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Aerobic Compost Tea, Compost and a Combination of Both Reduce the Severity of Common Scab (*Streptomyces scabiei*) on Potato Tubers

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Abstract: A field experiment was conducted in Woodstock, New Brunswick, Canada to study the efficacy of compost tea and compost on reduction of tuber diseases in potato. A randomized complete block design replicated four times was established in a commercial field setting with four treatments (control, compost, compost tea and compost + compost tea). Tubers were assessed for disease severity, tuber number, tuber weight, defects and total yield. Treatment of potato plants with compost, compost tea or a combination of compost + compost tea significantly reduced the severity of common scab tuber disease by 81, 42 and 81%, respectively, compared to the untreated control. Treatments were ineffective against the potato tuber diseases fusarium dry rot, black scurf and silver scurf. Potato plants treated with compost tea and a combination of compost + compost tea produced higher yield compared to all other treatments. However, the number and weight of knobby tubers were significantly higher in compost tea treatment and significantly lower in the combined treatment of both compost + compost tea compared to other treatments. This is the first study to report on the effect of compost and compost tea against common scab of potatoes.

Key words: Black scurf, compost tea, control, disease, dry rot, potato, *Solanum tuberosum*, scab, silver scurf

INTRODUCTION

Organic teas are concentrated liquid fertilizers and inoculum of beneficial microbes which could be used in crop production for control of plant pathogens and enhance growth of host plants. Unlike chemical fungicides that indiscriminately kill both pathogenic and beneficial microorganisms, the use of composts and compost teas function on an entirely different principle. Application of composts enhances soil fertility, sustains productivity (Dick and McCoy, 1993; Maynard, 1994) and provides efficient control of plant pathogens (Kwok *et al*., 1987; Hoitink *et al*., 1991; Gamliel and Stapleton, 1993; Hoitink and Boehm, 1999; Stone *et al*., 2004). Compost teas are regarded as sources of plant nutrients and beneficial organic compounds which play important role in suppressing plant pathogens (Anonymous, 2004). The production of compost tea is usually done by mixing compost, water and

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optional nutrient additives in an open container. It is left undisturbed for a defined number of days and later applied to plants as a foliar spray or soil drench (Weltzien, 1991; Abbasi *et al*., 2002). Production of compost tea aerobically by bubbling air through slurry during a 24 h extraction process has been reported (Brinton *et al*., 1996; Al-Mughrabi, 2006). Application of compost tea has been documented to significantly suppress several diseases including gray mold, apple scab, collar rot, downy mildew, potato blight, powdery mildew and damping-off (Weltzien and Ketterer, 1986; Budde and Weltzien, 1988; Chen *et al*., 1988; Andrews and Harris, 1992; Boehm *et al*., 1993; Elad and Shtienberg, 1994). Aerobic compost teas applied as foliar sprays exert an influence in the phyllosphere (plant leaf surface) by coating the leaf with live microbes. The beneficial microorganisms including bacteria, protozoa and fungi form a physical barrier against the disease causing agents and provide a competitive environment in which the pathogenic species lose out. In addition, compost teas also stimulate healthy plant growth as a foliar nutritional source, translating into healthier plants, which are more resistant to disease attack. Compost teas used as pre-plant drench (applied to the soil) can be viewed as inoculating the soil with plant-available nutrients and beneficial soil organisms. It is believed that aerobic compost tea applied to the soil can replenish the soil with beneficial organisms which can reduce the reliance on traditional fertilizers by stimulating the mineralization of organic matter and by solubilizing nutrients tied-up on soil particles.

The efficacy of compost tea has provided variable results and this has been attributed in part to differences in procedures used for preparation of compost extracts, its source, composition, quality and maturity (Weltzien, 1991) and also the variable response of pathogen groups to components of compost extracts. To optimize plant disease suppression, numerous compost tea production parameters such as aeration, compost source, nutrient additives, production duration and spray adjuvants have been considered and manipulated (Weltzien, 1991; Scheuerell and Mahaffee, 2002; Scheuerell and Mahaffee, 2006). Though initial reports from the studies on compost tea focused on few production parameters, consensus on optimal compost tea production parameters for plant disease suppression has not been reached (Scheuerell and Mahaffee, 2006). The dominant microbial population in aerated and non-aerated compost tea was bacteria which can be used as basis in measuring plant disease suppression (Weltzien, 1991; Ingham, 2000). The increase in population of total and active bacteria in compost tea is believed to have resulted in a higher level of plant disease suppression which is yet to be confirmed with suitable data (Ingham, 2000). Inspite of this, the use of compost and compost tea has proved to be a suitable alternative in plant disease suppression on different crops. The present study was conducted with the objective of evaluating the efficacy of compost and compost tea in suppressing potato tuber diseases when applied under commercial field conditions.

MATERIALS AND METHODS

Experimental Set up

The aerobic compost tea and compost trials were conducted in commercial potato field located in Woodstock, New Brunswick, Canada. The field history consisted of preceding crop of barley under seeded to ryegrass, ploughed-in late fall. The experiment was a randomized complete block design with four treatments: (1) control without any treatment application, (2) compost alone, (3) compost tea alone and (4) a combination of compost + compost tea. Each treatment was replicated four times, each consisting of four rows. Fertilizer was applied in bands at a rate of 230-250-215 kg ha^{-1} of N, P and K (ammonium sulfate based).

The compost was spread prior to planting at a rate of 0.4 mt ha^{-1}. Aerobic compost tea was applied one week after planting at 140 L ha^{-1} using a back-pack sprayer. The field was maintained throughout the growing seasons using standard practices commonly followed by potato growers in New Brunswick, Canada (Bernard *et al*., 1993).

After emergence, 2×10 linear feet of the two middle rows per treatment were marked to ensure consistent crop density. During harvest, the 10 foot strips were adjusted to include 16 plants. From these 10 foot strips potatoes were harvested by hand and transferred to potato bags. The bags were weighed on-site. Tubers were graded and number and weight were recorded for each tuber size category including <50 mm, >50≤ 55 mm, >55 ≤ 70 mm, >70 ≤ 75 mm, >75 mm, >280 g, sunburn, knobby and tubers with growth cracks or are rough. The tubers were also assessed for disease severity of common scab (*Streptomyces scabiei*), silver scurf (*Helminthosporium solani*), black scurf (*Rhizoctonia solani*), dry rot (*Fusarium sambucinum*) and others. Disease severity was expressed as a percentage of tuber surface area infected using a 0-100% scale (Cruickshank *et al*., 1982; Dorrance and Inglis, 1997). Data were analyzed by analysis of variance in CoStat (CoHort Software, Monterey, CA, USA) and when a significant treatment effect was found, the test of least significant difference (LSD, p = 0.05) was used to separate means.

RESULTS AND DISCUSSION

The results indicate that all treatments were not significantly different from each other in the number and weight of tubers produced at harvest. The number and weight of knobby tubers were significantly higher in compost tea treatment and significantly lower in the combined treatment of both compost + compost tea (Table 1, 2). Although all treatments did not differ significantly among themselves with respect to number and weight of tubers in various seed size categories, in most cases the higher number and weight of tubers were either for treatments receiving compost tea application or a combination of compost and compost tea. The highest total weight (yield) of tubers produced was obtained from compost tea treatment, followed by compost + compost tea treatment (Table 1, 2).

After harvest, the tubers were assessed for severity of dry rot, black scurf, common scab and silver scurf. The treatments containing compost tea, compost and compost + compost tea had no significant effect on disease severity of dry rot, black scurf and silver scurf. Among the different diseases assessed, only common scab was significantly reduced by the compost and compost tea treatments. Treatment of potato plants with compost, compost tea or a combination of compost + compost tea significantly reduced the severity of common scab tuber disease by 81, 42 and 81%, respectively, compared to the untreated control (Table 3).

The use of compost tea or organic tea extractions have shown modest to major control of plant diseases in potato and other crops (Ketterer and Weltzien, 1988; Weltzien, 1991; Gamliel and Stapleton, 1993; Hoitink and Boehm, 1999; Abbasi *et al*., 2002; Stone *et al*., 2004; Scheuerell and Mahaffee, 2006). The severity of bacterial leaf spot on radish, lettuce and tomato were reduced under controlled environmental conditions when composted pine bark mix fortified with the biocontrol agent *Trichoderma hamatum* was used (Al-Dahmani *et al*., 2005). In another study, plots amended with composted cannery wastes resulted in anthracnose fruit rot reduction in tomatoes in comparison to non amended plots with a 33% increase in marketable yield (Abbasi *et al*., 2002).

The use of compost extracts under field conditions on tomato plants resulted in marginally effective control of bacterial spot on fruit under high disease pressure to ineffective control on foliage (Al-Dahmani *et al*., 2003). Aerobic compost had a lesser impact on the plant pathogens causing apple scab, downey mildew, brown fruit rot and peach leaf curl (Wittig, 1996). Application of aerated and non aerated compost tea resulted in modest control of powdery mildew and Botrytis on grapes (Travis *et al*., 2003). The use of compost tea and amendments showed that black scurf, common scab and stem canker were not reduced significantly in plots where potato was grown every year (Larkin, 2007). The same set of amendments with compost tea resulted in significant reductions of black scurf, common scab and stem canker in plots wherein potato was grown following rotations with barley and clover. Significant reductions of pathogen population may not be achieved, sometimes,

Table 1: Effect of compost tea and compost treatments on the number of harvested potato tubers

	Tuber No.									
	Tuber size category						Defective tubers			Total
Treatments	<50 mm	>50 = 55 mm	>55 = 70 mm	>70 = 75 mm	>75 mm	>280 g	Knobby	Sunburn	Rough	tuber No.
Untreated control	71^{a1}	34^{a}	44^{a}	11^{a}	8^{a}	24^{a}	2^{ab}	1^{a}	27^{a}	221^{a}
Compost	86^{a}	33^{a}	47^{a}	10^{a}	5^{a}	22^{a}	2^{ab}	0^{a}	31^{a}	235^{a}
Compost tea	81^{a}	31^{a}	53^{a}	13^{a}	8^{a}	21^{a}	6^{a}	1^{a}	39^{a}	253^{a}
Compost + Compost tea	78^{a}	38^{a}	56^{a}	9^{a}	4^{a}	18^{a}	1^{b}	0^{a}	33^{a}	237^{a}
LSD @ 0.05%	23	12	12	9	4	10	4	1	13	33

[1]Each value is the mean of four replicates. Within each column, means followed by same letter are not significantly different from each other at p = 0.05

Table 2: Effect of compost tea and compost treatments on weight of harvested potato tubers

	Tuber weight (kg)									
	Tuber size category						Defective tubers			Total bag
Treatments	<50 mm	>50 = 55 mm	>55 = 70 mm	>70 = 75 mm	>75 mm	>280 g	Knobby	Sunburn	Rough	weight (kg)[2]
Untreated control	3.6^{a1}	4.6^{a}	9.9^{a}	3.7^{a}	3.6^{a}	9.2^{a}	0.7^{b}	0.1^{a}	5.9^{a}	25.8^{a}
Compost	4.2^{a}	4.7^{a}	10.3^{a}	3.7^{a}	2.2^{a}	8.0^{a}	0.6^{b}	0.0^{a}	5.7^{a}	25.3^{a}
Compost tea	4.2^{a}	4.0^{a}	11.6^{a}	3.9^{a}	3.9^{a}	8.6^{a}	2.5^{a}	0.1^{a}	6.9^{a}	27.8^{a}
Compost + Compost tea	3.9^{a}	5.3^{a}	12.4^{a}	2.9^{a}	1.9^{a}	6.7^{a}	0.2^{b}	0.1^{a}	6.2^{a}	26.6^{a}
LSD @ 0.05%	1.4	1.9	2.4	2.5	1.9	3.9	1.2	0.2	2.5	3.1

[1]Each value is the mean of four replicates. Within each column, means followed by same letter are not significantly different from each other at p = 0.05, [2]Total bag weights of tubers do not include the weights of defective tubers

Table 3: Effect of compost tea and compost treatments on severity of potato tuber diseases

	Disease severity[1]			
Treatments	Dry rot	Black scurf	Common scab	Silver scurf
Untreated control	0.28[a2]	0.00[a]	1.25[a]	0.00[a]
Compost	0.13[a]	0.00[a]	0.44[b]	0.00[a]
Compost tea	0.33[a]	0.03[a]	0.83[b]	0.01[a]
Compost + Compost tea	0.26[a]	0.01[a]	0.44[b]	0.03[a]
LSD @ 0.05%	0.24	0.03	0.43	0.03

[1]Disease severity was calculated using a 0-100% scale (Cruickshank *et al*., 1982; Dorrance and Inglis, 1997), [2]Each value is the mean of four replicates. Within each column, means followed by same letter are not significantly different from each other at p = 0.05

because the bacterial communities in compost tea are unable to get established on surfaces of potato plant foliage or they might have been washed off at the time of foliar application (Sturz *et al*., 2004). Reduction in disease suppression may, also, be due to the fact that the additives added to encourage microbial reproduction in compost tea might support saprophytic growth of plant pathogens and might neutralize the potential of biological control (Scheuerell and Mahaffee, 2004; Scheuerell and Mahaffee, 2006).

It is suggested that the microbes which are present in compost teas or compost bring about the suppression of plant pathogens using various mechanisms. Those mechanisms include induction of resistance against pathogens; an example is the production of chemical inhibitors while suppressing *Phytophthora* root rot in media amended with hardwood bark (Hoitink *et al*., 1977; Hoitink, 1980). The other mechanism is by inhibiting spore germination (Cronin *et al*., 1996). The microbes in compost or compost tea antagonize and compete with pathogens through antibiotic effects of parasitism, hyperparasitism and nutrient competition (Defago, 1993; Whipps, 2001). They extend the root system of plants and thereby improve nutrient uptake, plus increased food storage and soil respiration. Evidence has also been provided to show that production of siderophores, pseudobactins and pseudomycins by *Pseudomonas* sp. exerted a powerful suppressive effect on other microorganisms (Kloepper *et al*., 1980). Suppression of plant pathogenic fungi by ten proteins from secondary metabolites produced by either plant or biocontrol agent has also been reported (Kai *et al*., 1990).

The results obtained in this study and other previous reports showed that certain beneficial microorganisms can be water-extracted from aerated organic slurries and used in foliar or root applications. The group of microorganisms which can be used for such purposes include mycoparasites (Boehm and Hoitink, 1992), rhizosphere colonies (Chao *et al*., 1986), hyperparasitic fungi (Kloepper *et al*., 1980; Scher and Baker, 1982; Hijwegen and Buchenauer, 1984; Schonbeck and Dehne, 1986), epiphytic microbes (Wood, 1951; Redmond *et al*., 1987) along with individual microbes such as *Pseudomonas* (Jager and Velvis, 1985), *Azotobacter* (Meshram, 1984), *Trichoderma* and *Gliocladium* (Hubbard *et al*., 1983; Papavizas, 1985). Apparently disease suppressive microbes that have been extracted from compost are able to colonize the surface and roots of plants when applied properly. Organic or compost teas simply concentrate these beneficial microbes and allow the grower to apply them in a convenient, concentrated form as nutrients and for resistance and disease control (Cantisano, 1994). More research is needed to realize the exact nature or reasons for disease suppression or inability to suppress pathogens by compost or compost tea.

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