Effect of Fungicidal Seed Treatments on Common Root Rot of Spring Wheat and Barley

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Common root rot of hard red spring wheat, durum and barley occurs throughout the spring grain regions of the Great Plains in the United States and Canada. The disease is caused primarily by the fungus *Cochliobolus sativus* (formerly known as *Helminthosporium sativum*). The fungus persists as thick-walled, resistant spores in the soil and it is these spores which are important in causing common root rot infections (Clark and Wallen, 1969; Sallans, 1965).

Common root rot (CRR) regularly causes substantial losses in the spring cereal areas of the Canadian prairie provinces and North Central United States. Yield losses to common root rot have been calculated to average about 10 percent in barley and about half that in spring wheat on a long-term, region-wide basis, with losses in individual fields in some years in excess of 30 percent (Ledingham et al., 1973; Piening et al., 1976; Stack, 1991).

Crop rotation and use of partially resistant cultivars have been the major disease management tools. Control of CRR in these ways has not been entirely successful because many farmers find it difficult or uneconomic to grow non-cereal crops often enough to provide adequate control. In addition, many susceptible cultivars continue to be widely grown because of agronomic or quality factors.

Protectant fungicide formulations have long been applied to cereal seed to prevent seed decay, damping-off and seedling blight, and seed-borne diseases such as smuts. *Cochliobolus sativus* may cause a seed-borne infection known as black point, and protectant fungicides have been used successfully to prevent seedling blight from this infection. None of the older protectant seed-treatment materials, however, have been successful in reducing the soil-borne phase of common root rot in the adult crop. During the past two decades many new systemic fungicides have become available and some were shown to be active against the seed-borne phase of *C. sativus* but not the soil-borne infections (Richardson, 1972; Sterling et al., 1977). Some systemic cereal seed treatments have controlled the soil-borne disease of CRR. Unfortunately, although these products reduced the root rot index, they often did not increase yields (Chinn, 1978; Verma, 1983; Verma et al., 1981). The purpose of this study was to test some of these systemic fungicides for root rot control on spring wheat and barley under North Dakota conditions.

METHODS

Eight seed treatment fungicides were compared for root rot control in replicated trials between 1983 and 1990 (Table 1). Not all materials were present in all trials. All field plots were planted either at Fargo, Erie or Williston on land known from previous studies to have high levels of natural inoculum of *C. sativus* (El-Nashaar and Stack, 1989; Stack, 1987, 1989). Six experiments were done with barley and nine with spring wheat, all using a randomized complete block design with four, five or eight replicates. Plots were planted in May and managed according to normal cereal cropping practices. They were harvested in early August.

To evaluate effectiveness of the compounds, disease was measured using the subcrown internode index (sci-index) (Ledingham et al., 1973). This index evaluates disease severity on the area between the seed and the crown, the sub-crown internode. Scores range from 1 to 4; a rating of 1 = no infection

Table 1. Wheat and barley seed treatments: formulations and rates.

Material	Trade Name	Formulation	Rate (a.i.)
Imazalil	Fungaflor	10%EC/6.5%L	100 mg/kg
Maneb	DB-Green	50%FL	740 mg/kg
Nuarimol*	------	3.3%EC	75 mg/kg
Triadimenol	Baytan	30%F	100 mg/kg
Flutriafol*	------	2.5%FL	100 mg/kg
Carboxin/Thiram	Vitavax 200	17%FL	450 mg/kg
Propiconazole*	Tilt	1.125SL	15 mg/kg
Difenoconazole*	Dividend	3 FS	20 mg/kg

* Products *not* currently registered as seed treatments for wheat or barley

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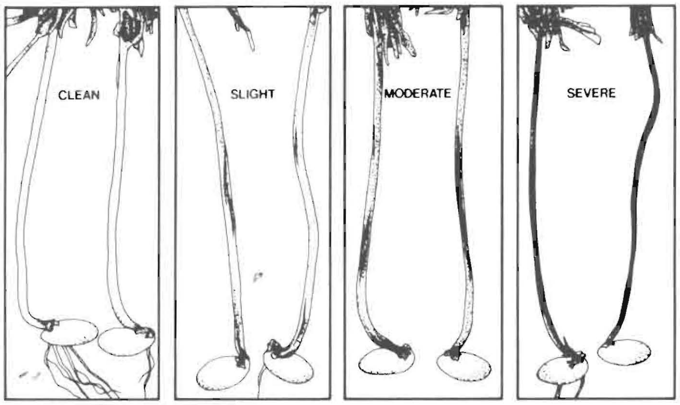

Figure 1. Common root rot disease rating scale. Sub-crown internodes of barley from left to right illustrating the clean (1), slight (2), moderate (3), and severe (4) disease categories, respectively. The dark elongate lesions are typical of those caused by ***Cochliobolus sativus.***

observed and a rating of 4 = severe infection (Figure 1). Ten to 20 plants from each experimental unit were individually scored at milk or soft dough stage, and these scores were averaged. Since CRR levels vary considerably from year to year, the scores for the treatments were expressed as a percentage of the CRR score of the non-treated control in each experiment. Yields were determined after harvesting, threshing, and cleaning grain and drying to constant moisture. Yields are also expressed as percentages of the control yield.

Cultivars used in each trial were standard commercial wheats or barleys. In most wheat trials Waldron or Len were used; barley trials used Larker, Morex, or Robust. All cultivars tested are quite susceptible to CRR.

RESULTS

Seed treatments containing maneb or carboxin had little effect on adult plant CRR (Tables 2A, 3A). In most trials the systemic fungicides imazalil, nuarimol, triadimenol,

Table 2. Effect of fungicide seed treatment on common root rot of spring wheat.

A. EFFECT ON DISEASE SEVERITY INDEX.

	Disease Severity (% of Nontreated Control)								
	Experimental Trial[1]								
Treatment	F.83	F.84	E.84	W.84	F.85a	F.85b	F.88	F.89	F.90
Imazalil	90	84	86	65	100	94	92	82	82
Maneb	98	91	99	89	106	106			
Nuarimol	89	79	83	65	95	81			
Triadimenol	93	76	77	68	100	90	89	78	91
Imaz.+Triadimenol				98	98	100			
Flutriafol							77		78
Carboxin							102	90	
Propiconazole								75	80
Difenoconazole								80	86
FLSD(.05)	9.1	11.9	ns	21.8	ns	10.3	11.9	17.9	11.4

B. EFFECT ON YIELD.

	Crop Yield (% of Nontreated Control)							
	Experimental Trial[1]							
Treatment	F.83	F.84	E.84	W.84	F.85a	F.88	F.89	F.90
Imazalil	137	83	121	127	100	74	98	93
Maneb	113	80	101	115	98			
Nuarimol	148	101	84	97	98			
Triadimenol	142	92	108	133	105	90	92	96
Imaz.+Triadimenol					102	56		
Flutriafol						75		107
Carboxin						93	102	
Propiconazole							100	71
Difenoconazole							105	113
FLSD (.05)	19.3	15.4	ns	ns	ns	ns	11.4	20.7

[1]Exp. Trials: F = Fargo, E = Erie, W = Williston, ND, and year

propiconazole, difenoconazole, and flutriafol did significantly reduce the sci-index (Table 2A, 3A).

Yield response to the seed treatment materials was not consistent with their effect on CRR (Table 2.B, 3.B; Figure 2, 3). Neither carboxin nor maneb had much effect on CRR in wheat, nor did they have much effect on yield. Propiconazole reduced root rot in both wheat and barley but was phytotoxic and gave overall yield reductions in both crops. Flutriafol also reduced disease ratings but it reduced yields in wheat. Treatment with nuarimol reduced root rot in both wheat and barley but gave little yield response on wheat, while it gave a 5 percent yield increase on barley. Imazalil also reduced CRR on both wheat and barley; on wheat it gave an average 4 percent yield improvement while on barley yields were slightly reduced.

Triadimenol and difenoconazole were the most promising materials, reducing CRR on both wheat and barley and giving positive yield responses. Triadimenol gave yield increases averaging 7 percent and 8 percent and difenoconazole treatment resulted in 9 percent and 4 percent yield increases on wheat and barley, respectively.

DISCUSSION

The sub-crown internode index (SCI-index) rating system was developed to make it possible to do large field studies on common root rot by giving a rapid disease assessment. The validity of the index relies on three factors: 1) scoring of many plants; 2) correlation of infection on the various below-ground plant parts; 3) use on spring grains under dryland conditions where *C. sativus* is the principal pathogen. Violation of these conditions (for example: on winter wheat in more humid

Table 3. Effect of fungicide seed treatment on common root rot of spring barley.

A. EFFECT ON DISEASE SEVERITY INDEX.

	Disease Severity (% of Nontreated Control)					
	Experimental Trial[1]					
Treatment	**F.84**	**W.84**	**F.85**	**F.88**	**F.89**	**F.90**
Imazalil	83		88		86	94
Nuarimol	83	77	96			
Triadimenol	83	63	90	80	94	99
Carboxin	99	110		102	114	
Imaz.+Triadimenol			87	91		
.Flutriafol				76		94
Propiconazole					96	94
Difenoconazole					76	97
FLSD. (05)	12.0	20.2	ns	10.6	14.4	ns

B. EFFECT ON YIELD.

	Disease Severity (% of Nontreated Control)				
	Experimental Trial[1]				
Treatment	**F.84**	**F.85**	**F.88**	**F.89**	**F.90**
Imazalil		91		100	99
Nuarimol	110	95			
Triadimenol	111	99	120	104	108
Carboxin	96		101	105	
Imaz.+Triadimenol		82	89		
Flutriafol			106		96
Propiconazole				104	86
Difenoconazole				106	99
FLSD (.05)	ns	ns	20.0	ns	20.4

[1]Exp. Trials: F = Fargo, E = Erie, W = Williston, ND, and year

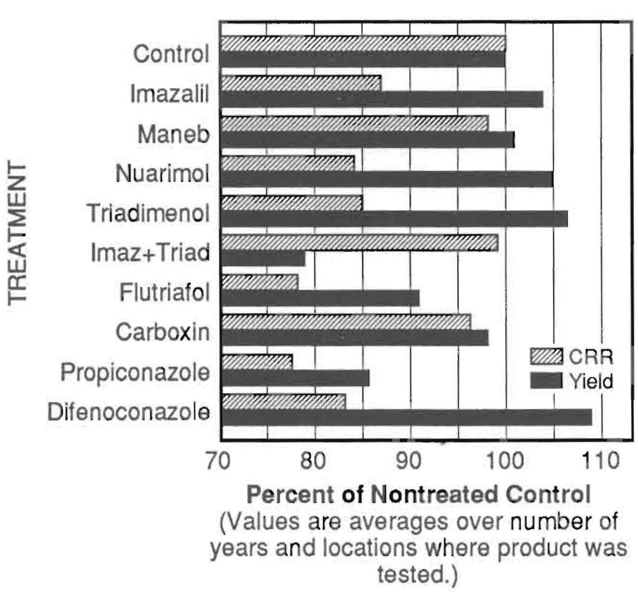

Figure 2. Effect of fungicide seed treatment on common root rot and yield of spring wheat.

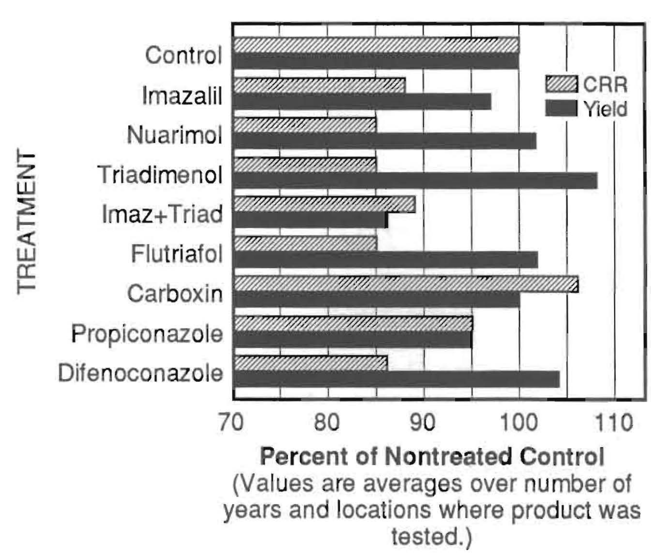

Figure 3. Effect of fungicide seed treatment on common root rot and yield of spring barley.

climates or where other pathogens predominate) reduces the usefulness of the index or may invalidate it completely.

The compounds tested are systemic in a polar manner—they move mainly upward in the plant. A seed-applied systemic might protect the sub-crown internode and the crown from infection but not the lateral roots. Thus, evaluation of only the sub-crown internode area may indicate that a product is adequately protecting the sub-crown internode and crown but the rating doesn't indicate if root infections have been reduced. The results of Salas (1991) support this idea. He found frequency of isolation of *C. sativus* from crowns and sub-crown internodes of field grown adult plants was significantly reduced by imazalil seed treatment but that isolation from roots was not affected.

In most years, it is the crown roots which sustain the adult plant. Selectively protecting the sub-crown internode and the crown but not the roots is unlikely to reduce losses since common root rot usually acts to reduce yields by stressing the plant, interfering with normal root function, and aggravating any environmental stress such as dry soil. Selective protection in such a manner may account for the ability of a compound like imazalil to reduce the sci-index but not always give a yield response. In occasional years, crown roots do not develop normally and the plant is sustained almost entirely by the seedling root system. In such plants, protection of the sub-crown internode might be expected to strongly influence the yielding ability of the plant.

CONCLUSIONS

1. The sci-index is NOT suitable as the sole disease measure to determine efficacy of seed-applied systemic fungicides.

2. Systemic fungicidal seed treatments should continue to be tested for control of common root rot as new chemicals become available.

3. Economic yield returns are possible with some compounds when wheat or barley are grown in situations with a high risk of common root rot. Root rot risk factors include recropping to cereals, planting susceptible cultivars, and planting on land known to have a history of root rot problems.

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