Preliminary Results on the Potential Long-term Cost-effectiveness of Spraying HLB-Infected Citrus Trees in California

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Issue

Citrus greening disease, or Huanglongbing (HLB), has inflicted significant damage on citrus production across Florida and Texas. This disease, caused by the phloem-organized bacterium *Candidatus* Liberibacter asiaticus (*C*Las) and vectored by the Asian citrus psyllid (ACP), leads to nutrient deficiency in infected trees with decreased fruit yield and quality. Upon HLB infection, the disease swiftly spreads throughout the tree (Farnsworth et al. 2014), producing unripened fruit before the trees die from the disease.

Florida's struggle with Huanglongbing serves as a stark example of the potential harm this disease poses to citrus growers who have not been affected yet. The spread of HLB in Florida incurred an estimated cost of $4.5 billion to the state's economy between 2007 and 2011 (Alvarez et al. 2016; Farnsworth et al. 2014; Hodges and Spreen 2012). Florida's citrus value in 2022 fell to around $585 million (USDA-NASS 2023b). Annual production decreased by 8 million tons between 2004 and 2020 (Simnett and Kramer 2020). As of the 2022-2023, Florida orange production was down to approximately 720,000 tons (CPDPP 2023).

In California, the incidence of residential *C*Las+ ACP and HLB+ trees have been escalating rapidly. ACP was initially detected in residential trees in San Diego County in 2008 and is established throughout southern California in both residential and commercial citrus groves (Byrne et al. 2018; Hoddle 2012). Counties in California with identified HLB+ infections include San Diego, Riverside, Los Angeles, San Bernardino, Orange, and most recently, Ventura. None of these infections have occurred in commercial groves. According to the CDFA, the number of identified HLB+ trees reached 7,868 as of

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May 24, 2024.[1] In July 2023, the number of infected trees was 5,708 (Johnston et al. 2023), a concerning rate of transmission among residential trees of nearly 38% in less than a year. These results come on the heels of two CLas+ ACP being found in commercial groves in two different southern California counties (CPDPP 2020; CPDPP 2022). These events motivate our efforts to identify effective HLB management practices for California and elsewhere as there is still no known cure for HLB.

As noted, California has not yet experienced a HLB tree infection in a commercial grove. To prevent such infections, many growers spray insecticides to control the ACP populations. The California Department of Food and Agriculture conducts surveys and trapping to monitor for ACP as well as release taramixia (parasitic wasps) to control ACP populations, and outreach, among other practices, to help in the battle to control the spread of HLB. Another possible option is removing infected trees (rogueing) once a symptomatic tree is identified. The experience with HLB in Florida and Texas with implementing a three-pronged approach of tree removal (rogueing), insecticide spraying and re-planting with HLB-free trees may suggest otherwise (Graham et al. 2020). Moreover, Li et al. (2020) express that rogueing is not cost-effective in Florida. These negative outcomes may be due to production of processing oranges rather than fresh market fruit, which brings a much lower price, or as suggested by Yuan et al. (2021), the approach lacked region-wide implementation. It is worth noting that California primarily produces for the fresh fruit market (USDA-NASS 2023b) and thus may see different outcomes when spraying and or rogueing.

In this research note, we evaluate spraying of insecticides to control ACP and their effect on preventing and managing HLB in a newly planted California Navel orange grove that sells to the fresh market over a 20 year lifespan, which is a sufficient time frame to evaluate the effects of HLB on the productive and profitable lifespan of the grove to see how cost-effective this practice is by itself relative to taking no action to control ACP or HLB. Utilizing a simulation model, we assessed the impact of three spray efficacy rates (90%, 80%, and 70%) in this research note. We select these efficacies based on past observations and given growers cannot necessarily select the efficacy rate given environmental conditions and pest resistance to insecticides will influence efficacy. We consider rogueing and both rogueing and spraying approaches in other research notes, which can be found at https://www.csus.edu/faculty/k/kaplanj/researchnotes/.

Methods

We use a budget approach to estimate the effects of HLB on Navel orange production for a representative California grove and potential benefits from alternative spraying strategies to reduce HLB effects. Data from UCCE cost and returns studies (O'Connell et al. 2015; Kallsen et al. 2021) and California County Agricultural Commissioner Reports (USDA-NASS 2023a) are used to derive costs, prices, and yield conditions for Navel orange production for a representative newly planted grove in southern California. Table 1 lists the costs used for deriving grove profits. Table 2 provides the prices per box and maximum boxes per acre derived from California County Agricultural Commissioner Reports (USDA-NASS 2023a) and used in the analysis.

Cultural cost year 1	$7,756.43/acre
Cultural cost year 2	$1,789.04/acre
Cultural cost year 3	$2,066.17/acre
Cultural cost year 4	$3,198.23/acre
Cultural cost year 5	$4,590.30/acre
Cultural cost year 6+	$7,859.15/acre
Spraying cost	$0.246/tree

Table 1: Cultural costs and spraying costs

	$/Box	Boxes/acre
Low	6	541
Average	13.5	836
High	21	1,176

Table 2: Price per box and average annual maximum yield per acre (boxes per acre) of Navel oranges

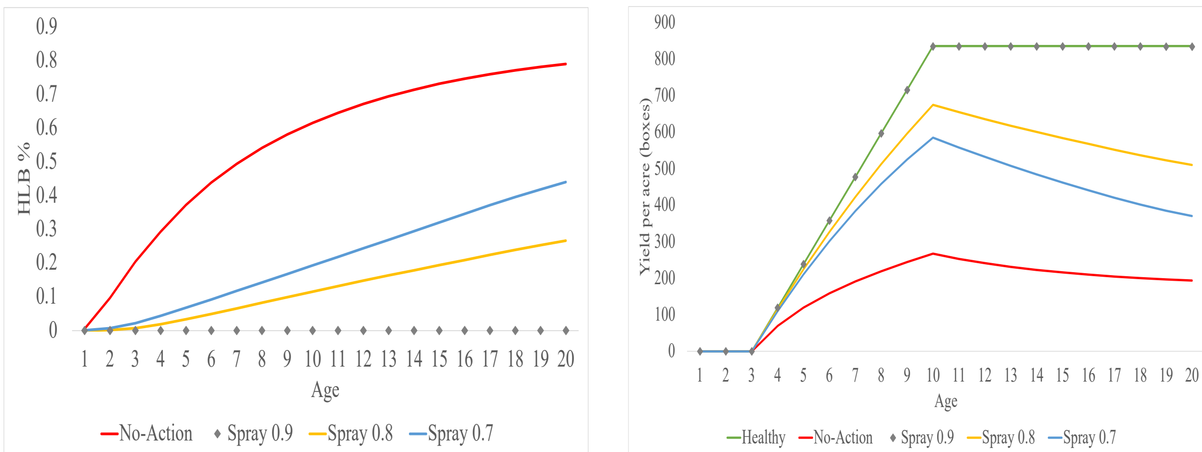
An agent-based model adapted from Lee et al. (2015) and Haynes et al. (2021) simulates citrus flushes, ACP, and HLB spread in a newly planted Navel orange grove. Simulated data are required given field trials to measure HLB spread or treatment effectiveness are not possible. The simulation model generated HLB severity spraying scenarios for the three insecticide efficacy rates. Figure 1a shows the average HLB severity for the different efficacy rates and when taking no action a 20-year time frame.

To estimate healthy (uninfected) yield in each year for each scenario, we use a weighted-average of the yield per acre for data from the California County Agricultural Commissioner Reports (USDA-

[1] Source: https://maps.cdfa.ca.gov/WeeklyACPMaps/HLBWeb/HLB_Treatments.pdf

NASS 2023a) as the average maximum yield per acre[2] shown in Table 2 and the age-yield profile reported in the UCCE cost and returns studies (O'Connell et al. 2015; Kallsen et al. 2021). For the infected grove over the timeframe, a yield factor, estimated by Bassanezi et al. (2011) is multiplied by the healthy yield in a given year and then applied to the remaining trees in the infected grove in that year and then across the different grove ages. As can be seen in Figure 1a, the 90% efficacy spray results in negligible HLB severity (below 0.001%) such that the yield for the 90% efficacy rate spray is nearly identical to that of the healthy grove (Figure 1b). As the efficacy decreases, HLB severity increases and yields differ noticeable from those for a healthy grove.

We use a weighted-average of Navel orange prices from the California County Agricultural Commissioner Reports (USDA-NASS 2023a) to derive the average price per 37.5 lb box. We also consider the lower and upper bounds for the 95% confidence levels for the low and high price scenarios, respectively. For the simulated citrus grove, we assume there are 110 trees per acre. We use the estimated age-yield profiles in Figure 1b to calculate profits for the healthy groves, infected groves where no action is taken to control HLB, and infected groves where spraying scenarios are adopted over a 20-year lifespan as this is sufficient time to observe the effects of HLB spread and effectiveness of spraying scenarios on yields and grove profits. We evaluate cumulative profits across the different scenarios, and highlight when cumulative profit become positive and how long the grove remains profitable as HLB spreads.



(a) HLB severity by grove age for a representative California Navel orange grove infected with HLB and the grove operator takes no HLB action or applies ACP insecticide spray at varying efficacy rates. When a grove operator spray efficacy is at 90%, the HLB severity is negligible.

(b) Yield per acre by grove age for a representative California Navel orange grove that is HLB-free, or is infected and the grove operator takes no HLB action or applies ACP insecticide spray at varying efficacy rates. The mature yield for an HLB-free grove is assumed to be 836 boxes/acre/year.

Figure 1: HLB severity and yield (boxes/acre/year) for a representative California Navel orange grove for groves that are HLB free, infected but no HLB action taken, and infected and varying ACP insecticide spray efficacy rates are illustrated.

Findings

Only when the price-average annual maximum yield combinations are \$13.5/box, 1,176 boxes/acre; \$21/box, 836 boxes/acre; and \$21, 1,176 boxes/acre do we see positive profits for the healthy and the spray efficacy scenarios (Tables 3 and 4). The 90% efficacy spray produced nearly identical profits to the healthy grove given HLB severity was very similar across the time frame (Table 4). Healthy grove scenarios were profitable throughout all high price per box scenarios and did maintain success in average price per box scenarios with average yield and high yield. Table 4 provides the cumulative profit per acre for practices that were profitable throughout the 20-year simulation. Cumulative profits became positive in the same year for these scenarios and both maintained positive profits thereafter. We can see in Table 3 that as the efficacy of the spray decreased, profits declined further from the

[2] This underestimates the yield when a grove is established since the data captures yields for all ages.

healthy grove profits levels. With the best-case scenario of a high price per box of $21 and yield of 1,176 boxes, the healthy grove generated the highest profit of $208,456 (Table 4). With the same price and yield scenario, the 90% spray scenario profits were near the healthy grove's at $207,598. Profits were maintained for the 80% and 90% sprays until the end of simulation using the price and yield scenarios in Table 3. For the price of $21 per box and 836 boxes per acre, the 70% spray scenario had profits last from year 13 to year 19. For the high price and yield scenario, the 70% spray scenario profits last throughout the 20-year long simulation. The year when cumulative profits become positive increases as the efficacy declines and in all but one case profits remain positive throughout the time frame.

	First Year Cumulative Profits > 0		
	$13.5/box, 1176 boxes/acre	$21/box, 836 boxes/acre	$21/box, 1176 boxes/acre
Healthy	year 10	year 9	year 7
No-Action	-	-	-
Spray 0.9	year 10	year 9	year 7
Spray 0.8	year 11	year 10	year 8
Spray 0.7	-	year 13	year 9

Table 3: Grove age when cumulative profits are greater than zero for the first time for a healthy grove, an HLB infected grove (No Action), and HLB infected groves where the three different spray efficacies are applied during the 20-year simulated time frame. Scenarios not shown did not generate positive profits at any age except for the healthy grove scenarios which were profitable but are not listed.

	$13.5/box, 1176 boxes/acre	$21/box, 836 boxes/acre	$21/box, 1176 boxes/acre
Healthy	$84,976.60	$108,496.60	$208,456.60
No-Action	-	-	-
Spray 0.9	$84,229.70	$107,728.50	$207,598.20
Spray 0.8	$26,622.90	$44,025.70	$117,987.60
Spray 0.7	-	-	$73,152.20

Table 4: Cumulative profits per acre over the 20-year for the profitable insecticide spraying scenarios. Scenarios not shown did not generate positive profits at any age except for the healthy grove scenarios which were profitable but are not listed.

Key Insight

- Increasing the efficacy of the spray will limit the severity of HLB and expedite the achievement of successful results. The yield and profits for the 90% efficacy spray scenario are similar to a healthy grove, However, growers are not able to select efficacy rates but rather face uncertainty given the influence of environmental factors and pest resistance, among others factors, on efficacy rates.
- The profitability of spraying for ACP to manage HLB is heavily influenced by the price per box and yield per acre. When prices are at average levels, then yields need to be well-above average for positive profits to be generated when spraying with 90% and 80% efficacy rates. When the price is above average and yields are at or well-above average, then spraying at all three rates provides positive profits.

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