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KENTUCKY PEST NEWS

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Number 1215 **October 27, 2009**

CORN

"Yield Penalty" in Continuous Corn: What is the Role of Root Diseases?

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For decades, mono-cropping without rotation has been known to often result in reduced yield. Indeed, long-term studies at the University of Kentucky show that first-year corn-after-corn commonly experiences a "yield penalty" that growers should factor into their economic analysis (Figure 1). One of the interesting things about this yield penalty is that it appears to be greater as corn yield increases. This suggests that, in the future, the "rotation effect" will be not diminished (rather, will be enhanced) in the presence of better varieties, better management, and excellent corn growing conditions.

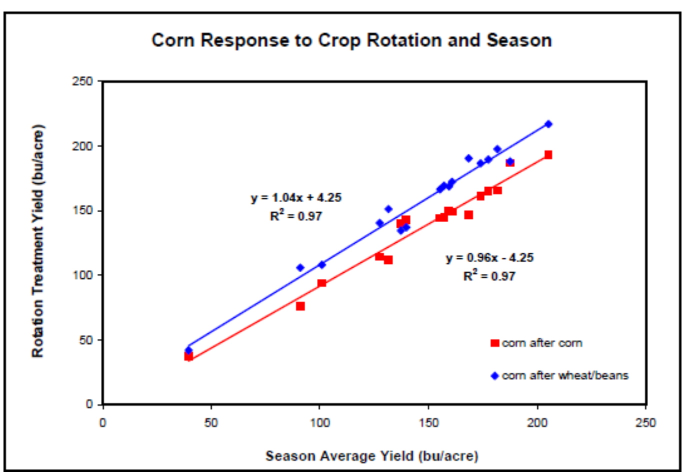

Figure 1. Comparison of yields first-year corn-after-corn vs. a one-year rotation for the 1989 to 2006 production seasons.

Late this season, we observed very little foliar disease in any of the plots in these long-term studies (as is often the case, according to Dr. Grove). While diseases like gray leaf spot and northern leaf blight certainly can be very damaging in continuous corn, these diseases were much too limited in these trials (well below 1% severity during late dent) to affect yield. We also observed that there were more green leaves on corn in rotation than on corn following corn, as well as higher yields (Figure 2).

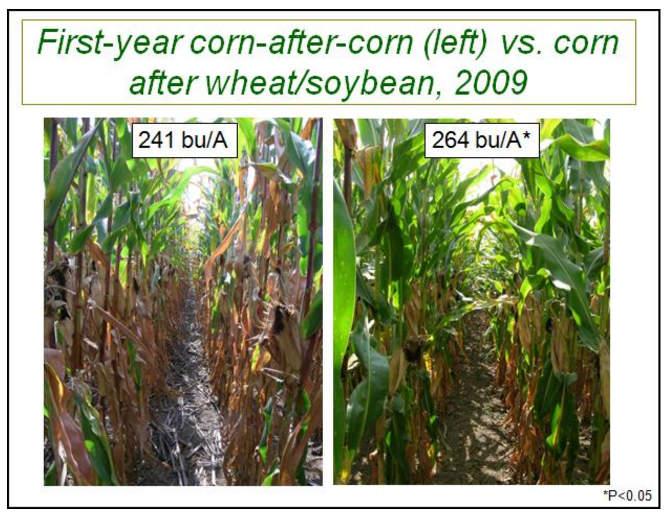

Figure 2. Earlier senescence of plants in plots of first-year corn-after-corn (6.6 green leaves per plant) than in rotated plots (8.6 green leaves per plant, P<0.05). Yields were also significantly higher in the rotated plots.

The facts from these trials are:
There was no significant pressure from diseases associated with corn residue (gray leaf spot, northern leaf blight).
Plants in continuous corn plots exhibited earlier senescence, working its way up the plant (which are symptoms commonly associated with root infections or root-feeding insects on many crops).
Foliar nutrient analyses suggest that nutrient deficiencies were not the cause of the differences in leaf greenness observed in UK's experiments comparing corn-after-corn vs. rotated corn.

These facts lead us to wonder about the role of root-attacking microorganisms in the yield penalty observed in many UK trials (fungi, nematodes, others?). (Root-attacking insects such as western corn rootworm are also likely to be involved with long-term continuous corn, though not likely in this trial, as explained below).

Research on whether soil-borne diseases account for part—or all—of this yield penalty in corn have been, surprisingly, limited. Ohio State researchers found evidence that a soil-inhabiting *Pythium* species might become damaging to corn roots on poorly drained soils under continuous corn, but these weren't clearly proven to be causing reduced yields (reference #1). Researchers at the University of Georgia (reference # 2) showed that soil-borne pathogens were involved in yield declines observed in a cropping system where corn was grown as a continuous double-crop over several seasons, but that was a production system very different from the Corn Belt. Unfortunately, these and other studies we have seen have not clearly identified root diseases as a significant factor in the yield penalty in continuous corn grown in the Corn Belt.

Western corn rootworm has been a pest since the early 1980's in Kentucky with active infestations restricted to continuous-corn fields. Typically it takes a few years to build an economic infestation, but the more years a field remains in continuous corn the greater the likelihood of rootworm problems. Initially when corn rootworm moved into Kentucky, injury to corn was very easy to see as lodging and 'goose-necking' of corn were often in evidence. However, today's hybrids tolerate rootworm feeding better with reduced levels of lodging. To diagnose a rootworm infestation, root samples need to be dug, roots washed and examined for the characteristic root pruning, scarring, and proliferation of secondary root regrowth. Having stated this, corn rootworms are NOT the sole cause of yield penalties with continuous corn, they may not even be the most common cause. While corn rootworms have the potential to reduce yields in continuous corn, it is unlikely in this case given the insecticide treatments applied in this study and that this was the first year of corn following corn.

So this Extension article can't really present any solutions for growers. Of course, answers are what we want, but arriving at the answer requires first framing the right question. And so, we wonder: what role do root diseases play in the "yield penalty" of continuous corn?

1. Deep and Lipps, 1996. *Crop Protection* 15:85-90.
2. Sumner et al., 1990. *Plant Disease* 74:704-710.

Bt-Corn Technology for 2010
By Ric Bessin

There are many types of corn hybrids have been genetically engineered to produce different *Bacillus thuringiensis* (Bt) endotoxins. In effect, these hybrids produce their own insecticide, but different hybrids may produce different selective insecticides. Be sure to correctly match the type of Bt-hybrid with the pest that needs to be controlled.

Bt-corn Technology Available for Commercial Use (October 2009)

Event	***Company[1]***	***Bt gene***	***Trade name***	***Pests controlled or suppressed***	***Minimum refuge size[2]***	***Refuge location***
Bt 11	Syngenta Seeds Inc	CryIA(b)	Agrisure CB	European and southwestern corn borers	20% of total corn acreage	Within ½ mile
MON 810	Monsant	CryIA(b)	YieldGard	European and southwestern corn borers	20% of total corn acreage	Within ¼ to ½ mile[3]
TC 1507	DowAgrosciences, Mycogen, Pioneer Hi-Bred Intl.	CryIF	Herculex I	European and southwestern corn borers, black cutworm, fall armyworm, and corn earworm	20% of total corn acreage	Within ¼ to ½ mile[3]
MON 863	Monsanto	Cry3Bb1	YieldGard Rootworm	Corn rootworms	20% of total corn acreage	Within field or adjacent to Bt field
MON 863 + Mon 810	Monsanto	CryIA(b) + Cry3Bb1	YieldGard Plus	European and southwestern corn borers and corn rootworms	20% of total corn acreage	Within field or adjacent to Bt field
DAS 59122-7	Dow Agrosciences Pioneer Hi-Bred Intl	Cry34Ab1 + Cry35Ab1	Herculex RW	Corn rootworms	20% of total corn acreage	Within field or adjacent to Bt field
TC 1507 + DAS 59122-7	Dow Agrosciences Mycogen Pioneer Hi-Bred Intl	CryIF + Cry34Ab1 + Cry35Ab1	Herculex XTRA	European and southwestern corn borers, black cutworm, fall armyworm, corn earworm, and corn rootworms	20% of total corn acreage	Within field or adjacent to Bt field
MIR 604	Syngenta Seeds Inc	mCry3A	Agrisure RW	Corn rootworms	20% of total corn acreage	Within field or adjacent to Bt field
Bt 11 + MIR604	Syngenta Seeds Inc	Cry1A(b) + mCry3A	Agrisure CB/RW	European and southwestern corn borers, and corn rootworm	20% of total corn acreage	Within field or adjacent to Bt field
Mon 88017	Monsanto	Cry3Bb1	YieldGard VT RW	Corn rootworms	20% of total corn acreage	Within field or adjacent to Bt field
Mon 810 + Mon 88017	Monsanto	Cry1Ab + Cry3Bb1	YieldGard VT Triple	European and southwestern corn borers and corn rootworms	20% of total corn acreage	Within field or adjacent to Bt field
Mon 89034 + Mon 88017	Monsanto	Cry3Bb1 + Cry1A.105 + Cry2Ab	YieldGard VT Triple Pro	European and southwestern corn borers, corn earworm, fall armyworm and corn rootworms	20% of total corn acreage	Within field or adjacent to Bt field
TC 1507 + DAS 59122-7 + Mon 89034 + Mon 88017	Dow Chemical Co. and Monsanto	CryIF + Cry34Ab1 + Cry35Ab1 + Cry3Bb1 + Cry1A.105 + Cry2Ab	SmartStax	European and southwestern corn borers, corn earworm, fall armyworm and corn rootworms	5% of total corn acreage	Within field or adjacent to Bt field

[1] Companies that own these technologies often license other seed companies to use the trait.
[2] The minimum refuge size is for non-cotton growing areas.
[3] Maximum distance from each Bt corn field its refuge is reduced to ¼ mile if the field will be treated with an insecticide for corn borer control.

Growers using these hybrids still need to monitor their fields regularly for other pests (such as corn leaf
aphids, and western and northern corn rootworms) that are not controlled by these new toxins.

Resistance Management and Bt Corn
A major concern with the use of these new hybrids is the development of Bt-resistance. The potential for corn borer and rootworm populations developing tolerance or becoming resistant to Bt increases as Bt-corn acreage increases. Growers need to prevent resistance rather than try and fight it once it becomes a problem. The EPA, Land Grant Universities, and industry have developed an effective resistance management plan that must be followed by all growers using Bt corn. The primary method to prevent or delay insect resistant is to always plant a corn borer/rootworm refuge depending on the type of Bt corn used. A refuge means that at least a minimum portion of your corn acreage is planted with non-Bt hybrids. This will provide a place for the Bt-susceptible corn borers/rootworms to develop. The refuge must be within the field or immediately adjacent to the Bt corn field if the field has any Bt rootworm traits or within a ¼ to ½ mile is the Bt corn has no traits that control corn rootworms. Each farm using Bt corn must have their own refuge on that farm.

FRUIT CROPS

Grape Berry Moth in 2009
By Ric Bessin

While the grape berry moth is a key pest of grapes, many of our vineyards are relatively young and in past years this pest received little attention. This fall I've received several reports of increasing damage at harvest from grape berry moth. Damage at harvest can hurt growers in three ways, loss in berry yield, loss in quality through contamination, and/or increased labor if the clusters are cleaned and sorted. Problems are likely to increase as many of our vineyards become mature and generally vineyards near wooded areas are at greater risk. Both cultural and insecticidal controls are used to manage this insect.


Figure 3. Grape berry moth damage.

The larvae of this insect damages commercial vineyards by feeding on the grape blossoms and berries. Infested berries may appear shriveled with fine webbing. Damage by grape berry moth may increase mold, rots and numbers of fruit flies. While grape berry moth larvae may only damage a few berries in a cluster, it is impractical for growers to remove damaged berries and webbing from clusters. Hosts include wild and cultivated grapes. The adult moth is small, active, and about 1/4 inch long. When it is at rest with its wings folded, there is a brown band across the middle of the insect, the hind portion is gray-blue with brown markings, while the front portion is gray-blue without markings.


Figure 4. Grape berry moth (photo by R. Isaacs, Michigan State University)

Adults emerge in late May and lay eggs of the first generation singly on fruit stems near bloom time. Eggs hatch in about 5 days. Under a flimsy web, the larvae feed for about 21 days on the blossoms and young fruit. The full grown larva is 2/5 inch long, pale olive-green, and can have a purplish tinge from the food it has eaten. The second and third generation larvae may spend much of their time within the berry, but do move to adjacent berry and also exit to pupate. They may produce webbing in the center of clusters as do spiders.

Figure 5. Grape berry moth larvae and entrance hole in berry.

The pupa is about 1/5 inch long, greenish-brown to dark brown and found under a flap cut in the leaf surface. The grape berry moth overwinters as a pupa in leaf litter. In mid July, larvae move to leaves where they make a semi-circular slit, fold the flap over themselves and pupate. Adult moths emerge from the pupae in 10 to 15 days. Moths begin laying eggs for the next generation after 4 to 5 days. There may be 2 or 3 generations per year. Some of the cocoons of the second or third generations fall to the ground where they overwinter. Webbing over blossoms and berries, and leaf flap cocoons are indicative of grape berry moth. In winter, the cocoons may be found in leaf litter under the vines.

Figure 6. Grape berry moth pupa enclosed in leaf flap.

To manage grape berry moth where it has been a problem, remove or bury leaf litter under vines in the winter to eliminate over wintering pupae. Leaf can also be buried in the spring under at least 1 inch of compacted soil brought up from the row middles. This needs to be done at least two weeks before bloom. Although larvae first appear when the grapes are in bloom, insecticides should be applied when the berries are the size of small peas. Insecticidal control of second generation is more difficult due to an extended flight period of moths as well as the difficulty of getting adequate spray coverage inside the cluster as berry size increases. Pheromone traps are a much more useful tool to help time sprays for the second and third generation. In general, pheromone trap catches are not a reliable method for determining the size of pest populations, but the information is useful in timing insecticide sprays. They are available to monitor for adult moth activity and enhance timing of insecticides for grape berry moth control. A list of available insecticides can be found in ID-94, Midwest Commercial Small Fruit and Grape Spray Guide, 2009. The numbers of insecticide applications will depend on grower tolerance to injury.

Recent studies in some states have shown mating disruption with synthetic pheromones to be an effective alternative in situations where there is no immigration of moths from outside sources. Mating disruption relies on releasing enough of the pheromone in the vineyard so that males cannot find female moths. Eggs laid by unmated females fail to hatch. Various systems are commercially available for mating disruption of grape berry moth. Minimum orchard size may vary with the type of mating disruption used.

SHADE TREES AND ORNAMENTALS

Holly Black Root Rot is Active

By John Hartman

Some Kentucky gardeners and County Extension Agents have observed a decline in the health of landscape hollies due to black root rot infections. Black root rot, caused by the fungus *Thielaviopsis basicola* can do significant damage to hollies in landscape beds (Figure 7). Black root rot is most frequently observed on Japanese holly, blue holly, and inkberry in Kentucky. Susceptible blue holly cultivars include: Blue Angel, Blue Maid, Blue Prince, Blue Princess, Blue Stallion, China Boy, China Girl and Dragon Lady. While English and

Chinese hollies are reportedly resistant, American and Yaupon hollies are considered to be only moderately resistant. Other ornamentals known to be susceptible include begonia, cyclamen, geranium, gloxinia, oxalis, petunia, phlox, poinsettia, sweet pea, verbena, and viola (pansy). Black root rot may also affect alfalfa, cotton, cowpea, eggplant, peanut, snapbean, soybean, tobacco, and tomato.

Figure 7. Leafless, dead twigs appearing within the canopy of a black root rot-infedcted holly.

Symptoms. The first symptoms of black root rot include yellowing and marginal scorch of the foliage and shoot dieback (Figure 8). Later, twigs or stems may die back and eventually the entire plant may die. The root system of the declining plant is stunted and decayed (Figure 9). These symptoms could be confused with Phytophthora root rot which was also widespread in landscapes this year. Unlike Phytophthora, black root rot causes black lesions on the infected roots which, in the early stages of disease, contrast sharply with the adjacent healthy white portions (Figure 10). Lesions may appear on the tips of feeder roots or elsewhere along the root.

Figure 8. Leaf yellowing and scorch symptoms of a dying shoot from a black root rot-infected blue holly.

Diagnosis can be confirmed by microscopic analysis which reveals the characteristic chlamydospores of the fungus embedded in the root tissues (Figure 11).

Figure 9. Inkberries with black root rot. Roots of the plant on the right are severly decayed. (C. Kaiser photo)

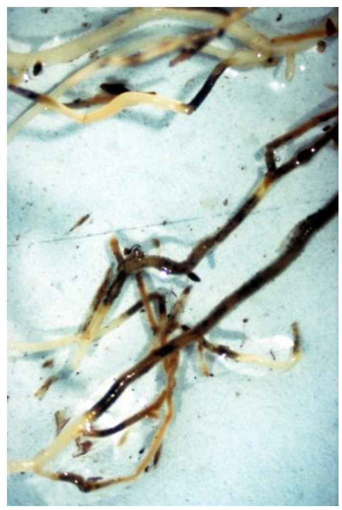

Figure 10. Blackened tips and lesions of infected holly roots. Note that contrasting portions of the root still appear to be healthy.

Figure 11. As roots decay, the dark, segmented chlamydospores of *T. basicola* survive in the soil for several years. In this microscopic view, conidia of the fungus can also be seen.

Disease Management. Gardeners and nursery growers need to be aware that the black root rot fungus can persist indefinitely in the soil or it can survive as a saprophyte on plant debris, so once a landscape or nursery bed is contaminated with the fungus, it is difficult to remove.

- Plant only disease-free plants in the landscape. Sometimes diseased, but well-watered and fertilized, nursery-grown hollies or bedding plants will appear to be healthy but, after they are placed in the landscape, they may decline due to more stressful growing conditions. This means it is very important to examine root systems prior to planting. If blackened roots are evident, plants should be rejected.
- Avoid planting susceptible plants in soils known to be infested with the fungus. While the fungus is widespread, it may be present in higher levels in soils where black root rot was previously a problem on other plants such as petunia or pansy. Occasionally, when old agricultural lands are developed for housing, homeowners may find they have also purchased a black root rot problem from a former tobacco or alfalfa field as well.
- In the landscape, badly infected plants should be removed and the site replanted with a non-susceptible host.
- There are no effective fungicide drenches available for controlling black root rot in the landscape. Steam pasteurization or chemical fumigation will eradicate the fungus from propagation and growing media in nurseries. The fungicide Medallion is registered for managing this disease in greenhouses.

DIANGOSTIC LAB HIGHLIGHTS

By Julie Beale and Paul Bachi

Recent samples in the PDDL have included downy mildew and frogeye leaf spot on soybean; hollow stalk on tobacco; crown rot (*Phytophthora*) on strawberry; and Septoria leaf spot on tomato.

On ornamentals and turf, we have seen Botrytis stem canker on poinsettia; anthracnose on liriope; Rhizoctonia crown/root rot on petunia; bacterial leaf spot on hydrangea; Septoria leaf spot on viburnum; Verticillium wilt on maple; Phytophthora root rot on arborvitae, chamaecyparis and rhododendron; and anthracnose, take-all patch and yellow patch on bentgrass.

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