Towards a Durable Management Strategy for White Mold in New York Vegetable Production

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White mold, caused by the fungus, *Sclerotinia sclerotiorum* is a soilborne disease, and results in substantial annual losses in crop production in New York.

Why is white mold challenging to manage?

1. **Survival in the soil.** *Sclerotinia sclerotiorum* survives in the soil predominantly as sclerotia, which are black resting bodies of the fungus (Fig. 1). The majority of these sclerotia die within the first 12 to 18 months. A small proportion of the sclerotia remain viable for up to five years. Sclerotia germinate and produce apothecia upon which ascospores are produced (Fig. 1). These ascospores are transported by the wind to susceptible tissue. Only a small number of sclerotia are required to cause substantial crop loss because of the large numbers of ascospores produced.
2. **Wide host range and susceptible varieties.** Many of the crops encountered in a typical vegetable rotation, including bean (snap, dry, soybean, and lima), potato, carrot, table beet, squash, cabbage, and tomato are susceptible to white mold. Broadleaf weeds are also hosts of *S. sclerotiorum*. No resistant varieties are available for these crops.
3. **High yields exacerbate white mold.** In general, agronomic management of crops for high yields, such as dense plant populations, irrigation, and nitrogen application, promote canopy development and make conditions within the canopy conducive for infection by *S. sclerotiorum*.

Fig. 1. *Sclerotinia sclerotiorum* sclerotia (above) and germinating sclerotia with apothecia (below).

Integrated management of white mold

A systems-based approach is important for the management of white mold.

Reducing soilborne inoculum. White mold usually develops from inoculum that is present within the same field. Farm hygiene practices which prevent introduction of *S. sclerotiorum* include:

1. Clean seed. Ensure the use of seedlots that have been cleaned to remove sclerotia.
2. Farm hygiene. Prevent transport of infested soil on contaminated machinery or debris or surface water run-off.
3. Weed management. Ensure effective broadleaf weed control.
4. Crop rotation. Rotation to non-hosts (cereals and corn) is essential for the management of white mold. The optimal rotation will depend upon the infestation density within the field. For example, if sclerotial density is high, rotation with a non-susceptible crop for more than 5 years may be required.
5. Tillage. Sclerotia are degraded by exposure to wet/dry and freezing/thawing cycles which are often extreme on the soil surface. They are also susceptible to colonization by soil micro-organisms, which is often encouraged deeper within the soil profile. In contrast, deep burial of sclerotia inhibits germination and may lead to prolonged survival. Inversion of the soil profile may further introduce a new sclerotial population to the surface to contribute to disease in the following year. In no-till cropping systems, adopting no-till systems and rotation to non-hosts has been shown to be effective at reducing sclerotial populations.
6. Biological control. The most common biological control product for *S. sclerotiorum* is Contans®, which is a commercial formulation of the fungus *Coniothyrium minitans* which parasitizes sclerotia. It may be applied to crop debris after harvest or prior to planting.

Manipulating conducive conditions. White mold is exacerbated by factors that promote canopy growth and are, in turn, linked with high yields in many crops. Orientating rows to the prevailing winds (e.g. west/east) to promote airflow and reduce leaf wetness may assist in canopy drying following irrigation and rainfall, leading to less frequent infection periods. Ensuring canopy growth is not excessive by exceeding the optimal rate of nitrogenous fertilizers and other techniques such as increasing row spacing and reducing plant density will also promote airflow and decrease disease incidence. Irrigation practices which promote canopy drying prior to the onset of night dews may also assist in management.

Fungicides. Cultural methods of control are routinely recommended as part of an integrated program but are often insufficient to achieve economic control. Management in many crops still relies upon the use of protective fungicides but is often suboptimal. The objective of fungicide application is the protection of the dying flower petals of which *S. sclerotiorum* infects. Control by fungicides alone in indeterminate beans, such as lima and light red kidney beans, is therefore more challenging due to an extended flowering period.

Here we present the results of a replicated trial conducted at The New York Agricultural Experiment Station, Geneva (2014) to quantify the efficacy of fungicides for white mold in processing snap bean. The trial was planted on 16 June (var. 'Huntington') and fungicides were applied at 100% bloom (22 July), pin-pod (30 July), and 5 Aug (re-blooming after substantial hail damage). The trial was inoculated with *S. sclerotiorum* ascospores on 24 July and 6 August. Germinated sclerotia were also placed in plots on 6 August until harvest. The efficacy of fungicides on white mold incidence and yield was assessed. The incidence of white mold on pods was significantly reduced by all fungicides. Fungicides had no significant effect on marketable or total yield. A cost-benefit analysis compared the fungicides to the industry standard (thiophanate-methyl; Topsin® formulations), assuming a fixed application cost and price of marketable beans (Table 1).

Table 1. Efficacy of fungicides on incidence of white mold and marketable yield in snap bean in 2014.

Product (rate)[a]	Active Ingredient (s)	Resistance Group[b]	Incidence of white mold on pods (%)	Marketable yield (t/A)	Cost of fungicide ($)	Net benefit ($/A)
Nontreated			10 a	6.3	-	-
Omega 500F (0.85 pt)*	Fluazinam	29 (L)	4.1 b	7.8	49.14	59.16
Luna Tranquility (0.7 pt)	Fluopyram + Pyrimethanil	7 + 9 (M)	4.0 b	7.5	38.97	36.18
Switch 62.5WG (14 oz)*	Fludioxonil + Cyprodinil	12 + 9 (M)	4.3 b	7.0	79.52	-347.12
Endura (11 oz)*	Boscalid	7 (H)	2.9 b	8.6	59.09	433.73
Proline 480 SC (5.7 fl oz)	Prothioconazole	3 (M)	2.3 b	7.6	31.10	111.40
Topsin 4.5 FL (30 fl oz)**	Thiophanate-methyl	1 (H)	2.5 b	9.0	15.63	596.22
Cannonball WP (7 oz)*	Fludioxonil	12 (L/M)	2.5 b	8.0	46.34	75.96
Rovral 4F (2 pt)*	Iprodione	2 (M)	3.4 b	6.7	30.24	-135.44
Propulse (10.3 fl oz)	Fluopyram + Prothioconazole	7 + 3 (M)	2.9 b	6.2	NA	NA

[a]Asterisk indicates if registered in New York on snap bean. ** indicates the current industry standard.

[b]Risk of resistance development according to the Fungicide Resistance Action Committee: L = low; M = medium; H = high.

These findings enable the selection of active ingredients in different resistance groups for best management practices.

Further Work

The long-term goal of this program is to develop new and innovative tactics for white mold management. Much of these studies will be conducted within a research field at The New York Agricultural Experiment Station inoculated with *S. sclerotiorum* in 2014. This research will initially focus on the effects of tillage, soil arthropods, and commercial biological control agents to degrade sclerotia, conditions and cues for sclerotial germination, and potential to inhibit germination.

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