UNCONVENTIONAL APPROACHES TO COMBAT SOYBEAN DISEASES

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Introduction

White mold (*Sclerotinia sclerotiorum*) is a disease frequently found in high yield potential soybeans [*Glycine max* (L.) Merr.]. Soybean producers who adopt management techniques to maximize yield are often penalized by this disease. Several factors responsible for the onset of white mold relate to how we manage soybean canopy closure. A dense canopy provides an environment that enhances white mold pathogen development. Canopy is influenced by plant health, narrow row spacings, high plant populations, high fertility, early planting dates, and sometimes herbicide tolerant varieties that do not succumb to postemergent herbicide "setback" by burning canopy foliage. Essentially, all practices that promote rapid and aggressive soybean plant growth will encourage rapid canopy closure.

The number one defense to combat a soybean disease is through genetic resistance. Choosing varieties with good levels of resistance should be the foundation of a white mold management plan. Afterward, management practices can be modified to further enhance the level of resistance in the variety selected to suppress white mold. Modifications can include altering plant canopy through practices such as wider row spacings, reduced seeding rates, and delaying planting dates. The main drawback with each of these modifications is the potential negative effect each has on soybean yield. What then can be done to maintain high yield practices while minimizing white mold?

It is common knowledge that crop rotations have the ability to increase yield, minimize inputs, reduce the cost of external inputs, and promote crop health through breaks in insect and pathogen cycles. The phenomenon of "rotation effect" has been coined to describe a chain of events or effects that promotes better health and yield by a crop due in part to the crop that was grown previously. Interruption of disease and insect cycles positively influences the "rotation effect". Corn [*Zea mays* (L.)] usually performs better following soybeans than when corn follows corn. Similarly, soybeans perform better the longer the frequency between the current crop and previous crop of soybean. A typical corn-soybean rotation may work well with corn, but may not be a "long" enough interval to prevent soybean crops from susceptibility to soybean diseases, like white mold and brown stem rot (*Phialophora gregata*).

Objectives

Previous research conducted by the University of Wisconsin demonstrated the disease-controlling advantages of small grains in a corn-soybean rotation. Sclerotinia

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sclerotia density declined each year a non-host crop was planted. Two or more years of corn, small grains or other non-host crops also lowered white mold severity in soybean. Growing two years of corn then following with soybeans is an improved soybean rotation system, but many producers would prefer to eliminate the need for corn insecticides and the expense of additional nitrogen for corn when corn follows corn. Substituting a small grain like wheat [*Triticum vulgare* (L.)] or oats [*Avena sativa* (L.)] for one year of corn will eliminate the need for a corn insecticide, but most producers find that there is an economic disadvantage to raising wheat or oat. This situation led us to consider some "unconventional" management systems which incorporate small grains in the rotation without sacrificing the production year to a less profitable cash crop.

The first objective of this study was to find a reliable method to reduce the incidence of white mold even with susceptible soybean varieties. The second objective was to seed small grains ahead of soybeans in an attempt to promote formation of a closed crop canopy to encourage germination of sclerotia ahead of soybean flowering. A third objective was to use small grains as a cover crop to promote better soybean canopy health.

Materials and Methods

Phase One of this study conducted for two years (1998-1999) compared two treatments: 1) oat cover crop followed by soybean and 2) no cover crop followed by soybean. The trial conducted near Whitewater,WI, on a Milford clay loam was planted using four replicates in 1998 and six replicates in 1999. All cover crops and soybeans in this study were planted using large-plots (20 feet x 500 feet). Belle oats were no-til planted with a John Deere 750 no-til grain drill (Deere and Co., E. Moline, IL) at 2.0 bu/acre on 7.5" row spacings and a 0.75" depth on a Milford clay loam soil on April 15, 1998 and March 27, 1999. Jung 8221RR (Jung Seed Genetics, Randolph, WI) soybeans were no-til seeded May 04, 1998 and May 10, 1999 into the live-oat plots plus equal-sized no-oat plots at 225,000 seeds per acre on 7.5" row spacings and 1.0 inch depth. Oats were chemically killed with a mixture of 1.0 qt/acre Roundup Ultra (glyphosate, a product of Monsanto, St. Louis, MO) plus 2.0 oz/acre Pursuit (imazethapyr, a product of BASF, Research Triangle Park, NC) when soybeans reached V2 growth stage (June 10, 1998 and June 05, 1999). The no cover crop plots also received the same herbicide treatment on the same date. Data collected included grain yield and moisture, plant height, lodging, stand density, white mold and brown stem rot incidence. Apothecia counts (per meter^2) were made June 10, July 01 and August 01, 1998 and June 01, June 05, July 01, August 01, 11, 16 and 23, 1999. Plots were harvested September 29, 1998 and September 17 1999 using an International Harvester 1660 combine (Case Corp., Racine, WI) with 20.0 foot 1020 grain platform and AgLeader PF2000 yield monitor (AgLeader Technology, Ames, IA). A Parker Model 150 weigh wagon (Parker Industries, Jefferson, IA) was used for individual plot weights.

Phase Two of this study conducted for one year (2000) compared four treatments: 1) winter wheat cover crop followed by soybean, 2) oat cover crop followed by soybean, 3) barley [***Hordeum vulgare*** **(L.)**] cover crop followed by soybean, 4) no cover crop followed by soybean. The trials were conducted at three southern Wisconsin locations near Milton on a St. Charles silt loam, near Janesville on a Plano silt loam, and near Whitewater on a Kidder sandy loam. For 2000, we further expanded our cover crop comparisons to include two soybean varieties. These varieties consisted of one with average susceptibility to white mold (WM-) and one with above average tolerance to white mold (WM+). Soybean varieties planted at Whitewater (May 05, 2000) and Janesville (April 30, 2000) were Dairyland DSR218 (WM+) (Dairyland Seed Co., West Bend, WI) and Dekalb CX232 (WM-) (Dekalb Seed Division of Monsanto, St. Louis, MO), non-Roundup Ready. Asgrow AG2001 (WM+) (Asgrow Seed Division of Monsanto, St. Louis, MO) and Spangler 249RR (WM-) (Spangler Seedtech, Jefferson, WI) were planted at Milton (April 28, 2000), both Roundup Ready. Soybean plots were no-til seeded at 225,000 seeds per acre at a 1.0 inch depth. The experiment was established in large 20 foot x 1000 foot on-farm plots in a randomized complete block arrangement of treatments with two replicates.

Winter wheat cover crop plots were planted October 01, 1999 at all three locations at 2.0 bu/acre and a 0.75 inch depth. Spring oat and spring barley cover crop plots were seeded April 07, 2000 at Milton and Janesville and April 14, 2000 at Whitewater. Oat and barley plots were no-til seeded at Milton and Janesville and conventionally at Whitewater at 2.0 bu/acre at a 0.75 inch depth. Winter wheat plots all received 1.0 qt/acre Roundup Ultra as a burndown either three days before planting soybeans at Whitewater (May 02, 2000) or after planting at Milton and Janesville (May 02, 2000). Oat and barley cover crop plots received 8 oz/acre Select (clethodim) herbicide to kill small grains (June 03 at Whitewater and Janesville and June 04 at Milton). All plots at Whitewater and Janesville received 4 oz/acre Pursuit (June 03, 2000). Milton plots received 1.5 qts/acre Roundup Ultra on June 17, 2000.

Soybean plots were harvested Sept 25, 28 and 30, 2000 at Milton, Janesville and Whitewater, respectively, using an International Harvester 1460 combine with 16.5 foot 1020 grain platform. Yields were determined using an AgLeader PF3000 yield monitor with GPS and a Parker Model 150 weigh wagon.

Data collected included grain yield and moisture, plant height, lodging and density, aphid and bean leaf beetle density and relative injury, virus-like plant symptoms, percent green stem, white mold and brown stem rot incidence. Apothecia counts (per meter^2) were conducted in each cover crop plot every five days from April 01 to August 31, 2000.

Results and Discussion

1998 disease and yield data – Growing conditions in 1998 were generally good to excellent for soybeans. Rainfall was generally adequate at Whitewater, but not excessive. Apothecia counts from oat + soybean cover crop plots had much higher apothecia numbers in June than either of the later dates or for any of the soybean only plots, Table 1. Canopy was quite dense in these small grain plots on June 10. Chemical control of these oat strips was applied after apothecia measurements on June 10. The dramatic decrease in apothecia density by July 01 in these oat plots and the low counts in the soybean only (no cover crop) plots indicates that oat plots may have provided an early environment favorable to "spending off" apothecia.

Table 1. Apothecia counts / meter^2 at three sampling dates. Whitewater, WI. 1998

Cover crop	June 10	July 01	August 01
Oat/soybean	3.8	0.5	0.1
Soybean	0.3	0.1	0.5
LSD(P=0.10)	**1.5**	**0.3**	**0.1**

The encouragement of early apothecia production in oat plots resulted in lower white mold incidence, Table 2, in these plots, whereas in soybean only plots white mold incidence was higher.

Soybean grain yield in oat/cover crop treatments yielded 73.8 bu/acre versus 69.2 bu/acre for the no cover crop treatment (LSD P=0.10 = 2.5 bu/acre).

Table 2. White mold incidence (%) at three sampling dates. Whitewater, WI. 1998

Cover crop	**August 01**	**September 01**	**September 28**
Oat/soybean	0.1	0.4	0.4
Soybean	1.1	2.0	2.0
LSD(P=0.10)	**1.0**	**1.5**	**1.5**

1999 disease and yield data – Growing conditions at Whitewater for 1999 were very different from 1998. After June 17 very little measurable rain was received until late August. Soil conditions were deficient for moisture. However, there were many days in July and August with a heavy dew on soybean plants each morning. This provided a "perfect" environment for germination of sclerotia, hence the increase in white mold incidence. Apothecia counts were expanded to six sampling dates. As in 1998, the oat cover crop plots had much higher apothecia numbers earlier in the season compared to soybean plots with no cover crop, Table 3. Oat plots had high early season apothecia numbers which dropped dramatically after chemical control of oats. No apothecia were detected in these plots after July 01. Apothecia were not present at early season sampling dates in soybean only, no cover crop plots, but as soybean canopy closed, apothecia densities rose quickly and never diminished. No foliar symptoms of white mold were detected in oat/soybean plots,

Table 3. Apothecia counts / meter^2 at six sampling dates. Whitewater, WI. 1999.

Cover crop	**June 05**	**July 01**	**Aug 01**	**Aug 11**	**Aug 16**	**Aug 23**
Oat/soybean	3.1	0.1	0.0	0.0	0.0	0.0
Soybean	0.0	0.0	0.2	2.2	1.4	1.6
LSD(P=0.10)	**0.5**	**NS**	**NS**	**0.7**	**1.2**	**0.3**

while soybean plants in the soybean/no cover plots had a significant infection at the first date and increased with each subsequent reading, Table 4. There was no significant soybean grain yield difference between oat cover crop or soybean only plots (57.2 bu/acre vs. 56.5 bu/acre)(LSD P=0.10 = NS).

Table 4. White mold incidence (%) at four sampling dates. Whitewater, WI. 1999

Cover crop	August 01	August 16	September 02	September 16
Oat/soybean	0.0	0.0	0.0	0.0
Soybean	3.7	6.0	7.5	10.0
LSD(P=0.10)	**1.2**	**1.5**	**0.9**	**1.2**

2000 disease and yield data – The weather was generally more favorable for soybean growth in 2000, compared to 1999, at these southern Wisconsin locations. Moisture was more plentiful, however, rainfall came in large amounts over brief periods of time. Several times during the season soil would be very dry then recharged by a single large rainfall only to dry up again later. Other factors became of interest, namely from bean leaf beetles and soybean aphids each having some potential effect on yield. Table 5 illustrates eleven of those sampling dates
and the density of apothecia for each cover crop averaged across all three locations.
Once again, our small grain cover crop plots enhanced sclerotia germination earlier in the

Table 5. Apothecia counts / meter^2 at eleven sampling dates. Means from Janesville, Milton and Whitewater, WI. 2000.

			Cover crop		
Date	**Wheat/SB**	**Oat/SB**	**Barley/SB**	**Soybean**	**LSD(P=0.10)**
April 15	0.0	0.0	0.0	0.0	**NS**
April 20	1.3	0.0	0.0	0.0	**0.5**
May 02	1.7	1.7	1.3	0.0	**0.3**
May 17	1.7	1.7	1.7	0.7	**0.7**
June 02	0.0	1.0	1.0	0.0	**0.5**
June 17	0.0	0.0	0.0	0.0	**NS**
July 02	0.0	0.0	0.0	0.7	**0.2**
July 17	0.0	0.0	0.0	1.3	**0.6**
August 01	0.0	0.0	0.0	1.0	**0.3**
August 16	0.0	0.0	0.0	1.0	**0.4**
August 31	0.0	0.0	0.0	1.7	**0.8**

season well ahead of soybean flowering. Soybean only plots delayed apothecia production until July at the same time that soybeans began to flower. Apothecia remained in soybean only plots through August.

Tables 6, 7 and 8 illustrate incidence of white mold at each of the three locations at four sampling dates. White mold incidence follows the trends detected from 1998 and 1999.

Table 6. White mold incidence (%) at four sampling dates. Janesville, WI. 2000.

Cover crop	August 01	August 16	September 02	September 16

Wheat/soybean	0.0	0.0	1.5	5.3
Oat/soybean	0.0	0.0	0.0	0.0
Barley/soybean	0.0	0.0	0.0	0.0
Soybean	0.5	2.0	3.5	6.0
LSD(P=0.10)	**NS**	**NS**	**2.1**	**1.8**

Table 7. White mold incidence (%) at four sampling dates. Milton, WI. 2000.

Cover crop	**August 01**	**August 16**	**September 02**	**September 16**
Wheat/soybean	0.0	0.0	0.0	1.0
Oat/soybean	0.0	0.0	0.0	1.0
Barley/soybean	0.0	0.0	0.0	1.0
Soybean	0.0	0.0	0.0	1.0
LSD(P=0.10)	**NS**	**NS**	**NS**	**NS**

Table 8. White mold incidence (%) at four sampling dates. Whitewater, WI. 2000.

Cover crop	**August 01**	**August 16**	**September 02**	**September 16**
Wheat/soybean	0.0	0.0	0.5	2.0
Oat/soybean	0.0	0.0	0.0	0.3
Barley/soybean	0.0	0.0	0.0	0.3
Soybean	0.0	2.0	3.5	6.8
LSD(P=0.10)	**NS**	**0.7**	**0.7**	**0.9**

White mold was not the only disease observed in 2000. The conditions were "perfect" for brown stem rot expression. Table 9 illustrates the effect brown stem rot had on Milton plots, severely reducing yield at that site. The Milton location has a long history of a corn-soybean rotation (30+ years). However, cover crop did not influence brown stem rot severity. Soybean variety did respond to brown stem rot incidence (AG2001 averaged 36.9 bu/acre whereas SP249RR averaged 43.3 bu/acre, LSD P=0.10 = 2.1 bu/acre).

Table 9. Brown stem rot incidence at four sampling dates. Milton, WI. 2000.

Cover crop	**August 01**	**August 16**	**September 02**	**September 16**
Wheat/soybean	3.8	20.5	47.5	71.3
Oat/soybean	2.5	20.8	45.0	68.8
Barley/soybean	1.3	15.8	38.8	67.5
Soybean	5.0	21.3	43.8	63.8

LSD(P=0.10)	NS	NS	NS	3.0

Grain yields of soybean in 2000 for soybeans seeded in barley cover crop plots were generally lowest for all treatments, Table 10. Soybean yields in oat cover crop plots yielded similar to soybean with no cover crop. The surprising winner were soybeans seeded into winter wheat plots. Soybean yields from winter wheat plots were 10.3 to 13.4 bu/acre higher than no cover crop plots and 10.6 to 14.3 bu/acre higher than oat cover crop plots, except at Milton where there were no differences between cover crop treatment.

Table 10. Grain yield (bu/acre) of soybean plots following four cover crop treatments at Janesville, Milton and Whitewater, 2000.

Cover crop	**Janesville**	**Milton**	**Whitewater**
Wheat/soybean	70.8	40.0	74.9
Oat/soybean	60.2	39.5	60.6
Barley/soybean	53.5	40.0	57.4
Soybean	57.4	40.9	64.6
LSD(P=0.10)	**3.2**	**NS**	**2.9**

2000 Aphid, Bean Leaf Beetle, Virus-like symptom measurements and observations – An interesting effect detected in 2000 was the effect of cover crop on aphids, bean leaf beetles and virus-like symptoms. During apothecia counts a rating was also made for aphid density (scale of 1 to 9, with 9 indicating very heavy infestation), bean leaf beetle density (similar 1 to 9 scale) and percent pod feeding injury as well as percent virus-like symptoms and green stem. Across all three locations, aphid density and infestation was greatest on soybean only plots, followed by wheat, and least on oat and barley cover crop plots. Aphids preferred a drier, less moist canopy.

Bean leaf beetles were in our plots as early as mid-May feeding on soybean cotyledons. Generally a greater density of feeding occurred in soybean only plots. Wheat, oat and barley plots were similar in beetle injury, much less than soybean only plots.

Another observation was made for virus-like plant leaf symptoms (i.e. puckered leaves, mosaic patterns, etc.). Virus symptoms on soybean plants occurred at a level of 10-15% for oat cover, 15-20% for barley cover, 20-25% for wheat cover and greater than 30% for soybean only plots. At harvest green stem percent infected plants showed similar trends where soybean only plots had the highest incidence of green stem (3-5%).

Conclusions

Phase One and Two data demonstrates that an early spring-seeded small grain used as a cover crop will encourage an environment favorable to sclerotia germination and apothecia production. The cover crop plot data from three years at Whitewater demonstrates a "flush" of apothecia between June 01 and July 01, well ahead of soybean flowering, Figure 1. Soybean plots without a cover crop delayed canopy closure until July

Figure 1. Apothecia developing in Small Grain + Soybean or Soybean only plots during 1998, 1999, and 2000 growing seasons. 3-year means. Whitewater, WI.

Figure 2. Apothecia developing in Small Grain + Soybean or Soybean only plots at Janesville, Milton and Whitewater, WI. April 05 to August 31, 2000. Three-location means.

when soybeans began flowering and at a time when they are most susceptible to white mold infection. Figure 2 shows data from our three 2000 locations from April to September following a similar trend to Figure 1. After only one year of data, winter wheat also appears to flush out apothecia, but earlier in the season than oats or barley.

Environmental conditions in 1998, 1999 and 2000 may not have seemed favorable for white mold establishment, but apothecia numbers show that conditions were present for white mold to occur. White mold did occur but not at very high levels. White mold was reduced in plots where a cover crop was grown. Yield increases due to cover crop may be part of an overall rotation effect providing relief from both apothecia production, reduction of pathogens and possibly due to a health aspect to the plant as a growth hormone effect. Additionally, a dense growth may provide some relief from aphids and other insects. We have winter wheat seeded again at three locations for 2001 research plots. We plan to use oats as a spring cover crop, but will probably drop the barley cover crop treatment.

Winter wheat may prove to be the “easiest” treatment because it can be fall-seeded and then burned off during normal preplant soybean weed control. Oats prove to be more of a challenge because timing of chemical control has always been difficult due to rain at that time. Plus, oats can create a greater opportunity to compete directly with the soybeans if not controlled on time. We hope that 2001 will provide us additional data to promote seeding of small grains as an alternative, albeit unconventional, method to manage soybean diseases such as white mold. Additional benefits of seeding a small grain crop prior to soybean would be control of soil erosion and weed suppression.

Literature Cited

For additional information please examine the following sources:

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Soybean Plant Health Website: www/plantpath.wisc.edu/soyhealth/index.htm

North Central White Mold Coalition Website: ww/plantpath.wisc.edu/NCSRPwhitemold/