EVALUATING FUNGICIDES AND SEED TREATMENTS FOR CONTROLLING RHIZOCTONIA SOLANI ON SUGARBEET

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Minnesota and North Dakota produce 60% of the total sugar beet production in the United States. In this region, *R. solani* has become the most important problem which limits sugar beet production.

The objective of this research was to evaluate the efficacy of penthiopyrad used as seed treatment for controlling *R. solani*, and determine if resistant cultivar and/or foliar application of azoxystrobin will improve disease control.

Materials and Method

The experiment was conducted at NDSU greenhouse located in Fargo, North Dakota. Greenhouse conditions were set at 12-hour photoperiod and temperatures ranging from 22±2°C. Sunshine Mix 1 peat soil (Sun Gro Horticulture Inc.) was used to fill trays of 27 x 13 x 13 cm in size. Plants were watered daily to maintain adequate soil moisture that favors plant growth as well as disease development. A known pathogenic isolate of *R. solani* AG 2-2 IIIB was grown on sterilized barley and used to inoculate seeds. Azoxystrobin at 167 g a.i./ha was applied using a Generation III Research Sprayer (Devries Manufacturing Hollandaise, MN) calibrated to spray the fungicides at 20 psi with a speed of 3.91 miles per hour using a single flat fan nozzle (4001E).

Two cultivars of sugar beets – one resistant and one susceptible to *R. solani*, were treated by Betaseed Inc. with penthiopyrad at 5, 7, and 14 g a.i./unit (unit: 100000 seeds). Ten seeds were sown within a furrow at 1.5-cm soil depth per tray. Inoculation, which was made after planting or in-furrow application of azoxystrobin, was done by placing one *R. solani* infested barley grain close to seeds in the furrow. On 14 days after inoculation (DAI), foliar application of azoxystrobin in an 18-cm band was sprayed on the plants from seeds treated with penthiopyrad at 0, 5, 7, and 14 g a.i./unit. There were 20 treatments which included a non-inoculated and inoculated check. Stand counts were taken at 10, 20, 30, and 45 DAI.

The experimental layout was a randomized complete block design (RCBD) with four replicates. This trial was repeated twice under the same environmental conditions. Levene's test was performed on variances across the experiments to test for homogeneity before the data were combined. Using SAS software (Version 9.3; SAS Institute, Cary, NC), Analysis of variances (ANOVA) was used to analyze data, and treatment means were separated by Fisher's Protected Least Significant Difference (LSD) at a 95% confidence level.

Results

There were significant differences among the treatments at $P < 0.001$ levels of confidence. Plant stand for the non-inoculated check, as expected, was the highest among all treatments and remained stable from 10 DAI to 45 DAI (Table 1). Within the same fungicide treatment, Rhizoctonia-resistant seeds failed to significantly improve plant stand compared to the susceptible variety. On 10 DAI, sugar beet seeds treated with penthiopyrad or azoxystrobin at planting had significantly higher plant stand than those without any fungicide treatments. From 10 DAI to 20 DAI, there was a slight decrease in plant stand from those seeds treated with penthiopyrad at 5 g a.i./unit, whereas an increase was observed for seeds treated with penthiopyrad at 14 g a.i./unit and azoxystrobin applied in-furrow. Penthiopyrad with 7 g a.i./unit failed to follow the same pattern. Most stand loss occurred between 20 DAI and 45 DAI. Of those seeds treated with fungicides at planting, penthiopyrad treated with 5 g a.i./unit and with 7 g a.i./unit alone experienced a dramatic decline of at least 20%, with the highest stand loss of 52.5% in Rhizoctonia-resistant seeds with 7 g a.i./unit penthiopyrad alone. However, azoxystrobin used as an in-furrow application maintained high percentage of plant stand (>80%) without any stand loss during the period. On the other hand, the inoculated check and azoxystrobin applied foliarly at 14 DAI followed a downward trend during the duration of the trial.

Through contrast analysis (Table 2), selected treatments were categorized into different groups for comparisons. There was no difference between resistant and susceptible variety. All the rates of fungicide treatments (penthiopyrad and/or azoxystrobin) significantly reduced stand losses from *R. solani* compared with the inoculated check, but no fungicide treatments, including azoxystrobin applied as an in-furrow method, were comparable to the non-inoculated checks. When penthiopyrad was used alone as a seed treatment, 14 g a.i./unit provided a statistically better disease control than 5 and 7 g a.i./unit and was effective as azoxystrobin applied in-furrow. Foliar application of azoxystrobin without seed treatment at 14 DAI failed to provide satisfactory control where the plant stand was significantly lower than other fungicide treatments. The same foliar application following penthiopyrad seed treatment was applied at 14 DAI. The only time foliar application of azoxystrobin significantly improved plant survivors was when penthiopyrad was used at 7 g a.i./unit as a seed treatment.

Discussion

The greenhouse study demonstrated that penthiopyrad was not phytotoxic to sugar beet. Disease severity was high since the plant stand from the inoculated checks was reduced significantly on 10 DAI. Penthiopyrad at 14 g a.i./unit performed significantly better than 5 and 7 g a.i./unit probably because the latter two rates were too low to provide effective disease control at 20 DAI.

For disease management in heavily infested Rhizoctonia fields, the use of a resistant or moderately resistant cultivar is recommended to be combined with fungicide applications for effective control. No difference was found between the treatments with the use of resistant and susceptible cultivars. Several possible reasons might contribute to this result: disease pressure was very high - less than 10% of plants survived in the inoculated check - that resistant and susceptible plants were both killed; difference in level of resistance between varieties might be too small to be distinguished; and most importantly, another greenhouse study showed that regardless of cultivars, all sugar beet plants at or before four weeks old were highly susceptible to *R. solani* (data not published).

Azoxystrobin in both in-furrow and foliar sprays is highly effective to manage *R. solani* but it must be applied before infection takes place. Azoxystrobin was applied alone on 14 DAI after inoculation and failed to control the disease, most probably because infection had already occurred and azoxystrobin did not have curative properties. Therefore, the efficacy of a combined practice of seed treatment followed by foliar application depends on whether penthiopyrad was able to be effective until azoxystrobin is applied. Azoxystrobin was ineffective following penthiopyrad seed treatment at 5 g a.i./unit because the rate was so low that infection had started before 14 DAI. 7 g a.i./unit penthiopyrad alone experienced a dramatic decrease in plant stand at 30 DAI, whereas 7 g a.i./unit penthiopyrad plus azoxystrobin at 14 DAI was able to improve disease control for as long as 14 g 7 g a.i./unit penthiopyrad a.i./unit did, indicating that the period that 7 g a.i./unit penthiopyrad can be effective against *R. solani* was probably around 20 days.

The widespread use of Rhizoctonia-susceptible crops such as corn, soybean, edible bean, and sugarbeet in the region may have led to higher inoculum levels in the field and higher incidence and severity of Rhizoctonia root rot. Penthiopyrad, a new generation of SDHI (Succinate dehydrogenase inhibitor) fungicide can be used as a safe seed treatment and along with post application of azoxystrobin provide effective control of *R. solani* when the crop is most susceptible to the pathogen.

Table 2: Effect of cultivars, penthiopyrad seed treatment, and azoxystrobin application on sugar beet plant stand at 10, 20, 30, and 45 Days after inoculation with *R. solani*.

Trt #.	Variety	Inoculation[a]	Penthiopyrad (a.i./unit)[b]	Azoxystrobin[c]	Plant survivors (%)[d]			
					10 DAI	20 DAI	30 DAI	45 DAI
1	Resistant	Yes	5 g		81.3% a-e	72.5% c	50.0% h	35.0% de
2	Susceptible	Yes	5 g		81.3% a-e	78.8% abc	70.0% c-f	41.25% cd
3	Resistant	Yes	5 g	Foliar appl	88.8% abc	82.5% abc	61.3% e-h	50.0% c
4	Susceptible	Yes	5 g	Foliar appl	85.0% a-e	78.8% abc	67.5% d-g	56.25% c
5	Resistant	Yes	7 g		91.3% ab	86.3% abc	56.3% fgh	33.8% de
6	Susceptible	Yes	7 g		71.3% edf	73.8% bc	55.0% gh	48.8% c
7	Resistant	Yes	7 g	Foliar appl	90.0% abc	86.3% abc	82.5% abc	81.3% ab
8	Susceptible	Yes	7 g	Foliar appl	75.0% c-f	80.0% abc	76.3% bcd	73.8% b
9	Resistant	Yes	14 g		77.5% b-f	80.0% abc	74.3% b-e	71.3% b
10	Susceptible	Yes	14 g		76.3% b-f	78.8% abc	76.3% bcd	73.8% b
11	Resistant	Yes	14 g	Foliar appl	82.5% a-e	83.8% abc	71.3% cde	68.8% b
12	Susceptible	Yes	14 g	Foliar appl	70.0% ef	77.5% bc	73.8% b-e	73.8% b
13	Resistant	Yes		In-furrow	86.3% a-d	87.5% ab	87.5% ab	87.5% a
14	Susceptible	Yes		In-furrow	76.3% b-f	81.3% abc	81.3% a-d	81.3% ab
15	Resistant	Yes		Foliar appl	62.5% fg	41.3% d	27.5% i	26.3% e
16	Susceptible	Yes		Foliar appl	52.5% gh	42.5% d	31.2% i	23.8% e
17	Resistant	Yes			36.3% i	41.3% d	8.8% j	5.0% f
18	Susceptible	Yes			46.2% hi	33.8% d	8.8% j	8.8% f
19	Resistant	No			93.8% a	93.8% a	93.8% a	93.8% a
20	Susceptible	No			93.8% a	93.8% a	93.8% a	93.8% a
	LSD (P=0.05)				15.8%	15.1%	14.2%	12.9%

a: Inoculation with *R. solani* was made at planting.

b: Resistant and susceptible sugar beet cultivars to *R. solani* were treated with penthiopyrad at 5, 7, and 14 g a.i./unit.

c: Azoxystrobin at 167 g a.i./ha was applied in-furrow at planting or as foliar application in an 18-cm band at 14 DAI.

d: Means followed by the same letters are not significantly different at a 95% confidence level.

Table 2: Contrast analysis between two classified groups of treatments

Classified group #1		Classified group #2	Means[a]	Means[b]	Pr > F
Resistant(Trt 1,3,..19)[b]	vs	Susceptible(Trt 2,4,…20)[c]	55.4%	57.5%	0.730
5g a.i./unit(Trt 1,2)	vs	7g a.i./unit(Trt 5,6)	38.1%	41.3%	0.941
7g a.i./unit(Trt 5,6)	vs	14g a.i./unit(Trt 9,10)	41.3%	73.2%	0.010*
5g a.i./unit(Trt 1,2)	vs	14g a.i./unit(Trt 9,10)	38.1%	73.2%	0.008*
5g a.i./unit(Trt 1,2)	vs	5g a.i./unit + foliar appl(Trt 3,4)	38.1%	53.1%	0.154
7g a.i./unit(Trt 5,6)	vs	7g a.i./unit + foliar appl(Trt 7,8)	41.3%	77.6%	<0.001**
14g a.i./unit(Trt 9,10)	vs	14g a.i./unit + foliar appl(Trt 11,12)	73.2%	71.3%	0.904
5g a.i./unit(Trt 1,2)	vs	In-furrow(Trt 13,14)	38.1%	84.4%	<0.001**
7g a.i./unit(Trt 5,6)	vs	In-furrow(Trt 13,14)	41.3%	84.4%	<0.001**
14g a.i./unit(Trt 9,10)	vs	In-furrow(Trt 13,14)	73.2%	84.4%	0.081
foliar appl(Trt 15, 16)	vs	In-furrow(Trt 13,14)	25.1%	84.4%	<0.001**
foliar appl(Trt 15, 16)	vs	5g a.i./unit(Trt 1,2)	25.1%	38.1%	<0.001**
foliar appl(Trt 15, 16)	vs	7g a.i./unit(Trt 5,6)	25.1%	41.3%	<0.001**
foliar appl(Trt 15, 16)	vs	14g a.i./unit(Trt 9,10)	25.1%	73.2%	<0.001**
foliar appl(Trt 15, 16)	vs	5g a.i./unit + foliar appl(Trt 3,4)	25.1%	53.1%	<0.001**
foliar appl(Trt 15, 16)	vs	7g a.i./unit + foliar appl(Trt 7,8)	25.1%	77.6%	<0.001**
foliar appl(Trt 15, 16)	vs	14g a.i./unit + foliar appl(Trt 11,12)	25.1%	71.3%	<0.001**
foliar appl(Trt 15, 16)	vs	Non-inoc check (Trt 19,20)	25.1%	93.8%	<0.001**
foliar appl(Trt 15, 16)	vs	Inoculated check(Trt 17, 18)	25.1%	6.9%	0.042*
5g a.i./unit(Trt 1,2)	vs	Non-inoc check (Trt 19,20)	38.1%	93.8%	<0.001**
7g a.i./unit(Trt 5,6)	vs	Non-inoc check (Trt 19,20)	41.3%	93.8%	<0.001**
14g a.i./unit(Trt 9,10)	vs	Non-inoc check (Trt 19,20)	73.2%	93.8%	<0.001**
5g a.i./unit(Trt 1,2)	vs	Inoculated check(Trt 17, 18)	38.1%	6.9%	<0.001**
7g a.i./unit(Trt 5,6)	vs	Inoculated check(Trt 17, 18)	41.3%	6.9%	<0.001**
14g a.i./unit(Trt 9,10)	vs	Inoculated check(Trt 17, 18)	73.2%	6.9%	<0.001**
5g a.i./unit + foliar appl(Trt 3,4)	vs	In-furrow(Trt 13,14)	53.1%	84.4%	0.003*
7g a.i./unit + foliar appl(Trt 7,8)	vs	In-furrow(Trt 13,14)	77.6%	84.4%	0.452
14g a.i./unit + foliar appl(Trt 11,12)	vs	In-furrow(Trt 13,14)	71.3%	84.4%	0.062
5g a.i./unit + foliar appl(Trt 3,4)	vs	Non-inoc check (Trt 19,20)	53.1%	93.8%	<0.001**
7g a.i./unit + foliar appl(Trt 7,8)	vs	Non-inoc check (Trt 19,20)	77.6%	93.8%	0.007*
14g a.i./unit + foliar appl(Trt 11,12)	vs	Non-inoc check (Trt 19,20)	71.3%	93.8%	<0.001**
5g a.i./unit + foliar appl(Trt 3,4)	vs	Inoculated check(Trt 17, 18)	53.1%	6.9%	<0.001**
7g a.i./unit + foliar appl(Trt 7,8)	vs	Inoculated check(Trt 17, 18)	77.6%	6.9%	<0.001**
14g a.i./unit + foliar appl(Trt 11,12)	vs	Inoculated check(Trt 17, 18)	71.3%	6.9%	<0.001**
In-furrow(Trt 13,14)	vs	Non-inoc check (Trt 19,20)	84.4%	93.8%	0.046*
In-furrow(Trt 13,14)	vs	Inoculated check(Trt 17, 18)	84.4%	6.9%	<0.001**

a - Mean of treatments in classified group #1; b - Mean of treatments in classified group #2; * indicates significance at P≤0.05 level of confidence; ** indicates significance at P≤0.001 level of confidence.