REPORT TO THE AGRICULTURAL RESEARCH FOUNDATION FOR THE OREGON PROCESSED VEGETABLE COMMISSION
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Project Title: Evaluation of Fungicides for the Control of Gray and White Mold in Snap Beans

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Is there any avenue to maintain Ronilan?

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Background and Justification: Cancellation of the registration of the fungicide, Ronilan, is slated to occur in 2005. Finding effective alternatives before that date for use in snap bean is critical. The goal of the project is to evaluate alternative fungicides for their effectiveness in controlling Gray Mold (*Botrytis cinerea*) and White Mold (*Sclerotinia sclerotiorum*) on snap bean using Ronilan as the industry standard.

Selected products used in the 2000-02 trials demonstrated effectiveness against both white and gray molds but efficacy was not always equal to that of Ronilan. In 2000, Boscalid (Endura) and Fluazinam (Omega) 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 Boscalid, Fluazinam, and Cyprodinil + Fludioxonil (Switch) 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.

Candidate fungicides that hold promise include Endura, Omega, and Switch. Endura has been registered on snap bean and the product will be available for the 2004-growing season. Omega is a registration objective of Syngenta and is supported by the IR-4 Project. Combining these materials with adjuvants could improve their efficacy. Use of adjuvants on the effectiveness of these alternatives needs study as well as further study of these alternative fungicides is necessary to expedite registrations.

Objective: The purpose of this research was to verify fungicide performance observed in previous years as well as to examine currently-registered Boscalid (Endura) in combination with adjuvants to see if Endura efficacy could be improved.

Procedures: Two randomized complete block field trials were established in the Willamette Valley - using the snap bean varieties 'Savannah' and '91G'. Plot size was 5' by 20' and each site included four replications. One trial was conducted in a commercial field with the 'Savannah' variety and the other with '91G' was located at the OSU Horticultural Research Farm in Corvallis. The fungicides and rates used are listed in Table 1. Due to design limitations, the commercial field site did not include Omega, Stylgard309, or Ronilan combined with Endura. Treatments in the Veg. Farm plot were applied with a CO_2 backpack sprayer by B. McReynolds on 19 Aug 2004 at full bloom to 2" pods. Two applications were done at the commercial site; the first spray application was done on 19 Aug 2004 at 10-30 % bloom and the second was on 1 Sep 2004 at full bloom to 3"pods. Phytotoxicity ratings made 7 days after first application and 24 hours after second application. Treatment efficacy comparisons were done by stripping pods at least 2 inches in length from 10-15 plants from each plot at each site. Pod counts, pod weights, and presence of mold were determined by B. McReynolds and C. Ocamb.

Table 1. Fungicides examined for mold control in snap bean during 2004

Material(s)	Spreader/Sticker/Surfactant	Chemistry
Endura (11 oz/A)		Boscalid
Omega 500F (8.8 fl oz/A)		Fluazinam
Ronilan EG (1 lb/A)		Vinclozolin
Endura (11 oz/A) +	MSO 100 (2 qt/100 gal)	methylated seed oil
Endura (11 oz/A) +	Stylgard309 (1.5 pt/100 gal)	silicone surfactant mixture
Endura (11 oz/A) +	First Choice Crop Oil concentrate (1 qt/A)	Paraffin-based
Endura (11 oz/A) +	Breakthrough (8 oz/100 gal)	100% organo polymethylsiloxane, non-ionic
Endura (11 oz/A) +	Latron B1956 (4 oz/100 gal)	commonly used non-ionic surfactant
Endura (11 oz/A) +	A Plus Spreader, (1/2 pt/100 gal)	non-ionic surfactant containing glycols and dimethlysiloxane
Endura (11 oz/A) +	First Choice 4440 spreader/sticker (1/2 pt/100 gal)	cottonseed oil, alkylphenoxy polyethoxy ethanols, and IPA
Endura (11 oz/A) +	Prev-AM (1%)	cold pressed orange oil and borax
Ronilan (0.5 lb/A) + Endura (11 oz/A)		
Nontreated		

Results: No phytotoxicity effects were readily observed in the treatments tested, a slight necrosis of a few leaflets was observed with the combination of Endura and First Choice Crop Oil but it was only observed on less than 1% of the treated leaflets seven days after application. There were differences in disease incidence between the two study sites so data are presented separately. Disease incidence and yield on the OSU Veg. Farm are presented in Table 2 below and within each column, labeled an asterisk (*) are significantly different (P=0.05) according to a T-test statistic from the treatment mean(s) prefaced with an asterisk and in **bolded** font. Plants in nontreated plots were found to have close to 6 % white mold pod infection. Most of the fungicide/adjuvant combinations evaluated resulted in significantly lower mean percentage of white mold pod infection relative to the nontreated plants. Gray mold disease levels were much

lower than those found for white mold, averaging less than 0.3 % pod infection and no significant treatment effects were observed.

Slight differences in yield parameters were detected among treatments in the OSU Veg. Farm bean mold trial (Table 2). When plants were treated with Endura combined with First Choice 4440, Latron, or Prev-AM, significantly greater pod numbers were produced compared to the Ronilan standard. Average pod weight per plant was significantly higher in the Omega, Endura/First Choice 4440, and Endura/Prev-AM treatments compared to the Ronilan standard.

Mold levels were low in the plots on the commercial farm. Disease incidence and yield of this study site are presented in Table 3 below and within each column, means labeled an asterisk (*) are significantly different (P=0.05) according to a T-test statistic from the treatment mean(s) prefaced with an asterisk and in **bolded** font. The greatest white mold pod infection number was detected in the Endura/Prev-AM treatment and Ronilan or Endura combined with A Plus, First Choice Crop Oil, or Latron resulted in significantly fewer white mold pod infections compared to the Endura/Prev-AM treatment. Nontreated plots were found to have the greatest number of gray mold pod infections and five of the Endura/adjuvant combinations resulted in significantly lower gray mold levels.

Slight differences in yield parameters were detected among treatments at the commercial farm site. Endura combined with A Plus or First Choice 4440 also had significantly greater pod numbers compared to the nontreated plots. In addition, all the fungicide applications, with the exception of Latron and Prev-AM, resulted in significantly greater pod numbers compared to the Endura/MSO100-treated plots. Average pod weight per plant was significantly higher in the Endura/A Plus, Endura/Breakthrough, and Endura/First Choice 4440 treatments compared to the nontreated plots or plants treated with Endura/MSO100.

Table 2. Results from 2004 '91 G' snap bean mold trial on OSU Veg. Farm

Treatment	Mean % pods with white mold	Mean % pods with gray mold	Mean pod #/plant	Mean pod wt/plant (kg)
Nontreated	***5.93**	0.00	21.10	0.112
Ronilan EG	1.74 *	0.00	***19.43**	***0.096**
Omega 500F	1.99 *	0.00	22.93	0.127 *
Endura	1.84 *	0.00	21.71	0.109
Endura+A Plus Spreader	5.87	0.16	22.70	0.111
Endura+Breakthrough	1.62 *	0.00	22.23	0.114
Endura+First Choice 4440	4.91	0.00	24.37 *	0.125 *
Endura+First Choice Crop Oil	2.67 *	0.16	22.17	0.109
Endura+Latron B1956	2.57 *	0.21	24.90 *	0.119
Endura+MSO 100	0.68 *	0.12	20.35	0.104
Endura+Prev-AM	1.89 *	0.00	23.63 *	0.124 *
Endura+Stylgard309	2.15 *	0.00	20.00	0.097
Ronilan (0.5 lb/A) + Endura	2.20 *	0.00	20.50	0.112

Table 3. Results from 2004 'Savannah' snap bean mold trial in a commercial site

Treatment	Mean % pods with white mold	Mean % pods with gray mold	Mean pod #/plant	Mean pod wt/plant (kg)
Nontreated	0.21	***0.64**	***20.28**	***0.053**
Ronilan EG	0.00 *	0.29	24.53	0.065
Endura	0.15	0.29	23.97	0.064
Endura+A Plus Spreader	0.00 *	0.14 *	25.65 *	0.072 *
Endura+Breakthrough	0.08	0.00 *	24.13	0.073 *
Endura+First Choice 4440	0.26	0.27	25.33 *	0.068 *
Endura+First Choice Crop Oil	0.00 *	0.08 *	23.49	0.062
Endura+Latron B1956	0.00 *	0.00 *	22.60	0.068
Endura+MSO 100	0.16	0.00 *	19.08	0.051
Endura+Prev-AM	***0.39**	0.23	21.70	0.060

Conclusions: White molds were quite low and gray mold levels were even lower thus differences in means were not great enough to rank the individual treatments and only pair-wise comparisons could be made. The site on the OSU Veg. Farm had greater levels of white mold but very low gray mold incidence and vice versa for the second site on-farm. However, results from the 2004 studies show that Endura in combination with First Choice Crop Oil or Latron B1956 can reduce white mold pod incidence comparable to Ronilan applications, under the disease pressure in our studies. Other adjuvants included in our studies may also improve efficacy of Endura, which is currently registered on snap bean.

Thiophanate-methyl (Topsin M) controls white mold well but has little effect on gray mold because many gray mold strains are resistant to these fungicides. Rovral (iprodione) controls gray mold but is weak in controlling white mold. Thus these two fungicides, though registered on snap bean, were not included in our studies. The combination of these two fungicides could be examined in the Willamette Valley during 2005 as they may be effective together (though not as effective as Ronilan on gray mold) and less costly than Endura (Shah, Dillard, and Cobb; 2002). The fungus, *Coniothyrium minitans*, is a parasite of sclerotia of *Sclerotinia sclerotiorum* (causal agent of white mold) and is sold as the product Intercept or Contans. Because the biocontrol fungus needs in this product to be applied 3-4 months before disease onset and is negatively affected by temperatures greater than 86 F, it is necessary to make fall applications of *Coniothyrium minitans* in the Willamette Valley. It is applied by spraying on the soil surface and then incorporated in the upper two inches soil with a disc, rotary hoe, or similar equipment. Effectiveness of Intercept depends on the mycoparasite in the product coming in contact with the pathogen's sclerotia in the soil and thusly, is dependent on good incorporation in the upper soil layer. Survival of only a few sclerotia is all that is necessary to cause serious disease in a field. But Intercept offers a way to reduce populations of sclerotia and it can be used in organic agriculture. Use of atrazine and lactofen is associated with reduced white mold levels of soybean (Dunn, Diers, and Hammerschmidt; 1999) but the beneficial lactofen (Cobra) effect on soybean was only observed under high disease pressure, not in sites of low-medium pressure where seed yield was adversely affected.

Crop rotation is of use in both organic and convention agricultural production. Rotation with cereals and corn for at least 2 years between bean crops can help reduce gray mold levels but most other plants are susceptible to the white mold fungus, including pea, lettuce, carrot, cabbage, parsnip, potato, sunflower, radish, other crucifers, and cucurbits. In addition, spores from neighboring fields can be blown in so rotation effects are important but limited. However, it is important to recognize that crop rotation may be important for other diseases which affect snap bean.

Wet, cool conditions are the primary environmental conditions that promote development of both gray and white mold. Midwestern soybean studies showed that warmer than normal summer temperatures were associated with less white mold disease, while cooler than normal summer temperatures were associated with more prevalent white mold in soybean (Workneh and Yang; 2000). While rainfall was reduced during the spring and early summer of 2004, perhaps the warmer summer temperatures experienced in the Willamette Valley from 2002 through 2004 resulted in reduced bean mold disease. Plant canopy density is also strongly associated with disease development, and will influence temperature and moisture parameters within a bean field. Canopy density is modulated by row spacing or planting density, shoot architecture, and soil fertility. In addition to close plant spacing, irrigation practices that keep plants wet for a longer time favor the disease. More erect/open plants, more open plant spacing, or row orientation towards the direction of prevailing winds can all reduce the duration of moisture after irrigation or rainfall, thus reducing levels of both white and gray mold. More open plant canopies or plant spacing would also facilitate fungicide deposition on bean plants. Because blossoms are the primary site of infection, both mold fungi invade senescing tissues before colonizing other tissues like stems or pods, blossom production in the top of the plant may result in lower disease levels because of decreased moisture levels at the top of the plant or improved fungicide coverage.

There are certainly both long-term and short term goals in management of white and gray mold on snap bean. The emergency registration of Ronilan during the 1980's and early 90's was driven by the yield losses in snap bean. The use of Ronilan has allowed snap bean growers to decrease row spacing and potentially have less concern with irrigation or other management strategies. But with the removal of snap bean from the Ronilan label, there is a need for a replacement of Ronilan with more dependable effectiveness than that currently achieved with Endura or the other registered products. An unless an equally effective fungicide(s) is found, management of white and gray mold on snap bean will require Willamette Valley growers to pay greater heed to cultural practices that affect disease development and depend less on a single solution for the control of both diseases. There are unregistered chemical options that can be evaluated in future trials. Application timing of Endura with the addition of selected adjuvants may also enhance the effectiveness of this newly registered product. It may also be prudent to re-examine the effectiveness of combinations of the older, registered chemistries.