

A Systems Approach to Mitigate Oriental Fruit Fly Risk in ‘Sharwil’ Avocados Exported from Hawaii

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Abstract

A multi-component systems approach is proposed to reduce the risk of oriental fruit fly infestation in ‘Sharwil’ avocados exported from Hawaii into the United States to an acceptable level. This systems approach is based on poor host status, limited distribution and low prevalence. Recent surveys suggest oriental fruit fly populations are naturally low in Hawaii’s small avocado orchards. Maintaining low oriental fruit fly numbers in orchards during the shipping period should reduce the rate of infestation to negligible levels. Population levels will be monitored using protein bait traps and if needed, suppression will be achieved using selective reduced-risk insecticide baits. ‘Sharwil’ avocados will be shipped only to northern tier states and will only be shipped during the winter months of November to March, when temperatures in the distribution area are inhospitable to tropical fruit pests. The cumulative effect of multiple safeguards should provide quarantine security against oriental fruit fly and other quarantine pests in exported avocados.

INTRODUCTION

Avocados, *Persea americana* Miller, grown in Hawaii cannot be exported to the United States mainland without quarantine treatment for *Bactrocera cucurbitae* (Coquillett) (melon fly), *Bactrocera dorsalis* (Hendel) (oriental fruit fly), and *Ceratitis capitata* (Wiedemann) (Mediterranean fruit fly). The most widely grown cultivar of avocado is ‘Sharwil’, a Mexican-Guatemala hybrid that has been grown in Hawaii since 1955. Avocado growers would like to export ‘Sharwil’ fruit to United States mainland markets.

Both Armstrong et al. (1983) and Armstrong (1991) reported that ‘Sharwil’ avocados in Hawaii, attached to the tree, are not naturally infested by the melon fly, oriental fruit fly or Mediterranean fruit fly at harvest maturity. They suggested that fruit could be exported safely as a non-host using a systems approach where fruit are harvested with stems attached, brought to the packinghouse within 12 h, sorted to remove damaged fruit and packed in fruit fly-proof cartons. Avocados are typically harvested at the hard, mature green stage and ripened at room temperature until they soften before consumption. ‘Sharwil’ avocado, like other avocado cultivars, becomes an increasingly favorable host for fruit flies as it ripens and softens after harvest (Armstrong, 1991; Oi and Mau, 1989). A systems approach for export of Hawaii ‘Sharwil’ avocados to the U.S. mainland, based on non-host status, was approved by U. S. Department of Agriculture (USDA) and Animal and Plant Health Inspection Service (APHIS) but the rule was rescinded in 1992, when live oriental fruit fly larvae were found in mature green fruit attached to the tree.

Subsequently, Liquido et al. (1995) studied natural infestation rates in the field and found a low level of infestation by oriental fruit fly. Therefore, ‘Sharwil’ avocado is naturally a poor host, rather than a non-host for this pest, as previously thought. No infestation by Mediterranean fruit fly or melon fly was detected. Subjective firmness measures taken in the field at harvest indicated that 'firm ripe' and 'fully ripe' fruit can

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occur on the tree late in the season (2.2% ripe fruit) and are much more likely to be infested by oriental fruit fly than hard, mature green fruit.

Recent studies of Sharwil avocado infestation by oriental fruit fly and population densities in commercial orchards suggest a modified systems approach may be feasible. Follett (2009) exposed harvest mature 'Sharwil' fruit in cages to high densities of oriental fruit flies and Mediterranean fruit flies and only oriental fruit fly was capable of successfully infesting fruit within 24 h of harvest. This study quantified the relationship between avocado firmness and fruit fly attack by taking fruit penetrometer readings after exposure to fruit flies. While rate of infestation was negatively correlated with fruit firmness (number of pupae = $14.13 - 0.18$ (firmness [N]) ($F_{1,95} = 112.8$, $P < 0.001$) even some hard fruit (60-80 N) were infested (Fig. 1, Follett, 2009). Klungness et al. (2009) surveyed fallen 'Sharwil' avocado fruit and found a low level of infestation by oriental fruit fly and a 15-month survey using protein bait traps demonstrated that adult female oriental fruit flies were present at only low levels in commercial orchards (Fig. 2). Therefore, data from Liquido et al. (1995), Klungness et al. (2009) and Follett (2009) suggest that only oriental fruit fly is a quarantine pest of concern in commercially harvested fruit in the area where 'Sharwil' avocados are grown and that oriental fruit fly can infest commercial grade fruit, albeit rarely. A modified systems approach was developed for export 'Sharwil' avocados based on poor host status, low prevalence of oriental fruit fly and limited sales distribution. The low prevalence components and limited distribution are additions to the previous protocol to further reduce the risk of oriental fruit fly introduction to the U.S. mainland.

A PROPOSED SYSTEMS APPROACH

There are a number of components (Table 1) of the proposed systems approach and each component is discussed below. Underpinning the approach is the understanding that 'Sharwil' avocado fruit are rarely infested by oriental fruit fly and that the frequency of infestation and the risk of introduction can be reduced to an acceptable level.

'Sharwil' Cultivar

The identity of avocados must be ensured as cultivars may differ in their susceptibility to fruit flies (Hennessey et al., 1995). 'Sharwil' is a distinct cultivar and existing orchards and trees must be certified as 'Sharwil' based on horticultural characteristics. 'Sharwil' trees have a low, spreading form and a moderate, regular bearing habit. Trees produce "B" type flowers that shed pollen in the morning. 'Sharwil' fruit are oval-shaped and small-seeded, with a green skin, yellow-green flesh and rough skin surface. Typical fruit size is 8 to 10 oz. (Chen et al., 2009).

Harvest Maturity

'Sharwil' fruit without the stem attached or with blemishes or faults are more likely to be infested by fruit flies (Armstrong, 1991). Mature green fruit, with pedicel firmly attached to trees, should be harvested and packed within 12 h after harvest. Pedicel or fruit stem end length on fruit packed for export should be no longer than 0.5 cm. Fruit should have no surface blemishes or damage. Avocados are classified as mature green fruit if they are hard, meaning the fruit skin and flesh beneath cannot be depressed when applying pressure by hand. Mature green Sharwil avocados are very poor hosts and rarely infested by oriental fruit fly. Fruit without stems and fruit with surface blemishes or damage are more likely to be infested. Harvesting and packing only hard, mature green fruit with stems attached and with no surface blemishes or damage will minimize the risk of exporting infested fruit.

Low Pest Prevalence

Most systems approaches require low prevalence of fruit flies in the field. After many years of study, only oriental fruit fly has been found to infrequently infest 'Sharwil' avocados on the tree. Natural infestations by melon fly and Mediterranean fruit fly have not

been observed. Therefore, low prevalence should be maintained for oriental fruit fly before and during the shipping period. ‘Sharwil’ avocado is a very poor host and maintaining low oriental fruit fly numbers in orchards should result in negligible infestation levels. An official operational plan will be developed to specify the phytosanitary procedures required to establish and maintain low prevalence in orchards. Trap type for monitoring oriental fruit fly levels must be determined. Because male lure traps attract flies from long distances, they are probably of limited value in predicting numbers of fruit flies within the small avocado orchards typical of Hawaii. Protein bait traps capture female flies and are attractive over short distances providing a better indication of population levels within orchards (Klungness et al., 2009). In the 15-month survey for oriental fruit fly throughout the ‘Sharwil’ avocado production area in west Hawaii, protein bait trap counts averaged between 0.1-1.1 female flies per trap per week (Fig. 2). One of the 18 orchards that were surveyed had moderately high trap catches (Aug-Oct) well before the start of the harvest season (Dec-Apr), suggesting that fruit fly use of alternate hosts near the orchard may influence trap catch. This surveillance program to validate the low prevalence status for oriental fruit fly is continuing. Maintaining trapping counts below an average of 3 female flies per trap per week would be in line with approved USDA APHIS systems approach programs elsewhere. Given the poor host status of ‘Sharwil’ avocado for oriental fruit fly this level appears appropriate but APHIS will have to establish what an acceptable level of pest prevalence should be. Growers would have to demonstrate low prevalence in their orchards through trapping before entering the export program. Exceeding the specified level would trigger in-field control measures and criteria for remaining in the program or for re-entry into the program.

Oriental fruit fly suppression can be achieved by several means, including selective reduced-risk insecticide bait treatments (Pinerio et al., 2009, 2010), and male annihilation using methyl eugenol and a toxicant (Vargas et al., 2009). The International Plant Protection Convention (IPPC) has published several guidelines that pertain to the establishment and maintenance of low prevalence areas (IPPC, ISPM Nos. 8, 22, 30) and these can be used to develop program parameters.

Inspection for Surface Pests

Surface pests can also be of quarantine concern and their presence can cause rejection of a consignment (Follett and Neven, 2006). A variety of medium risk quarantine pests are associated with ‘Sharwil’ avocados exported from Hawaii in addition to the high risk fruit flies (Table 2). High risk pests pose significant phytosanitary risks and port-of-entry inspections alone are considered an insufficient safeguard, so additional phytosanitary measures are necessary in order to reduce risks to acceptable levels. Medium risk pests also pose a significant risk but inspection alone can be sufficient to provide quarantine security. Avocados inspected at the packing house should be free of light brown apple moth, *Epiphyas postvittana*, the honeydew moth, *Cryptoblabes gnidiella*. Scale and mealybug pests such as *Aleurodicus dispersus*, *Coccus viridis*, *Dysmicoccus neobrevipes*, *Maconellicoccus hirsutus*, *Nipaecoccus viridis*, *Paracoccus marginatus* and *Pseudococcus cryptus*. All are external feeders and should be detectable with the naked eye.

Orchard Certification and Compliance Agreements

‘Sharwil’ trees will be certified in each orchard or orchard block by USDA APHIS. Each orchard should be maintained to create a low prevalence production site as part of an area-wide pest management program. Monitoring with specific traps placed at defined densities will be done to confirm low prevalence of oriental fruit fly and other pests in the orchard. This would mainly involve protein bait trapping for adult fruit flies. Applicable guidelines for maintaining low prevalence for oriental fruit fly will be applied, including monitoring intervals, field sanitation, bait treatments and other appropriate population suppression measures such as male annihilation. A compliance agreement will confirm the growers’ understanding of the methods, conditions and procedures necessary

to participate in the export program.

Post-Harvest Safeguards

Safeguards to prevent pest infestation after harvest would include: packing within 12 h of harvest; insect-proof covers for field boxes; storing field boxes in pest-proof areas; pre-season packinghouse certification; double doors and screens in packinghouses; packing only certified fruit during the shipping season; fruit with stem attached no longer than 0.5 cm; packing in clean, new pest-proof cartons; fruit inspection at the packinghouse; packing cartons free of leaves and twigs; and limited permit documents with all consignments.

Orchard Sanitation

In many tropical crops, sanitation can significantly reduce the population of fruit flies in the orchard, lowering trap catches and the likelihood of fruit infestation. Removal of dead green avocado fruit (previous season's fruit) from trees removes old fruit that may ripen during the normal harvesting season. Collection or destruction of fallen, damaged fruit from the ground removes susceptible fruit that can breed fruit flies.

Limited Sales Distribution and Harvest Period

Limiting the time of year that a commodity is exported and/or the geographic area where consignments may be shipped to can help ensure that infested commodities pose minimal risk of introducing a tropical invasive pest. 'Sharwil' avocados will be shipped only to 28 northern tier states and the District of Columbia and will only be shipped during the winter months of November to March when temperatures in the distribution area are inhospitable to tropical fruit pests. This will reduce the likelihood of oriental fruit fly or other avocado pests becoming established in the distribution area.

CONCLUSIONS

There remains strong interest in Hawaii in exporting 'Sharwil' avocados to the U.S. mainland. Results from Liquido et al. (1995), Klungness et al. (2009), and Follett (2009) suggest that oriental fruit fly will rarely occur in avocado fruit exported from Hawaii. A modified multi-component systems approach was developed to improve on the previous systems approach to reduce the risk of oriental fruit fly introduction into the United States to an acceptable level. This systems approach is based on poor host status, limited distribution (28 northern states during the winter months of November through March) and low pest prevalence. The limited distribution and low prevalence components are additions to the previous protocol to further reduce the risk of oriental fruit fly introduction. This approach is similar to that used to import Mexican Hass avocados from 1997-2001 (Peterson and Orden, 2006). Failure of the previous systems protocol for Hawaii may have been due to the presence of firm ripe and fully ripe fruit on the tree (Liquido et al., 1995). Subjective or quantitative measures of fruit firmness may be a useful component of a multiple component systems approach as an additional safeguard to reduce infestation and the risk of introducing oriental fruit fly. Data suggest that only oriental fruit fly naturally attacks 'Sharwil' avocado in Hawaii, albeit rarely, and that oriental fruit fly populations in orchards in the main production areas are naturally low.

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Tables

Table 1. Potential components of a systems approach for export of Hawaii ‘Sharwil’ avocados.

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- Sharwil cultivar
 - Harvested mature green with stems attached and no blemishes
 - Low prevalence for oriental fruit fly through protein bait trap monitoring
 - Inspection for surface pests
 - Orchard certification and compliance agreement with USDA APHIS
 - Post-harvest safeguards
 - Orchards sanitation program
 - Limited sales distribution only to 28 northern tier states
 - Limited harvest period only during winter months of November to March
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Table 2. High- and medium-risk quarantine pests associated with ‘Sharwil’ avocados exported from Hawaii.

Risk potential	Organism	Species	Order: Family	Common name		
High	Insect	<i>Bactrocera cucurbitae</i>	Diptera: Tephritidae	Melon fly		
		<i>Bactrocera dorsalis</i>	Diptera: Tephritidae	Oriental fruit fly		
		<i>Ceratitidis capitata</i>	Diptera: Tephritidae	Mediterranean fruit fly		
Medium	Insect	<i>Aleurodicus dispersus</i>	Hemiptera: Aleyrodidae	Spiralling white fly		
		<i>Ceroplastes rubens</i>	Hemiptera: Coccidae	Red wax scale		
		<i>Coccus viridis</i>	Hemiptera: Coccidae	Green scale		
		<i>Cryptoblabes gnidiella</i>	Lepidoptera: Pyralidae	Honeydew moth		
		<i>Dysmicoccus neobrevipes</i>	Hemiptera: Pseudococcidae	Gray pineapple mealybug		
		<i>Epiphyas postvittana</i>	Lepidoptera: Tortricidae	Light brown apple moth		
		<i>Maconellicoccus hirsutus</i>	Hemiptera: Pseudococcidae	Pink hibiscus mealybug		
		<i>Nipaecoccus viridis</i>	Hemiptera: Pseudococcidae	Hibiscus mealybug		
		<i>Paracoccus marginatus</i>	Hemiptera: Pseudococcidae	Papaya mealybug		
		<i>Pseudococcus cryptus</i>	Hemiptera: Pseudococcidae	Citriculus mealybug		
		Bacteria	Bacteria	<i>Botryosphaeria parva</i>	Dothideales: Botryosphaeriaceae	

Source: Draft pest risk assessment, “Qualitative Pathway-Initiated Risk Assessment for the Movement of Mature Green ‘Sharwil’ Avocado, *Persea americana* Mill. from Hawaii into Continental United States”, USDA-APHIS Plant Protection and Quarantine, Riverdale, Maryland, USA, 2009.

