Impacts of strobilurin fungicides on yield and soil microbial processes for Minnesota strawberry production

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This project is examining the impact of the strobilurin fungicides on strawberry production in Minnesota. The strobilurin fungicides are unique because they are the first synthetic, site-specific agents that provide significant control of a wide variety of fungi (Wedge et al., 2007). They were given the name "strobilurin" since the first isolate of this fungicide was derived from the pine cone fungus (*Strobilurus tenacellus*). The strobilurin fungicides are effective fungicides and positive plant effects have also been observed in a variety of crops (e.g. Sudisha et al., 2005). However, negative impacts on crop yields have also been observed with strobilurin use (e.g. Wrather et al., 2004). Strobilurin fungicides are extremely selective fungicides and interfere with the energy production of ATP (adenosine-5'-triphosphate) in the fungi mitochondrial cells. Specifically, they target the electron transfer at the site of quinol oxidation (Q_o site) in the cytochrome BC1 complex, thus they are properly referred to as the *Q_oI fungicides* based on this mechanism (Vincelli, 2002). However, this is the only mode of control, and thereby any alteration at the biochemical site would result in a Q_oI-resistant strain (Brent and Hollomon, 1998). Due to this activity, strobilurins have been noted for their exceptional fungi control [particularly for leather rot (*Phytophthora cactoru*) (Rebollar-Alviter et al., 2005)]. Research is being conducted at the Pine Tree Apple Orchard in White Bear Lake, MN to evaluate the impacts of these fungicides on strawberry production – both on yield and soil system effects. We are currently in our second year of this planned three year research program.

Results

The first year of the project compared the effects on strawberry yields and diversity of the soil microbial community as a consequence of strobilurin (pyraclostrobin) application (at label specified rates) with supplemental micronutrient foliar fertilization (AgroK –Vigor Cal Phos™ with Boron; Minneapolis, MN). We observed a significant difference in yields between the control (no fungicide or fertilizer) and the fungicide + fertilizer treatments (64% increase) (Figure 1A). However, there were no significant yield differences between the control and fertilizer as well as the fertilizer and fungicide + fertilizer plots. In 2009, we did not evaluate the additional micronutrient fertilizer and solely compared the fungicide application. The observed increase in yield was not statistically significant (Figure 1B). Note the high variability in the yields of the fungicide plots.

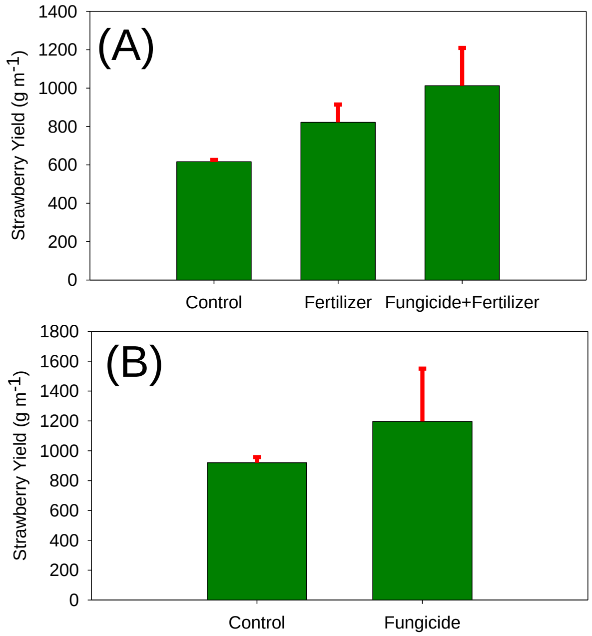

Figure 1. Illustration of the impact of strobilurin application on strawberry yields (grams total berries per meter of plant row) in a) 2008 (with micro-nutrient fertilizer) and b) 2009 (without fertilizer effect). Different letters indicate statistical significance ($p<0.05$).

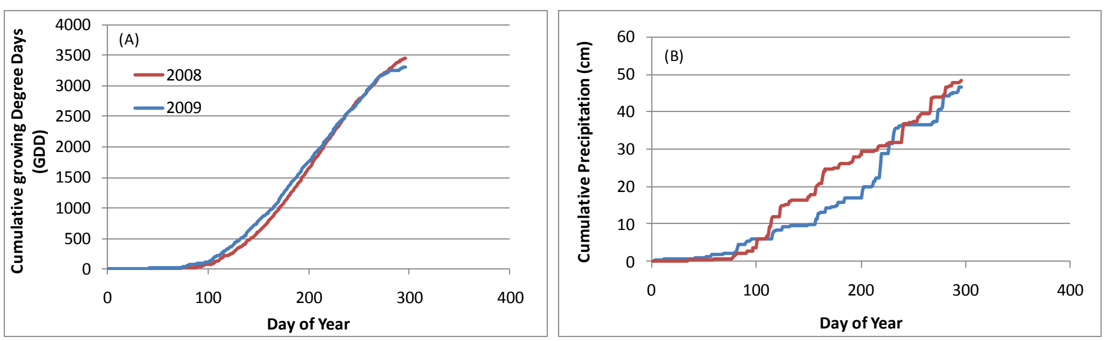

Figure 2. Comparison for 2008 and 2009 of cumulative (A) growing degree days (GDD) and (B) precipitation for the field site.

Air temperature and precipitation patterns were similar in both years (Figure 2). 2008 was slightly cooler [1255 growing degree days (GDD) versus 1391 GDD in 2009 on July 1; Figure 2A]. Furthermore, 2008 was slightly wetter with 26.2 cm of cumulative precipitation by July 1 compared to 15.7 cm in 2009. (Note: Irrigation was conducted both years and not included in these precipitation totals.) The replicated field plots were located at the field row edge (to ease site management), which could add variability in the irrigation coverage of the plots as well (data not collected). The potential exists that there was increased water stress in 2009 and this could have impacted the lack of a statistical yield increase in 2009. These differences also highlight the variable nature of “yield bumps” with fungicide use (e.g. Vincelli and Hershman. 2009).

For the soil microbial results in 2008, there were significant decreases in the number of yeasts and molds in the fungicide treated plots (37% reduction) with a corresponding increase in pseudomonads (240%) in the fungicide treated plots (Figure 3). No significant differences were observed in the heterotrophic bacteria, anaerobic bacteria, actinomycetes, or nitrogen-fixing bacteria as a consequence of the fungicide treatment (Figure 3). There was no detectable leaching of the fungicide into the soil system, despite the supplemental irrigation for the strawberry production and the sandy soil texture. The only detectable quantity of pyraclostrobin was observed in the straw mulch covering (~1.5 ug/g_{straw}), and this dropped to undetectable levels 2 weeks after application (<1.0 ug/g_{straw}) in both years (Table 1).

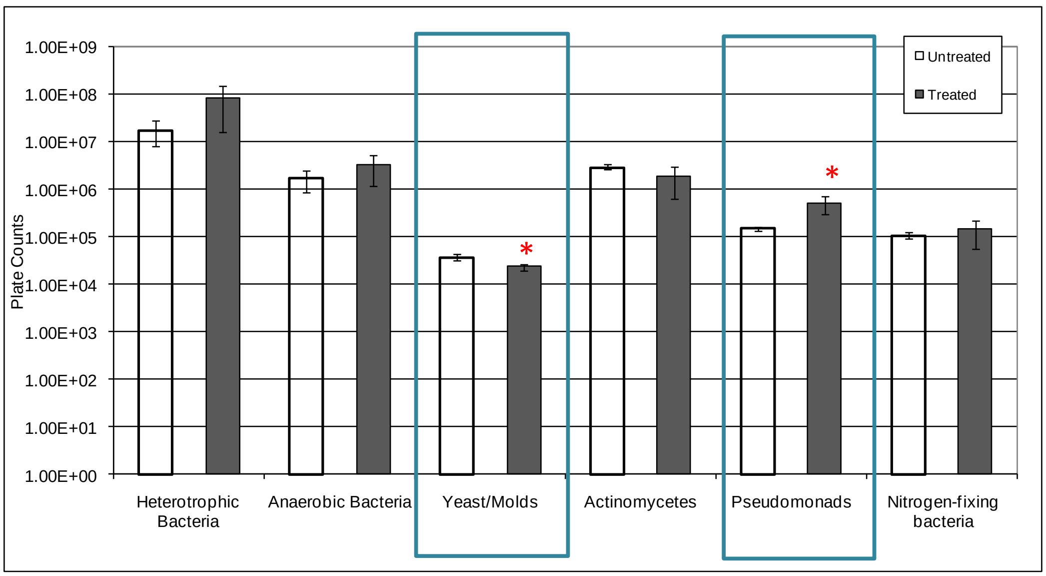

Figure 3. Illustration of the impacts of strobilurin application on microbial populations in 2008. Boxed groupings had statistical significant differences between the control and treatment plots ($p<0.05$).

Table 1. Results of sampling for the presence of strobilurin in surface straw mulch and soil (to a 50 cm depth). These samples were taken within 1 week of application. Levels decreased to non-detectable quantities 1 week after application.

	ug strobilurin per g soil (or straw)	
	2008	**2009**
Surface Straw Mulch	1.5	1.0
0-5 cm	<1.0	<1.0
5-10 cm	<1.0	<1.0
10-15 cm	<1.0	<1.0
15-20 cm	<1.0	<1.0
20-25 cm	<1.0	<1.0
25-50 cm	<1.0	<1.0

In 2009, we did monitor greenhouse gas fluxes biweekly to examine the impacts of the fungicide application on the trace gas exchange. Initially there is a decrease in the flux of carbon dioxide immediately following fungicide application, but this quickly returns to control levels 1 week after application. There were no significant differences noted for methane or nitrous oxide flux or 10 cm soil gas concentrations as a result of the fungicide application. For the remainder of the season, there were no notable differences between the gas fluxes of carbon dioxide, methane, and nitrous oxide.

Conclusions

To date, we have observed no long-term negative impacts on the soil system or strawberry production as a consequence of strobilurin application. In fact, there was a statistically significant increase in strawberry yield as a consequence of strobilurin application in 2008, and a non-significant increasing trend in 2009. This lack of statistical significance could indicate the importance of climate or synergy between the fertilizer and strobilurin applications. These interrelationships are planned to be evaluated in the final year of the project. The yield bumps seen in other agricultural crops is often overstated and varies as a function of multiple variables (Vincelli and Hershman. 2009). In addition, there was no data that indicated any leaching risk of the fungicide into the soil system, despite irrigation use for strawberry production. For further information please contact kurt.spokas@ars.usda.gov.

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