Olive Fruit Fly: Timing the Harvest to Manage the Pest

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The olive fruit fly is one of the primary pests of California olives. The choice of harvest date is one tool available to growers for managing economic losses from olive fruit fly infestations. Harvesting earlier reduces losses and requires fewer insecticide applications for managing an infestation. However, harvesting earlier results in smaller olives. Growers face a trade-off between reduced losses and insecticide costs and a higher price per unit sold.

The olive fruit fly is one of the primary pests of olives. Growers can reduce damage and pest management costs by harvesting earlier, but this can also reduce price. The implications of this trade-off vary by region, and differ in terms of growing conditions and cultivar.

The olive fruit fly has been in the news again this season, due to substantial fruit infestations last fall that were reminiscent of those in the mid-2000s. Infestations by the olive fruit fly are a major concern to growers because the fly decreases the quality and yield of fruit. Native to West Africa, the fly has been a longtime pest for olives in the Mediterranean region. It is a relatively recent problem for California growers, with its first detection in 1998. Today, the olive fruit fly is one of the primary pests of California olives.

In this article, we model the impact of infestations on growers' profits. We consider harvest date as an additional tool for the management of damage caused by the olive fruit fly. Its population is dependent on weather factors including temperature, humidity and precipitation, as well as on certain management practices such as irrigation. Olive fruit development is dependent on these same factors, so both costs and revenues are affected by harvest date.

Sources of Economic Damage

The olive fruit fly damages the olive fruit during the fly's reproductive process. A female adult fruit fly lays eggs in the olive fruit, leaving behind a distinguishable mark on the surface of the olive called an ovipositional sting. As the larvae develop inside the olive, they feed on the pulp of the fruit causing the fruit to drop early or rot. Larvae may pupate within the fruit or exit the fruit to pupate in the soil.

The physical damage caused by the olive fly translates to economic damages in several ways. There is little to no tolerance for larval presence in whole canned table olives, and infestation may cause total rejection of a shipment. Fruit damaged by an olive fruit fly may rot more quickly after harvest than uninfested fruit, making them unsuitable for oil production unless they can be crushed immediately following harvest. Finally, infestations occurring late in the ripening period may cause premature fruit drop, directly reducing yield.

Table olive processors in Europe normally have a 1% threshold for damage from the olive fruit fly. In California, table olive processors have zero tolerance because damaged fruit are unacceptable for canning. Olive oil processors usually have a threshold of damage around 10%; damage decreases oil quality by increasing its acidity. Thus, the cost of damage to growers (and the benefit of control) depends on whether they sell their olives for canning or oil. We focus on table olives.

Table olive prices vary by size and cultivar group. Larger fruit is rewarded with a higher price, but larger fruit is also more susceptible to damage by the olive fly. Therefore, the extent and the cost of damage varies for growers depending on the cultivars they produce. Table 1 (page 6)reports the average price by cultivar group and size category for 2000–2010. Group I cultivars tend to be larger and receive higher prices. All else equal, the cost of damage is greater for producers of Group I cultivars.

Available Management Practices

Growers can choose from among several nonchemical and chemical options to limit fruit infestations, either in combination or alone. Field sanitation is one management tool. Removing fallen fruit quickly and harvesting before fruit drop reduces the number of larvae that pupate in

Table 1. Price by Size and Cultivar Group, 2000–2010

Group and size	Volume (mm3)	Average Price (USD/ metric ton)
Group I: Ascolana, Barouni, Sevillano, St. Agostino		
Cull/ undersize	--	$10.99
Extra-large limited	5,255-6,282	$305.25
Extra-large canning	6,282-7,052	$347.99
Jumbo	7,052-8,336	$911.47
Colossal	8,336-9,363	$9,457.26
Super colossal	>9,363	$972.53
Group II: Haas, Manzanillo, Mission, Obliza		
Cull/ undersize	--	$10.99
Sub-petite	<1,800	$293.04
Petite	1,800-2,608	$421.24
Small	2,608-2,877	$576.92
Medium	2,877-3,415	$115.38
Large	3,415-3,685	$1,133.7
Extra large	>3,685	$1,139.8

Source: Price data provided by the Olive Growers' Council of California (personal communication, Adin Hester, 11 July 2011).

the soil, thus reducing overwintering fly populations that are a source for infestations the next season. Ensuring that no fruit stays on the trees after harvest minimizes the reproductive options available to the flies during the winter. These sanitation methods alone cannot suppress damage to a level acceptable for canning because the fly is highly mobile and can migrate from nearby groves.

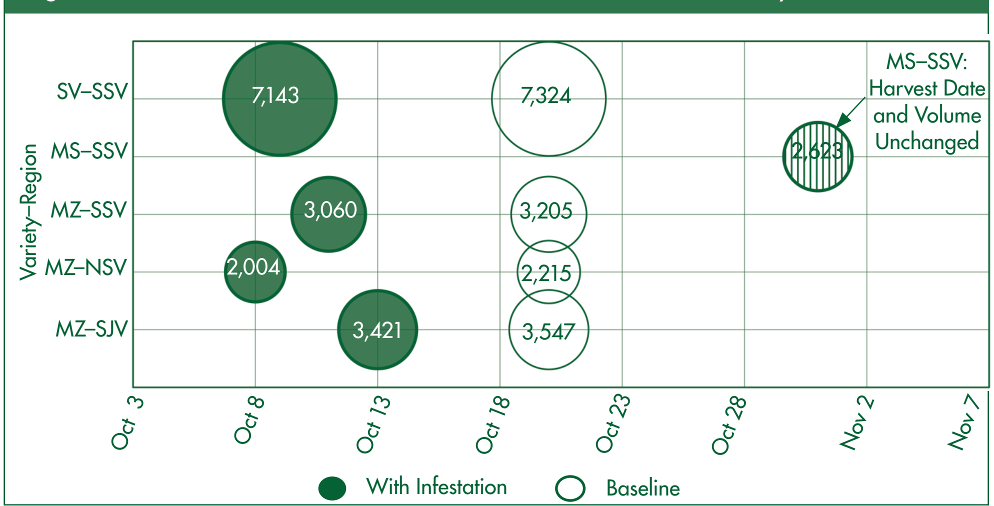
Only a few insecticides have been available in California for managing infestations, including GF-120 NF Naturalyte Fruit Fly Bait (Dow AgroSciences LLC) and Surround (kaolin clay, Englehard Corporation). Both products are certified for use on an organic crop. GF-120 or kaolin clay treatment should begin around mid-June, or earlier depending on location, at pit hardening. Growers must apply multiple applications of GF-120 each season until harvest while Surround must be applied as needed to ensure the fruit remains coated. Growers may now use Danitol (Valent), a pyrethroid. Danitol is normally only used later in the season and in limited amounts per season because its use may result in secondary pest outbreaks.

At this time, options for biological control are limited. While some parasitoids native to California do attack the fly, they are not effective enough to provide control when olive fly pressure is high. Researchers have explored areas in Africa and Asia for a parasitoid of the olive fruit fly that could be imported to California, and have also evaluated parasitoids of other fruit flies to see if they could similarly attack the olive fruit fly. To date, studies are still being conducted on the effectiveness of different parasitoids.

Growers can also shift their harvest date. Because olive fruit flies are more likely to infest large fruit, removing the fruit earlier decreases the likelihood of infestation. However, harvesting olives earlier means they are smaller, while larger olives obtain higher prices (Table 1). About two months before harvest, processors and the Olive Growers' Council of California negotiate to set prices, which allows growers to know the exact return for delivering larger fruit. If there is no chance of infestation, growers can choose an optimal harvest date that balances the increased price received for larger fruit with the risks of over maturation or fruit damage due to freezing. With the added concern of infestation, when choosing a harvest date growers must also consider the cost of insecticide applications and that the risk of infestation increases as olive size increases

In order to analyze the optimal combination of the two pest management strategies of insecticide use and moving the harvest date, we formulate a model of olive production which gives growers two decisions—whether and when to apply insecticide and when to harvest their crop. In the model, the amount of damage due to infestation at any point in the season is determined by insecticide applications. In addition to damage to harvested fruit, infestation impacts the quantity of fruit harvested by affecting premature fruit drop, which, in turn, impacts crop revenue. The harvest decision affects the size of fruit harvested (and the price received by the grower) and the amount of insecticide used.

Figure 1. Harvest Date and Olive Volume With and Without Fruit Fly Infestation



Approach

We identify the profit-maximizing combination of pesticide applications and harvest date in a single season for five growers, differentiated by cultivar and/or production region, with and without an olive fruit fly infestation. The three production regions are the Northern Sacramento Valley (NSV), which includes Butte, Shasta, and Tehama Counties; the Southern Sacramento Valley (SSV), which includes Colusa and Glenn Counties; and the San Joaquin Valley (SJV), which includes Fresno, Kern, Madera, and Tulare Counties. We consider three cultivars: Sevillano (SV), Mission (MS), and Manzanillo (MZ).

The five cultivar-region pairs we analyze are MZ-SSV, MZ-NSV, MZ-SJV, SV-SSV, and MS-SSV. This set allows us to analyze differences in growers' profit-maximizing decisions by geographic regions that vary in climate, as well as differences in decisions by varieties for the Southern Sacramento Valley, which have different potential sizes and belong to different cultivar groups for pricing purposes. Table 2 reports overall acreage and production for the California olive industry. Table 3 shows the distribution of acreage and cultivars across these regions. Comparing Tables 2 and 3, the variety-region pairs considered here represent a significant portion of the California olive industry.

We calculate the amount of fruit damaged on a given day in the growing season depending on any insecticide application. Damaged fruit may drop early and then cannot be harvested. The number of days between damage and fruit drop is not known precisely; we utilize a difference of two weeks. Thus, yield is the number of fruit undamaged by olive fruit flies two weeks before harvest. We then compute profits for each day and its associated damages.

Revenues and costs determine profits while price and damage determine revenue. Undamaged fruit generates revenue, while excessive damage can lead to the rejection of a delivery, resulting in zero revenues. The total cost of insecticide treatments depends on the cost per treatment and the number of treatments applied. Insecticide costs are the only costs allowed to be affected by olive fruit fly infestations.

Table 2. California Olive Industry Data

Year	Bearing Acres	Production (tons)	Total Value ($1,000's)	Quantity Canned (tons)	Percentage Used for Canning: In Tons	Percentage Used for Canning: By Value
2009	31,000	46,300	32,209	4,500	53%	65%
2010	36,000	206,000	136,796	25,000	61%	79%
2011	41,500	71,200	52,168	26,500	37%	54%
2012	44,000	160,000	130,038	78,500	49%	67%

Source: California Department of Food and Agriculture

Results

Figure 1 summarizes changes in the profit-maximizing harvest date and the resulting olive size for all five cultivar-region pairs. The vertical axis lists the cultivar-region pairs, and the horizontal axis represents time. We report two harvest dates: one in the absence of infestation and one when the olive fruit fly is present. The bubbles corresponding to each date represent the olive fruit size at harvest. In the absence of infestation, the optimal harvest date does not vary significantly by cultivar or region. The presence of the olive fruit fly induces differences in the optimal harvest date, which vary by region and across cultivars. Earlier dates are associated with smaller olive sizes as shown in the figure.

We analyze the Manzanillo cultivar for all three production regions. In the absence of an infestation, the profit-maximizing harvest date is October 20 for all regions. An infestation moves the optimal harvest date earlier for all regions, but the time difference varies. The difference is the smallest in the SJV, where the profit-maximizing harvest is seven days earlier. The difference is largest in the NSV, twelve days earlier.

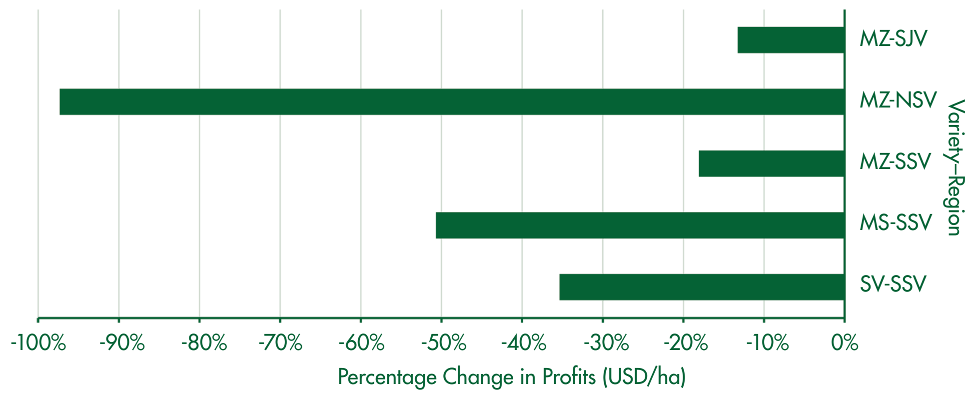
The variation in the effect on harvest date for the same variety is due to differences in weather conditions across regions, which alter olive fruit fly development and olive growth. Earlier harvest dates result in smaller olives. This effect can be seen in Figure 1 by comparing the olive

Table 3. Table Olive Production in Acres, by Cultivar and Region, 2012–13

Cultivar	Acres/Region: SSV	NSV	SJV	Total
Sevillano (SV)	446	1,308	560	2,314
Manzanillo (MZ)	3,043	3,142	13,987	20,172
Other	22	277	80	379
Total	3,511	4,727	14,627	22,865

Source: California Olive Committee, 2012

Figure 2. Change in Profits with Olive Fruit Fly Infestation



volumes at the time of harvest with and without an olive fruit fly infestation for each cultivar-region pair.

The three cultivars produced in the SSV also show differences in the profit-maximizing adjustment in the harvest date. The Sevillano has the largest adjustment; the profit-maximizing harvest date is eleven days earlier when the olive fruit fly is present. At the other extreme, the Mission cultivar's profit-maximizing harvest date remains unchanged as shown in Figure 1, by the identical olive volume and date. Mission olives are relatively small and unattractive to the olive fruit fly, so the increased cost of damage is relatively small.

Figure 2 reports the percentage change in profits for each cultivar-region pair. As with the harvest date, the percentage change varies by region and cultivar. For the Manzanillo variety, the decrease in profits associated with an olive fruit fly infestation is largest in the NSV, 97%, while it is only 13% in the SJV. SJV Manzanillo producers benefit more from the ability to adjust the harvest date than producers in other regions, likely due to the more rapid growth of olives, which provides more revenues to offset increased yield loss and damage.

The relative magnitudes of changes in profits do not correspond exactly to changes in harvest date, due to differences in pricing schedules, the growth of olives over time, and the increase in damage over time. This is clearest for the Mission cultivar. While its profit-maximizing harvest date does not change, profits decrease 51%.

Conclusion

The invasion of the olive fruit fly has complicated growers' management decisions. Unlike some pests, damage is influenced by the same factors that influence olive quality (size) and, hence, price. Growers can reduce damage and pest management costs by harvesting earlier, but this can also reduce price. The implications of this trade-off vary by region and differ in terms of growing conditions and cultivar.

This analysis demonstrates that harvest timing can be an important pest management tool for growers in certain situations. Its value, relative to other tools, depends on differences in damage, yield, costs, and price associated with a change in harvest date.

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For additional information, the authors recommend:

Zalom, F.G., and B. VanSteenwyk. "Olive Fly Update." *Topics in Subtropics Newsletter*, Vol. 11 No. 4. Nov-Dec 2013. ceventura.ucanr.edu/newsletters/Topics_in_Subtropics49512.pdf.

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