EVALUATION OF ACTINOGROW® FOR CONTROL OF *APHANOMYCES* AND *RHIZOCTONIA* ON SUGARBEET SEEDLINGS

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Damping-off and early-season root rot of sugarbeet are caused by two common soil pathogens, *Rhizoctonia solani* and *Aphanomyes cochlioides*. Commercial sugarbeet seed is treated with standard fungicides (Apron and Thiram), and sometimes is supplemented with Tachigaren. Apron controls seed rot caused by *Pythium*, a common soil pathogen; Thiram has some activity against *Pythium* and *Rhizoctonia;* Tachigaren controls *Aphanomyces* and also has activity against *Pythium*. Several companies continue to develop and evaluate new seed treatment products for control of seedling pathogens.

ActinoGrow® (produced by SipcamAdvan) is a high concentration of patented beneficial bacteria on a 100% water soluble powder. Product evaluations show that ActinoGrow suppresses a wide range of common soilborne diseases of agricultural crops when applied as a soil drench. The active ingredient is the bacterium *Streptomyces lydicus* WYEC 108 (1×10^7 = 10 million propagules per gram of product). When soil temperatures are 45 ^{0}F or higher, the bacterium forms a protective barrier as it colonizes plant roots and also exudes beneficial secretions that suppress and control soil pathogens. It is active in soils with a pH of 4.0 to 10.0 and spore shelf life is guaranteed at 12 months. Information is needed to determine effectiveness of ActinoGrow as a seed treatment for control of *Aphanomyces* and *Rhizoctonia* on sugarbeet.

OBJECTIVES

Greenhouse trials were established to evaluate efficacy of in-furrow application of various rates of ActinoGrow for controlling damping-off and seedling root rot caused by 1) *Rhizoctonia* and 2) *Aphanomyces* on sugarbeet.

MATERIALS AND METHODS

Rhizoctonia. Field soil was inoculated with a mixture of *R. solani* isolates including AG 4, AG 2-2 IV, and AG 2-2 IIIB (0.32g of ground barley grain inoculum per each isolate in 24 Liter of soil). Then, soil was added to plastic pots (4 x 4 x 4 inches) and sown with pelleted seed of a susceptible sugarbeet variety (16 seeds per pot); all seed was treated with the fungicides Apron + Thiram. ActinoGrow was applied in-furrow at planting at the equivalent rates of 3, 6, 9, and 12 oz product in 100 gallons of water A^{-1}. Controls included an in-furrow application of Quadris (azoxystrobin at the equivalent of 14.3 fl oz of product A^{-1} in 22-inch rows) and a non-treated control. Six replicate pots per treatment were arranged in a randomized complete block design in a growth chamber at 70 $\pm$ 2 °F for 1 week for optimal emergence and then increased to 77 $\pm$ 2 °F (14 hour photoperiod) for disease development. Soil was kept moist to favor disease. Stand counts were made three times per week starting at emergence and dying seedlings were removed to prevent disease spread. Dying seedlings were washed, surface-treated, assayed in water, and microscopically examined within 24 to 48 hours to identify pathogens. At 4 weeks after planting, surviving seedlings were rated for root rot with a 0 to 3 scale (0 = healthy, 3 = seedling severely diseased and dying). These ratings and numbers of dead seedlings during the 4-week assay were used to calculate a Rhizoctonia Root Rot Index Value on a 0 to 100 scale (0 = healthy and 100 = all seedlings dead and soil severely infested with *Rhizoctonia*).

Aphanomyces. Field soil naturally infested with a high population of *A. cochlioides* (soil index value = 85, maximum = 100) was sown with pelleted seed of a susceptible sugarbeet variety, as previously described. Half the pots were planted with seed treated with Tachigaren (45g product per 100,000 seed) and the other half had no Tachigaren. ActinoGrow was applied in-furrow at planting at the equivalent rates of 3, 6, 9, and 12 oz product in 100 gallons of water A^{-1} in pots with and without Tachigaren-treated seed. Controls included seed with and without Tachigaren that were not supplemented with ActinoGrow. There were six replicates per treatment and the experiments were conducted as previously described.

Statistical analysis. Data were subjected to analysis of variance and if significant at $P = 0.05$, means were separated by Fishers Protected Least Significant Difference (LSD).

RESULTS

Rhizoctonia. Seedlings started to emerge at 4 days after planting (Fig. 1). Maximum stands were reached at 6 days after planting and there were no significant differences among treatments (Fig. 1). Then, Rhizoctonia damping-off started to reduce stands for all treatments, except the Quadris control, which maintained excellent stands. At 4 weeks after planting, the Quadris treatment averaged 98% stand, which was significantly higher than the Apron + Thiram control (27%) and all ActinoGrow in-furrow treatments (Fig. 1, Table 1). ActinoGrow applied at the rate of 3 oz A^{-1} resulted in a significantly higher stand (31%) than the 6 oz rate (14%) and the 9 and 12 oz rates were intermediate (16 and 22%, respectively). The Rhizoctonia root rot index value was significantly lowest for the in-furrow application of Quadris (4) compared to all rates of ActinoGrow and the control, which were statistically the same and averaged a root rot index of 81 (range: 74 to 88; Table 1).

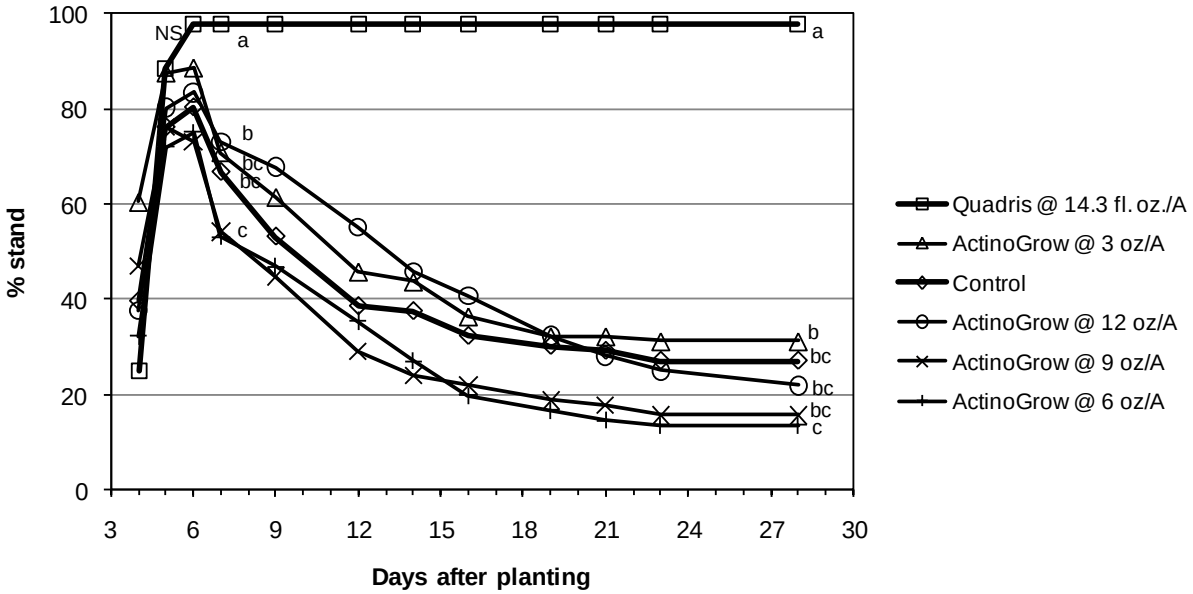

Fig. 1. Percent stand from sugarbeet seed sown into field-collected soil infested with *Rhizoctonia solani* AG 4, AG 2-2 IIIB, and AG 2-2 IV and treated with several in-furrow rates of ActinoGrow; controls include seed not treated with an in-furrow product and seed treated with Quadris (azoxystrobin in-furrow at the equivalent of 14.3 fl oz A^{-1} in 22-in rows). All seed was treated with fungicides Apron + Thiram. Each data point is an average of six replicates (16 seeds sown per replicate). At 28 days after planting, data points followed by the same letter are not significantly different ($P = 0.05$); NS = not significantly different.

Table 1. Emergence, final stand, and root rot index of sugarbeet seed sown into field-collected soil infested with *Rhizoctonia solani* AG 4, AG 2-2 IIIB, and AG 2-2 IV and treated with several in-furrow rates of ActinoGrow; controls include no treatment with an in-furrow product and in-furrow application of Quadris (azoxystrobin). All seed was treated with fungicides Apron + Thiram.

Treatment	Emergence (%)[z]	Final stand (%)[z]	Root rot index[z]
Control	89	27 bc	77 a
Quadris @ 14.3 fl. oz./A	98	98 a	4 b
ActinoGrow @ 3 oz./A	93	31 b	74 a
ActinoGrow @ 6 oz./A	83	14 c	87 a
ActinoGrow @ 9 oz./A	84	16 bc	88 a
ActinoGrow @ 12 oz./A	87	22 bc	79 a
LSD ($p = 0.05$)	NS	17.7	16.8

[z] For each column, values followed by the same letter are not significantly different, $P = 0.05$; LSD = Least Significant Difference; NS = not significantly different.

***Aphanomyces*.** There were no interactions between ActinoGrow and seed treatment (with or without Tachigaren), Table 1) so the main effect of Tachigaren seed treatment and in-furrow treatment with ActinoGrow are presented separately in Table 2 and Fig. 2.

Emergence was excellent for seed treated with and without Tachigaren (averaged across all ActinoGrow treatments and the control, Table 2 and Fig. 2A), but about 2 weeks after planting, Aphanomyces damping-off started to reduce stands dramatically across all treatment (Fig. 2A). At 4 weeks after planting, stands and root rot were severe for all treatments, however, Tachigaren-treated seed resulted in significantly more seedlings (Table 2, Fig. 2A) and a lower root rot index (Table 2) than non-Tachigaren treated seed.

Emergence also was excellent for all rates of ActinoGrow and the control (averaged across seed with and without Tachigaren, Table 2 and Fig. 2B). About 2 weeks after planting, Aphanomyces damping-off started to kill seedlings, regardless of treatments, and by 4 weeks after planting stands were low and there were no significant differences between rate of ActinoGrow and the control (Fig. 2B and Table 2). Root rot indices were significantly lower in the control compared to all in-furrow rates of ActinoGrow except for the 9 oz A^{-1} rate, which was intermediate (Table 2).

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Table 2. Emergence, final stand, and root rot index of sugarbeet seed (treated with fungicides Apron + Thiram, with or without 45 g Tachigaren per unit) sown into field soil naturally infested with *Aphanomyces cochlioides* and treated at planting with in-furrow applications of ActinoGrow (various rates).

Main effect[Y]		Emergence (%)[z]	Final stand (%)	Root rot index[Z]
Tachigaren seed treatment				
No Tachigaren		99	15	88
45g Tachigaren		97	35	74
	P-value	0.117	0.0006	0.006
In-furrow ActinoGrow[z]				
Control		99	40	66 b
ActinoGrow @ 3 oz/A		97	20	86 a
ActinoGrow @ 6 oz/A		99	19	88 a
ActinoGrow @ 9 oz/A		97	29	76 ab
ActinoGrow @ 12 oz/A		98	18	89 a
	P-value	0.509	0.058	0.032
	LSD (*P* = 0.05)	NS	NS	16
Tachigaren x ActinoGrow *P*-value		0.421	0.065	0.173

[Y] There were no interactions between Tachigaren and ActinoGrow so main effects are presented.

[Z] For each column, values followed by the same letter are not significantly different, *P* = 0.05; LSD = Least Significant Difference; NS = not significantly different.

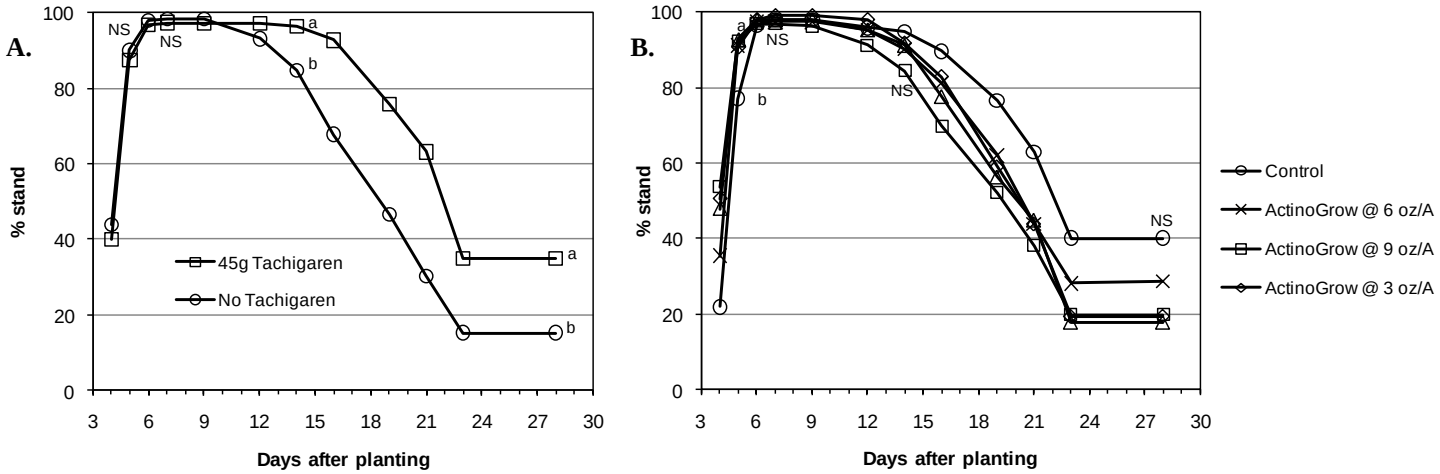

Fig. 2. Percent stand from sugarbeet seed (treated with fungicides Apron + Thiram, with or without 45 g Tachigaren per unit) sown into field soil naturally infested with *Aphanomyces cochlioides* and treated at planting with in-furrow applications of ActinoGrow (various rates). Average stand when **A.** seed treated with Tachigaren vs. no Tachigaren (each data point is an averaged across four rates of ActinoGrow and a control) and **B.** soil treated in-furrow with various rates of ActinoGrow compared to a control (each data point is averaged across Tachigaren and non-Tachigaren treated seed). Each treatment was replicated 6 times, 16 seeds sown per pot. For each date, data points followed by the same letter are not significantly different ($P = 0.05$); NS = not significantly different.

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DISCUSSION

In our trials, in-furrow applications of ActinoGrow did not control Rhizoctonia or Aphanomyces damping-off. During the experiment, soil temperatures were favorable for growth of the *Streptomyces* bacterium in ActinoGrow, as well as both pathogens. Disease started within days after planting because of high populations of both pathogens and favorable environmental conditions for infection. The *Streptomyces* bacterium likely did not have enough time to become established around roots at sufficient population densities before infections occurred, especially because of high and active pathogen densities. Seedlings of all sugarbeet varieties are highly susceptible to both pathogens, so it is important that roots be protected – and it is unknown how quickly *Streptomyces* colonizes sugarbeet roots. Nor is it known if *Streptomyces* colonizes roots of some sugarbeet varieties more effectively than others.

For optimal disease control, chemical fungicides and biological control agents (such as *Streptomyce*s in ActinoGrow) need to be well-established at adequate levels BEFORE infections occur to protect plants. This explains why Quadris (azoxystrobin) was so effective in controlling Rhizoctonia damping-off. However, even chemical fungicides have short-comings, as illustrated in our trial by the unusually low protection of Tachigaren seed treatment against *Aphanomyces*. This likely occurred because of natural decomposition of Tachigaren on seed while in storage (our seed may have been treated several months earlier). Thus, residual levels were insufficient for good control of *Aphanomyces.* In the case of biological control agents, care must be taken to ensure optimal benefits. This may mean allowing extra time for the bacterium to increase and become well-established before pathogen infections occur. ActinoGrow may be more effective in fields when populations of pathogens are low, where environmental conditions favorable for disease develop slowly, and/or where late-season root rots occur (and currently are not controlled by registered fungicides). Field trials will continue to determine if ActinoGrow has an effect on sugarbeet root diseases under various field conditions.

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