Effect of Alternative Fungicides on Alternaria solani Control and Productivity of Organic Tomatoes

Final Report for GNC02-007

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Project Information

Summary:

The efficacy of organic fungicides and compost teas to control Septoria leaf spot (Septoria lycopersici Speg.) on tomatoes was evaluated. Tomato plants (‘Mountain Spring’) were transplanted into black plastic mulch in May of 2003 and 2004, inoculated with 7.5 x 108 conidia×ha-1 and treated with: (i) control (no foliar spray), (ii) alternated applications of chlorothalonil plus copper hydroxide and mancozeb plus copper hydroxide (iii) Copper hydroxide only, (iv) Bacillus subtilis only, (v) WCCM tea, (vi) VCCM tea, and (vii) SporanTM. The only treatments effective in reducing disease severity were copper hydroxide and copper hydroxide plus chlorothalonil or mancozeb. Treatments that received B. subtilis, SporanTM , or compost extracts were not effective at controlling S. lycopersici.

Introduction:

Managing diseases of tomatoes organically poses challenges for producers in humid climates. Septoria lycopersici is a common fungal disease of tomatoes. Resistant or tolerant cultivars are not available; therefore growers must rely on cultural and chemical control practices, including the use of copper (Cu) fungicides for disease control (Jones et al., 1991). There are currently five Cu based fungicides allowed in certified organic production. Concerns regarding the use of Cu fungicides have been expressed due to their potential to reduce crop yield (Rhoads et al., 1989) and to cause toxicity to earthworms, nematodes (Burrows and Edwards, 2002), and entomopathogenic fungi (Ropek and Para, 2002). Furthermore, the potential for Cu accumulation in the soil surface (Kabata-Pendias and Pendias, 1992) and concerns about pathogen resistance also have led producers to seek alternatives.

An alternative disease-management technique available to organic producers is the use of biological control agents that are commercially available or producer created. Bacillus subtilisâ (Bacillus subtilis Cohn; AgraQuest, Davis, CA) is a commercially available, broad-spectrum biofungicide registered for use on tomatoes to control foliar diseases caused by bacterial and fungal pathogens. However, independent research regarding its efficacy in controlling S. lycopersici has not been repeated.

Compost tea, a liquid extract with microorganisms (Diver, 1998), is a producer-created biofungicide. There are two main ways in which teas can be made; one includes aeration whereas the other does not. Research on non-aerated compost teas has found that control of plant pathogens in the phyllosphere from beneficial organisms is acquired through induced resistance, inhibition of spore germination, antagonism, or competition. Such studies have not been performed on aerated compost tea (Scheuerell and Mahaffee, 2002). Bacteria and fungi are the agents in compost tea that control foliar diseases, specifically those belonging to the genera Bacillus Cohn, Pseudomonas van Hall, Serratia Sm., Penicillium Link, and Trichoderma Pers. (Brinton et al., 1996). There are many factors that affect the efficacy of compost tea including compost source, dilution ratio, and organism extraction and application methods (Scheuerell and Mahaffee, 2002).
The efficacy of these new commercial organic products and techniques available to farmers has not been evaluated. Scientific evaluation of the efficacy of pesticide products registered for use in organic agriculture is vital for growers' success.

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Project Objectives:

Our objectives were to evaluate the efficacy of organic fungicides and compost tea from either windrow-composted cattle manure (WCCM) or vermicomposted cattle manure (VCCM). We also compared the efficacy of organic and conventional fungicides.

Cooperators

- Hank Tabor

  Major Professor

Research

Materials and methods:

Research was conducted for two seasons at the Iowa State University Horticulture Station near Gilbert, IA. The field site was a Clarion loam soil defined as a fine loamy, mixed, superactive, mesic Typic Hapludoll. The 2003 field site was planted in muskmelons (Cucumis melo L.) in 2001 and soybeans [Glycine max (L.) Merr.] in 2002. The 2004 field site was planted in muskmelons in 2003 and tomatoes, squash, and green beans in 2002.

For 2003 the average temperature close to normal at the beginning of the season and rainfall was below normal. The deviation from normal temperature in May, June, July, and August was + 0.1, -0.5, -0.7, and +2.0 °C, respectively (Figure1). Rainfall deviation from normal for May, June, July, and August was -14, -45, +10, and -73 mm, respectively (Figure 2).

For the 2004 growing season fruit ripening was delayed because of lower than normal temperatures. The deviation from normal temperature in May, June, July, and August was +1.6, -1.0, -2.0, and -2.4 C respectively, below average for June, July, and August. Temperatures reached 32 C only twice during the growing season and did not exceed 32 C. This resulted in delayed fruit set. Average rainfall in 2004 was greater than normal at the beginning of the season. Rainfall deviation from normal for May, June, July, and August was +89, -71.0, -12.5, and +6.0 mm, respectively.

‘Mountain Spring’ tomato plants were transplanted on 16 May 2003 and 12 May 2004 into black plastic mulch. All treatments except for the conventional treatment received 8 Mg×ha –1 of compost that contained 1.4% nitrogen and 27% moisture in 2003 and 22 Mg×ha –1 of compost that contained 0.52% nitrogen and 27% moisture in 2004. Compost used in 2003 was windrow composted cornstalk bedded cattle manure from Terra Fact, Corp. near Lake Park, IA. Compost used in 2004 was windrow sand bedded cattle manure from the Iowa State University dairy farm. The nitrogen (N) applied by compost in each year was 83 kg×ha –1. The conventional treatment received 67 kg×ha –1 of N as urea in both 2003 and 2004. Compost and urea were broadcast uniformly and incorporated to a 20- cm depth before laying plastic mulch. Plants were pruned once at the first flower cluster on 12 June 2003 and 17 June 2004 and staked and tied according to the Florida method. Plants were irrigated with a trickle system to maintain the 20-cm-depth tensiometer readings at

Research results and discussion:

Results
Differences in disease severity occurred early and were consistent throughout the 2003 growing season. Plants in the two treatments that received copper hydroxide remained disease-free and there was no additional effect on disease severity of adding conventional fungicides to copper hydroxide. Treatments that received copper hydroxide had 50% lower disease severity than the untreated control by the end of the season. There was no difference in disease severity between plants that received B. subtilis or compost extracts and the control treatment as 50% of leaves on plants in all four treatments showed disease symptoms by the end of the season. The composting method did not affect disease severity between the two types of compost teas, VCCM and WCCM. Again, 50% of leaves on plants that received compost tea applications showed disease symptoms.

Differences in disease severity in 2004 showed a similar trend to that of 2003; disease severity was less in treatments that received copper hydroxide than those that did not. However, unlike the 2003 growing season there was a significant difference in disease severity between plants that received copper hydroxide only, and those that received copper hydroxide plus conventional fungicides. Plants in treatments that received copper hydroxide only, were Neither B. subtilis nor rosemary oil was effective at controlling S. lycopersici, and B. subtilis was not effective at controlling X. campestris. The B. subtilis product label recommends its use for control of X. campestris in conjunction with Cu-based fungicides. Results from this research indicate that B. subtilis alone cannot control X. campestris and S. lycopersici when disease pressure is high. There was phytotoxic damage on plants that received rosemary oil, however, it is possible that during the first treatment application plants may have received a concentrated amount of fungicide because of inadequate sprayer mixing.

Compost tea was not effective at controlling S. lycopersici or X. c. pv. vesticatoria. Furthermore, there was no difference in disease severity between compost tea made from window-composted cattle manure or VCCM, indicating that composting method did not affect efficacy of the compost tea. These results are consistent with those of Plotkin (2002), who showed compost tea was ineffective at controlling Alternaria solani (Elli. & Mart.) L.R. Jones & Grout and Septoria spp. on field tomatoes. However, compost teas have been found to control some important diseases of fruits and vegetables. Tsror (1998) found that a compost tea of commercial cattle manure incubated for 7 or 14 d controlled A. solani on field-inoculated tomato plants. The degree of control was similar to that obtained with Kocideâ (copper hydroxide; Griffin L.L.C., Valdosta, GA) or Funguranâ (copperferroxychlorid; Spiess Urania, Hamburg, Germany), both Cu-based fungicides. Compost tea made from dairy cattle manure reduced disease caused by Botrytis cinerea Pers., on grapes (Vitus L. spp.) by 48% (Trankner, 1992). In growth chambers, compost teas made from either composted cattle or chicken manure controlled B. cinerea on tomato and pepper plants and grape berries (Elad and

Shtienberg, 1994). Further research is necessary to determine what preparation and application factors affect the efficacy of compost teas on S. lycopersici. Investigating other composting sources, adjusting the dilution ratio, or changing application rate and timing may increase efficacy.

Copper hydroxide controlled both X. campestris and S. lycopersici. To our knowledge, the efficacy of this product for both pathogens on tomatoes has not been demonstrated previously. This information is useful for organic producers because copper hydroxide is one of six Cu fungicides allowed in certified organic production.

In both 2003 and 2004 plants in treatments that received copper hydroxide fungicides were the only ones in which expected yields the region were obtained, between 29 and 33 Mg·ha –1 (Foster et al., 2003). While there were differences in culled fruit weight, marketable fruit size, and the number of marketable fruit in 2003, a lack of differences in culled fruit weight and marketable fruit size in 2004 indicates that marketable fruit number is likely the main factor affecting yield. Fruit number is a result of flower production and/or percent of flowers that set fruit. On determinate tomato plants, such as 'Mountain Spring', flower clusters are often found at the end of plant branches. A healthier plant, i.e. one with less disease, would result in a bushier plant with more branches, and thus more flowers. In 2003 plants in treatments that did not receive copper hydroxide fungicides were 5-25% diseased by the second harvest and 25-50% diseased by the third and fourth harvest. In 2004 plants were 25% diseased by 27 July, two weeks before the first harvest and 85% diseased by the first harvest. Plants in these treatments had less green leaf area for photosynthesis, thus they were smaller and less branched, which could have resulted in less flower production, leading to decreased yields.

The use of compost tea to control S. lycopersici should not be promoted in tomato production at this time. However, further investigations are warranted because there are many factors that can affect the tea efficacy. Future research should focus on compost source, using compost with known populations of beneficial species. Populations of beneficial species should be tracked throughout the entire brewing/ application process to determine methods that favor beneficial species. Finally, composting methods should select for beneficial organisms specific to a particular pathogen if the information is available.

The use of chlorothalonil and mancozeb is only necessary when resistance to Cu-fungicides by X. campestris and S. lycopersici is a concern. This is beneficial because consumers are becoming increasingly aware of the impacts agricultural chemicals have on the environment. Producers will benefit from marketing their tomatoes as either organic, sustainable produced, or "low input", providing them with a competitive advantage over conventional producers.

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Participation Summary

Project Outcomes

Recommendations:

Areas needing additional study

Since there are currently no other viable alternatives to copper fungicides in certified organic production future research should focus on ways producers can reduce Cu fungicide applications to address concerns regarding soil accumulation, yield loss, microorganism toxicity and disease resistance associated with Cu.

The use of compost tea to control S. lycopersici should not be promoted in tomato production at this time. Even so, further investigations are warranted because there are many factors that can affect the tea efficacy, including the age of the compost source. The composts used in this experiment were cured, meaning that most of the easily degradable organic substrates were already decomposed. Thus, it is likely that the diversity of organisms present in the compost was low. At this stage, the bacterial population within the compost is low, particularly when compared to the fungi population. There is some skepticism as to how well fungi can reproduce and survive in an aqueous environment. Furthermore, thermophilic bacteria, those that can survive temperatures between 60 and 65 C, such as Bacillus sp. may not present in cured compost (CIWMB, 2001). Compost tea efficacy may have been greater if non-cured compost was used. Future research into compost teas should focus on identifying the beneficial organisms present in the compost source used to make the tea and monitoring their populations throughout the brewing and application process. Tea components, such as salt, pH and other elements should be evaluated for their impact on microorganism survival. Also, making adjustments to how the tea is prepared, such as dilution ratio or fermentation time may increase efficacy. Application rate and timing may also increase efficacy.