

# Activity of Actigard® on Development of Phytophthora Root and Crown Rot on Pepper Plants

Michael E. Matheron and Martin Porchas

## Abstract

*Phytophthora blight of peppers (Capsicum annum), caused by the oomycete pathogen Phytophthora capsici, occurs in most regions where this crop is grown. The root and crown rot phase of the disease develops on plants in areas of the field where soil remains saturated with water after an irrigation or rainfall. Subsequent periods of soil saturation encourage further disease development. Actigard (acibenzolar-S-methyl), is a chemical activator of plant disease resistance, has no known direct antifungal effects and is thought to mimic salicylic acid in the signal transduction pathway that leads to systemic acquired resistance (SAR). Foliar applications of Actigard were evaluated for suppression of root and crown rot on pepper plants growing in the greenhouse in pots and inoculated with Phytophthora capsici or grown in soil naturally infested with the pathogen. Inhibition of stem cankers on pepper cultivars Bell Tower and AZ9 after two to four treatments with Actigard was significantly greater than on plants receiving a single treatment of the chemical. Inhibition of stem canker elongation on Bell Tower or AZ9 peppers ranged from 93.2 to 97.2% and 87.4 to 92.4% when plants were inoculated with P. capsici at 1 or 5 weeks, respectively, after the fourth application of Actigard. Survival of chile pepper plants in field soil naturally infested with P. capsici was significantly increased by three foliar applications of Actigard compared to nontreated plants in all three trials when pots were watered daily and in two of three trials when pots were flooded for 48 hr every 2 weeks. When soil was flooded every 2 weeks, establishing conditions highly favorable for disease development, plants treated once with Ridomil Gold survived significantly longer than those treated with Actigard. On the other hand, when water was provided daily without periodic flooding, establishing conditions less favorable for disease development, there was no significant difference in plant survival between the two chemicals in two of three trials. Growth of shoots on chile pepper plants treated with Actigard, watered daily and grown in soil containing P. capsici generally was greater than nontreated plants. Pepper plants subjected to periodic saturated soil conditions and receiving three foliar applications of Actigard plus a soil treatment of Ridomil Gold survived significantly longer and produced a greater amount of shoot growth than plants treated with either chemical alone. This work suggests that Actigard could be an important management tool for Phytophthora root and crown rot on pepper plants.*

## Introduction

Phytophthora blight of peppers (*Capsicum annuum*), caused by the oomycete pathogen *Phytophthora capsici*, occurs in most regions where this crop is grown. The root and crown rot phase of the disease initially can appear on plants early in the growing season in areas of the field where soil remains saturated with water after an irrigation or rainfall. Subsequent periods of soil saturation encourage further disease development. As the crop canopy develops and covers the rows within the field, the foliar blight phase of the disease may occur on the stems, leaves and developing pepper fruits. The efficacy of the systemic fungicide Ridomil (metalaxyl) for control of Phytophthora blight on pepper has been well documented. Recently, the manufacturer replaced Ridomil with Ridomil Gold (mefenoxam), which was the active component in the fungicide Ridomil and is applied in a similar manner as Ridomil, but at lower rates. Ridomil Gold was widely used for the first time in 1997 in pepper fields in North Carolina and New Jersey, after which resistance to this chemistry was detected in 57% of tested field isolates of *P. capsici* in these states. The greatest number of isolates resistant to Ridomil Gold were recovered from fields where this compound was used exclusively, rather than in combination or in alternation with other fungicides. There is an urgent need for efficacious materials in addition to Ridomil Gold to minimize the development of resistance to this chemistry by *P. capsici* and to prevent failure of disease control in treated pepper fields. Actigard (acibenzolar-S-methyl) is a chemical activator of plant disease resistance, has no known direct antifungal effects and is thought to mimic salicylic acid in the signal transduction pathway that leads to systemic acquired resistance (SAR). The purpose of these studies was to evaluate the potential efficacy of preinfection treatments with Actigard for management of the root and crown rot phases of Phytophthora blight on pepper plants grown in pots in the greenhouse.

## Materials and Methods

The first experiment was conducted to compare the effect of one to four applications of Actigard and one application of Ridomil Gold on stem canker development on bell pepper and chile pepper after inoculation with *P. capsici*. The leaves and stems of five 2-month-old Bell Tower (bell pepper) and AZ9 (chile pepper) plants were treated from one to four times (with a 7-day interval between treatments) with Actigard at 75 Fg of active ingredient (a.i.)/ml with a handheld sprayer. A mean volume of 5.9 ml of spray solution was applied to each plant, an amount sufficient to thoroughly wet leaves and stems. Treatments were scheduled so that plants receiving one application of Actigard were sprayed on the same day that the other sets of plants were receiving their last treatment. When the last treatment of Actigard was administered, five plants of each pepper cultivar were treated with Ridomil Gold by spraying 3 ml of solution containing 3.1 mg a.i. in total onto the lower stem of each plant, with the excess material running into the potting mix. One week after the last application of Actigard or Ridomil Gold, the stem of each plant was inoculated with *P. capsici*. A circular wound just deep enough to remove the epidermis was made on the stem approximately 8 cm above the soil surface with a 5-mm-diameter cork borer. A 5-mm-diameter agar disk containing mycelium from an actively growing culture of *P. capsici* on V8 juice agar then was placed onto the wound and secured in place with plastic tape. After 2 weeks, disease severity was recorded by measuring the length of the canker at the inoculation site. This experiment was conducted three times.

Another stem-inoculation experiment was performed to compare the duration of protection after four applications of Actigard to one application of Ridomil Gold. The leaves and stems of five 2-month-old Bell Tower and AZ9 plants were treated four times (with a 7-day interval between treatments) with Actigard (75 Fg a.i./ml). When the last treatment of Actigard was administered, another set of five plants of each pepper cultivar were treated with Ridomil Gold, as described earlier. At 1 and 5 weeks after the last treatment, stems of plants were inoculated with *P. capsici*. Plants were maintained in the greenhouse for 2 weeks, then rated for disease severity by measuring the length of the canker at the inoculation site. This experiment was performed twice.

The third series of experiments were focused on disease development in naturally infested soil. Two-month-old chile pepper plants (Anaheim TMR-23) were purchased from a commercial nursery for these experiments. The stems and leaves of plants were treated three times (with approximately a 10-day interval between treatments) with Actigard (75 Fg a.i./ml). A clay-loam soil was collected from a field containing chile pepper plants with symptoms of Phytophthora root and crown rot. Between the second and third application of Actigard, these pepper seedlings were transplanted into 10-cm-diameter x 10-cm-deep plastic pots containing the field soil. A set of pepper plants not receiving Actigard

were treated with Ridomil Gold (100 Fg a.i./ml) by drenching the soil in each pot with 200 ml of fungicide solution. Control plants were treated with water only. An additional control treatment was established by planting seedlings in field soil that had been heat-sterilized (121°C, 60 min). Peppers were maintained in the greenhouse for 2 months with one set of plants receiving irrigation water daily and the other set of plants watered daily and the soil flooded for 48 hr every 2 weeks. Flooding was accomplished by placing the plastic pot containing a pepper plant into a slightly larger container, filling the container with water and maintaining the water in the container for 48 hr. Each treatment contained 10 replicate plants. During the course of the experiment, the date when plants wilted permanently due to development of Phytophthora root and crown rot was recorded. The experiment was terminated after 60 to 63 days, when the fresh weight of pepper plant shoots was measured. Infection by *P. capsici* was confirmed by isolating the pathogen from infected plants. This experiment was conducted three times. The protocol of the third trial of the experiment differed from the preceding trials in the following aspects: i) chile pepper seedlings were planted in infested soil 2 days after the third application of Actigard; ii) inclusion of an additional treatment consisting of three applications of Actigard (75 Fg a.i./ml) before transplanting into infested soil and one application of Ridomil Gold (100 Fg a.i./ml) on the day of transplanting; iii) termination of the experiment after 103 days.

## Results and Discussion

Inhibition of stem canker expansion on Bell Tower and AZ9 pepper plants after four treatments with Actigard was significantly greater than on plants treated once with the chemical and was not significantly different from peppers treated once with Ridomil Gold (Table 1). Reduction of stem canker expansion on Bell Tower and AZ9 ranged from 93.2 to 97.2% and 87.4 to 92.4% when plants were inoculated with *P. capsici* at 1 or 5 weeks, respectively, following the fourth application of Actigard (Table 2).

Survival of Anaheim TMR-23 chile pepper plants treated three times with Actigard and grown in field soil naturally infested with *P. capsici* was significantly greater than nontreated plants in all three trials when watered daily and in two of three trials when flooded for 48 hr every 2 weeks (Table 3). When the soil was flooded every 2 weeks, establishing conditions highly favorable for disease development, plants treated once with Ridomil Gold survived significantly longer than those plants treated with Actigard. On the other hand, when watered daily without periodic flooding, which established conditions less favorable for disease development, there was no significant difference in plant survival between the two chemicals in two of three trials. Shoot growth on plants treated with Actigard was significantly greater than on nontreated plants in all three trials when watered daily, but was significantly greater in only one of three trials under periodic soil flooding. When soil was flooded periodically, plants receiving three foliar applications of Actigard plus a soil treatment of Ridomil Gold survived significantly longer and produced a greater amount of shoot growth than those treated only with Actigard or Ridomil Gold (Table 3). When irrigated daily, there was no difference in survival among plants treated with Actigard, Ridomil Gold or Actigard + Ridomil Gold; however, shoot growth after treatment with Actigard was greater than that on plants treated with Ridomil Gold or Actigard + Ridomil Gold.

The efficacy of Actigard as a potential chemical management tool for Phytophthora root and crown rot on pepper plants has been demonstrated in these greenhouse studies. Field evaluation of Actigard is needed to determine if the product is efficacious in different pepper production regions where Phytophthora root and crown rot is prevalent. The effect of the compound on the foliar blight phase of the disease was not addressed in these studies; however, a recent field trial in Florida demonstrated the ability of four applications of Actigard to provide significant suppression of Phytophthora blight on bell pepper. The availability of Actigard as a chemical disease management tool, with a different mode of action than Ridomil Gold, could prolong the effectiveness of Ridomil Gold for disease control. However, successful sustainable management of Phytophthora blight on bell and chile peppers will require the implementation of a multifaceted disease management system with chemical inputs as one component.

**Table 1. Reduction in length of stem canker on two pepper cultivars inoculated with *Phytophthora capsici* after treatment with one to four applications of Actigard or one application of Ridomil Gold**

Michael Matheron and Martin Porchas, Yuma Agricultural Center, University of Arizona.

Treatment	Reduction in stem canker length (%) <sup>y</sup>		
	Bell Tower	AZ9	Both cultivars
Actigard: 1 application	57.7 a <sup>z</sup>	69.2 a <sup>z</sup>	63.5 a <sup>z</sup>
Actigard: 2 applications	67.3 a	90.9 b	79.3 b
Actigard: 3 applications	69.9 ab	84.5 b	80.6 b
Actigard: 4 applications	86.1 bc	90.0 b	88.1 bc
Ridomil Gold: 1 application	97.3 c	96.9 b	97.0 c

<sup>y</sup> Percentage reduction of stem canker expansion on plants treated with Actigard or Ridomil Gold compared with nontreated plants.

<sup>z</sup> Each value is the mean of 15 replicate plants from three runs of the experiment. Values in each column followed by a different letter are significantly different ( $P=0.05$ ) according to the Duncan-Waller  $k$ -ratio (LSD) test.

**Table 2. Reduction in length of stem canker one or five weeks after four applications of Actigard or one application of Ridomil Gold on two pepper cultivars inoculated with *Phytophthora capsici***

Treatment	Reduction in stem canker length (%) <sup>x</sup>	
	1 wk <sup>y</sup>	5 wk <sup>y</sup>
Bell Tower		
Actigard	97.2 b <sup>z</sup>	92.4 ab <sup>z</sup>
Ridomil Gold	100.0 b	95.9 b
AZ 9		
Actigard	93.2 a	87.4 a
Ridomil Gold	97.8 b	97.6 b

<sup>x</sup> Percentage reduction of stem canker expansion on plants treated four times with Actigard or once with Ridomil Gold compared to that on nontreated plants.

<sup>y</sup> Weeks after last treatment.

<sup>z</sup> Each value is the mean of 10 replicate plants from two runs of the experiment. Values in each column followed by a different letter are significantly different ( $P=0.05$ ) according to the Duncan-Waller  $k$ -ratio (LSD) test.

**Table 3. Effect of Actigard and Ridomil Gold on chile pepper plant survival and shoot weight under two soil moisture regimes for plants grown in soil naturally infested with *Phytophthora capsici***

Treatment <sup>x</sup>	Duration of plant survival <sup>y</sup>			Fresh weight of shoots (g)		
	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
<b>Plants flooded for 48 hours every 2 weeks</b>						
Nonsterile soil	9 a <sup>z</sup>	9 a	33 a	1.0 a	1.8 a	3.3 a
Actigard <sup>x</sup>	25 b	28 b	50 a	7.1 b	4.0 a	6.2 a
Ridomil Gold	40 c	60 c	81 b	2.7 a	16.5 bc	15.5 b
Actigard + Ridomil Gold	-----	-----	101 c	-----	-----	30.2 c
Sterilized soil	63 d	60 c	103 c	16.0 d	20.4 d	30.2 c
<b>Plants watered daily</b>						
Nonsterile soil	17 ab	22 b	42 a	3.4 a	3.5 a	6.8 a
Actigard <sup>x</sup>	44 c	54 c	103 c	11.9 c	15.4 b	41.2 d
Ridomil Gold	57 d	60 c	84 bc	8.1 b	19.7 cd	16.6 b
Actigard + Ridomil Gold	-----	-----	103 c	-----	-----	31.9 c
Sterilized soil	63 d	60 c	103 c	15.7 d	19.4 cd	21.9 b

x Plants were treated three times by applying Actigard to the foliage and stems of plants. For trials 1 and 2, plants were transplanted into soil naturally infested with *P. capsici* between the second and third application of the compound. For trial 3, plants were transplanted into the infested soil 2 days after the third application of Actigard. For the combined Actigard + Ridomil Gold treatment in trial 3 as well as the Ridomil treatment in all three trials, the product was applied as a soil drench on the day of transplanting into infested soil.

y Each value represents the average elapsed time in days from initiation of the experiment to death of plants. Plants were considered dead when leaves wilted permanently. Trials 1, 2 and 3 were terminated after 63, 60 and 103 days, respectively.

z Each value is the mean of 10 replicate plants. Values in each column followed by a different letter are significantly different ( $P=0.05$ ) according to the Duncan-Waller *k*-ratio (LSD) test.