10.6 The Plantation Edge Effect of HLB – A Geostatistical Analysis.

Gottwald T. 1Irey M. and 2Gast T.

1USDA, ARS, US Horticultural Research Laboratory, Fort Pierce, Florida, USA; 2Southern Gardens Citrus, US Sugar Corp., Clewiston, Florida, USA.

When viewing maps of Huanglongbing (HLB) incidence on an areawide scale, it becomes apparent that HLB is aggregated not only within individual plots but across plots as well within regional areas. When entire plantations are examined, unique characteristics of the disease distribution become more visible. Especially during assessments of early incidence at the plantation scale, there appear to be accumulations of HLB-diseased trees in various areas within the plantation. At first examination, it appears that there is a higher incidence of HLB at the edges of the plantation. However, with continued visual scrutiny of the distribution pattern, the observer’s eye is also drawn to apparent HLB-diseased tree accumulations associated with roads, canals, ponds, and other geographical features within the citrus plantation as well. Each of these features can be defined as an interface of some void of plant material immediately adjacent to areas with dense citrus planting. It is within the citrus planting immediately adjacent to these voids where a higher than expected number of HLB-diseased trees accumulate. It is this higher than expected accumulation that we describe as an “edge effect”.

It is intuitively obvious that the spatial process behind edge effects is related to bacteriferous psyllid transmission, and thus to psyllid movement and migration. As psyllid forage for new feeding sites, between and among plantations and individual blocks, they apparently preferentially accumulate at the interface or edges of plantings. This is not to say that they do not penetrate into plantings/blocks as well, but there is a higher than expected accumulation at the edge of this interface, indicating that a majority of the migrating psyllid population will alight within the first few trees that they come to at the edge of a planting or block. Therefore, the HLB-disease distribution is an indirect indicator of psyllid migration and foraging preferences and response. By understanding this edge effect, we might be able to take advantage of it for psyllid control/disease management strategies either by preferentially employing management strategies at the edges of plantings or using this information to design plantings with minimal edge-interfaces, to avoid/reduce infection. The goal of this study was to describe the edge effect in analytical terms such as disease gradients for various planting/void type interfaces, and use these descriptions to develop models and strategies for second generation plantation design.

Materials and Methods:
Based on the commercial survey of trees with visual symptoms of HLB, the spatial pattern of HLB was determined over two large contiguous plantings of commercial citrus of 1,320 ha (SG) and 4,574 ha (DG) in South Florida. The area was completely surveyed via a 100% census of trees five times over a 2-year period. The commercial planting was a mixture of sweet orange cultivars but predominately Valencia and Hamlin on various rootstocks and composed of multiple blocks. Block size was 4 ha with 14 rows of 110-115 plants per row or ~1,500 trees/block. Incidence of HLB was assessed by visual inspection. The GPS location of each symptomatic tree and date when the symptoms were assessed were recorded on GIS-referenced maps of the plantation.

Edge effects calculations were accomplished by using ArcMAP to interrogate intensively mapped geo-referenced data sets. To examine the planting perimeter edge effect, concentric annuli were drawn within the total planting at 10 m increments (Fig. 1). The number of
Results and conclusions:
When the perimeter of the entire plantation was examined as a whole, there was a strong, decreasing curvilinear relationship with distance (Fig. 3). This was further examined as an
inverse power function (IPF), often used to describe disease gradients of other pathogens. The IPF demonstrated a rapid decrease in HLB incidence with distance indicating a significant perimeter edge effect. The plots were then broken into directional quadrants as described above. These were also fitted to either IPL or simple linear disease gradient functions where more appropriate when linear regression provided a better fit to the data than IPL (Fig. 4). These gradients were all significant but not always as strong as the gradient of the entire perimeter. The gradients to the W and SW were better fit by an IPL and therefore show sharper drops in the edge effect in those directions, whereas, the gradients for the other directional quadrants were less consistent over distance. All demonstrated decreasing linear trends with distance (Fig. 4). The incidence of HLB across these gradients was higher in the N, E, NE and SE directions compared to the W, S, NW and SW directions, respectively. This provides evidence that the higher incidence of HLB-diseased tree accumulations were predominately expressed on the eastern perimeter, which is visually discernable in Figure 1. This is consistent with the initial accumulation of diseased trees on the eastern perimeter of the planting indicating migration of bacterialiferous psyllids from the east and south (Gottwald, et al. 2007).

The potential effect of internal planting roads and irrigation ditches was also examined (Fig. 5). The main road in the E-W direction gives primary access across the plantation. The first few trees on both sides of the road do not thrive as well as the majority of trees in the adjacent blocks because of the effects of the marl of the road. The block separations in the N-S direction are numerous and composed of an irrigation ditch bounded by two dirt roads, separating blocks by ca. 23 m (75 ft) and give access to individual blocks. These N-S ditch-roads had a very strong edge effect as seen by a good IPL model fit and a rapid decrease of
HLB trees from the N-S ditch-roads inward into the planting. The E-W road did not demonstrate any perceptible edge effect over distance. This may be indicative to the general migration pattern within the plantation from east to west, resulting in accumulation along the N-S voids cause by ditch-roads in that orientation. However, you can see a spike in HLB-diseased trees about 30-40 meters in from the edge. The may be due to the effects of the marl described above.

Multiple ponds within the planting were examined and the effect of decreasing density of HLB trees over distance from the voids created by ponds into the citrus plantings demonstrated a pronounced edge effect and were well fit by the IPL model as well (Fig. 5 right).

The relative density of HLB-infected trees within the first 30 meters from each of the interface/features examined for their edge effect are shown in Table 1. From this table, you can see that the density ($D$) of HLB-infected trees/ha was highest for the perimeter of the SG planting and for the eastern (E) and southern (SE) quadrants of the SG planting. Ponds and N-S roads also had a higher than expected density, but this was only about 40-42% of the density of the strongest perimeter density.

These results all provide evidence that the interface of the planting with zones of non-citrus at its perimeter as well as voids internal to the planting created by roads, canals, ponds and other features all contribute to HLB epidemics as potential linear and/or curvilinear foci of disease, because HLB infections tend to accumulate in proportionally higher incidence at these interfaces. The shape and perimeter of citrus plantings are defined predominately by the land area available. However, there are opportunities to reduce the internal voids that accumulate HLB infections when new plantings are established by limiting internal voids created by planting infrastructure. Strategies to limit such voids in new plantings will be explored in future modeling exercises.

**Literature cited**

