HLB Grower Web Tool – Technical Note

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Introduction

This technical note details the underpinnings of the HLB Grower Web Tool, found online at https://www.csus.edu/faculty/k/kaplanj/economic_tools/hlbtool.html. At this website, a citrus grower enters information about their operation and the tool illustrates, through a series of graphs, how cumulative profits, HLB spread, and yield reductions vary over a five-year period for an established grove. The displayed results are derived from an agent-based model (ABM), which captures the interaction between the Asian citrus psyllid (ACP) population, which vectors *Candidatus* liberibacter asiaticus (*C*Las), the presumptive causal agent for Huanglongbing (HLB), and different ACP insecticide spraying strategies. In what follows, we describe the agent-based model, the estimation of the functions shown in the graphs, and provide illustration of the output.

Agent-Based Model

To gain insight into how insecticide applications affect the spread of HLB within a community of growers, we adapt an ABM, first developed by Lee et al. (2015), by expanding it to include 9 citrus growers, their citrus trees, and invading ACP which can infect the trees with HLB. As the overall spread of the ACP and HLB depend on the spray decisions of all 9 growers, we add to the ABM by incorporating grower perception of their neighbors' spraying decision (defined as Alpha in the ABM and the graphs on the tool website), and grove economic and production conditions.

The model consists of a 33x75 lattice, with each cell representing a citrus flush patch. Nine groves of size 11x25 are assigned to growers who are identified by their position in the 3x3 grower grid. We then simulate the spread of ACP/HLB by introducing infected ACP into varying positions on the grid on day 80 of the 5-year simulation. Our model uses the same ACP and HLB parameters as Lee et al. (2015). In the simulation, three spray strategies are considered. We define Group/Coordinated Action as spraying within a 21-day window of designated dates corresponding with the California's Psyllid Management Areas (PMA), growers are encouraged to apply insecticide effective against ACP on specified dates throughout the year,[1] and Individual Action as spraying within a 60-day window of the dates. The day a grower chooses to spray is randomly determined in the window provided by the intervention strategy they choose. Growers can also choose no intervention, which we call No Action. The ABM simulation can then estimate how different combinations of window size, Alpha, and insecticide efficacy influence how long it takes HLB to reach a grove (defined in this analysis as survival time), affecting yield, and cumulative profits.

Estimated Functions

The graphs presented on the tool website were generated based on estimated functions derived from data generated from simulation experiments using the ABM. The experiments are designed to measure how a grower's risk of infection and in-grove level of HLB spread is affected by a given strategy and spray efficacy over time. We test each of the 3 strategies in the 9 possible grower locations with 54 different invasion types (6 distributions of psyllids in the initial grove multiplied by 9 possible initial groves), two levels of neighbor coordination (Alpha), and 3 levels of insecticide efficacy (0.65,0.75,0.85). Figure 1 show the average result for HLB severity for the different Alphas and stratgeies when insecticides are an 85% efficacy rate. Since HLB severity is constrained to the unit interval, we opt to use beta regression (Ferrari and Cribari-Neto 2004) to estimate in-grove HLB spread. The factors that determine HLB severity include Alpha, spray strategy, efficacy and length of infection. The HLB severity function is then used to relate HLB spread into relative yield using the formula provided by Bassanezi (2011),

$$relative\ yield = e^{(-1.85*hlbSeverity)}$$

as shown in Figure 2. The yield function, in turn, is used directly in the cumulative profit plot, where yield, price, and cost data come for entries on the website. Spray cost calculations are based on 6 sprays per year. These costs are subtracted from the estimated yield reduction multiplied by the average annual yield per acre, which is multiplied by the average return per carton to generate returns per acre.

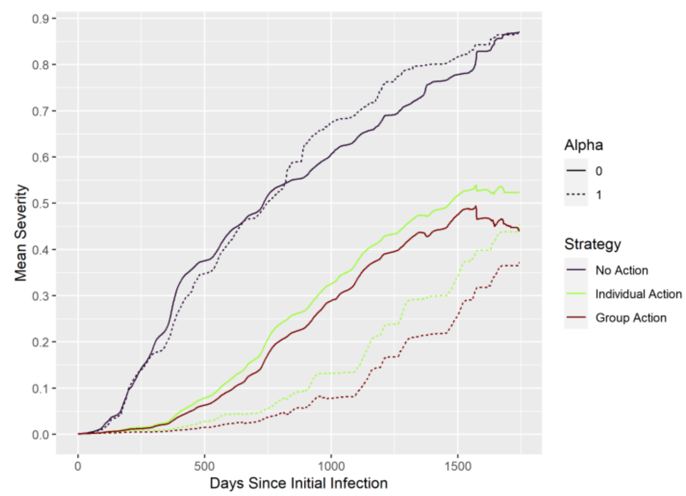

Figure 1. HLB Spread by strategy at 85% efficacy

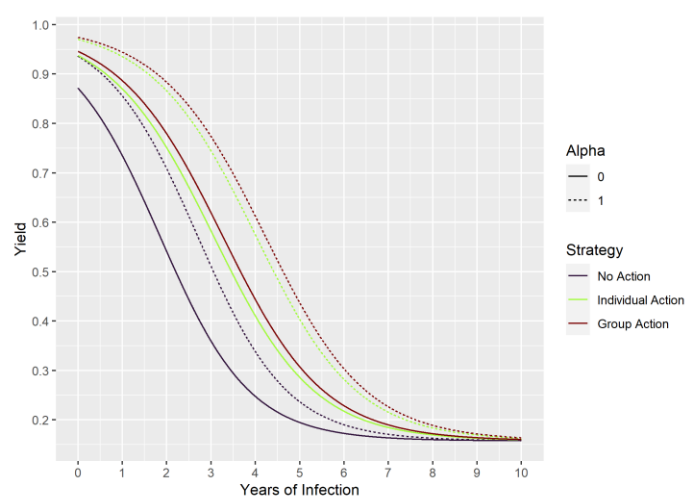

Figure 2. Predicted Yield by infection time at 85% efficacy

[1] See https://ucanr.edu/sites/ACP/Grower Options/Grower Management/Eradication Strategies/ and https://citrusinsider.org/psyllid-and-disease-control/treatments/treatment-schedules-by-region/ for more information.

For more information about this tool contact: Jonathan Kaplan (kaplanj@csus.edu) or Ajay Singh (singh@csus.edu).

References

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