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Project Title: Evaluation of Fungicides for the Control of Gray and White Mold in Snap Beans

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Background and Justification: Cancellation of the registration of an effective bean mold fungicide, Ronilan, occurred at the end of the 2005 growing season. Finding equivalent alternatives for use in snap bean is critical. The goal of the project is to continue evaluations of alternative fungicides for their effectiveness in controlling white mold (*Sclerotinia sclerotiorum*) and gray mold (*Botrytis cinerea*) on snap bean.

Effective registered fungicides for control of bean mold include Endura (boscalid), Topsin (thiophanate-methyl), and Rovral (iprodione) (Table 1). Topsin controls white mold well but has little effect on gray mold because many gray mold strains are resistant to these fungicides. Rovral controls gray mold but has been perceived to be inferior to Ronilan in controlling white mold but this may be due to more limited application timing. Endura (boscalid) is a relatively new chemistry in snap bean production but has single mode of action for controlling mold diseases, thusly, is prone to development of resistance. Unlike Ronilan, Topsin, Rovral, and Endura are all lacking in curative problems. If Topsin, Rovral, or Endura are used after infection has occurred, these fungicides would appear ineffective or less effective. Thus timing of application is critical for preventing infection of blossoms that lead to bean pod and stem infections.

Two biological products are also labeled for snap bean, Contans (*Coniothyrium minitans*) and Serenade (*Bacillus subtilis*). The microbe in Contans parasitizes sclerotia of *Sclerotinia sclerotiorum* but efficacy requires physical contact between Contans and sclerotia as Contans will not move or grow towards sclerotia. Contans requires two to three months with soil temperatures between 40 and 77 F to be effective at parasitizing sclerotia. Published reports indicate that Contans can reduce the population of sclerotia in soil but protective fungicides are still needed on snap bean. Serenade has some efficacy as a protective fungicide but may be best as a tank-mix partner. Fungicides not registered on snap bean but that hold promise for bean mold management include Omega, Switch, and other experimental products. Further study of the non-registered alternative fungicides is necessary to expedite registrations.

Selected products used in McReynolds' trials during 2000-2002 demonstrated effectiveness against both white and gray molds but efficacy was not always equal to that of Ronilan. In 2000, Endura and Omega (fluazinam) applications both resulted in good control of white mold and gray mold on bean pods but whole plant ratings were more severe than that found with Ronilan. In 2001, white mold and gray mold levels on bean pods from plots treated with Endura, Omega, and Switch (cyprodinil + fludioxonil) all were statistically comparable to the Ronilan treatment but these alternative fungicides all had a greater incidence of white mold on pods than that found with Ronilan. The 2002 studies had very little disease, probably due to the drier conditions in the Willamette Valley. Two field studies conducted during 2004 showed that Endura combined with certain surfactants controlled white mold and percentage of pods infected were similar to that found in Ronilan treatments while very little gray mold was found in either trial.

Studies conducted during 2005 in replicated small plots showed that a tank-mix of higher rates of Rovral with Topsin controlled white mold and control of both white and gray mold is expected. A half-rate (of labeled rate) of Rovral combined with a half-rate of Topsin may be adequate under moderate disease pressure but further research is warranted. A tank-mix of Endura with Topsin or application of Endura after Topsin + Rovral should also control both white and gray mold. Microthiol Disperss is labeled for use on snap bean to control leaf spot and powdery mildew. Our studies showed that two applications of Microthiol Disperss with Topsin + Rovral resulted in good control of white mold. However, if temperatures exceed 90 F within 3 days after application of Microthiol Disperss, crop injury may occur. These results from our 2005 field studies are encouraging for snap bean mold management in the absence of Ronilan.

Objective: The purpose of this proposed research was to evaluate and compare performance of registered fungicides (Topsin, Rovral, Endura, Switch, and Serenade) and non-registered materials in reducing white mold and grey mold in snap bean field studies. Spray timing as well as fungicide rates were also be examined.

Procedures: Four field trials were established in the Willamette Valley using the snap bean variety 91G. One trial was conducted in a commercial field (Dickman's Farm), another was located at the OSU Horticultural Research Farm in Corvallis, and two were on the OSU Botany Farm. Bean plots on the OSU Botany Farm were infested with sclerotia of *Sclerotinia sclerotiorum*; field 1 was planted with sunflowers during 2005 and heads were successfully inoculated with white mold during 2005, field 2 was infested with sclerotia produced in the lab during the winter of 2005-06 and sclerotia were spread in the field after a conditioning period. The site located on the OSU Vegetable Farm was in Chehalis silt loam soil and the site was on the commercial farm in Marion County (Dickman's Farm) was in Dayton silt loam soil. The sites on the OSU Botany Farm were in Chehalis silt loam soil. Plots were 5' by 20' and were arranged in a randomized complete block design with four replications. The OSU Vegetable Farm field was planted on 26 June 2006 using a 30-in row spacing (190,000 seeds/A) and 433 lb of 12-19-10 fertilizer was banded at planting followed by 30 lb N/A as urea banded at the second to third trifoliolate leaf stage. Dual Magnum (0.98 lbs ai/A) and Cobra (0.156 lb ai/A) were used for weed control, followed by cultivation at the second trifoliolate leaf stage and hand weeding. The on-farm site was planted 29 June using a 20-in row spacing (206,000 seeds/A) and a preplant broadcast of 14 lb/A urea and 98 lb/A muriate of potash was applied. Then a planter sidedress of 30 gal/A of 10-34-0 fertilizer and 6 gal/A of thiosul, and a broadcast of 150 lb/A ammonium sulfate was applied 4 weeks after planting. Eptek 7EC (3.5 pt/A) and Trust (0.5

pt/A) were broadcast and incorporated with a tiller 4 days before planting, and Basagran (2 pt/A) and Poast (2 pt/A) were broadcast 24 days after planting for weed control. The OSU Botany Farm fields were planted on 28 June and 5 July using a 30-in row spacing (190,000 seeds/A) and 400 lb/A of 12-29-10-8 fertilizer was banded at planting followed by 100 lb/A of 40-0-0-6 banded at the second to third trifoliolate leaf stage. For weed control, Eptek 7EC (3.5 pt/A) and Trifluorolin (0.5 pt/A) were broadcast and incorporated 4 days before planting; Basagran (2 pt/A) and Poast (2 pt/A) were applied 24 days after planting. Asana XL (8 oz/A) was applied one week after 10 % bloom for control of beetles.

All fields were sprinkler-irrigated weekly with 1" to 1.5" of water. Fungicide treatments (Table 1) were applied with a CO_2 backpack sprayer calibrated to deliver 22 gal of water/A at 38-40 psi using three 8002 flat fan nozzles. The dates and weather conditions of the 10% bloom applications and 100% bloom applications are shown in Table 2. Phytotoxicity ratings were made 7 days after application.

Table 1. Bean mold fungicide programs evaluated during 2006 in replicated small plot trials

Timing	Treatment & rate/A
	nontreated
10 % bloom, repeat application 7 days later	Endura (8 oz) + MSO 100 (2 qt/100 gal)
10 % bloom, repeat application 7 days later	Rovral 4F (1.5 pt) + MSO 100 (2 qt/100 gal)
10 % bloom, repeat application 7 days later	Topsin 4.5FL (30 fl oz)
10 % bloom, repeat application 7 days later	Switch 62.5WG (11 oz)
10 % bloom, repeat application 7 days later	Rovral 4F (1.5 pt) + Topsin 4.5FL (20 fl oz) + MSO 100 (2 qt/100 gal)
10 % bloom	Rovral 4F (2 pt) + Topsin 4.5FL (40 fl oz) + MSO 100 (2 qt/100 gal)
100 % bloom	Rovral 4F (2 pt) + Topsin 4.5FL (40 fl oz) + MSO 100 (2 qt/100 gal)
10 % bloom, repeat application 7 days later	Endura (5 oz) + Topsin 4.5FL (20 fl oz) + MSO 100 (2 qt/100 gal)
10 % bloom, repeat application 7 days later	Switch 62.5WG (6 oz) + Topsin 4.5FL (20 fl oz)
10 % bloom	Switch 62.5WG (6 oz) + Topsin 4.5FL (20 fl oz)
10 % bloom, second application 7 days later	Rovral 4F (1.5 pt) + Topsin 4.5FL (20 fl oz) + MSO 100 (2 qt/100 gal) followed by Endura (8 oz) + MSO 100 (2 qt/100 gal)
10 % bloom, repeat application 7 days later	Rovral 4F (1.5 pt) + Topsin 4.5FL (20 fl oz) + Microthiol Disperss (6 lb) + MSO 100 (2 qt/100 gal)
10 % bloom	Rovral 4F (2 pt) + Topsin 4.5FL (40 fl oz) + Microthiol Disperss (6 lb) + MSO 100 (2 qt/100 gal)
100 % bloom	Rovral 4F (2 pt) + Topsin 4.5FL (40 fl oz) + Microthiol Disperss (6 lb) + MSO 100 (2 qt/100 gal)
10 % bloom, repeat application 7 days later	Serenade MAX (1 lb) + Topsin 4.5FL (35.7 fl oz) + Break-Thru (2 oz/100 gal)
10 % bloom, repeat application 7 days later	Serenade MAX (1 lb) + Rovral 4F (1.5 pt) + Break-Thru (2 oz/100 gal)
10 % bloom, repeat application 7 days later	Serenade MAX^{O} (1 lb) + Kumulus DF^{O} (7 lb)
10 % bloom, repeat application 7 days later	Omega 500F (4 fl oz) *
10 % bloom, repeat application 7 days later	Proline (Jau 6476) at 5.7 oz + Induce at 0.125 v/v *

Table 2. Dates and conditions of 2006 bean mold fungicide applications and hand-harvest date

Site	Crop Stage	Spray Date	Time	Temp (F)	% relative humidity	Wind speed (mph)	Harvest Date
Dickman's Farm	R1	7 Aug	12:30 PM	89	45	2.2	28 Aug
	R2	14 Aug	11:30 AM	78	46	1.5	
Veg farm	R1	8 Aug	2:40 PM	80	51	2.5	29 Aug
	R2	15 Aug	1:30 PM	71	51	4	
OSU Botany Farm (Field 1)	R1	9 Aug	10:10 AM	76	55	1	31 Aug
	R2	16 Aug	11:00 AM	65	55	2	
OSU Botany Farm (Field 2)	R1	15 Aug	10:00 AM	67	65	1.2	5 Sep
	R2	22 Aug	10:30 AM	66	72	2	

The number of pods, presence of white or gray mold on pods $\geq$ 2 inches in length, and number of stems with white or gray mold were determined for 30 individual plants selected arbitrarily from each plot. Means were calculated on the % pods or stem number affected per plant. Treatments were compared with Tukey's W statistic (P=0.05). The weights of healthy and moldy bean pods were calculated for nontreated plots on OSU experimental farms if mold was detected in order to determine the percentage of yield loss.

Results: Very low levels of white or gray mold were found at all locations. Disease was most probably inhibited by the higher temperatures that occurred during bloom and pod set of 2006; somewhere between 82 and 86 F limits white mold development. Hotter daily mean temperature occurred during the latter half of August 2006 compared to 2005 (Fig. 1), which was a critical time for disease development in our plots.

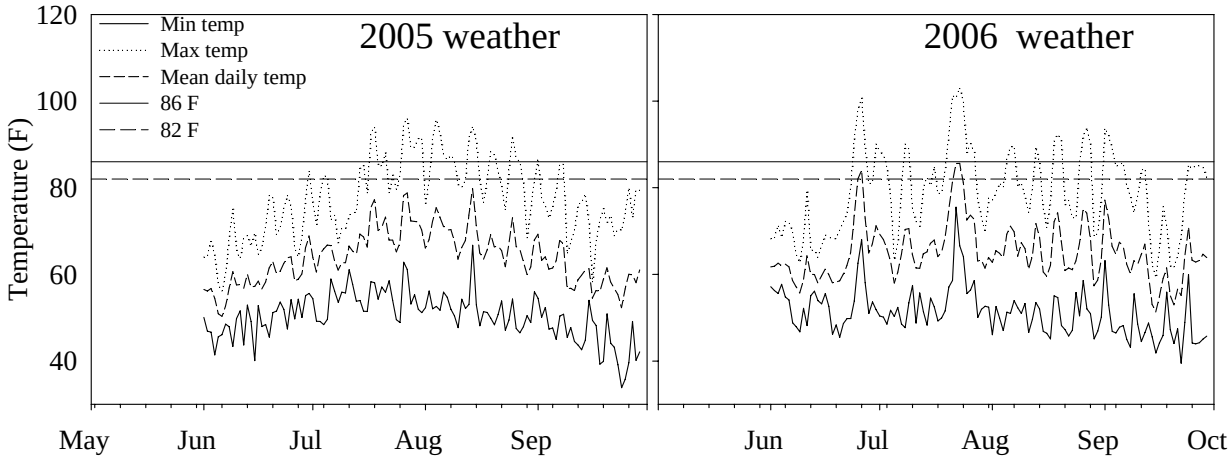

Figure 1. Daily minimum, maximum, and mean temperature at BPP farm during 2005 and 2006

When treatment means were calculated per plot (plants were sub-samples), there were no significant differences among the treatments; generally only the nontreated and Rovral+Topsin 2-spray program were sampled since disease levels were so low (Table 3). The level of bean mold infection (% yield loss), based on either wt/wt or pod#/pod#, was less than 1%. The number of healthy pods, weight of pod yield, and average weight per pod did not appear to be affected by the applications of Topsin+Rovral tank mix. The total number of bean pods per plot

was lowest in the Veg Farm site and highest at Dickman's Farm, while the two Botany Farm sites were in-between.

When treatment means were calculated on a per-plant basis (Table 4), significant differences were found at the Veg Farm site in the number of healthy pods per plant as well as white mold levels; however, these differences are of little practical value because disease levels were still extremely low with 1.4 % of pods affected with white mold based on number of pods $\geq$ 2 inches. The percent of pods and pin beans affected with white mold was slightly higher at Dickman's Farm compared to the nontreated plants, but again disease levels were extremely low, well below 1%. The number of bean pods per plant was lowest in the Veg Farm site and highest at Dickman's Farm, while the two Botany Farm sites were in-between.

Conclusions: Sclerotia of white mold germinate and produce a small fruiting structure which releases millions of spores into the air. Under moist conditions, spores may infect senescent tissue such as blossoms. After colonizing blossoms or senescing leaves, the white mold fungus can invade any healthy plant part it contacts. So, to protect developing bean pods, pods must be protected from contact with infected blossoms. Oregon growers must manage more closely for bean mold because the currently registered materials lack the kick-back activity associated with Ronilan, thus timing of applications is important.

Our studies during 2006 at all locations did not have sufficient mold levels for comparing fungicides, levels of active ingredients, or application timing. Our studies during 2005 did show that a tank-mix of Rovral with Topsin controlled white mold and control of both white and gray mold would be expected. The full labeled rate of each material in the combination will give good mold control. Tank mixtures with Rovral (1.3 pt) combined with Topsin (20 fl oz) **in a two-spray program** may be adequate under **moderate disease pressure** but further research is warranted. A tank-mix of Endura with Topsin or application of Endura after Topsin + Rovral should also control both white and gray mold. The full labeled rate of each material in the combination will give good control of white mold. Mixtures with as little as a 5 oz of Endura combined with Topsin (20 fl oz) should be adequate under **moderate disease pressure**, but again further research is warranted. The results from our 2005 field studies are encouraging for snap bean mold management in the absence of Ronilan.

Bean mold appeared to be an economic problem in a few snap bean fields during the early part of the 2006 season. From what I can decipher about these affected fields, there was (1) a delay in the application of first spray (if there are pin beans – it's too late); or (2) use of a low rate in a one-spray program. Our 2005 data suggest that Rovral 4F (1.3 pt) + Topsin 4.5FL (20 fl oz) in a one spray program or Rovral 4F (1.3 pt) + Topsin 4.5FL (15 fl oz) in a two-spray program are not very effective under higher disease pressure. Thirdly, sometimes the field was held too long after the second fungicide application. Finally, it seems that some snap bean loads were rejected most years, even while Ronilan was registered on snap bean.

Table 3. Mean pod number and disease incidence per plot (treatment) from 2006 snap bean mold trials

Veg Farm -- Treatment & rate/A	Timing	* Healthy pod #	* Yield (g)	* Wt (g) per healthy pod	* Moldy pod #	* Wt. of diseased pods (g)	% mold loss (wt/wt)
nontreated		283 A	1343 A	4.8 A	4.0 A	11.9 A	0.9
Rovral 4F (1.5 pt) + Topsin 4.5FL (20 fl oz) + MSO 100 (2 qt/100 gal)	10 % bloom, repeat application 7 days later	375 A	1481 A	3.9 A	2.3 A	4.1 A	0.3
Rovral 4F (1.5 pt) + Topsin 4.5FL (20 fl oz) + MSO 100 (2 qt/100 gal) followed by Endura (8 oz) + MSO 100 (2 qt/100 gal)	10 % bloom, second application 7 days later	334 A	1336 A	4.1 A	0.8 A	9.6 A	0.7

Dickman's Farm -- Treatment & rate/A	Timing	* Healthy pod #	* Moldy pod #	% mold loss (pod#/pod#)
nontreated		512 A	1.0 A	0.2
Rovral 4F (1.5 pt) + Topsin 4.5FL (20 fl oz) + MSO 100 (2 qt/100 gal)	10 % bloom, repeat application 7 days later	507 A	0.8 A	0.1

BPP Farm field 1 -- Treatment & rate/A	Timing	* Healthy pod #	* Yield (g)	* Wt (g) per healthy pod	* Moldy pod #	* Wt. of diseased pods (g)	% mold loss (wt/wt)
nontreated		424 A	1958 A	4.8 A	0.5 A	3.1 A	0.2
Rovral 4F (1.5 pt) + Topsin 4.5FL (20 fl oz) + MSO 100 (2 qt/100 gal)	10 % bloom, repeat application 7 days later	402 A	1668 A	4.2 A	0 A	0 A	0
Rovral 4F (1.5 pt) + Topsin 4.5FL (20 fl oz) + MSO 100 (2 qt/100 gal) followed by Endura (8 oz) + MSO 100 (2 qt/100 gal)	10 % bloom, second application 7 days later	417 A	1942 A	4.7 A	0 A	0 A	0

BPP Farm field 2	Healthy pod #	Wt (g) per healthy pod	Moldy pod #	% mold loss (wt/wt)
nontreated	460		0	0

* Means are based on the pod number, % pods, or stem number per plot. Thirty plants were evaluated from each plot and there were four replicate plots per treatment. For each location, column numbers followed by the same letter are not significantly different at P=0.05 as determined by Tukey's multiple range test.

Table 4. Mean pod number and disease incidence per plant from 2006 snap bean mold trials

Veg Farm -- Treatment & rate/A	Timing	* Healthy pod #	* Pod # (healthy & diseased)	* % pods with white mold	* % pods and pin beans with white mold	* Stem # with white mold	* % pods with gray mold	* % pods and pin beans with gray mold	* Stem # with gray mold
nontreated		9 B	10 B	1.4 A	1.5 A	0.19 A	0 A	0 A	0.01 A
Rovral 4F (1.5 pt) + Topsin 4.5FL (20 fl oz) + MSO 100 (2 qt/100 gal)	10 % bloom, repeat application 7 days later	12 A	13 A	0.1 B	0.1 B	0 B	0 A	0 A	0 A
Rovral 4F (1.5 pt) + Topsin 4.5FL (20 fl oz) + MSO 100 (2 qt/100 gal) followed by Endura (8 oz) + MSO 100 (2 qt/100 gal)	10 % bloom, second application 7 days later	11 A	11 AB	0.1 B	0.4 B	0.01 B	0 A	0 A	0 A

Dickman's Farm -- Treatment & rate/A	Timing	* Healthy pod #	* Pod # (healthy & diseased)	* % pods with white mold	* % pods and pin beans with white mold	* Stem # with white mold	* % pods with gray mold	* % pods and pin beans with gray mold	* Stem # with gray mold
nontreated		17 A	18 A	0.1 A	0.2 A	0.1 A	0.1 A	0.2 A	0.1 A
Rovral 4F (1.5 pt) + Topsin 4.5FL (20 fl oz) + MSO 100 (2 qt/100 gal)	10 % bloom, repeat application 7 days later	17 A	17 A	0.0 A	0.0 B	0.0 A	0.1 A	0.1 A	0.0 A

BPP Farm field 1 -- Treatment & rate/A	Timing	* Healthy pod #	* Pod # (healthy & diseased)	* % pods with white mold	* % pods and pin beans with white mold	* Stem # with white mold	* % pods with gray mold	* % pods and pin beans with gray mold	* Stem # with gray mold
nontreated		14 A	14 A	0 A	0 A	0.05 A	0.1 A	0.1 A	0.02 A
Rovral 4F (1.5 pt) + Topsin 4.5FL (20 fl oz) + MSO 100 (2 qt/100 gal)	10 % bloom, repeat application 7 days later	13 A	13 A	0 A	0 A	0 A	0 A	0 A	0 A
Rovral 4F (1.5 pt) + Topsin 4.5FL (20 fl oz) + MSO 100 (2 qt/100 gal) followed by Endura (8 oz) + MSO 100 (2 qt/100 gal)	10 % bloom, second application 7 days later	14 A	14 A	0 A	0 A	0 A	0 A	0 A	0 A

BPP Farm field 2	Timing	Healthy pod #	Pod # (healthy & diseased)	% pods with white mold	% pods and pin beans with white mold	Stem # with white mold	% pods with gray mold	% pods and pin beans with gray mold	Stem # with gray mold
nontreated		15	15	0	0	0	0	0	0

* Means are based on the pod number, % pods, or stem number per plant. Thirty plants were evaluated from each plot and there were four replicate plots per treatment. For each location, column numbers followed by the same letter are not significantly different at P=0.05 as determined by Tukey's multiple range test.