0.70 puparia per g). Legacy, Biloxi, and Spring High fruit were least susceptible to infestation, producing only 0.20–0.25 oriental fruit fly puparia per g of fruit. Sapphire and Biloxi had relatively small fruit (1.5 and 1.4 g, respectively) whereas Emerald, Legacy, and Spring High had the largest fruit (2.5–3.7 g), which illustrates the inconsistent pattern of infestation relative to fruit weight.

For Mediterranean fruit fly, the cultivar effect was significant for the number of puparia per gram of fruit ($F_{17,39} = 5.8$; $P = 0.001$) but not significant for the percentage adult emergence ($F_{17,39} = 2.8$; $P = 0.64$). Blue Crisp, Jubilee, Windsor, and Legacy were most susceptible to infestation, producing 0.41–0.50 Mediterranean fruit fly puparia per g (Table 2). Biloxi and Sharpblue fruit were least susceptible to infestation, producing only 0.03–0.06 Mediterranean fruit fly puparia per g of fruit.

For melon fly, the cultivar effect was significant for the number of puparia per gram of fruit ($F_{17,39} = 4.3$; $P = 0.03$) but not significant for the percentage adult emergence ($F_{17,39} = 0.6$; $P = 0.71$). Sapphire was the

**Table 1. Number of oriental fruit flies developing at 2 wk after forced infestation in cages of various cultivars of blueberries and holding on sand in the laboratory**

| Cultivar[a] | Replicates | Total no. fruit | Total no. gravid flies | Fruit wt (g) | No. puparia | No. puparia/g fruit | % adult emergence |
|---|---|---|---|---|---|---|---|
| Sapphire | 4 | 200 | 200 | 74.1 (3.4) | 106.5 (15.8) | 1.42 (0.17)a | 86.5 (1.8)a |
| Emerald | 4 | 200 | 200 | 126.2 (3.7) | 88.8 (9.5) | 0.70 (0.07)ab | 82.9 (0.3)ab |
| Sharpblue | 4 | 200 | 200 | 69.8 (3.2) | 45.5 (16.2) | 0.63 (0.20)ab | 89.0 (5.3)a |
| Jubilee | 4 | 200 | 200 | 87.8 (4.5) | 49.8 (29.5) | 0.57 (0.34)ab | 98.3 (3.5)a |
| Jewel | 4 | 200 | 200 | 118.5 (8.5) | 66.5 (11.2) | 0.56 (0.09)ab | 82.6 (3.4)ab |
| Blue Crisp | 4 | 200 | 200 | 51.6 (1.7) | 26.5 (5.9) | 0.53 (0.12)ab | 81.5 (5.3)ab |
| Sunshine Blue | 4 | 200 | 200 | 67.6 (6.0) | 33.8 (5.1) | 0.52 (0.09)ab | 86.0 (4.2)a |
| Misty | 4 | 200 | 200 | 50.0 (3.9) | 23.3 (7.2) | 0.44 (0.13)ab | 87.5 (5.1)a |
| Windsor | 4 | 128 | 128 | 63.6 (3.3) | 24.3 (2.7) | 0.38 (0.04)ab | 90.3 (3.9)a |
| O'Neal | 2 | 52 | 52 | 40.8 (3.5) | 13.5 (2.5) | 0.34 (0.09)ab | 83.2 (10.5)ab |
| Southern Belle | 2 | 56 | 56 | 62.8 (2.2) | 21.0 (10.0) | 0.33 (0.15)ab | 73.8 (10.1)ab |
| Springhigh | 2 | 56 | 56 | 103.6 (5.3) | 27.0 (19.0) | 0.25 (0.17)b | 57.6 (7.6)b |
| Biloxi | 4 | 200 | 200 | 68.7 (5.1) | 15.5 (2.0) | 0.23 (0.04)b | 89.6 (4.1)a |
| Legacy | 4 | 110 | 110 | 87.7 (7.4) | 17.3 (5.1) | 0.20 (0.07)b | 78.0 (4.2)ab |

Data are means (±SEM) of replicates where a number of fruit were exposed to an equal number of flies in cages. Means within a column followed by the same letter are not significantly different ($P \geq 0.05$; Tukey's test).

[a] Cultivars are sorted by decreasing number of puparia per gram.

most susceptible cultivar to infestation by melon fly, as it was with its congener oriental fruit fly, producing 0.11 puparia per g of fruit (Table 3). The other cultivars were poorly infested, producing >0.03 melon fruit fly puparia per g of fruit. Blue Crisp, Legacy, Misty, and Sunshine Blue produced no puparia.

For the preferred host papaya, the fruit fly species effect was not significant for the number of puparia per gram of fruit ($F_{2,24} = 0.4$; $P = 0.66$) but was significant for the percentage adult emergence ($F_{2,24} = 4.6$; $P = 0.02$). The mean number of puparia per gram of papaya fruit ranged from 1.1 to 1.4 for the three fruit fly species (Table 4). The percentage of adult emergence was relatively high (72–94%) for each fly species. The large number of flies reared from ripe papayas demonstrated the suitability of the host testing methods for blueberries and the competence of adult female fruit flies used in the tests.

## Discussion

Most of the blueberry varieties grown worldwide originated from breeding programs in the United States (Strik 2005), and the low-chill southern highbush cultivars tested in this study are widely grown in other parts of the world. In Chile, 55% of the cultivars are northern highbush and 35% are southern highbush, whereas most of the cultivars planted in Argentina are southern highbush. Northern highbush predominate in northern Europe and southern highbush are mainly grown in southern Europe. Primarily southern highbush blueberries are being grown in Mexico.

Each of the blueberry cultivars tested was infested by oriental and Mediterranean fruit flies, confirming that the fruit flies will oviposit on fruit and that these fruit were suitable hosts for development. However, fruit fly susceptibility was significantly different be-

**Table 2. Number of Mediterranean fruit flies developing at 2 wk after forced infestation in cages of various cultivars of blueberries and holding on sand in the laboratory**

| Cultivar[a] | Replicates | Total no. fruit | Total no. gravid flies | Fruit wt (g) | No. puparia | No. puparia/g fruit | % adult emergence |
|---|---|---|---|---|---|---|---|
| Blue Crisp | 4 | 200 | 200 | 59.0 (5.9) | 29.0 (4.8) | 0.50 (0.10)a | 85.5 (3.2)a |
| Jubilee | 4 | 200 | 200 | 96.3 (5.0) | 43.8 (15.3) | 0.44 (0.14)a | 88.5 (1.7)a |
| Windsor | 4 | 128 | 128 | 65.7 (6.6) | 28.0 (4.8) | 0.43 (0.06)a | 80.2 (2.8)a |
| Legacy | 2 | 90 | 100 | 73.9 (2.0) | 30.5 (6.5) | 0.41 (0.08)ab | 81.6 (5.9)a |
| Star | 3 | 125 | 125 | 74.0 (11.9) | 20.3 (3.2) | 0.28 (0.01)ab | 92.9 (3.8)a |
| Sapphire | 4 | 200 | 200 | 60.7 (2.7) | 14.5 (1.8) | 0.24 (0.03)abd | 82.2 (6.3)a |
| South Moon | 3 | 54 | 54 | 43.2 (4.1) | 10.0 (3.1) | 0.22 (0.06)abcd | 83.7 (5.2)a |
| Emerald | 4 | 200 | 200 | 92.8 (2.1) | 20.3 (4.2) | 0.22 (0.04)abcd | 65.4 (6.1)a |
| Misty | 4 | 200 | 200 | 61.2 (6.8) | 12.0 (2.3) | 0.20 (0.04)abcd | 88.9 (3.9)a |
| Sunshine Blue | 4 | 160 | 160 | 68.9 (7.1) | 11.3 (3.3) | 0.17 (0.06)abcd | 81.1 (9.6)a |
| Jewel | 4 | 200 | 200 | 108.4 (3.2) | 18.5 (5.4) | 0.17 (0.05)abcd | 80.1 (3.1)a |
| Springhigh | 4 | 102 | 102 | 81.0 (2.9) | 8.5 (3.9) | 0.10 (0.05)bcd | 75.7 (14.7)a |
| Millennia | 4 | 112 | 112 | 75.7 (2.9) | 6.3 (1.1) | 0.08 (0.01)bcd | 85.7 (8.2)a |
| Biloxi | 4 | 200 | 200 | 67.0 (5.5) | 3.5 (0.6) | 0.06 (0.01)c | 95.0 (5.0)a |
| Sharpblue | 4 | 200 | 200 | 54.0 (2.4) | 1.5 (1.2) | 0.03 (0.02)cd | 70.0 (30.0)a |

Data are means (±SEM) of replicates where a number of fruit were exposed to an equal number of flies in cages. Means within a column followed by the same letter are not significantly different ($P \geq 0.05$; Tukey's test).

[a] Cultivars are sorted by decreasing number of puparia per gram.

**Table 3. Number of melon flies developing at 2 wk after forced infestation in cages of various cultivars of blueberries and holding on sand in the laboratory**

| Cultivar[a] | Replicates | Total no. fruit | Total no. gravid flies | Fruit wt (g) | No. puparia | No. puparia/g fruit | % adult emergence |
|---|---|---|---|---|---|---|---|
| Sapphire | 4 | 200 | 200 | 57.3 (5.1) | 7.0 (2.9) | 0.112 (0.040)a | 86.9 (7.2)a |
| Windsor | 4 | 200 | 200 | 86.1 (2.2) | 2.5 (1.6) | 0.028 (0.017)b | 95.2 (4.8)a |
| Jubilee | 4 | 200 | 200 | 66.7 (10.5) | 1.3 (0.9) | 0.019 (0.014)b | 87.5 (12.5)a |
| Biloxi | 4 | 200 | 200 | 63.0 (1.7) | 0.75 (0.25) | 0.012 (0.004)b | 100a |
| Jewel | 4 | 200 | 200 | 113.5 (12.1) | 1.0 (0.71) | 0.010 (0.007)b | 83.3 (16.7)a |
| Sharpblue | 4 | 200 | 200 | 65.6 (1.7) | 0.5 (0.5) | 0.007 (0.007)b | 100a |
| Emerald | 4 | 200 | 200 | 99.0 (1.5) | 0.25 (0.25) | 0.002 (0.002)b | 100a |
| Blue Crisp | 4 | 200 | 200 | 76.1 (2.9) | 0.0 | 0.0b | |
| Legacy | 2 | 60 | 60 | 40.9 (1.2) | 0.0 | 0.0b | |
| Misty | 4 | 200 | 200 | 66.1 (11.9) | 0.0 | 0.0b | |
| Sunshine Blue | 2 | 72 | 72 | 89.6 (0.2) | 0.0 | 0.0b | |

Data are means (±SEM) of replicates where a number of fruit were exposed to an equal number of flies in cages. Means within a column followed by the same letter are not significantly different ($P \geq 0.05$; Tukey's test).
[a] Cultivars are sorted by decreasing number of puparia per gram.

tween cultivars, and cultivar susceptibility differed between oriental fruit fly and Mediterranean fruit fly. The number of puparia per gram of fruit ranged from 1.42 (Sapphire) to 0.20 (Legacy) for oriental fruit fly and from 0.50 (Blue Crisp) to 0.03 (Sharpblue) for Mediterranean fruit fly. The most susceptible blueberry cultivar to oriental fruit fly, Sapphire, produced ≈3 times as many puparia per gram fruit as did the most susceptible cultivar to Mediterranean fruit fly, Blue Crisp. Sharpblue was a good host for oriental fruit fly but a poor host for Mediterranean fruit fly. Emerald was a significantly better host for oriental fruit fly than Mediterranean fruit fly. Biloxi and Springhigh were relative poor hosts for both fruit flies. Several cultivars, such as Blue Crisp, Jubilee, and Windsor, produced approximately the same number of oriental fruit fly and Mediterranean fruit fly puparia per gram fruit. The number of puparia per gram of fruit was similar between ripe papaya and Sapphire blueberry for oriental fruit fly (Tables 1 and 4). Although our data suggest that the low-chilling blueberry fruits can be good hosts for oriental fruit fly and Mediterranean fruit fly, all cultivars were relatively poor hosts for melon fly under the test conditions used in this study.

Variability in cultivar susceptibility to fruit flies is not unique to southern highbush blueberries. In a previous study, 'Berkeley', a northern highbush cultivar and unsuited to production in lower chilling areas, was an acceptable oviposition host for oriental fruit fly and Mediterranean fruit fly but a poor one for fruit fly development (0.02–0.06 puparia per g fruit), whereas the northern highbush 'Bluecrop' was a good ovipositional and developmental host for both species (0.60–1.06 puparia per g) (Follett 2009).

Whether low-chill blueberries will be a significant natural host for oriental fruit fly and Mediterranean fruit fly is not known. Our study demonstrates that oriental fruit fly and Mediterranean fruit fly will oviposit into low-chill blueberry cultivars and that these cultivars are physiologically suitable for development. Further field studies are needed to determine whether these blueberry cultivars are significant ecological hosts (Aluja and Mangan 2008). Low-chill blueberries grown in southern China and Thailand will be exposed to oriental fruit fly, and cultivars grown in Argentina, Spain, and South Africa potentially will be attacked by Mediterranean fruit fly. Information is lacking on field infestation rates of blueberry by oriental fruit fly, probably because blueberry plantings within the distribution of this fruit fly have been limited, and only one study is available for Mediterranean fruit fly. Vaccaro and Bouvet (2006) sampled 12 low-chill blueberry cultivars from the main growing regions of Argentina for infestation by Mediterranean fruit fly. Mediterranean fruit fly was reared from five cultivars, with infestation rates ranging from 0.02% ('Reveille') to 1.7% (Sharpblue); Misty, Jewel, South Moon, Emerald, Star, and 'Santa Fe' were not infested in their study. Additional studies are needed to determine blueberry cultivar susceptibility to other tephritid fruit flies, particularly the *Anastrepha fraterculus* (Wiedemann) in central and South America; *Anastrepha* spp. in Mexico; Caribbean fruit fly, *Anastrepha*

**Table 4. Numbers of oriental fruit fly, Mediterranean fruit fly, and melon fly developing at 2 wk after forced infestation in cages of ripe papayas and holding on sand in the laboratory**

| Fruit fly species | Total no. replicates | Total no. fruit | No. gravid flies | Mean fruit wt (g) | No. puparia | No. puparia/g fruit | % adult emergence |
|---|---|---|---|---|---|---|---|
| Oriental | 9 | 9 | 450 | 336.1 (11.1) | 406.4 (84.0) | 1.22 (0.26)a | 93.8 (6.6)a |
| Mediterranean | 10 | 10 | 500 | 317.2 (11.1) | 343.3 (59.5) | 1.07 (0.18)a | 72.3 (3.2)b |
| Melon | 8 | 8 | 400 | 297.5 (14.4) | 451.6 (107.7) | 1.44 (0.32)a | 81.5 (5.3)ab |

Data are means (±SEM) of replicates where a single fruit was exposed to 50 gravid fruit flies in cages. Means within a column followed by the same letter are not significantly different ($P \geq 0.05$; Tukey's test).

*suspensa* (Loew), in Florida; *Ceratitis* spp. in South Africa; and *Bactrocera tryoni* (Froggatt) in Australia.

The reasons for the differences in cultivar susceptibility to fruit fly infestation are not known. Resistance to tephritid fruit flies may be the result of biophysical or biochemical attributes of the fruit that affect insect oviposition behavior or due to biochemical attributes that act as physiological deterrents to development (Greany 1994). Liburd et al. (1998) found that blueberry cultivar susceptibility to a temperate climate tephritid, blueberry maggot, *Rhagoletis mendax* Curran, was due to time of maturity and recommended early maturing varieties to avoid infestation. This option is not practical for low-chill blueberries grown in tropical climates where fruit flies may be active throughout the year. Future studies with Hawaii's fruit flies will directly compare blueberry cultivars of high and low susceptibility and will attempt to identify resistance factors and their mechanisms.

The information from this study will aid in development of pest management recommendations for blueberry. Planting of cultivars of lower susceptibility may result in lower infestation levels and reduce crop loss. Once the traits conferring resistance are identified and characterized, resistant genotypes could be exploited by blueberry breeding programs (Lyrene 2005). Irradiation and cold quarantine treatments are options for export of blueberries grown in areas invaded by these fruit flies (Follett et al. 2008, Follett 2009).

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