

REPORT TO THE OREGON PROCESSED VEGETABLE COMMISSION: 2011

Title: Impact of biological control, oat cover crops and resistant germplasm on white mold of bean and root rot of corn.

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SUMMARY:

Contans Experiment:

One low rate (1.5 lbs/A) post-harvest Contans treatment destroyed 95% of the white mold sclerotia generated on a diseased bean crop over a two year period; there were more than 4 times more viable sclerotia after two years in the Contans treatment (5% of the original number of sclerotia) than in the control (22% of the original number of sclerotia).

In 2010, beans grown in the Contans treatment fields had significantly lower pod and foliar disease severity than those grown in the control treatment fields. In 2011, foliar disease severity was 50% lower in the Contans treatment fields than in the control fields (9% vs 18%), but pod disease incidence was higher (17% vs 14% incidence). We do not understand at this time why there was less foliar disease severity in the Contans treated fields but higher pod disease incidence. As was shown in 2010, the moderately resistant cultivar OR-6230 exhibited significantly less foliar and pod disease incidence than 91G.

Cover Crop Experiment:

All cover crop treatments except Monida oat/vetch suppressed radicle and nodal root rot of both varieties at 63 days after incorporation (corn 8 leaf stage). Overall, the single species cover crops were most suppressive, and only the single species cover crops (vetch and both oat varieties) suppressed root rot at 143 days after incorporation (corn harvest).

Vetch and the oat/vetch mixtures mineralized nitrogen immediately after incorporation (pre-plant), with no difference in quantity of N mineralized amongst those treatments. In contrast, both varieties of oat cover crops immobilized N. At the time of the PSNT sampling, mineralizable N in the vetch and oat/vetch treatments was not significantly different from the control, while the oat treatments remained significantly lower than the control (oats continued to immobilize N). Growing oat and vetch in a mixture appears to overcome the immobilization of the oat cover crop.

There were no significant differences in yield of sweet corn. Yield in sweet corn is the result of the collective impact of many variables including root rot severity and nitrogen availability. In this experiment, oat/vetch mixtures supplied more N to the corn crop, but did not in general suppress root rot. In contrast, oat cover crops suppressed root rot but immobilized N. Pure vetch cover crops suppressed root rot and supplied N.

Overall, vetch cover cropping resulted in the largest number of intact and living sclerotia whether on the surface or buried. Cover cropping with oat or oat mixtures numerically reduced sclerotial survival (although only the Walken oat and Walken oat/vetch treatments were significantly different) when compared to the control when the sclerotia were left on the soil

surface. Overall, cover crop treatments significantly increased colonization of sclerotia by other fungi when on the surface or buried.

INTRODUCTION:

White mold (WM, caused by *Sclerotinia sclerotiorum*, *Ss*) is a serious foliar and pod disease of snap beans grown for processing in western Oregon. Fields with > 6% infected bean pods are rejected by the processor, resulting in a complete crop failure. Ronilan (vinclozolin), a highly effective fungicide used through 2005 for the control of both white and gray mold (*Botrytis cinerea*), is no longer available to bean growers.

Topsin/Rovral or Topsin/Endura two-spray tank mix programs effectively control both diseases and growers shifted over to these fungicides in 2006. These fungicide programs are considerably more expensive than single Ronilan applications. Topsin must be applied 14 or more days before harvest (a problem mid-summer when bean development is rapid) and there are concerns about its sole use as *Ss* could develop resistance. Farmers are now seeking lower cost and biologically- and culturally-based WM management strategies that are practical and appropriate in the Willamette Valley.

Biology of white mold

Nearly 400 plant species can be attacked by *Ss*. This pathogen causes a single cycle disease initiated by soilborne survival structures (sclerotia). Sclerotia, which are formed on diseased host tissues, become resistant to decay as they mature and survive in soil for up to 8 years. In beans, new infections occur when sclerotia near the soil surface germinate, typically in response to the moist environment under a dense canopy, to form apothecia. Each apothecium produces millions of ascospores which infect bean flowers; the disease then spreads to stems and pods.

Biological control

Coniothyrium minitans (*Cm*) is a mycoparasite of *Ss* under natural conditions and was recently developed as a commercial product for WM suppression (Contans, www.prophyta.com). *Cm* can penetrate sclerotial tissue in less than 14 days. Infection of a sclerotium can be achieved by a single spore. *Cm* also can infect *Ss* mycelia when colonizing leaf tissue. *Cm* parasitizes sclerotia optimally over a temperature range of 50 - 68 °F (Turner & Tribe, 1976), with little activity occurring at > 80° or < 41 °F.

In this work, *Cm* inoculum was applied to the soil surface after flailing of diseased crop residues. Residues were then left on the soil surface. *Cm* in this scenario has 6 months or more to colonize, infect, and destroy sclerotia. Colonized sclerotia produce pycnidia. If left on the surface, these pycnidia produce conidial droplets under warm, wet conditions. During rain events, these droplets splash and disperse, generating new sclerotial infections. We have shown in previous work that the mild, wet, winter conditions in western Oregon generate a series of *Cm* colonization cycles - a "biological control epidemic" - after low rate Contans applications to surface residues containing white mold sclerotia, and this reduces sclerotial survival.

Integrated management of white mold with biological control and resistant cultivars:

Integrated pest management requires the integration of all available and cost effective control strategies into a 'systems plan' for disease management; overall disease risk is reduced as no single strategy is relied on for disease management. Jim Myers, OSU vegetable breeder, has developed snap bean varieties with moderate resistance to white mold. These varieties may not provide adequate control as a stand-alone white mold management strategy, but could be incorporated into a multi-tactic integrated approach. In this project we investigated the efficacy

of integrating biological control and moderate genetic disease resistance for white mold management in snap bean production.

Root rot of sweet corn

Root rot of sweet corn significantly reduces productivity of processed vegetable rotational systems (Hoinacki et al, 2002). The Stone laboratory screened cover crop species for suppression of corn root rot in processed vegetable production (Darby, 2003; Miyazoe, 2007). Overall, oat was more suppressive than other cover crops such as various mustards, rye, *Phacelia*, and legumes. In container studies, oat cover crops reduced severity of corn root rot by 18 percent on average (Darby, 2003; Darby et al, 2006). In follow-up field studies, oat was the only cover crop that suppressed corn root rot in each of the three years of the study. Suppression of corn root rot with oat cover crops was associated with an increase in corn yield under field conditions in some plantings. In other plantings, while root rot was suppressed, corn yield was unaffected by the oat cover crop treatment due to strong N immobilization by the oat cover crop (Miyazoe, 2007). Vetch grown in mixture with oats can supply N and thereby reduce N immobilization by the oats. It is not currently known if vetch/oat mixtures can correct the problem of N deficiency, while delivering the root rot suppressiveness of a pure oat cover crop.

The two oat cultivars we worked with in past experiments, *Avena strigosa* ‘Saia’ and *Avena sativa* ‘Monida’, were selected because cooperating processed vegetable growers currently grew them and they had been grown in previous OSU field studies. However, these two spring oat cultivars are not reliably winter-hardy here in the Valley. While some farmers choose to plant spring oat cover crops because they want them to winter kill, it isn’t always possible to get them in the ground early enough to achieve sufficient growth before kill and they produce very little biomass. These fall-killed cover crops do not take up mineralized nitrogen over the winter, an important benefit of living winter cover crops. In addition, the residues decompose during the mild, wet winter conditions, in some cases creating weedy, erosion-prone fields. For these reasons, a hardy winter oat cultivar (e.g. Walken) would in some cases be a better choice. The root rot suppressiveness of the winter hardy Walken oat cultivar has not been evaluated. In addition, there is currently no information on whether oat cover crops have any potential to decrease the viability of white mold sclerotia.

OBJECTIVES:

- 1. To evaluate the impact of a low rate Contans application on the following factors, in the second field season following the application:**
 - a) sclerotial survival,**
 - b) sclerotial colonization by *Coniothyrium minitans* and other fungi,**
 - c) disease incidence in plantings of susceptible and moderately resistant bean varieties.**
- 2. To evaluate the impact of Monida and Walken oats, common vetch, and oat/vetch cover crop mixtures on N status and root rot severity of subsequent sweet corn plantings and white mold sclerotial survival.**

MATERIALS AND METHODS:

OBJECTIVE ONE

1. To evaluate the impact of a low rate Contans application on the following factors, in the second field season following the application:

- a) sclerotial survival,**
- b) sclerotial colonization by *Coniothyrium minitans* and other fungi,**
- c) disease incidence in plantings of susceptible and moderately resistant bean varieties.**

Field preparation:

Four bean fields at the OSU Vegetable Research Farm and 4 bean fields at the OSU Lewis Brown farm were planted to 91G snap beans in July 2009, inoculated with white mold using the straw inoculation method, irrigated regularly to develop disease, and flailed at maturity in September, leaving many white mold sclerotia evenly distributed across the soil surface.

Sclerotial management:

Contans (1.5 lbs per acre) was applied to the 4 fields at the vegetable research farm (*Cm* treatment) on November 4 2009; the 4 Lewis Brown fields (control) remained untreated. In May 2010 sclerotia were collected from the field surface from all fields, bagged in the laboratory, and placed in the Lewis Brown (LB) and OSU Veg Farm (OS) fields on July 8 and July 12, respectively.

Bags will be collected in February, May and September of 2011 from the field and sclerotia will be surface-sterilized in 20% bleach for 10 minutes and rinsed with DI water. All sclerotia will be plated on PDA w/streptomycin and observed for development of *Ss* sclerotia, *Cm* pycnidia, and mycelia of other fungi.

Field snap bean experimental design and management:

Snap beans 91G and OR-6230 were planted in a randomized complete block design (6 plots of each variety in each of the 8 fields) on half of each field in late June 2011 at OS and LB, respectively (the other half of each field was planted to beans in 2010).

Bean foliage and pod evaluation at harvest:

Bean aboveground biomass was harvested from two 4 ft row sections per plot and weighed. Of the plants in the 8 ft of row, twenty randomly selected plants were evaluated for white mold disease severity on a scale of 0-5 (0=healthy; 1=1-10% foliage necrotic; 2=11-30% foliage necrotic; 3=31-60% foliage necrotic; 4=61-80% foliage necrotic; and 5=91-100% foliage necrotic). Pods were stripped from all 20 bean plants and weighed. Two hundred beans from each plot were weighed and evaluated for pod white mold incidence.

OBJECTIVE TWO

To evaluate the impact of Monida and Walken oats, common vetch, and oat/vetch cover crop mixtures on N status and root rot severity of subsequent sweet corn plantings and white mold sclerotial survival.

Field preparation and cover crop and sweet corn management:

A field at the OSU Vegetable Research Farm was planted to a cover crop trial in October 13 2010. The treatments included: oat Monida, oat Walken, common vetch, vetch/oat Monida,

vetch/oat Walken, and a no-cover crop control. Plot dimensions were 25' x 30', with 5 plots per treatment in a replicated complete block design. Cover crops were flailed and incorporated in June 10-14 2011. Supersweet Jubilee and Golden Jubilee were planted in the field on July 6, 2011 with an at-plant fertilizer application of 50 lbs N per acre. Corn was side dressed with 100 lbs N per acre as urea on August 25. Corn was harvested October 13-14, 2011.

Corn root rot and yield evaluation:

Ten corn plants per plot were randomly sampled from the row adjacent to the two center rows for evaluating root rot severity and aboveground dry matter at the 6-leaf stage (August 24-25). At harvest (October 13-14), ten plants per plot were randomly sampled from the two center rows. The sampled roots were washed, and percent necrosis of radicle and nodal roots were evaluated by visual assessment. Corn ears from two center rows per plot were harvested by hand at maturity to assess corn yield.

Corn ears from two center rows (one row Super Sweet Jubilee and the other Golden Jubilee) per plot (8ft length per row) were harvested by hand to assess corn yield. Ears of less than 15 cm edible corn kernels were discarded. Corn weight (T/A) was estimated without husking.

Nitrogen mineralization assessment:

Mineralizable N was evaluated pre-plant and pre-sidedress (as for PSNT). On each date, ten soil wedges were randomly sampled from each field plot with a sharpshooter shovel. Each soil core was sieved through a 4.75 mm sieve and mixed thoroughly. A 15 g moist sample was removed from each aggregated sample and placed into a 125 mL Erlenmeyer flask. Fifty ml of 2 M KCl was added to each flask. Flasks were shaken at 178 rev min⁻¹ for 1 hr, and the resulting solution was filtered with Whatman No. 42 filter paper. The filtrate was refrigerated at 4 °C in capped plastic cuvettes until analyzed. Inorganic N was analyzed by colorimetric analysis by the cadmium reduction method (Keeney and Nelson, 1982) by the OSU Central Analytical Laboratory. Gravimetric soil moisture content was determined for each sample by oven-drying approximately 10 g of soil at 105C and the obtained values were used to calculate soil N concentration on a dry soil basis.

White mold sclerotial viability:

Nine bags of sclerotia (15 sclerotia per bag) were installed on the soil surface of all plots on Nov. 25, 2010 (6 plots per treatment). Bags were removed from the field on June 4 2011 in preparation for cover crop incorporation and corn planting and then replaced (3 bags installed at 2 inch depth and 4 on the soil surface) on July 1, 2011. All bags were removed from the field on Oct. 14, 2011. One bag from the soil surface and one bag from 2 inch depth were plated on Oct.19-21, 2011.

RESULTS:

OBJECTIVE ONE:

1. To evaluate the impact of a low rate Contans application on the following factors, in the second field season following the application:

- a) sclerotial survival,
- b) sclerotial colonization by *Coniothyrium minitans* and other fungi,
- c) disease incidence in plantings of susceptible and moderately resistant bean varieties.

By June 2010 (time of planting of next crop), 4 of 15 sclerotia were alive in the Cm plots, while 10.5 were alive in the control plots (no Cm). By May 2011, 2 of 15 sclerotia were alive in the Cm plots, while 7 were alive in the control plots. By September 2011, less than 1 sclerotium was alive of the original 15 in the Cm treatment (less than 5% of the original number of sclerotia), while 3.3 were alive in the control treatment (22% of the original number of sclerotia). One low rate (1.5 lbs/A) post-harvest Contans treatment destroyed 95% of the white mold sclerotia generated on a diseased bean crop over a two year period; there were more than 4 times more viable sclerotia after two years in the Contans treatment (5% of the original number of sclerotia) than in the control (22% of the original number of sclerotia).

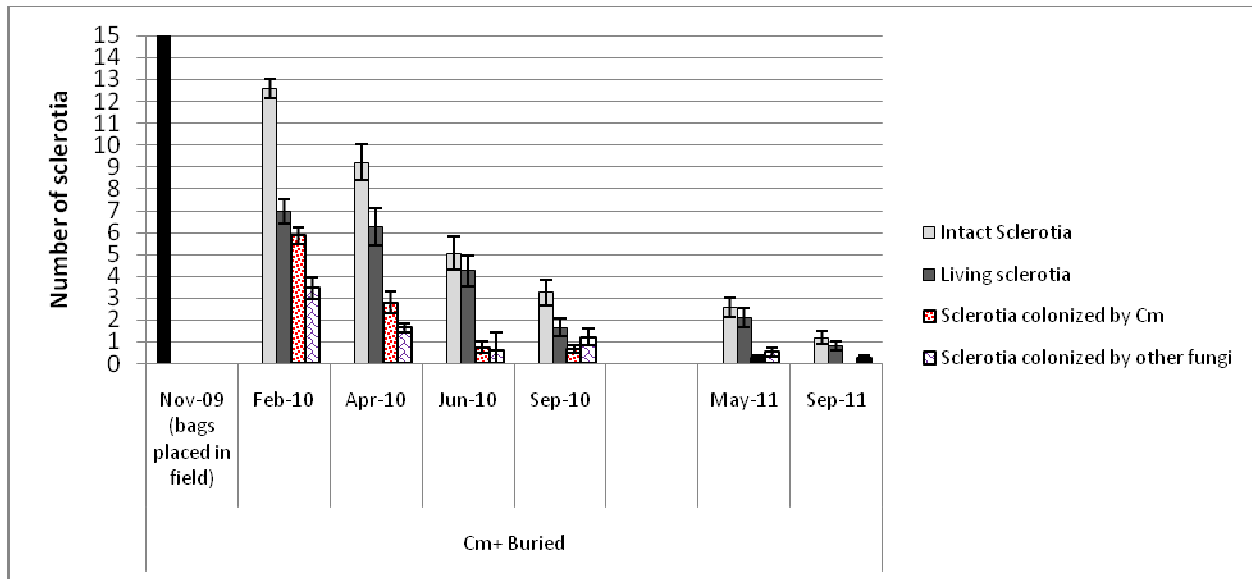


Fig. 1. Viability and colonization of sclerotia produced on beans in fall 2009 and collected throughout 2010 and 2011. Contans applied to the field in October 2009. Bags of sclerotia buried at approximately 2 inches below the soil surface.

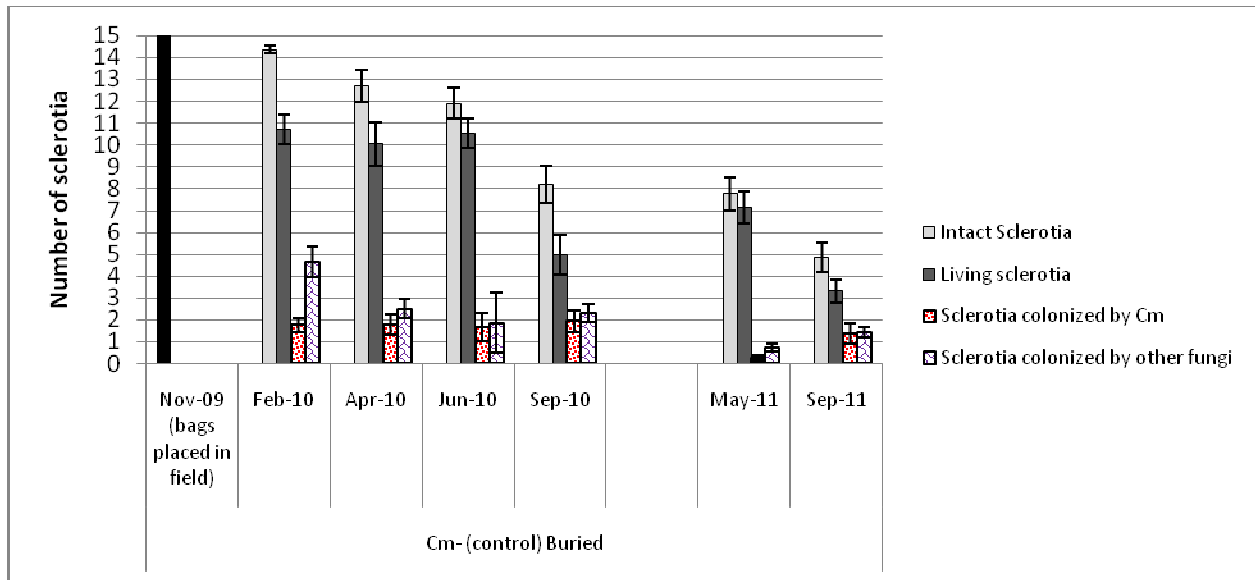


Fig. 2. Viability and colonization of sclerotia produced on beans in fall 2009 and collected throughout 2010 and 2011. Contans was NOT applied to the field. Bags of sclerotia buried at approximately 2 inches below the soil surface.

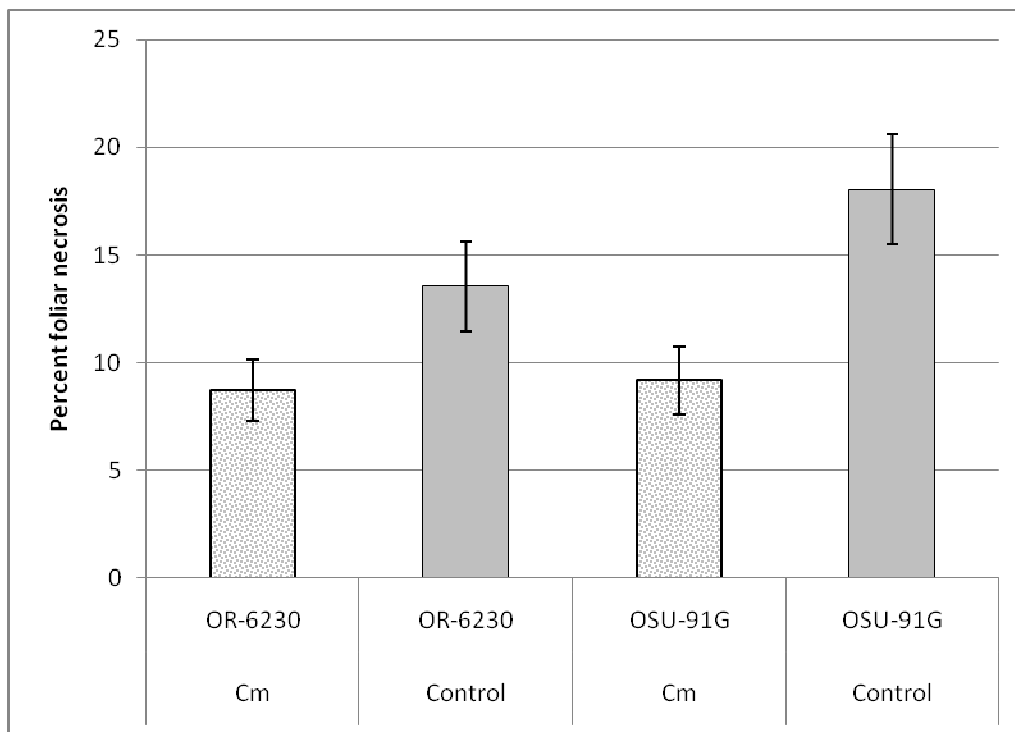


Fig. 3. Percent white mold foliar necrosis in snap bean.

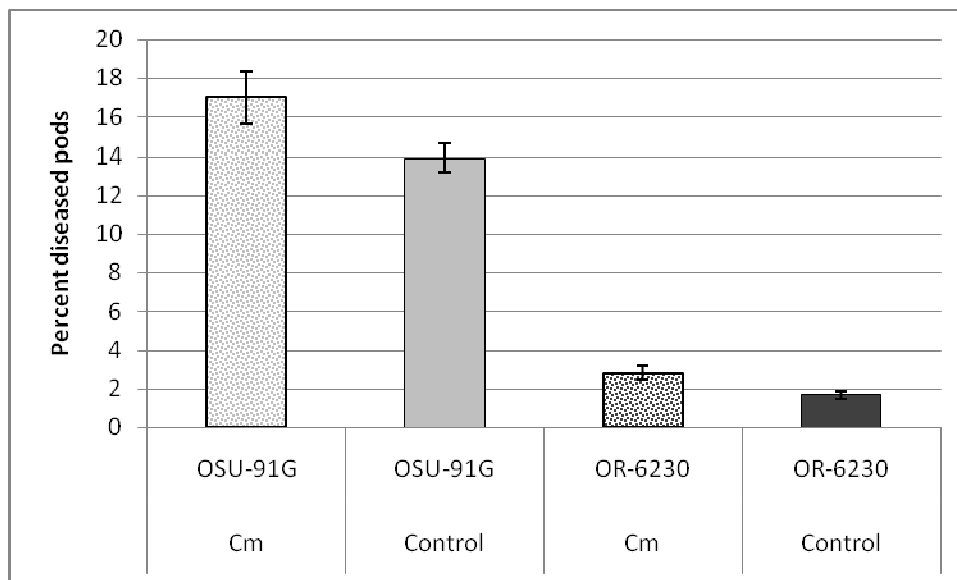


Fig. 4. White mold incidence on snap bean pods.

In 2010, beans grown in the Contans treatment fields had significantly lower pod and foliar disease severity than those grown in the control treatment fields. In 2011, foliar disease severity was 50% lower in the Contans treatment fields than in the control fields (9% vs 18%, Fig. 3), but pod disease incidence was higher (17% vs 14% incidence, Fig. 4). We do not understand at this time why there was less foliar disease severity in the Contans treated fields but higher pod disease incidence. As was shown in 2010, the moderately resistant cultivar OR-6230 exhibited significantly less foliar and pod disease incidence than 91G (Figs. 3 and 4).

OBJECTIVE TWO:

To evaluate the impact of Monida and Walken oats, common vetch, and oat/vetch cover crop mixtures on N status and root rot severity of subsequent sweet corn plantings and white mold sclerotial survival.

All cover crop treatments except Monida oat/vetch suppressed radicle and nodal root rot of both varieties at 63 days after incorporation (corn 8 leaf stage). Overall, the single species cover crops were most suppressive, and only the single species cover crops (vetch and both oat varieties) suppressed root rot at 143 days after incorporation (corn harvest).

Vetch and the oat/vetch mixtures mineralized nitrogen immediately after incorporation (pre-plant), with no difference in quantity of N mineralized amongst those treatments. In contrast, both varieties of oat cover crops immobilized N. At the time of the PSNT sampling, mineralizable N in the vetch and oat/vetch treatments was not significantly different from the control, while the oat treatments remained significantly lower than the control (oats continued to immobilize N). Growing oat and vetch in a mixture appears to overcome the immobilization of the oat cover crop. (Fig. 9)

Yield in sweet corn is the result of the collective impact of many variables including root rot severity and nitrogen availability. In this experiment, oat/vetch mixtures supplied more N to the corn crop, but did not in general suppress root rot. In contrast, oat cover crops suppressed root rot but immobilized N. Pure vetch cover crops suppressed root rot and supplied N. Nonetheless, there were no significant differences in yield of sweet corn (Table 1). The pure vetch cover crop

treatment resulted in the numerically highest yield of Golden Jubilee and the numerically lowest yield of Super Sweet Jubilee (Table 1), suggesting that varieties respond differently to cover crop variables.

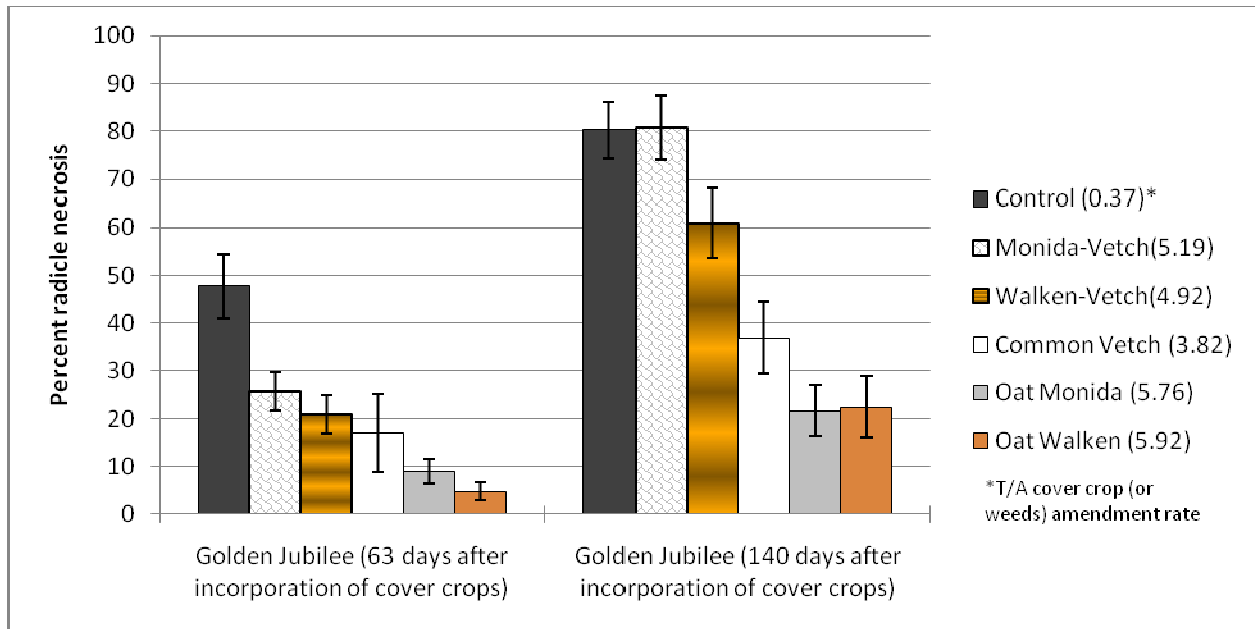


Fig. 5. Percent radicle necrosis at 63 days (8 leaf stage) and 140 days (harvest) after cover crop incorporation in roots of sweet corn Golden Jubilee grown in plots previously planted to no or listed cover crops.

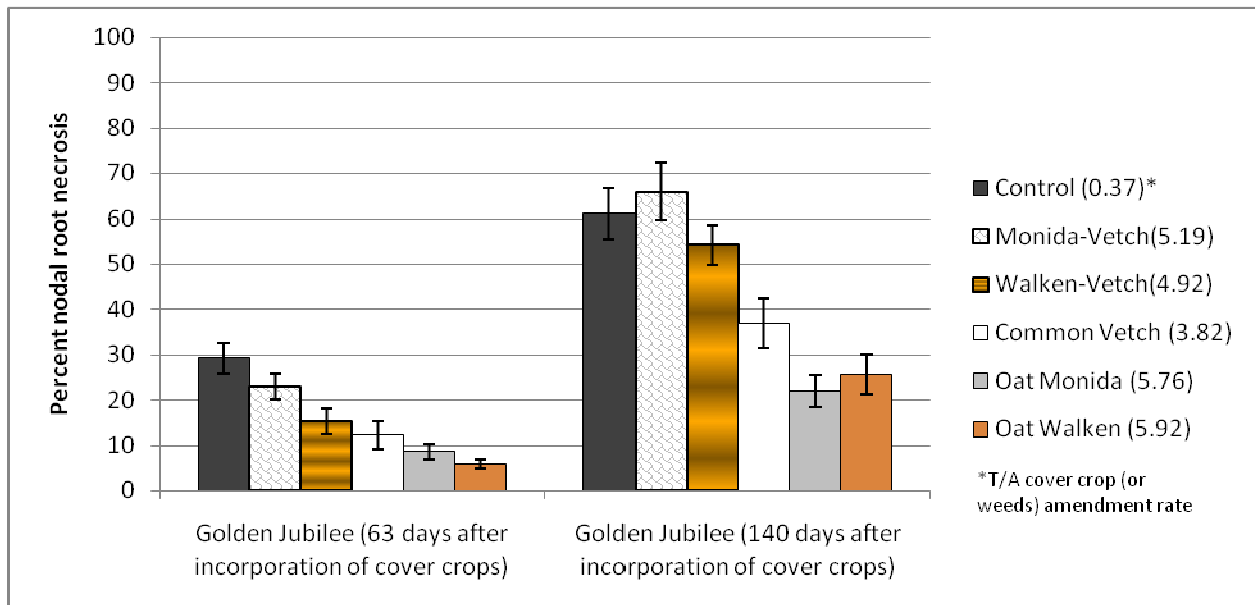


Fig. 6. Percent nodal root necrosis at 63 days (8 leaf stage) and 140 days (harvest) after cover crop incorporation in roots of sweet corn Golden Jubilee grown in plots previously planted to no or listed cover crops.

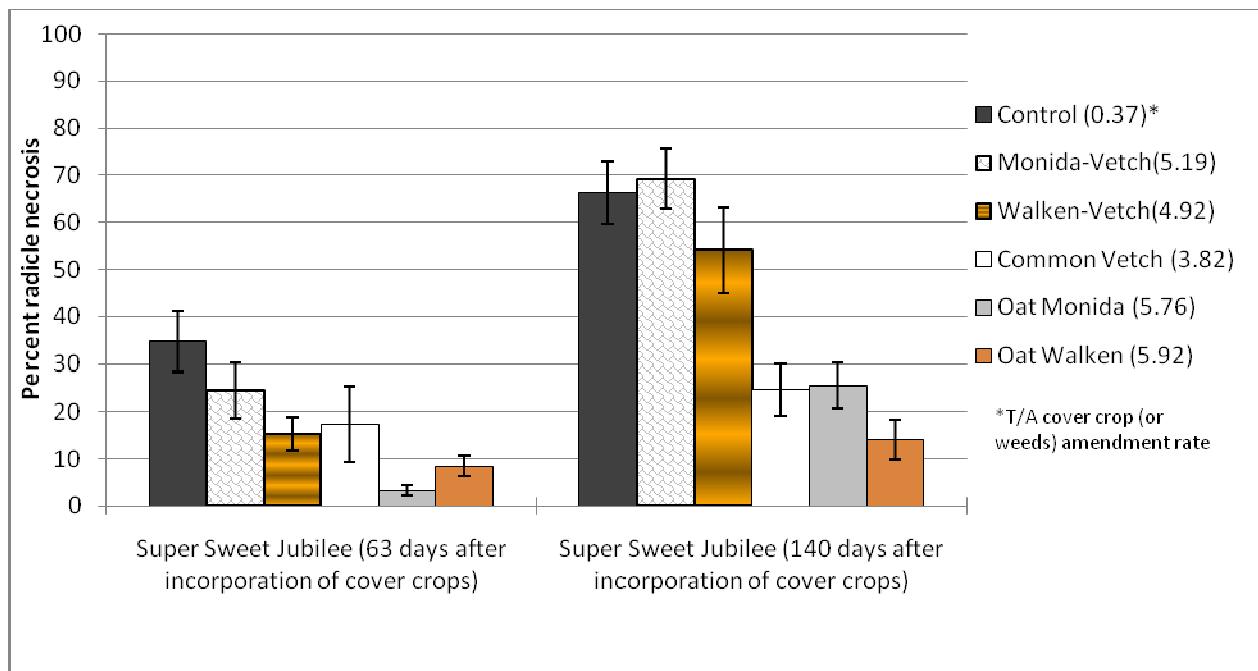


Fig. 7. Percent radicle necrosis at 63 days (8 leaf stage) and 140 days (harvest) after cover crop incorporation in roots of Super Sweet Jubilee grown in plots previously planted to no or listed cover crops.

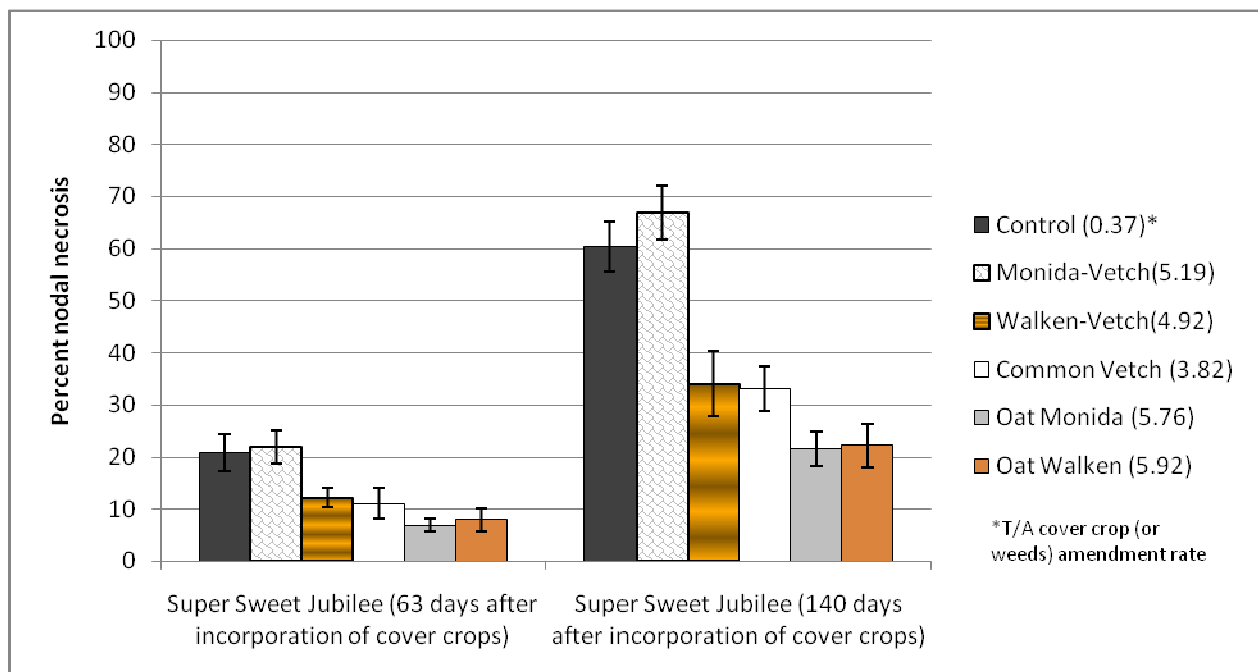


Fig. 8. Percent nodal root necrosis at 63 days (8 leaf stage) and 140 days (harvest) after cover crop incorporation in roots of Super Sweet Jubilee grown in plots previously planted to no or listed cover crops.

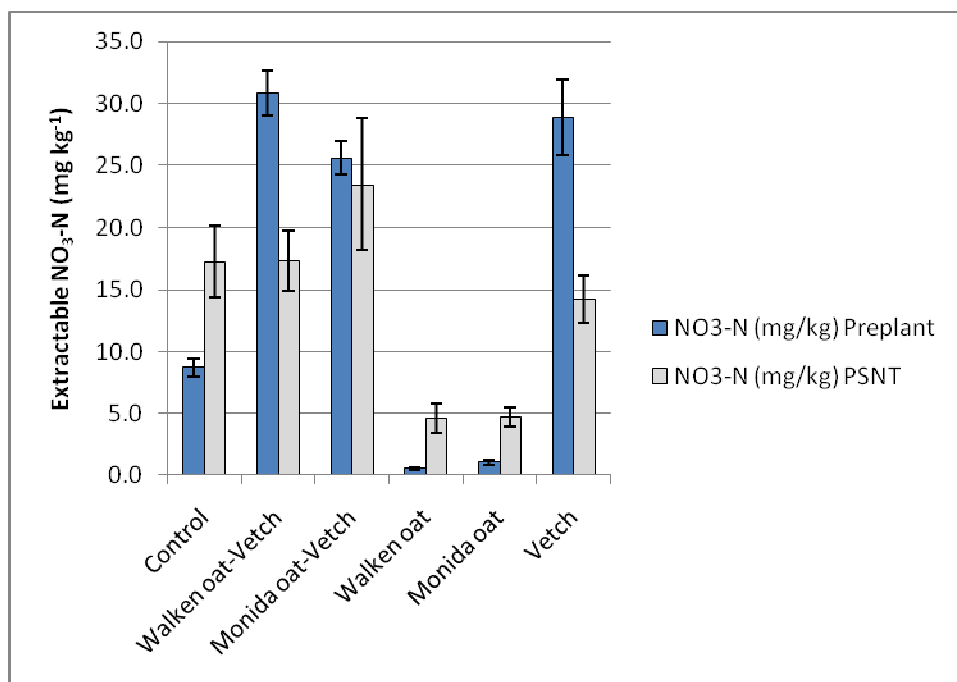


Fig. 9. Extractable NO₃-N at pre-plant and PSNT.

Table 1. Yield of sweet corn.

Variety	Ton/Acre (fresh wt) with husks	
	Golden Jubilee	Super Sweet Jubilee
Control	7.99	7.03
Monida oat	7.36	8.19
Walken oat	8.13	7.21
common vetch	9.22	6.45
Monida-vetch	8.75	6.97
Walken-vetch	9.35	6.75
LSD (P =0.05)	2.10	1.82

There were more intact sclerotia in late fall 2011 after incubation on the soil surface over the summer than when buried at approximately 2 inches below the soil surface over the summer (52% vs 26% of the original number of sclerotia), but there was no significant difference in the number of living sclerotia. Surface sclerotia were colonized more frequently by other fungi than sclerotia buried at 2 inch depth (71% vs 46% colonization). Overall, vetch cover cropping resulted in the largest number of intact and living sclerotia whether on the surface or buried. Cover cropping with oat or oat mixtures numerically reduced sclerotial survival (although only the Walken and Walken/vetch treatments were significantly different) when compared to the

control when the sclerotia were left on the soil surface; vetch cover cropping had no impact on survival. Overall, cover crop treatments significantly increased colonization of sclerotia by other fungi when on the surface or buried. (Fig.10)

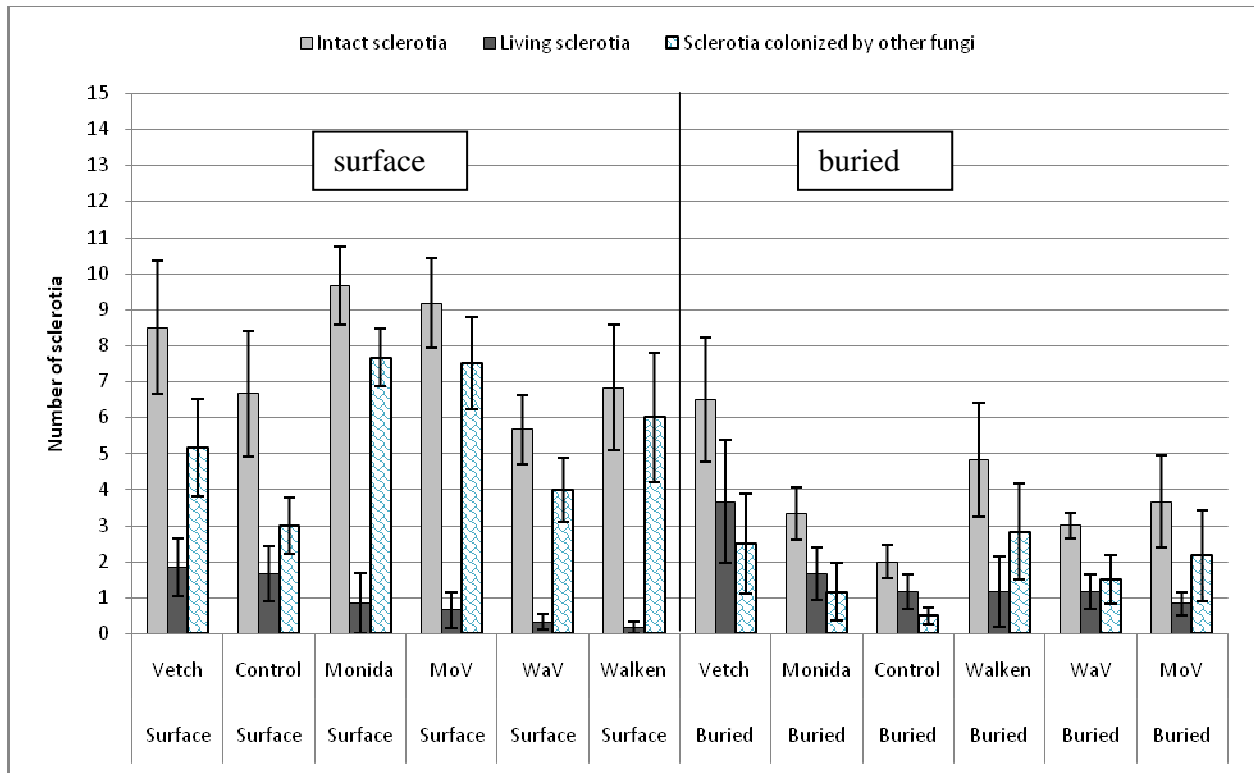


Fig. 10. Viability and colonization of sclerotia placed in field during cover cropping and corn cropping. Bags of sclerotia were incubated on the soil surface over the winter 2010-11 during cover crop growth, removed from the field for planting in June 2011, and then re-installed on the soil surface or buried at approximately 2 inches below the soil surface in July and removed October 2011.