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Foliar Fungicides in Seed Corn Production

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Since 1982, we have conducted a program to determine the fungicides that may be effective for controlling foliar diseases in inbred and hybrid corn. For the past seven years we have limited our research to only inbreds or sister line hybrids. In 1990, we started a cooperative program with seed companies and have conducted our research in commercial seed production fields in five greatly different years in terms of weather patterns. Thirty experiments have been established in seed production fields and 25 fields have been harvested for yield. Five experiments were abandoned because of herbicide injury interactions (2,4-D) with the fungicides, excessive Stewart's disease (a bacterial disease that cannot be controlled with fungicides and was devastating), or drought.

**Years of Experimentation**

In 1990, moderately wet conditions and mild temperatures prevailed before detasselling and then it was very dry with moderate temperatures for the balance of the growing season. In the central, southern, and southeastern parts of the state where we had the fungicide trials, we experienced heavy Stewart's disease, because of the mild winter. In spite of this, we had common rust, gray leaf spot, and Northern corn leaf blight as the dominant disease in different experiments.

The next year, 1991, brought drought conditions throughout most of the growing season. Of the four sites selected for experiments in eastern and southern Iowa, only two escaped the drought adequately and had gray leaf spot development. The disease developed slowly through most of the growing season and became quite heavy by late August.
Drought continued into the 1992 planting season and it was not until early July that the rainy weather set in and continued through into harvest. Diseases did not become apparent until several weeks following the sprays and the detasseling operations were completed. The diseases that developed were Northern leaf spot and common rust. Corn seed yields were excellent in sprayed plots.

The 1993 growing season was an unusual year. Excessively wet conditions and the coolest weather on record prevailed through most of the growing season. Common rust got established early and developed into epidemics in all eight fields selected for experiments; it was the most important disease in all fields. Anthracnose leaf blight developed early and was the most severe ever observed in Iowa, especially on some hybrids where rust did not dominate. In mid August, Northern leaf blight, Northern leaf spot, eyespot, and gray leaf spot began to develop where rust seemed to become arrested and significant green leaf tissue remained. Seed yields were depressed greatly by the rust and wet weather.

The weather was ideal for corn growth during most of the 1994 growing season. The temperatures were higher than the two prior years and the first rust lesion was not observed until about the third week in July, about six weeks later than in prior years. The temperatures were too warm for good rust development thereafter until late summer. Eyespot was apparent early in the season and became epidemic in Northern Iowa by mid August. Gray leaf spot started to develop in early to mid July in fields where corn followed corn and in late July in fields where corn followed soybeans. Northern leaf spot and Northern leaf blight started to develop by mid August.

The Diseases

The leaf diseases of corn can be categorized into seed borne, residue borne, insect borne, and continental. The seed borne characteristic of some diseases is important for introduction of the pathogen into a new area, but is a rare event and unimportant for development of epidemics. Most of the diseases affecting seed corn are borne on the residue of the prior years crop. This includes eyespot, gray leaf spot, anthracnose, Northern leaf spot, and Northern leaf blight, all of which are caused by fungi. Stewarts disease is bacterial and the bacterium overwinters in the body of the corn flea beetle, which is also the primary vector for the pathogen. The two rust diseases affecting Iowa corn are common rust and Southern rust. The rusts are continental pathogens; they overwinter only as a parasite of living corn plants in the tropical and semitropical regions of our hemisphere. Rust spores are blown north each year, infecting the green corn plants enroute.

The causal agent for Stewarts disease of corn is the bacterium *Erwinia stewartii*. When Iowa has very mild winters, which allows for survival of the corn flea beetle, Stewarts disease can be a serious problem in seed corn production. But the seed producer can do little to prevent the disease, other than to plant inbreds that carry good resistance. Fungicides have no effect on it. Stewarts disease is a problem for seed producers because the bacterium is on the quarantine list for most countries buying US produced corn seed.

A prevalent disease nearly every year is common rust, caused by the fungus *Puccinia sorghi*, which is a continental pathogen. It develops in cool, wet weather. Prolonged hot weather will arrest development of common rust. There is single gene resistance to this disease that is very
effective and also general resistance that slows the development of the epidemic. Southern rust, is incited by *Puccinia polysora* and this pathogen likes hot humid weather. It appears in Iowa most years in mid to late August, but the amount and severity depends on the weather. There is little resistance to Southern rust in Corn Belt inbreds.

Gray leaf spot, incited by *Cercospora zeae-maydis*, has become a problem nearly every year in Iowa since it was first discovered in Southeast Iowa about 15 years ago. By 1987 gray leaf spot was seen over the entire state. It can develop even in drought years, but seems to be more of a problem in warmer summers. 1994 was an ideal year for its development. Although it is observed earlier and is more severe where corn follows corn in rotation and reduced tillage is employed, it can develop into epidemic proportions in all seed fields. Some inbreds appear to possess some resistance the the disease.

Eyespot (*Kabatiella zeae*) is a perennial disease problem where corn follows corn and reduced tillage is used. In 1994 the conditions were ideal for its development and the epidemic spread into neighboring fields, especially in Northeast Iowa. A measured yield loss of >15% was made in a field corn field. Although it is more prevalent north of Interstate 80, it is common over all of Iowa.

Northern leaf spot appears every year and can be a severe problem in a few inbreds and in many of the seed production fields in Northcentral and Northeastern Iowa. The fungal pathogen, *Bipolaris zeicola* (=*Helminthosporium carbonum*), exists as several races. The race that has been most destructive in recent years is the one with high virulence on some germplasm of B73 heritage. Although the disease is evident very early in the season, it does not become epidemic until about mid August.

Northern leaf blight is incited by the fungus *Eyserohilum (Helminthosporium) turcicum*, which exists as several races. It can be seen every year in Iowa, but severe epidemics are sporadic. The conditions needed for an epidemic are unclear. The last widespread epidemic in Iowa was in 1990. Multigenic and single gene resistance is available, however the Ht gene used for resistance for 30 years, was defeated about 15 years ago by a new race of the fungus. The resistance defeating races, however, appear to diminish after use of the Ht gene is curtailed.

Anthracnose (*Colletotrichum graminicola*), is caused by a debris-borne pathogen. It appears early in the spring on the seedling leaves and in most years, except for 1993, it remains on the lower leaves through much of the growing season. Late in the season, the pathogen can be seen affecting stalk and crown tissues; the shiny black symptoms on the surface of corn stalks is diagnostic. It is present every year as a stalk rot pathogen.

**Fungicides**

There are four fungicides registered for control of foliar diseases in seed corn production fields. Propiconazole (*Tilt*), is the only systemic fungicide registered for use on corn. It can be applied only before silking has begun. There are no restrictions on feeding of the corn or fodder. Mancozeb is marketed by several companies under different brand names. Labels regulating its use differ with each company. In general, mancozeb can not be applied within 40 days of harvest. The major difference in the labels among brands is that with some brands you can not feed the harvest residue and fodder to livestock. Chlorothalonil (*Bravo*) can be
applied up to 14 days prior to harvest, but the harvest residue and fodder cannot be fed to livestock. Copper thallate (Tenncop SE) is an inorganic fungicide, cupric ion, carried with an organic resin that greatly improves the weatherability of the fungicide. It can be applied up to harvest and has no feeding restrictions. All of these fungicides must be applied according to the their label in terms of timing of application, dosage, equipment that may be used, amount of water diluent, need for adjuvants, harvest interval, worker reentry interval, protective clothing and equipment, and total amount that can be applied per season. **THE LABELS FOR THESE FUNGICIDES CAN CHANGE, THEREFORE YOU MUST READ AND UNDERSTAND THE LABEL BEFORE PURCHASING THE PRODUCT AND USING IT.**

**Results**

All of the fungicides were effective in being able to reduce the amount of disease, if applied in a timely manner. Although it was not researched extensively, copper thallate appeared to have some phytotoxicity to the inbreds being used. Application of the copper thallate did not result in yield increases and in the absence of much disease, it resulted in yield decreases. This may be a response of certain inbreds. Copper thallate was used only in those years when rainfall was sparse, and the fungicide may have accumulated on the leaves to levels that were phytotoxic. In the absence of much disease there was no evidence that any of the other three fungicides were phytotoxic.

The best fungicide varied from year to year, field to field, and pathogen to pathogen. One fungicide was never the better one all of the time. In general, when rust was the only problem, mancozeb and chlorothalonil tended to be the better fungicide. When gray leaf spot became dominant, the better fungicide was propiconazole. A treatment of propiconazole sprays prior to detasseling followed by mancozeb after detasseling, was commonly the better spray program when a mixture of pathogens was attacking the leaves. In general the fungicide sprays increased the number of saleable kernels/acre, and the number of medium and large size kernels produced per acre.

Timing of the spray was most important. The initial spray applications must be made before the epidemic begins and should continue at 7 to 10 day intervals until after detasseling. This requires scouting for the diseases. Waiting until after detasseling to begin a spray program will not result in good disease control, unless weather has precluded disease development up to that time.

Economic analyses were performed on all of the data. The seed had been sized into small mediums and larges and the units were bags of 80,000 kernels. We considered the costs of fungicides and application, the costs of processing the additional seed crop, the added payments to growers, and a value of $30 per bag wholesale for the seed. The protocols for applying the fungicides involved some applications that were unwarranted, because of low disease pressure, lateness in the season, drought, etc., therefore it was expected that some of the treatments in the experiments would result in monetary losses. In 1993, where we had 9 different protocols in 8 experiments, we found that 94% of the protocols resulted in net profits to the seed producer, who paid for all of the inputs. The extra profits due to spraying reached $650/acre but in many of the protocols were about $100-300/acre. In 1992, 75% of the protocols in the different experiments resulted in economic benefits. In the drought year of 1991, 44% were profitable. In 1990, when dry weather prevailed for most of the season, 42% of the
protocols were profitable. If we had based the profit margin on $80 per bag corn seed, the profitable ventures certainly would have been more frequent and returns would have been much greater than with using the $30/bag value for seed corn.

Criteria for Fungicide Applications

A seed company must consider various factors before embarking on a fungicide spray program.

Resistance. Possibly only the more susceptible inbreds will need to be considered for a spray program. However, the inbred may be resistant to one disease but susceptible to another.

Prior crop and tillage. Planting corn after corn will increase the disease potential for the residue borne diseases, especially eyespot and gray leaf spot. These fields should receive the greatest attention early in the season when scouting for problems. The pathogen will start on the lower leaves and spread upwards in the plant. If the inbred is resistant to Northern leaf spot (not a B73 pedigree) the appearance of this disease on the lower leaves should not be considered with as much concern as gray leaf spot. The first sprays for gray leaf spot should be made at the appearance of initial lesions of gray leaf spot on the lower leaves.

Weather. The fungi require moisture for development. They get it from dew and rain. Rain and wet soil is needed for inoculum production in plant residue. Moderate to warm temperatures are favorable for gray leaf spot and cool weather is best for common rust. If common rust appears by mid June, a spray program for rust may be beneficial if weather predictions are for moderate to cool temperatures, and rainfall. Several lesions of rust per plant by the 10 leaf stage would be reason to consider a spray program. If a dought is underway or threatening, gray leaf spot and rust can still develop with prolonged dew periods.

Growth stage of crop. Decisions of "to spray or not spray", are easier to make during the two to three weeks before detasselling and through detasselling. If the disease is developing, spray for it. A spray made 2 weeks before detasseling may be the best protection against the disease. Then follow with another spray immediately before detasseling. Sprays made later than 2 weeks after detasselling are less likely to be beneficial than sprays made earlier.

Disease. Rust and gray leaf spot are the greatest cause for concern. Anthracnose, eyespot, and Northern leaf spot would be of less concern. Northern leaf blight severity of one lesion per plant by detasseling time would be cause for concern if the inbred carried little resistance.

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