

Effect of Aerobic Compost Tea Inputs and Application Methods on Protecting Tomato from *Phytophthora capsici*

R.W. Nicol^a and P. Burlakoti
University of Guelph - Ridgetown Campus
Ridgetown ON
USA

Keywords: aerobic compost tea, *Solanum lycopersicum*, tomato, plant disease, *Phytophthora capsici*

Abstract

Numerous challenges exist in organic tomato production, one of the largest being a lack of amendments that can effectively serve as crop nutrients or pest controls and still be considered organic. Compost is a recognized organic input, and a recent development is the use of compost tea in fertility and biocontrol applications. Aerobic compost tea (ACT) is produced by aerating compost and water and allowing microbial activity to increase over a few days. An investigation into the biocontrol and fertility efficacy of different ACT formulations, as well as ACT crop application methods was completed. Four batches of ACT, two based on Sustane (commercial compost from poultry litter) and two based on spent mushroom compost, with or without nutritional additives, were made at a ratio of 31:1 water to substrate. In vitro antifungal bioassays revealed that all Sustane and spent mushroom compost ACTs reduced the growth of *Phytophthora capsici* whereas only ACT based on spent mushroom compost reduced the growth of *Botrytis cinerea*. A greenhouse trial using the tomato cultivar 'Glamour' was completed and ACT was applied by spraying the shoots or drenching the potting mixture either pre-inoculation or pre- and post-inoculation with *P. capsici*. All ACTs reduced disease progress although there were differences across application methods. Generally, drenching ACT reduced disease more than spraying and applying ACT twice (before and after pathogen inoculation) was also better than applying ACT once before inoculation. The percent reduction in disease progress ranged from an average of 6.4% for spraying ACT once to an average of 73.4% for drenching ACT twice. This same trend was observed in the plant biomass data. In addition, the biomass data suggests that ACT also offered fertility benefits to the tomato plants. ACT therefore holds promise as a sustainable biocontrol treatment as well as a source of plant nutrients for organically grown tomato.

INTRODUCTION

Organic vegetable producers often lack efficient pest control and fertility treatments that are available to conventional growers (Zheng et al., 2011). Compost has long been recognized as a useful addition to crops and compost tea is produced by mixing compost and water at a ratio of between 1:5 to 1:10 and allowing fermentation or other microbial activity to occur for a period of one to three days (Litterick et al., 2004; Ingham, 2005). Compost teas are often produced with aeration and are referred to as aerated compost tea (ACT).

ACT can be used as a source of nutrients for plants and applied as a foliar feed via spraying or to stimulate soil biological activity via drenching (Pant et al., 2011). For greenhouses, drenching could be very beneficial for the propagation stage of production, where soil life is just establishing, and where solid compost application is problematic. In addition, different types of ACT have been demonstrated to be effective at controlling fungal pathogens that pose ongoing challenges to greenhouse producers. Diseases in vegetables caused by *Botrytis cinerea*, *Erysiphe polygوني* and *Pythium ultimum* have also

^a micol@uoguelph.ca

been controlled to some degree by ACT (Scheuerell and Mahaffee, 2004; Segarra et al., 2009; Palmer et al., 2010). However, the inputs, production methods and other variables differ across studies and a standardized tea preparation is currently unavailable for greenhouse producers. Litterick et al. (2004) reviewed the utility of compost teas in controlling plant diseases but also highlighted the variable nature of results when they stated: “Efficacy varied and depended on the crop, the input materials used to make the compost, the compost production system, the extract/tea preparation method, and the experimental system, used to test the extract/tea”. Therefore, research on compost tea inputs, processes, efficacy and safety is still needed. The objective of the project was to evaluate ACT as a fertility and biocontrol treatment for organically grown greenhouse tomatoes.

MATERIALS AND METHODS

Four aerobic compost teas (ACT), two based on Sustane (commercial compost from poultry litter) and two based on spent mushroom compost were made by aerating 6 kg of substrate in 188 L of dechlorinated water for 70 h. One of the Sustane teas was created by adding 284 g of kelp extract, 454 g of potassium humate, and one of the spent mushroom compost teas was created by adding 284 g of kelp extract, 454 g of potassium humate and 15 g of vegetable oil.

In vitro antifungal activity assays were completed by adding 1 ml of ACT to a plug of *P. capsici* or *B. cinerea* that had recently been added to the surface of potato dextrose agar. Measurements of fungal hyphae were taken when control colonies reached the edge of a 90-mm petri dish.

P. capsici was used for whole plant greenhouse experiments. This isolate was retrieved from infected tomato grown by an organic greenhouse producer in a Kingsville ON and identified via sequencing of the ITS region and comparison to sequences in the NCBI database. Single spore cultures were grown on V8 agar medium (200 ml of Campbell V8 juice, 0.75 g of CaCO₃, and 15 g of agar in 800 ml of distilled water). The isolate was incubated for 7 days under continuous cool-white fluorescent light at 12 h light and dark cycles at 21±2°C. Inoculum was produced by first growing *P. capsici* on PDA for 7 days and then using this to infect sterile wheat kernels over a period of two to three weeks. Tomato seeds (‘Glamour’, ‘Cencara’ and ‘Florida 91’) were sown and single seedlings were grown in individual 4” plastic containers and watered daily. Three weeks after germination, three one centimeter depth holes were made close to the root (approximately one centimeter apart from main stem) in three sides and two to three infected wheat kernels were deposited and covered with fresh Sunshine #1 potting mix. Plastic containers with inoculated seedling were watered daily. A daily cycle of 14 h light and 10 h dark, with temperatures of 21±2°C was maintained in the greenhouse. Inoculated plants were examined for wilting symptoms daily starting five days after inoculation for the next 32 days. A plant was considered dead when the plant was irreversibly wilted. Plants were rated using the 0 to 5 scale described by Kim et al. (1989), where 0 = no visible disease symptoms; 1 = leaves slightly wilted with brownish lesions beginning to appear on stems; 2 = stem lesions extending to cotyledons, defoliated first and second leaves, damping off occurring in seedling plants or 30 to 50% of entire plant disease; 3 = stem lesions extending to second leaves, yellowing or defoliation of some upper brownish lesion developing to the petioles in seedling plants or 50 to 70% of entire plant diseased; 4 = long brownish lesions extending up to at least 10 cm from the soil, all leaves except the uppermost leaves defoliated, seedling tissues collapsing and shoots wilted or 70 to 90% of entire plant diseased; 5 = whole plant dead. The weight of whole plants was measured after drying.

ACT was applied to tomato either as by spraying the shoot or drenching the potting mix. For spraying, 5 ml of ACT was applied to 12 to 16 individual plants either two days before pathogen inoculation (pre-inoculation) or two days before and two days after inoculation (pre- and post-inoculation). For drenching, 10 ml of ACT was applied to the potting mix near the main stem of 12 to 16 individual plants in a circular fashion

either two days before pathogen inoculation (pre-inoculation) or two days before and two days after inoculation (pre- and post-inoculation). ACT was also applied to non-inoculated plants in order to evaluate potential fertility or disease causing activity of the ACT. A standard 20:20:20 fertilizer was applied to control (water) plants at the same time as ACT was applied to treatment plants.

All experiments were conducted twice and data are presented as an average of two experiments. Tomato greenhouse experiments were arranged in a randomized complete block (RCB) design with three replicates. Disease rating of tomato plants was used to calculate the area under the disease progress curve (AUDPC) according to Shaner and Finney (1977). Disease progress in the treatment plants was standardized to a percent reduction from control and analyzed using Systat 13. Data were first analyzed by ANOVA with confirmation that data was normally distributed with equal variance. Significant differences between application methods as well as across treatments applied pre- and post-inoculation were identified using a Tukey's separation of means.

RESULTS AND DISCUSSION

ACT exhibited a range of in vitro antifungal activity. All four ACT formulations consistently reduced the hyphal growth of *P. capsici* by more than 75% as compared to the control. For *B. cinerea*, only ACTs based on spent mushroom compost inhibited fungal growth. Spent mushroom ACT alone reduced *B. cinerea* growth by 50%, and spent mushroom ACT plus added nutrients reduced growth by 66.5%. In terms of fungal pathogens, the remainder of this report focuses on the ability of ACT to control disease caused by *P. capsici*.

A preliminary greenhouse trial with all three tomato cultivars and ACT based on Sustane only revealed that ACT reduced disease symptoms and improved plant biomass. This experiment was expanded to include different ACT formulations and application methods with 'Glamour'. All control tomato plants (water as well as teas and applications without *P. capsici* inoculation) exhibited no disease symptoms. Table 1 shows the effect of ACT formulations and applications on disease progress in tomato. Uninoculated control plants did not exhibit disease symptoms and data are presented as the percent disease reduction as compared to the control. For the spray application, spraying pre- and post-inoculation yielded significantly better disease progress than spraying only pre-inoculation. Drenching ACT was significantly better than spraying, but there was no significant difference between drenching pre-inoculation and drenching pre- and post-inoculation except for the ACT made with mushroom compost with added nutrients (Table 1).

Figure 1 represents data from replicated experiments that investigated the effect of ACT on tomato biomass (with and without *P. capsici* inoculation). For each experiment there were five controls: a water control (that included synthetic fertilizer at time of ACT application) plus four ACT controls, one for each of the application methods and timing. All of these controls did not receive inoculation by *P. capsici*. These figures demonstrate that ACT improved biomass when tomatoes were inoculated with the pathogen. The drenching application was generally better than spraying and drenching pre- and post-pathogen inoculation resulted in the largest biomass. Figure 1 also suggests that ACT could improve growth in the absence of fungal infection. That is, there is a trend of higher biomass in the ACT controls versus water control.

CONCLUSIONS

ACT exhibited in vitro as well as in planta biocontrol ability and may also be a useful source of plant nutrients. Application of the ACT via drenching was more effective than spraying. Future experiments will include an expanded experimental design in order to investigate the nutritional impact of ACT on growth in disease free plants. In addition, the effect of ACT on fruit yield from both uninoculated and inoculated plants will be determined. ACT is made from renewable and ultimately waste material, and therefore represents a means to sustainably manage tomato diseases.

ACKNOWLEDGEMENTS

This project was funded by the Natural Sciences and Engineering Research Council of Canada (NSERC) Engage program. Many thanks to Erievue Acres of Kingsville ON for being a research partner in this project.

Literature Cited

- Ingham, E.R. 2005. The Compost Tea Brewing Manual, Latest methods and research, 5th Edition, April, 2005. Soil Foodweb Incorporated, 728 SW Wake Robin Ave, Corvallis, Oregon 97333.
- Kim, Y.J., Hwang, B.K. and Park, K.W. 1989. Expression of age-related resistance in pepper plants infected with *Phytophthora capsici*. Plant Dis. 73:745-747.
- Litterick, A.M., Harrier, L., Wallace, P., Watson, C.A. and Wood, M. 2004. The role of uncomposted materials, composts, manures, and compost extracts in reducing pests and disease incidence and severity in sustainable temperate agricultural and horticultural crop production-a review. Critical Reviews in Plant Sciences 23:453-479.
- Palmer, A.K., Evans, K.J. and Metcalf, D.A. 2010. Characters of aerated compost tea from immature compost that limit colonization of bean leaflets by *Botrytis cinerea*. J. Appl. Microbiol. 109:1619-1631.
- Pant, A.P., Radovich, T.J.K., Hue, N.V., Talcott, S.T. and Krenke, K.A. 2011. Effects of vermicompost tea (aqueous extract) on pak choi yield, quality, and on soil biological properties. Compost Sci. Utilization 19:279-292.
- Scheuerell, S.J. and Mahaffee, W.F. 2004. Compost tea as a container medium drench for suppressing seedling damping-off caused by *Pythium ultimum*. Phytopathology 94:1156-1163.
- Segarra, G., Reis, M., Casanova, E. and Trillas, M.I. 2009. Control of powdery mildew (*Erysiphe polygoni*) in tomato by foliar applications of compost tea. J. Plant Pathol. 91:683-689.
- Shaner, E. and Finney, R.E. 1977. The effect of nitrogen fertilization on the expression of slow mildewing in Knox wheat. Phytopathology 67:1051-1056.
- Zheng, Y., Dixon, M.A. and Ferguson, G. 2011. Organic greenhouse vegetable production in Canada: challenges and opportunities. Acta Hort. 893:1195-1200.

Tables

Table 1. Effect of aerobic compost tea (ACT) on disease symptoms in tomato inoculated with *Phytophthora capsici*. ACT was made from Sustane without (ST) or with added nutrients (STN) or spent mushroom compost without (MC) or with added nutrients (MCN) and applied as a spray or drench, pre- or pre- and post-inoculation with *P. capsici*. Values are the mean percent reduction in disease progress as compared to the control (no ACT applied) \pm standard deviation.

ACT application	Reduction in disease progress (%)			
	ST	STN	MC	MCN
Pre-inoculation spray	6.97 \pm 3.96 a*	7.63 \pm 3.96 a	6.51 \pm 1.80 a	4.43 \pm 2.56 a
Pre- + post-inoculation spray	37.13 \pm 7.47 b	38.78 \pm 6.32 b	38.49 \pm 7.28 b	32.01 \pm 9.56 b
Pre-inoculation drench	70.67 \pm 16.5 c	71.27 \pm 15.56 c	65.13 \pm 14.13 c	56.51 \pm 6.82 c
Pre- + post-inoculation drench	74.50 \pm 8.13 c,d	75.88 \pm 6.88 c,d	70.04 \pm 6.87 c,d	73.18 \pm 8.88 d

* Means within each ACT formulation followed by the same letter are not significant as determined by a Tukey's test.

Figures

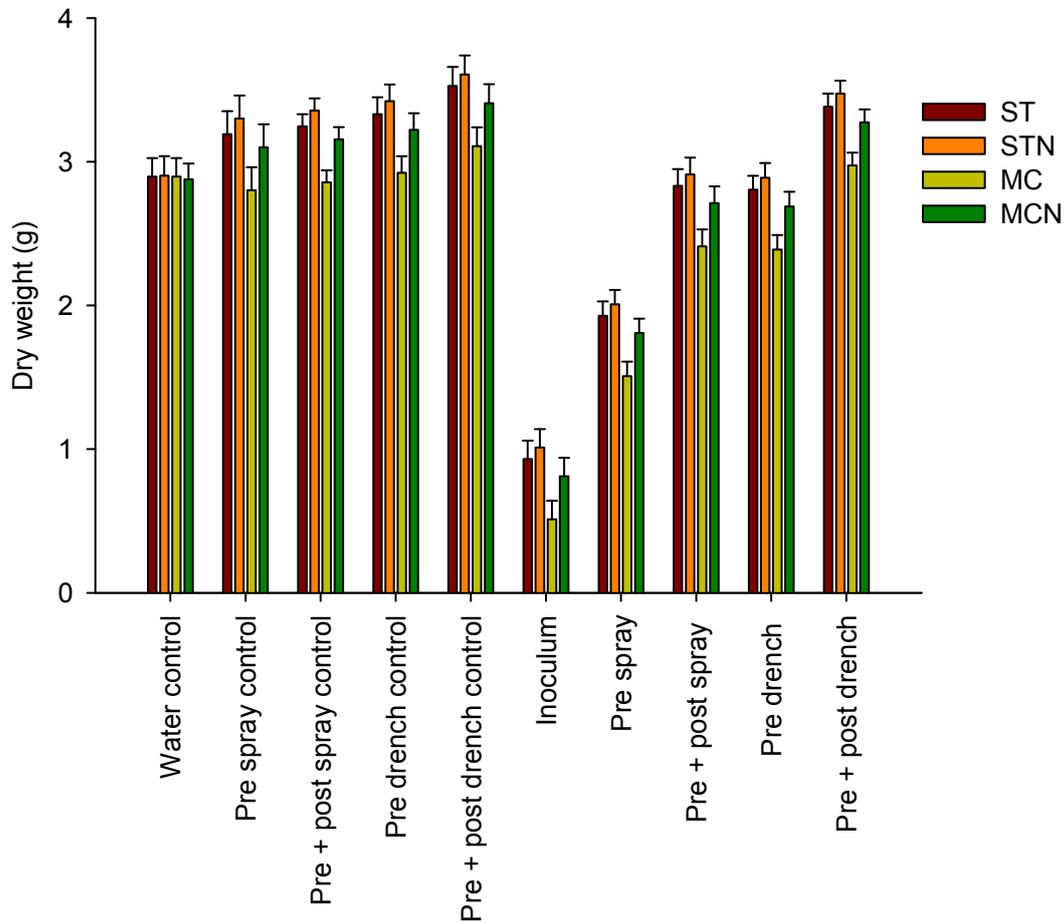


Fig. 1. The effect of ACT and application method on tomato biomass. ACT was applied as a spray or drench before (Pre) or before and after (pre + post) inoculation with *Phytophthora capsici*. The first five data sets, labelled as control, were not inoculated with the pathogen but received ACT applications at the same times as the inoculated plants. ACT was made from Sustane with or without added nutrients (ST, STN) or spent mushroom compost with or without nutrients (MC, MCN). Values are averages \pm standard deviation.

