ISSN 1682-296X (Print)
ISSN 1682-2978 (Online)

Bio Technology

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Biotechnology 5 (1): 69-74, 2006
ISSN 1682-296X

Antibiosis Ability of Aerobic Compost Tea against Foliar and Tuber Potato Diseases

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Abstract: Field trials were conducted in Wicklow, New Brunswick, Canada to study the antibiosis ability of aerobic compost tea against foliar and tuber diseases of potatoes. For soil drenching, extracts were prepared using three types of compost organic material including thermal compost, static wood chips and vermi castings. Kelp, humates, rock dusts, grain and alfalfa meal, soluble plant sugar and liquefied fish were added during a 24 h compost tea aerobic brewing cycle. For foliar application, soluble plant sugar, a natural yucca surfactant and liquefied fish were added as food to the compost tea prior to foliar application. Six treatments were used: untreated control (C); drench compost tea (DCT); foliar food (FF); foliar compost tea (FCT); drench compost tea+foliar food (DCT+FF) and drench compost tea + foliar compost tea (DCT+FCT). Both soil drenching and foliar application of compost tea or food lead to a significant increase in the severity of foliar late blight (*Phytophthora infestans*). Compost tea treatments had significant effects on emergence, stems number, silver scurf (*Helminthosporium solani*) and black scurf (*Rhizoctonia solani*). Foliar food applications increased the number of stems produced. The severity of silver scurf was the highest when drench compost tea treatment was used. In case of black scurf, the severity was the highest when a combination of both drench compost tea and foliar compost tea were applied. Treatments had no significant effect on dry rot (*Fusarium* sp.), common scab (*Streptomyces scabiei*), early blight (*Alternaria solani*), bacterial soft rot (*Erwinia carotovora* subsp. *carotovora*), yield, or size of tubers produced.

Key words: Biological control, compost tea, potato diseases, *Solanum tuberosum*

INTRODUCTION

Extracts produced from composted organic matter have been used for centuries for their beneficial effects on plant health (Abbasi *et al*., 2002). Compost tea is being used increasingly as an alternative plant disease control measure in organic agriculture (Anonymous, 2004). Several reports have shown that various types of such extracts applied on plant foliage can reduce the severity of certain foliar diseases such as gray mold, apple scab and powdery mildew (Achimu and Schlosser, 1991; Welzein, 1991; Jongebloed *et al*., 1993; Elad and Shteinberg, 1994; McQuilken *et al*., 1994; Scheuerell and Mahaffee, 2000). Most extracts are prepared from animal waste based composts (Abbasi *et al*., 2002), although extracts from other types of composts, weeds and plant by-products have also been effective against plant diseases (Osborn, 1943; Gillver, 1947; Dixit and Tripathi, 1975; Chaudhuri, 1982; Akhtar *et al*., 1986; Yohalem *et al*., 1996; Al-Mughrabi *et al*., 2001; Al-Mughrabi, 2003; Al-Mughrabi and Aburjai, 2003). Aerobic compost tea extracts can be prepared by bubbling air through the slurry during a 24 h extraction process (Brinton *et al*., 1996). However, compost extracts are commonly prepared by mixing mature compost with water in an open container in various ratios. The mixture is stirred and then steeped at ambient temperatures for several days. The extract is filtered and applied to the foliage or drenched into the soil (Abbasi *et al*., 2002). Compost tea is also produced by mixing compost tea with additives that are intended to increase microbial population densities during production (Anonymous, 2004; Scheuerell and Mahaffee, 2002).

The microflora of both non-aerated (Ingham, 2000) and aerated (Welzein, 1991) compost tea are typically described as being dominated by bacteria and therefore the bacterial population of compost tea could be a useful parameter to measure in relation to plant disease suppression. It has been proposed that increasing the population of total and active bacteria in aerobic compost tea will generally increase the level of plant disease suppression (Ingham, 2000). However, there is no published evidence supporting these assertions.

The potato (*Solanum tuberosum* L.) crop is intensively managed and requires frequent application of costly pesticides for high yield and quality (Stevenson, 1994). However, despite the extensive use of pesticides, an estimated 22% of potato yield is lost annually to diseases and pests (Ross, 1986). The objective of this study was to determine if compost tea applied as foliar and soil drench suppresses potato diseases and improves yield.

MATERIALS AND METHODS

Preparation of aerobic compost tea: Combinations of three types of compost/organic materials were used to prepare the aerobic compost tea (CT); thermal compost, static wood chip compost (no turning occurred once the pile was formed) and vermi-castings. During the 24 h compost tea aerobic brewing cycle, the following additives were introduced to non-chlorinated water and compost: Kelp, humates, rock dusts, grain/alfalfa meals, soluble plant sugar sources and liquefied fish. Prior to soil drenching, liquefied fish was added as food to the compost tea. For the foliar applications, soluble plant sugar sources, a natural yucca surfactant and liquefied fish were added as food to the compost tea, prior to application.

Experiment setup: The experiments were conducted in a field plot setting. Potato (cv. Shepody) seed pieces, ~60 g each, were hand planted. The experiment followed a one-way Randomized Complete Block Design with 6 treatments and 4 replicates. Each replicate consisted of a row 4.57 m long and 0.91 m wide. Seed pieces were spaced at 0.31 m within each row. The 6 treatments were: (1) untreated control [C]; (2) drench compost tea [DCT]; (3) foliar food [FF]; (4) foliar compost tea [FCT]; (5) drench compost tea + foliar food [DCT+FF] and (6) drench compost tea + foliar compost tea [DCT+FCT].

Compost tea application: Compost tea was drenched during planting at a rate of 140 L ha^{-1} or 60 mL per plot. Fertilizer, 10.7-11.8-11.8 NPK, was applied at planting at a rate of 1570 kg ha^{-1}. Foliar applications, at a rate of 46.8 L ha^{-1}, were made once a week starting 50 days after planting. In total, 5 foliar applications (Table 1 and 2) were made using a CO_2 sprayer under a pressure of 15-20 psi.

Data collection and disease assessment: Plant emergence was assessed 45 days after planting. Number of stems per plant was assessed 60 days after planting. Severity of foliar early and late blight diseases was visually assessed using a 0-100% scale by 5% of best estimate; 0% indicated no blight whereas 100% indicated that the plant is completely dead (James, 1971; Malcomson, 1976; Dorrance and Inglis, 1997). After harvest, tubers were graded according to size and total yield per treatment was calculated. Severity of tuber diseases such as common scab (*Streptomyces scabiei*), silver scurf

Table 1: Percent of leaf surface containing active bacteria after treatment applications

	Treatment[2]					
DAP[1]	C	DCT	FCT	DCT+ FCT	FF	DCT+ FF
45	12	13	28	48	11	38
52	NR[3]	NR	NR	NR	NR	NR
59	9	12	60	66	50	40
66	80	49	92	80	88	83
73	47	77	95	82	85	96

[1]Days after planting when treatments were applied. [2]C = untreated control; DCT = drench compost tea; FF = foliar food; FCT = foliar compost tea; DCT+FF=drench compost tea + foliar food; and DCT+FCT = drench compost tea + foliar compost tea. [3]NR=not recovered due to shipping problems

Table 2: Percent of leaf surface containing active fungi after treatments applications

	Treatment[2]					
DAP[1]	C	DCT	FCT	DCT+ FCT	FF	DCT+ FF
45	0	1	10	6	2	1
52	NR[3]	NR	NR	NR	NR	NR
59	2	2	5	4	6	4
66	3	2	6	9	2	4
73	2	5	8	8	2	8

[1]Days after planting when treatments were applied, [2]C = untreated control; DCT = drench compost tea; FF = foliar food; FCT = foliar compost tea; DCT+FF = drench compost tea + foliar food and DCT+FCT = drench compost tea + foliar compost tea, [3]NR = not recovered due to shipping problems

(*Helminthosporium solani*), black scurf (*Rhizoctonia solani*), dry rot (*Fusarium* sp.), soft rot (*Erwinia carotovora* ssp. *carotovora*), early blight (*Alternaria solani*) and late blight (*Phytophthora infestans*) were assessed as a percentage of tuber surface area infected using a 0-100% scale (James, 1971; Cruickshank *et al*., 1982).

The experiment was repeated and data were pooled prior to statistical analyses. Data were analyzed using the statistical analysis program CoStat (CoHort Software, Monterey, CA, USA). Mean separation was performed using Student-Newman-Keuls Test at p = 0.05.

Assessment of microbial density on leaf surfaces: During the course of the growing season, leaf samples were collected following the first tea application and then every 7 days thereafter. Assays were performed to determine microbial density on the leaves after the foliar applications. A specified number of leaf sections taken from leaves were treated with a fluorescent stain that is taken up only by active microorganisms. Leaf pieces were then assessed with an epi-flourescent microscope using a grid system. Counts obtained from sample pieces were averaged and used to determine percent leaf coverage of active organisms (Anonymous, 2004; Scheuerell and Mahaffee, 2002).

RESULTS AND DISCUSSION

Combined leaf coverage of 70 to 80% (with minimum of 5% fungi) could give significant disease suppression on a broad range of diseases and plant species (Personal Communication, Soil Foodweb). Such coverage was achieved for most treatment included in our trial (Table 1 and 2).

Application of compost tea as drench or foliar caused significant differences among treatments in terms of number of stems produced per plant ($p = 0.046$) and percent emergence ($p = 0.0184$) (Table 3). Figure 1 shows that only FF was significantly different than the rest of treatments where percent emergence was the lowest. Treatments had no statistically significant effect on yield (Table 3). However, some researchers concluded that compost tea treatments improved yield (Welzein, 1991). Number of stems was the highest in FF treatment, followed by DCT and DCT+FF treatments (Fig. 2). Drench or foliar treatments had no significantly different effect on the severity of dry rot, common scab, or early blight (Table 4). All treatments inhibited silver scurf on tubers ($p = 0.0009$) except for DCT and FF treatments (Fig. 3). FF application performed better than the DCT. In the case of black scurf, All treatments inhibited the disease on tubers ($p = 0.0022$) except those of DCT+FCT and FF (Fig. 4). However, the FF application was more effective in reducing the severity of black scurf than the DCT+FCT.

The most surprising observation was for foliar late blight. Despite achieving combined potato leaf coverage of 70-80% (with minimum of 5% fungi) for most treatment included in our trial (Table 1 and 2), all drench and foliar applications of tea and food increased the severity of late blight compared to the untreated control (Fig. 5). Treatments DCT+FF and DCT were the least conducive to late blight compared to other treatments. However, some studies cited that compost tea applied to the foliage had suppressed a range of foliar diseases (Scheuerell and Mahaffee, 2000), including late

Table 3: Mean squares and significant differences of plant growth parameters and yield among aerobic compost tea treatments

		Mean squares		
Source	d.f.	No. of stems	Emergence[a]	Yield
Treatment	5	2.98*[b]	3.89*	.35[ns c]
Error	18			
Total	23			

[a]Emergence was assessed 45 days after planting, [b]*Significant at 5%, [c]Not statistically significant at 5% level

Table 4: Mean squares and significant differences of disease severities among aerobic compost tea treatments

		Mean squares						
Source	d.f.	DR	SS	R	Scab	LB	EB	SR
Treatment	5	0.54[ns a]	4.26***[b]	3.80**	1.19[ns]	2.52*	114.77[ns]	ND[c]
Error	402							
Total	407							

DD: Dry Rot; SS: Silver Scurf; R: Rhizoctonia; LB: Late Blight; EB: Early Blight; Soft Rot, [a]Not statistically significant at 5% level. [b]*, **, *** Significant at 5%, [c]ND= Disease did not occur

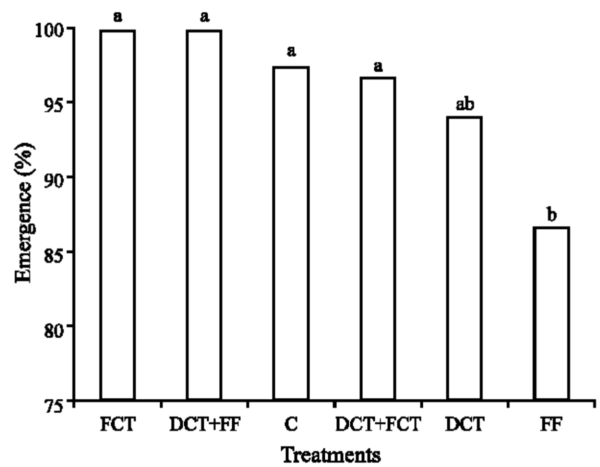

Fig. 1: Percent emergence (45 days after planting) of potato plants treated with various drench and foliar treatments. C = untreated control; DCT = drench compost tea; FF = foliar food; FCT = foliar compost tea; DCT+FF = drench compost tea + foliar food; and DCT+FCT = drench compost tea + foliar compost tea. Bars sharing the same letter are not significantly different at p = 0.05

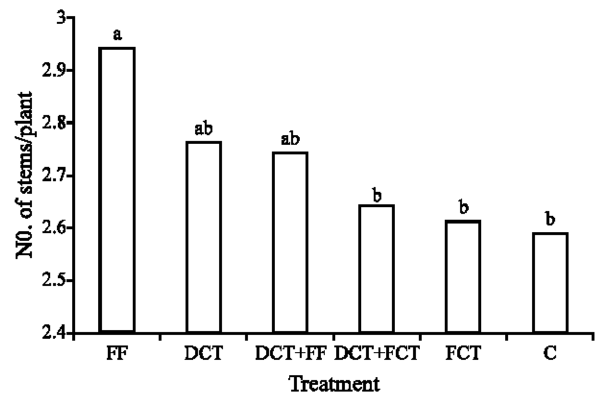

Fig. 2: Number of stems (60 days after planting) of potato plants treated with various drench and foliar treatments. C = untreated control; DCT = drench compost tea; FF = foliar food; FCT = foliar compost tea; DCT+FF = drench compost tea + foliar food; and CT+FCT = drench compost tea + foliar compost tea. Bars sharing the same letter are not significantly different at p = 0.05

Table 5: Mean squares and significant differences of number and weight of tubers of various seed sizes among aerobic compost tea treatments

		Mean squares													
		Seed size /weight/shape													
		Number of tubers							Weight of tubers						
Source	df	≤45 (mm)	50 (mm)	55 (mm)	70 (mm)	75 (mm)	>280 (g)	Knobby	≤45 (mm)	50 (mm)	55 (mm)	70 (mm)	75 (mm)	>280 (g)	Knobby
Treatment	5	1.4 ns [a]	0.96 ns	0.54 ns	1.96 ns	0.63 ns	1.00 ns	1.10 ns	3.11* [b]	1.13 ns	0.67 ns	2.02 ns	0.65 ns	1.00 ns	0.79 ns
Error	18														
Total	23														

[a]Not statistically significant at 5% level, [b]*Significant at 5%

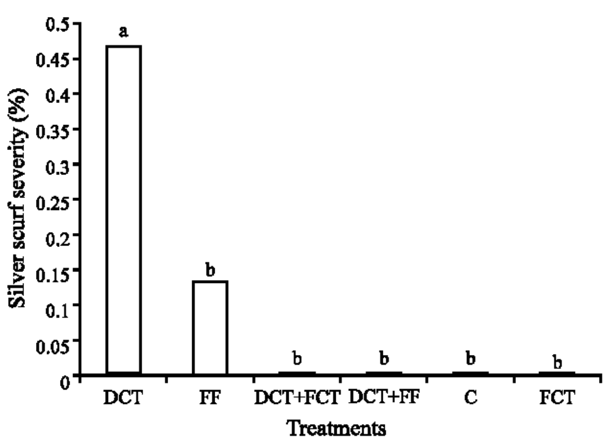

Fig. 3: Severity of silver scurf disease caused by *Helminthosporium solani* assessed on tubers harvested from plants treated with various drench and foliar treatments. C = untreated control; DCT = drench compost tea; FF = foliar food; FCT = foliar compost tea; DCT+FF = drench compost tea + foliar food; and DCT+FCT = drench compost tea + foliar compost tea. Bars sharing the same letter are not significantly different at p = 0.05

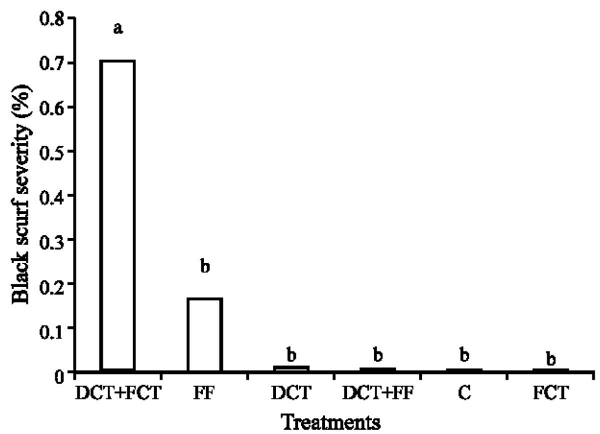

Fig. 4: Severity of black scurf disease caused by *Rhizoctonia solani* assessed on tubers harvested from plants treated with various drench and foliar treatments. C = untreated control; DCT = drench compost tea; FF = foliar food; FCT = foliar compost tea; DCT+FF = drench compost tea + foliar food; and DCT+FCT = drench compost tea + foliar compost tea. Bars sharing the same letter are not significantly different at p = 0.05

blight (Welzein, H.C., 1991). Sturz *et al.* (2004) studied the relative effectiveness of field applied foliar treatments of compost tea and Manzate® 75 DF in inhibiting potato late blight leaf infection and disease development, following inoculation of potato leaf tissue with *P. infestans*. They found that 55% of the leaves treated with compost tea were infected with late blight, compared to 5% for those treated with the fungicide Manzate. The same study concluded that foliar compost tea tank-mixes were found to contain bacterial isolates with significantly higher antibiosis ability against *P. infestans*. However, such populations were significantly reduced after compost tea was applied on the leaf surface and bacterial isolates recovered from potato foliage bore little or no resemblance to the bacterial communities in the spray tank mixes prior to application and failed either to become established on leaf surfaces or may simply have been washed-off during foliar application.

It should be noted that environmental conditions, such as high humidity and temperatures, were very conducive for late blight development throughout New Brunswick, Canada and Maine, USA. Outbreaks of late blight were reported in many other states of the USA and several European countries. High levels of inoculum were present and many specialized fungicides failed to halt the progress of the disease. This could have been the reason for the increased severity of late blight. However, our results prove that such treatments are not effective in protecting against late blight.

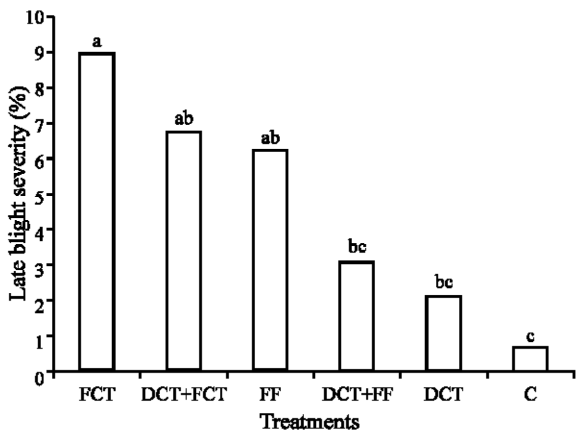

Fig. 5: Severity of late blight disease caused by *Phytophthora infestans* assessed on the foliage of plants treated with various drench and foliar treatments. C = untreated control; DCT = drench compost tea; FF = foliar food; FCT = foliar compost tea; DCT+FF = drench compost tea + foliar food; and DCT+FCT = drench compost tea + foliar compost tea. Bars sharing the same letter are not significantly different at p = 0.05

Although significant disease suppression is usually noted with high microbial levels, there are exceptions to the rule. More research is required to understand survival of organisms on leaf surfaces and selection by plants of organisms that will compete with, inhibit and consume disease-causing organisms. The effect of pesticides, herbicides and inorganic fertilizers on biology on leaf surfaces needs to be better understood as well and the leaf coverage assay is quite useful for determining biology on leaf surfaces.

In general, compost tea and food treatments had no effect on yield or size of tubers (Table 5).

ACKNOWLEDGMENTS

Excellent assistance was provided by Peter Scott (NBDAFA), Tim Livingstone (Jolly Farmers Inc.), Claude Bertheleme (NBDAFA), Rene Poirier (NBDAFA), Lisa Bernier (NBDAFA), Cyndi Phippen (NBDAFA) and Amy Burgoyne (NB Soil and Crop Improvement Association). Funding for this project was provided to New Brunswick Soil and Crop Improvement Association through Total Development Fund, Department of Agriculture, Fisheries and Aquaculture, New Brunswick, Canada.

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