Fig. 1. Map of India showing New Delhi and the two citrus regions which were visited, Punjab and Nagpur.

Fig. 2. Rough lemon seedlings planted at Punjab Agricultural University. They will be used for rootstocks for Kinnow mandarin.

Living with HLB in India

By Ron Brlansky, Megh Singh and Michael Rogers

Huanglongbing (HLB) is now present throughout Florida citrus and everyone agrees that strategies must be found to manage this serious disease to remain profitable. Historically, the disease probably has been in India since the early 1900s. Reports of a decline and dieback of citrus was first reported in the state of Punjab. The decline was originally thought to be psyllid damage; however, fruit with an "insipid" flavor were described.

Following conversations concerning HLB in India, Ron Brlansky, Michael Rogers and Megh Singh developed a trip there in October 2008 to investigate citrus production and how citrus growers and researchers manage HLB.

India is a large country, so two major production areas in the northwest (Punjab) and in the central (Nagpur) regions of India were visited (Fig. 1).

Singh, being native to India, designed the two-week trip. After a 16-hour flight from Newark, N.J., the three CREC scientists arrived in New Delhi, India. After an overnight stay in New Delhi, the group left the next morning via car, to drive to the state of Punjab, where some of the best crops are grown on some of the best agricultural land. We went first to Punjab Agricultural University in the city of Ludhiana (see map Fig. 1). The university is one of the premier agriculture universities in India and many students have come from there to do graduate work at the University of Florida and at CREC.

We visited the faculty in plant pathology, entomology and horticulture and were hosted by the president of the university, M.S. Kang, who was at one time a faculty member at the University of Florida's Everglades Research and Education Center. Both Rogers and Brlansky presented short seminars on the purpose of our visit and the ongoing problem of HLB in Florida. We saw some citrus propagation programs and learned that the primary rootstock used in India was rough lemon (Fig. 2).

We left Ludhiana and drove to Hoshiarpur to see groves of Kinnow mandarin on rough lemon rootstock. This mandarin is the primary citrus grown in this area. We were accompanied by H. S. Dhaliwal, a horticulturist at Punjab Agriculture University, and visited the groves of B. S. Ahluwalia. The Kinnow mandarin trees were impressive in size and the fruit yield and size was good (see Fig. 3). On

Fig. 3. Large Kinnow mandarin tree on rough lemon rootstock in the state of Punjab and near the city of Hoshiarpur.

Fig. 4. *HLB blotchy mottle symptoms on Kinnow mandarin in Hoshiarpur.*

close inspection of the trees, we could see some blotchy mottle symptoms indicative of HLB (Fig. 4); however Ahluwalia said that even with HLB, the trees produced well.

As with most mandarins, extra foliar nutritional sprays were applied to maintain fruit yield and size, and probably attribute to the masking of the blotchy mottle leaf symptoms. In this grove, tree age approached 25 years, which is probably unusual for trees in an area where HLB is prevalent. Evidence of Phytophthora foot and root rot in some trees was noted. Soil type was a clay loam and irrigation is by flooding.

In addition, we saw some 2-3-year-old Hamlin trees on rough lemon rootstock. These trees were part of a program in conjunction with Pepsico (Tropicana) to introduce other sweet orange cultivars in this region. The trees were infected with HLB, but were growing. However, no fruit set was seen.

In another, smaller grove, we did see some reduction in fruit size and yield in Kinnow mandarin; however, we learned that the grower didn't apply the recommended foliar fertilizer applications due to the high cost and low fruit return. At this location, we did see some citrus canker, but little fruit infection and no fruit drop. Temperatures can be relatively high (up to 110 degrees F) prior to the rainy monsoon season; however, while we were there, they were entering into the cooler, drier time of the year.

We next visited with a gathering of farmers from the region and discussed the situation with HLB. They admitted that HLB was a problem, but also said that Phytophthora root and foot rot were significant problems as well.

We left Hoshiarpur and went back to Ludhiana and then on to Abohar. Abohar is very close to the Pakistan border.

Next we visited Sharda Agricultural Farms owned by Mahesh Sharda. Again, the major cultivar grown was Kinnow mandarin and the rootstock was rough lemon. We were asked to present talks on the HLB research and management practices in Florida. Presentations were made to a group of approximately 300 citrus growers from the region.

We then went to the Sharda groves and viewed their citrus production and answered many questions posed by growers. While in Hoshiarpur we saw some citrus canker as well as HLB. In addition, we saw a lot of Phytophthora root and foot rot. This was mainly due to the fact that the growers commonly grow other crops between the rows and use cultivation rather than chemicals to control weeds. Weeds around the trunks of trees are cut with machetes and often resulted in trunk damage. Irrigation was by flooding, which enhanced infection by Phytophthora.

We then visited a large citrus nursery and again found plant production on the ground rather than on benches. Plants were housed in shade houses; however, they were not psyllid-proof and psyllid feeding damage was observed. We saw the propagation of rough lemon rootstock from seed and visited the trees where the seed originated. The rough lemon trees were large and growing well and producing abundant fruit for the seed. They were HLB-infected with symptoms that we have seen in our greenhouse inoculation work with HLB in Florida. In addition, we found the psyllids actively feeding on numerous other citrus trees.

We ended our stay in Punjab and the next day began a long trip back to New Delhi. The trip took us through many states of India and eventually through the town of Agra, home of the Taj Mahal.

Fig. 5. *HLB "yellow shoot" symptoms on Nagpur mandarin on rough lemon rootstock near the National Research Center for Citrus in Nagpur, India.*

Fig. 6. *Close-up of HLB blotchy mottle symptoms on Nagpur mandarin leaves inside the canopy.*

NAGPUR

We flew from New Delhi to Nagpur in the central part of India. Nagpur is the location of the National Research Center for Citrus, which is the principal location for citrus research in India. We were greeted by the center director, V. J. Shivankar, and taken on a tour of the research center groves. There we saw the rootstock and scion trials and other citrus collections. We saw many trees with HLB and, even though they were just emerging from the hottest months of the year, psyllid populations were already high in numbers. Phytophthora foot rot was very evident and again was due to tillage practices between rows and weed control near trees was with machetes. Irrigation was by flooding the grove. We were told that Phytophthora foot rot was their main problem.

We had a discussion on our HLB programs with the scientists at the research center and the problem of HLB in India. Rogers and entomologist C. N. Rao had meaningful discussion on psyllid management in India. Brlansky visited many of the plant pathology research labs and spent time with Dilip Ghosh, who spent a three-month technical training study at the University of Florida's Citrus Research and Education Center (CREC). Brlansky also visited with Ashish Das, who works on HLB diagnosis.

Das accompanied us on visits to multiple grove sites around Nagpur where we saw HLB in epidemic proportions. The symptoms of "yellow shoot" or huanglongbing were very obvious on Nagpur (Fig. 5) and canopy blotchy mottle symptoms were very apparent (Photo 6). The main cultivars in this region are Nagpur and Kinnow, all on rough lemon rootstock.

We saw an open field nursery where rough lemon was grown

Fig. 7. *Nagpur mandarin fruit recently harvested showing the reduction in fruit size. The camera lens cap in the photo is 2 1/4 inches in diameter.*

and grafted with the scion of choice. The rough lemon had early symptoms of HLB; thus the plants were already infected. At one location, harvesting of Nagpur was under way and the reduction in fruit size was clearly seen (Photo 7). We ended our trip to Nagpur and flew back to New Delhi.

While in New Delhi, we visited the Indian Agricultural Research Institute where a number of excellent plant pathologists and entomologists work and train students in agriculture research. Rogers and Brlansky both presented seminars on their research on HLB and on what we had seen on our trip through the two citrus production areas in India. They discussed research collaborations on HLB and other important citrus problems.

SUMMARY

In conclusion, we found that India is living with HLB; however, it is continually taking a toll on fruit production. Fruit size and yield of Kinnow mandarin on rough lemon rootstock in Punjab was minimal. With proper cultural methods and psyllid control, the cultivar seemed to tolerate HLB; however, other cultivars such as Nagpur were obviously severely affected. The production of new cultivars such as Hamlin is yet to be determined.

Phytophthora root and foot rot is a major problem, but control by cultural and chemical means can be accomplished. Psyllid control is variable in the areas that we visited, and it is very difficult to obtain satisfactory pest reduction.

Plant materials grown in nurseries and in open field nurseries are probably HLB infected prior to planting.

Use of the vigorous rootstock rough lemon may offset some of the reduction in yields, especially on cultivars such as Kinnow and Nagpur.

All of these production problems need further study in India. We plan to continue collaborative work, beginning with visits of Indian scientists to CREC (two visits are planned) and look forward to other cooperative interactions with other Indian citrus industry contacts.

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