Assessing spatial patterns of individual protective covers

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In previous and ongoing research performed at the Southwest Florida Research and Education Center (SWFREC), we have demonstrated that individual protective covers (IPCs) are effective in keeping psyllids off newly planted citrus trees. Trees have been HLB-free for more than two years after planting, and the IPCs provide additional benefits for plant health.

The question arose on whether the beneficial effects of IPCs would be maintained if only strategic trees were covered (i.e., trees on hot spots or at the edge of the grove) instead of all the trees in a solid planting. In other words, we were interested in finding out whether covering only a subsection of trees in a solid replant would be effective in maintaining a generally healthy and productive citrus grove. This would dramatically reduce the costs associated with purchasing and installing IPCs, so we started testing different layouts for IPCs deployment.

We want to understand if covering every tree in a block is necessary or if there are situations where some trees can remain uncovered and adjust to different psyllid pressure and geographical features of the grove. This research hinges on the edge-effect concept, which states psyllids are more abundant in the periphery of a grove. Having part of the trees uncovered in a grove without a significant increase in psyllid colonization would result in more targeted management and substantial savings for the grower.

THE EDGE-EFFECT CONCEPT

It is well documented that HLB and psyllid infection and distribution are not uniform in a grove. Although the spatial distribution and niche occupation of the Asian citrus psyllid in citrus groves is not completely understood, higher psyllid densities and flush shoot infestation levels are usually observed in trees located at the outer edges of groves. This has an important consequence for pest management and may potentially determine the efficiency of different IPC layouts in the grove.

Therefore, assessing whether all trees need to be covered or if some could be left uncovered [less likely to become colonized by psyllids and *Candidatus* Liberibacter (CLas) asiaticus infection] merited investigation. However, the main question is which trees should be covered with IPCs and which should not.

AN INTERESTING ANALOGY

We have applied a concept that is important in modern statistics to solve the question of which trees to cover — the survivorship bias concept. This concept merits a historical explanation to understand its relevance to psyllid

management in a Florida citrus grove.

In 1942, during World War II, the allied forces were suffering heavy bomber aircraft losses to enemy fire. The Statistical Research Group (SRG) at Columbia University examined the damage done to aircraft that returned from missions and recommended adding armor only to the areas that showed the least damage. This contradicted the U.S. military's thinking that the most-hit areas of the plane needed additional armor.

In the words of Abraham Wald, a member of the SRG who took the survivorship bias concept into account when considering how to minimize bomber losses: "Gentlemen, you need to put more armor-plate where the holes aren't because that's where the holes were on the planes that didn't return."

In other words, Wald noted that the military was only looking into the aircraft that had survived their missions; any bombers that had been shot down or were lost for other reasons were unavailable for assessment. The bullet holes in the returning aircraft then represented areas where a bomber could take damage and still fly well enough to return to base safely (Figure 1).

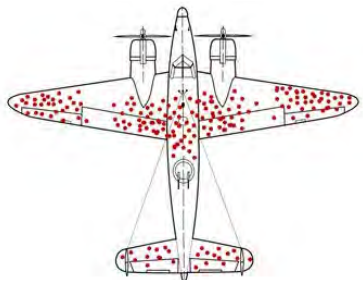

Figure 1. Red dots show damaged portions of World War II airplanes that returned safely to base after combat. Airplanes hit in other places did not return. Source: Wikipedia

What does this mean for psyllid management? Can we improve 'armor' in only some parts of our grove and have it still 'return to base safely' (remain economically viable)?

LOOKING AT THREE LAYOUTS

We are exploring different targeted or patterned IPC layouts for the most efficient and most cost-effective psyllid protection.

In the first layout (Figure 2A), the approach consists of only covering the perimeter trees with IPCs (targeted layout). Based on the edge effect, these are the trees most likely to be affected by psyllids in the grove.

A second layout consists of covering the perimeter trees (advanced targeted layout), based on the concept of survivorship bias (Figure 2B). In this case, exterior trees (the ones likely receiving more 'bullet' or psyllid impacts) are not covered, but the next interior rows are.

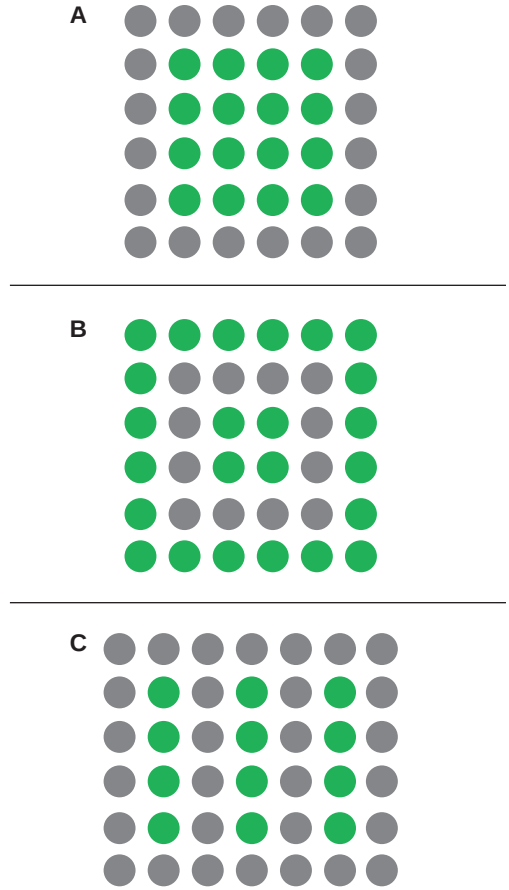

Figure 2. Individual protective cover (IPC) layouts currently under study: targeted layout (A), advanced targeted layout (B) and patterned layout (C). Grey dots represent IPC-covered trees. Green dots represent non-covered trees.

A third layout, a patterned layout, includes covering perimeter rows and alternating rows within the block (Figure 2C).

Psyllid populations and *C*Las titers are currently being monitored to determine the impact of different IPC layouts on these two important variables. Fruit yield and quality will be assessed. Management costs associated with each layout will be calculated relative to the benefits to determine grove productivity in the upcoming production seasons.

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