Potato Leafhoppers, Fire Blight and Prohexadione-Ca: A Look at Their Interaction under Field Conditions

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Abstract
Work done in Virginia in the 1990's suggested that potato leafhoppers were able to facilitate the bacterial disease fire blight on potted Gala/M.9 trees in growth room conditions. An abundance of research shows that the plant growth regulator Apogee® (prohexadione-Ca, a gibberellin biosynthesis inhibitor) has a significant effect in suppressing diseases, including fire blight, and some insects, on apple. This study was initiated to see whether potato leafhopper feeding on apple was affected by prohexadione-Ca, and whether potato leafhopper feeding and fire blight incidence would correlate under field conditions. A 2 x 2 x 2 field factorial trial was conducted using +/- prohexadione-Ca, +/- potato leafhoppers (using imidacloprid insecticide as an exclusion technique), and +/- Erwinia amylovora mist inoculation. Mature Gala apple trees on M.26 rootstock were used for the trial. Significant suppression of fire blight incidence was seen where potato leafhopper feeding was reduced using insecticide, as well as significant suppression of both potato leafhopper feeding and fire blight incidence where prohexadione-Ca was used. Leafhopper injury on one sample date, July 20, was highly significantly correlated with all subsequent samples of fire blight incidence.

INTRODUCTION
The goal of this project is to elucidate the role of certain insect vectors in the shoot blight phase of fire blight. This phase of the disease is less clearly understood than the blossom blight phase, yet a clearer understanding of the epidemiology of shoot blight could result in improved control of the disease with reduced inputs.

Very little is known about the role insects play in the dissemination of fire blight during the shoot blight phase. With some plant diseases, there is an evolved relationship between a specific insect vector and the pathogen, but no such vector appears to be involved in the fire blight system. Rather, a number of species are likely involved both within and across regions. Within a given region, the most likely insect species involved in shoot blight would be those that are abundant on apple in the early to mid-summer season, that feed on the rapidly-growing terminal tissue (especially in phloem tissue), and the insect’s feeding must penetrate the tissue to the extent that allows the bacteria to enter the plant. Attention has mostly been focused on insects with sucking mouthparts, since they are most likely to allow the bacteria to move into the plant, especially into the vascular tissues.

Potato Leafhoppers (Empoasca fabae Harris) are migratory insects of North and South America which feed on a wide variety of hosts, including cultivated apple. They are flush feeders, preferring new terminal growth, and they feed within the phloem. Their northern migration through May and June from overwintering sites in the extreme southern U.S. and central America tends to move them into apple producing regions at just about the time when apple terminals are growing rapidly and shoot blight is beginning in the event of a fire blight outbreak. Research done in the 1990’s suggested that these insects play a role in facilitating fire blight, by creating wounds through which the bacteria can enter the plant. Work done by us in 2001 showed that the plant growth regulator prohexadione-Ca suppressed potato leafhopper feeding comparably with the insecticide normally used to control this insect. Thus, we wanted to 1) verify that potato leafhoppers are involved in fire blight transmission, and 2) learn more about the interaction between the disease, the insect, and the plant growth regulator.
MATERIALS AND METHODS
A factorial experiment with +/- prohexadione-Ca, +/- potato leafhoppers, and +/- Erwinia amylovora bacteria in all combinations was performed. A block of 16-year-old ‘Gala’/M.26 apple trees, University of Massachusetts Cold Spring Orchard Research and Education Center at Belchertown, Massachusetts was used for the trial. Eight treatment combinations were applied in a randomized complete block design with eight replications, with blocks determined spatially. Prohexadione-Ca was applied at normal horticultural timing and rate. The insecticide imidacloprid was used at a very low rate to exclude leafhoppers, beginning when leafhoppers arrived, and every 10 days thereafter. E. amylovora was introduced by spraying a colony suspension of 1x10⁸ cfu/ml on to tree foliage when potato leafhoppers were judged sufficiently abundant and environmental conditions tended to favor infection (warm and humid), on 28 June. Data were collected weekly on shoot length, potato leafhopper feeding injury, and fire blight incidence.

RESULTS AND DISCUSSION
Shoot Growth
Only treatment with prohexadione-Ca affected shoot growth. After near-drought conditions in 2001, the early part of the 2002 growing season had sufficient rainfall to support tree growth, and early-season growth was very vigorous. Under moderate leafhopper population conditions, feeding injury did not affect growth.

Potato Leafhopper Injury
Imidacloprid and prohexadione-Ca each significantly reduced potato leafhopper feeding injury, and the combination of the two materials was more effective. Prior testing with the two materials on ‘McIntosh’ had shown a similar pattern. The combined effect is likely the result of better retention of the insecticide as a result of reduced terminal growth, so that any tissue that the leafhoppers are feeding on would be likely to retain some insecticide.

Fire Blight Incidence
Prohexadione-Ca and imidacloprid treatments each significantly affected the number of terminals showing fire blight on the final sample date, 10 Aug. The combination of the two materials showed reduced fire blight incidence numerically but was not statistically significant. The efficacy of prohexadione-Ca in suppressing fire blight is in line with many published results. Since it is highly unlikely that imidacloprid has bactericidal properties, it appears that controlling insects susceptible to imidacloprid had the effect of suppressing fire blight incidence.

In order to make a better assessment of leafhopper injury and fire blight incidence, we used SAS PROC GLM to correlate the two. Strikingly, the leafhopper feeding injury level on one sample date, July 20, was highly significantly correlated with all subsequent fire blight incidence samples. Thus, it appears that there was a critical time where leafhopper feeding injury had a major impact on fire blight incidence.

Why did injury on this particular sample date, which was nearly a month after the arrival of a substantial number of leafhoppers, and the inoculation with E. amylovora, seem to have such an impact? It is possible that some critical level of leafhopper population was reached at that time, but rainfall may have been the primary factor. After mid-June, rainfall in the region had been very limited. The first significant rainfall occurred on July 19; in addition, the humidity remained at >95% for a 24-hour period at that time. Work done in West Virginia by J.L. Norelli showed that epiphytic populations of E. amylovora, which decline during hot, dry conditions, can rapidly rebound after a significant rainfall. It is thus possible that the leafhoppers facilitated the entry of a newly-burgeoning population of E. amylovora into the leaf tissue, allowing the development of infection.

Further work is in progress, including a repetition of the factorial experiment;
work with potato leafhoppers in caged conditions, where other terminal-feeding insects are excluded (it would also be interesting, though alas not feasible, to exclude only potato leafhoppers from feeding!); and looking at whether potato leafhoppers are capable of vectoring the disease by carrying inoculum from tree to tree on their bodies.

In the meantime, some tentative conclusions are possible from these data. Control of potato leafhoppers could indeed be of some importance in reducing the incidence of fire blight in the Northeastern U.S. In addition, where there is significant rainfall and/or high humidity where fire blight is known to be present, there may be a critical window when leafhoppers should be excluded. Where prohexadione-Ca has already been applied, it may not be necessary to apply an insecticide, but given the numerical reduction in fire blight incidence seen here, a prudent grower may well elect to do so.

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