Strategy for Control of Seedling Diseases of Cotton

Several species of fungi can infect cotton seeds or seedlings. The activity of these fungi are greatly affected by environmental conditions that are sub-optimal for the germination and growth of cotton seeds. Disease is favored by cool, wet weather conditions during the first three weeks after planting. Specifically, the risk factors are a soil temperature less than 68° F, which is suboptimal for seed germination, and saturated or near-saturated soil. As seedlings develop, they become naturally resistant to infection as root systems become more extensive develop and root cells are lignified. Pre-emergent damping-off occurs when seeds are killed before germination or germinating seeds are killed prior to emergence from soil. Post-emergent damping-off occurs when the germinating seed has emerged from soil, but then dies. Fungal decay symptoms may be visible on these plants.

There are three major fungal pathogens causing seedling disease in Texas. The most prevelant pathogen is *Rhizoctonia solani*. This fungus produces brown or black lesions on the stems. The lesions may be sunken, which is a symptom known as "soreshin", or the lesions may girdle and pinch the stem at the soil surface, which is known as "wirestem". Post-emergent damping-off is a common consequence of infection by this fungus. Often, seedlings that have just emerged from soil may be prone to damping-off if cool, wet weather occurs. This fungus can also infect seedlings at soil temperatures higher than 68° F.

Several *Pythium* species cause seed decay and pre-emergent damping-off. The symptom on emerged seedlings is a rotting of the hypocotyl below the surface of the soil. The hypocotyl has a water-soaked or light brown appearance. The optimal conditions for disease caused by *Pythium* species are saturated soils and soil temperatures less than 68° F.

Thielaviopsis basicola is pathogenic on seedlings after emergence and it does not usually cause mortality. The optimal conditions for infection are 60-70°F soil temperatures and wet, but not saturated soil. The fungus blackens the tap root and cortex (exterior) of the hypocotyl. Lateral roots are killed, particularly on older plants. Plants may be stunted and flowering delayed. This fungus is primarily a problem in the High Plains of Texas, where it was found in 60% of surveyed soils. It has been occassionally observed on plants from other growing areas of Texas, but, to date, there has been no specific problem attributed to this pathogen in these areas.

Other fungal species have been reported to cause seedling disease in cotton, but their occurrence is infrequent and their impact relative to the three major pathogens is slight, unless they interact with the major pathogens. A prevalent, minor seedling pathogen is *Fusarium* spp. These pathogens tend to cause disease in plants growing under severe environmental stress.

There are several approaches that can be used to reduce the impact of seedling diseases. Crop rotation can help to reduce the amount of pathogens that the planted seed is exposed to. At present, there are no varieties specifically resistant to seedling pathogens. However, a general resistance to pathogens can be attained by planting high-quality seed. The objective is to get seed germinating and growing as rapidly as possible, particularly at cooler soil temperatures. Planting cotton when soil temperatures are greater than 68° F also supports this objective. The use of raised beds helps to decrease disease pressure because of their higher soil temperatures and better drainage. Also, the use of fungicide treatments is an essentially component of disease prevention or minimization. At the very least, seed should have a fungicide treatment. Under conditions where there is higher disease pressure, the seed treatment should be augmented with a hopper box or an in-furrow application of fungicide. Fungicide treatments are used to prevent losses occurring from a stand failure and the added expense and delay from replanting.

Combinations of fungicides are usually employed as seed treatments, as there is no one fungicide that adequately controls all pathogens. As a generalization, some of the more effective fungicides are also specific for a narrow group of fungi. Such fungicides are usually systemic and can protect the growing seedling for a longer period of time than protectant fungicides. Protectant fungicides, such as captan and PCNB, are very potent, but are not absorbed by the growing seedling and are not substantially leached in soil. The two types of fungicides serve a complementary role in protecting the seed and the seedling.

Purchased seed may often be pretreated with fungicides. Additional fungicides may be applied at the time of planting as a hopper box treatment or as in-furrow granules or spray. Table 1 shows individual fungicides that are labeled for seed treatment and the pathogens they target. When growers purchase seed, they can sometimes request a customized fungicide seed treatment. Commercially available mixtures of seed treatment fungicides are shown in table 2. They may not be complete in the range of protection offered. For example, while all provide protection against *Rhizoctonia,* some mixtures do not offer protection against *Pythium* or *Thielaviopsis*. These mixtures could also be mixed with the necessary fungicides shown in Table 1 to get a complete spectrum of control.

To decide what fungicides to choose, growers should try to determine which pathogens they have in their fields. This is most easily done in the years that disease problems occur. Seedlings with damping-off symptoms should be sampled and sent to a plant disease diagnostic clinic to identify the pathogen. This is particularly useful to know if either *Pythium* or *Thielaviopsis* are present.

In the absence of such specific information about which pathogen is present in a field, the ideal preventative seed fungicide mix includes systemic and protectant fungicides that are active against *Pythium*. and *Rhizoctonia*. Cotton planted in the High Plains should also be treated with a fungicide with activity against *Thielaviopsis*.

There are several protectant seed treatment fungicides available, some with a broad spectrum of activity against different groups of pathogens and some with a narrow spectrum of activity. Thiram and mancozeb have a broad spectrum of activity. Captan has activity against *Pythium*, but not *Rhizoctonia*. PCNB has activity against *Rhizoctonia*, but not other seedling pathogens. Fludioxinil is effective against *Rhizoctonia* and *Fusarium*, as well as some of the seedling pathogens that occur less frequently, and it has long residual activity.

Metalaxyl is a systemic fungicide with specific activity against *Pythium*, but not other seedling pathogens. It should always be included as a seed treatment. Metalaxyl contains equal proportions of two isomers (i.e. chemicals with the same formula, but the molecules are mirror images of each other). One isomer is active for disease control, the other is not. Mefenoxam (also known as metalaxyl-M) contains only the active isomer of metalaxyl. This permits the use of about half as much chemical as is contained in metalaxyl, but resulting in the same level of fungicidal activity.

Other systemic seed treatment fungicides include TCMTB, which has activity against *Rhizoctonia, Pythium,* and *Fusarium;* chloroneb, which has activity against *Rhizoctonia* and *Pythium*; and carboxin, which has good activity against *Rhizoctonia*. Triadimenol and myclobutanil are systemic fungicides with good activity against *Rhizoctonia solani*, and, at higher label rates, against *Thielaviopsis basicola*. Triadimenol has been reported to delay seedling emergence under cool, wet growing conditions.

A living bacterium, *Bacillus subtilis*, is available as a seed treatment, to be used in conjunction and not as a substitute for chemical fungicides. Its purpose is to extend the length of control beyond the point where chemicals lose their effectiveness. It has activity against *Rhizoctonia* and *Fusarium*, but not *Pythium* or *Thielaviopsis*.

Is there a particular combination of the aforementioned fungicides that are superior to others as a seed treatment? Probably not. Comparative trials with fungicides in various combinations suggest that the key to seedling disease control is to use a mixture of systemic and protectant fungicides that target at least *Pythium* and *Rhizoctonia*. When *Thielaviopsis* is also present, the addition of triadimenol or myclobutanil (at the appropriate rate) is beneficial.

The aim of using seed treatments is not to completely control damping-off, but to sufficiently suppress disease so that a good, uniform stand is obtained. The seed treatment is successful if there are no large gaps left within rows. In many cases, a seed treatment is sufficient for disease control.

When there is a greater risk of seedling disease, seed treatments need to be augmented with fungicides applied as a hopper (planter) box treatment, or as granules or liquid sprays applied to the soil surrounding the planted seed. Risk factors include an early planting date, planting in soils with a frequent history of seedling disease problems, replanting a field with a stand failure, planting into a field previously cropped to cotton, or, in some growing areas, planting into a no-till or reduced tillage field.

Hopper box fungicide treatments are shown in Table 3. With one exception, they are mixtures of chemical fungicides that offer protection against *Rhizoctonia* and *Pythium*, and include the same fungicides that are also registered as seed treatments. The exception is a formulation of a living fungus, *Trichoderma harzianum*, that has a label for general damping-off fungi and is compatible with chemical fungicides. Like the *Bacillus subtilis* bacterium, this fungus is intended to supplement and extend the activity of chemical fungicides. However, its benefits have not been consistently demonstrated. Hopper box dusts stick to fuzzy cottonseed, but may settle to the bottom of the planter box when acid-delinted seed is used. Planting seed deeper than 1.5 inches may result in a non-uniform distribution of chemical if a hopper box application is used.

In-furrow granular treatments are shown in Table 4. They include PCNB and mefenoxam formulations, which target *Rhizoctonia* and *Pythium*, respectively. An additional fungicide, not registered as a seed treatment, is etridiazole. This is a systemic fungicide that has good activity against *Pythium* and *Fusarium*, but it is not as effective against *Rhizoctonia*. In-furrow granules offer a better distribution of fungicide into the soil around the seed than hopper box applications.

In-furrow liquid fungicides are shown in Table 5. They include the same fungicides used for in-furrow granular treatments. There are two, additional fungicides, which are both systemic: iprodione, which has activity against *Rhizoctonia* and *Fusarium*, but not *Pythium*; and azoxystrobin, which has activity against *Rhizoctonia* and *Pythium*. In-furrow liquid applications give the best distribution of fungicide into the soil around the seed.

Table 1. Chemicals applied to seed for seedling disease control

Target Pathogen*	Chemical Name	Trade Name	Company
T,R	triadimenol	Baytan 30 Flowable	Gustafson
P, R, F, G	TCMTB (benzothiazole)	Ascend 30 Nusan 30 EC Nu-Flow T	Gustafson Wilbur-Ellis Wilbur-Ellis
R	chloroneb	Nu-Flow D Demosan 65 W	Wilbur-Ellis Kincaid Enterprises
G	captan	Nu-Gro Captan 4000 Captan 30-DD Captan 400	Wilbur-Ellis Gustafson Gustafson
R	PCNB	PCNB Flowable PCNB Seed-Coat PCNB 2-E RTU-PCNB	Wilbur-Ellis Wilbur-Ellis Wilbur-Ellis Gustafson
G	mancozeb	Dithane DF Dithane F-45 Dithane M-45 Dithane WSP Penncozeb 75 DF Penncozeb 80 WP	Dow Dow Dow Dow Cerexagri Cerexagri
R, F, G	fludioxonil	Maxim 4 FS	Syngenta
T,R	myclobutanil	Nu-Flow M	Wilbur-Ellis
P	metalaxyl “ ” ” “ mefenoxam (metalaxyl-m)	Allegiance-LS Allegiance FL Allegiance Dry Apron Flowable Apron TL Apron XL-LS	Gustafson Gustafson Trace Chemicals Wilbur-Ellis Wilbur-Ellis Syngenta
G	thiram	Thiram 42-S Thiram 50 WP	Gustafson Gustafson
R	carboxin	Vitavax 30 C Vitavax 34	Gustafson Gustafson

F, R, G	*Bacillus subtilis* (a bacterium)	Kodiak Flowable Kodiak Concentrate Kodiak HB	Gustafson Gustafson Trace Chemicals

*T = *Thielaviopsis basicola*; R = *Rhizoctonia solani*; P = *Pythium* spp.; F = *Fusarium* spp.; G = General damping-off pathogens.

Table 2. Mixtures of chemicals applied to seed for seedling disease control.

Target Pathogen*	Chemical Name	Trade Name	Company
T,R	triadimenol + thiram	RTU Baytan Thiram	Gustafson
P, R, F, G	TCMTB (benzothiazole) + chloroneb	Nu-Flow ND	Wilbur-Ellis
R, P	carboxin + metalaxyl + PCNB	Prevail	Trace Chemicals
R, P	chloroneb + metalaxyl	Nu-Flow AD	Wilbur-Ellis
R, F, G, P	fludioxonil + mefenoxam	Maxim XL	Syngenta
R, P	PCNB + metalaxyl + *Bacillus subtilis*	System 3	Helena
R	carboxin + thiram carboxin + PCNB	RTU Vitavax Thiram Vitavax-PCNB Flowable Fungicide	Gustafson Gustafson

*T = *Thielaviopsis basicola*; R = *Rhizoctonia solani*; P = *Pythium* spp.; F = *Fusarium* spp.; G = General damping-off pathogens.

Table 3. Hopper (Planter) Box Treatments Applied for Seedling Disease Control.

Target Pathogen*	Chemical Name	Trade Name	Company
R, P	PCNB + metalaxyl + *Bacillus subtilis*	System 3	Helena
R, P	carboxin + metalaxyl + PCNB	Prevail	Trace Chemicals
R, P	chloroneb + metalaxyl	Delta-Coat AD	Agriliance
R, P, G	chloroneb + TCMB	Nu-Coat	Wilbur-Ellis
G	*Trichoderma harzianum* (a fungus)	T-22 Planter Box	BioWorks

*R = *Rhizoctonia solani*; P = *Pythium* spp.; G = general damping-off pathogens.

Table 4. In-Furrow Liquid Granular Applied for Seedling Disease Control.

Target Pathogen*	Chemical Name	Trade Name	Company
R	PCNB	PCNB 10 Granular Terraclor 15 G Terraclor 6.5% plus Di-Syston 6.5%	Wilbur-Ellis CK Witko CK Witko
P	mefenoxam (metalaxyl-m)	Ridomil Gold GR	Syngenta
R, P	PCNB + etridiazole	Terraclor Super X 18.8 G Terraclor Super X with Di-Syston	CK Witko CK Witko
R, P	PCNB + mefenoxam	Ridomil Gold PC GR	Syngenta

*R = *Rhizoctonia solani*; P = *Pythium* spp.

Table 5. In-Furrow Liquid Chemicals Applied for Seedling Disease Control.

Target Pathogen*	Chemical Name	Trade Name	Company
R	PCNB	Terraclor 75 WP Terraclor 2E Terraclor Flowable	CK Witco CK Witco CK Witco
R	iprodione	Rovral Brand 4 Rovral Brand 75 WG Rovral Fungicide	Aventis Aventis Aventis
P	mefenoxam (metalaxyl-m)	Ridomil Gold EC	Syngenta
R, P	azoxystrobin	Quadris Flowable	Syngenta
R, P	PCNB + etridiazole	Terraclor Super X EC Terraclor Super X plus Di-Syston EC	CK Witco CK Witco
R, P	PCNB + mefenoxam	Ridomil Gold PC Liquid	Syngenta

*R = *Rhizoctonia solani*; P = *Pythium* spp.