ORGANIC FARMING RESEARCH FOUNDATION

Grant Report

Grant #:	**99-31**
Title:	***Effectiveness of compost extracts as disease suppressants in fresh market crops in BC***
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Amount Awarded:	$3945.00
Project Period:	1999
Report:	10 pp., including eight figures.

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Introduction

One of the major challenges facing organic producers is disease management. The losses in vegetable production due to disease can be significant and in some, cases, can devastate entire crops. Cultural methods of disease control are commonly used on organic farms. The application of organic chemicals for disease control is often a last resort and regulated while biological control is still not readily available. The use of compost extracts, then, presents a simple, inexpensive and potentially effective method to supplement the on-farm disease management program.

The effectiveness of using composts for disease control, particularly against fungal pathogens, has been studied extensively (Weltzein, 1991;Grobe, 1997; reviewed in Hoitink et al., 1997). Composts of various kinds have been used to reduce the incidence of *Pythium and Rhizoctonia* in a variety of vegetables and fruits (Gottschall et al., 1987; Weltzien and Ketterer, 1986). These results have led to further work using filtered extracts of composts. In some cases, the compost extracts were even more effective in controlling disease than conventional pesticides (Weltzien et al., 1987). Stindt and Weltzien (1988) at the University of Bonn achieved effective control *of Botrytis cinerea* in strawberries as well as blight in potatoes. Similarly, powdery mildew and root rot were significantly reduced in peas and beets in other trials in Germany (Thom and Moller, 1988). The results of studies on compost extracts have been variable and seem to be crop and region specific, amongst other factors. Therefore, a study was undertaken to look at the effectiveness of disease control with compost extracts on some cash crops in the Southern Interior of British Columbia.

Project Objectives:

1. To determine which compost extract is more effective in reducing disease in strawberries, lettuce, broccoli and leeks
2. To identify the point at which application of the compost extracts are more effective

Experimental Methods:

General description of study site:

The trials took place at Wildflight Farm located in the floodplain of the Shuswap River near Mara in the North Okanagan region of British Columbia. The annual rainfall of the area is approximately 1300 mm with warm, humid summers. The plots were established on level or slightly undulating land with a soil of a clay loam texture. This particular farm provides produce for the fresh market and a CSA, and thus grows a wide variety of vegetables including brassicas, tomatoes, potatoes, salad greens, onions, garlic, leeks, strawberries, cucurbits, carrots and beets.

Crop planting and other details

Strawberries were established 3 years ago at recommended at normal densities. Plots were superimposed onto the existing strawberry fields and were ribboned off. Regular cultivations were done to control weeds. No fertilizer or sprays were applied throughout the strawberry season. Similarly, compost extract treatments were superimposed onto existing leek fields. Here the spacing was 6 inches between plants and about 3 feet between rows. Leeks were cultivated for weeds several times prior to harvest. Lettuce (Paris cos variety) and broccoli (Pakman variety) were seeded into trays with the following soilless mix: 4:4:1 of chicken manure compost, peat and vermiculite, respectively. Some dolomitic lime was also added to adjust the pH to 7. Both seedlings were raised in the greenhouse until ready for transplanting. During this time, overhead watering was used and no extra fertilizer was added. Lettuce was planted out at I foot x I foot spacing while broccoli was planted at 1.5 feet x 3 feet spacing.

Compost extract preparation:

Cattle compost from Greenleaf (Olds, AB) and chicken manure compost from a poultry farm in Armstrong, BC was used for the extractions (see analysis in Results section). Both composts were actively turned for the first month and then only once a month for the next 3 months, then cured for another 6 months. A method of compost extraction proposed by researchers at the Wood's Hole Laboratory was used (Brinton, 1995). This resulted in an 8:1 water to compost dilution. Water was added to the respective composts (cattle and chicken) and the mixture was stirred for about 10 minutes every day of the week long extraction period. Subsequently, the extract was filtered through several cbeesecloths, stored outside away from sunlight until use on crops.

Application details

The compost extract was applied with a backpack sprayer that was rinsed thoroughly with water before and after each type of extract. Strawberries and leeks were already in the field while lettuce and broccoli were raised from seed and so, were sprayed in the greenhouse and depending on the treatment, in the field as well. Crops were sprayed as long as weather allowed (i.e. extended wet periods). Sprays were applied at a rate that ensured coverage of all foliage. Approximate application rates are listed below:

1. Strawberries
   *sprayed twice a week at 1.3 litres/m' (0.03 gallons/ft.^{2})
2. Lettuce
   *in the greenhouse, about 50 ml (2 ounces) was applied to 1 seedling tray (200 plants) prior to setting the lettuce out
   *initially in the field the same spraying regime as in the greenhouse was continued until the plants were larger
   *sprayed twice a week at approximately 1 litre/m^2 (0.02 gallons/ ft.^{2})
3. Broccoli
   *in the greenhouse, about 50 ml (2 ounces) was applied to 1 seedling tray (90 plants) prior to setting the lettuce out
   *sprayed twice a week at approximately 0.9 litres/m^2 (0.02 gallons/ft.^{2})
4. Leeks
   *sprayed twice a week at about 0.90 litres/m^2 (0.02 gallons/ft.^{2}

Plot layout and treatments:

All trials were on the same soil and were generally on level ground; where there were lower and higher areas of land, blocks were used to account for any effect of slope. Strawberries, lettuce and broccoli trials were all laid out in a completely randomized design while the leek trial was a randomized complete block design. Each treatment was repeated 4 times within the experimental plot. The following treatments were either imposed on existing plants in the field (strawberries and leeks) or assigned as of the greenhouse.

1. Strawberries and leeks
   a. cattle manure compost extract
   b. chicken manure compost extract
   c. water
   d. control (no extract or water)

2. Lettuce and broccoli

   a. cattle manure compost extract (applied in the greenhouse only)
   b. cattle manure compost extract (applied in the greenhouse and in the field)
   c. cattle manure compost extract (applied only in the field)
   d. chicken manure compost extract (applied in the Greenhouse only)
   e. chicken manure compost extract (applied in the greenhouse and in the field)
   f. chicken manure compost extract (applied only in the field)
   g. water only (applied in the greenhouse and in the field)
   h. control (nothing applied)

Measurements

Strawberries

The number and weight of ripe and uninfected, marketable strawberries were taken every two to three days for the length of the harvest (approximately I month, from June 18, 1999 to July 16, 1999). A scale of the incidence of *Botrytis cinerea* on the surface of the berries was used: 0=no infection, 1= 1-5% berry surface affected, 2= 6-15% berry surface affected, 3= 16-50% berry surface affected and 4 = 51-95% berry surface affected. This scale is similar to those used by other researchers investigating *B. cinerea on* strawberries (Elad and Shtienberg, 1994; Archbold et al., 1997).

Lettuce

Lettuce was harvested when heads were of marketable size and/or when it was needed for the CSA or farmer's market during the August 20, 1999 to September 3, 1999 period. This generally meant a harvest twice a week. The weight before and after trimming infected leaves off the head was recorded. Both lettuce bottom rot *(Rhizoctonia solanii)* and downy mildew *(Bremia lactucae)* were assessed together as total disease affecting the lettuce head. The following disease rating scale was used: 1= plant infected, but affected leaves were removed with minimal trimming, 2= moderate infection of wrapper leaves, but infection did not extend into the head (still marketable heads) and 3 = extensive infection (little or no marketable head left after infected leaves are removed) (Mahr et al., 1986).

Broccoli

Broccoli was harvested when heads were of marketable size between September 22, 1999 to October 15, 1999. Heads were weighed and the head diameter was measured. The incidence of head rot *(Rhizoctonia solani)* was measured using the following scale: 0=no disease, 1= 1% surface area affected, 2= 10% of surface area affected, 3=30% of surface area affected, 4=60% of surface area affected and 5= 1 00% of surface area affected. (Canaday, 1992).

Leeks

Leeks were harvested from November 3 to 9, 1999. Weight after trimming diseased leaves was taken and disease *(Peronospora destructor)* incidence was assessed as present or not present.

Lab analyses

Samples of compost and compost extracts were sent to NorWest Labs in Edmonton and Lethbridge, Alberta, for nutrient and microbiological analyses. At harvest, samples of sprayed foliage from broccoli and leeks were sent to the lab as well. Results are given in Tables 1 and 2 below.

Data analyses

All data was analyzed for normality and heterogeneity of variance prior to an ANOVA. Strawberry and leek data was analyzed as a one-way ANOVA (type of compost) while lettuce and broccoli data was analyzed as a 2-way ANOVA (type of compost and time of application). Significantly different means were separated using Tukey's test. All statistical analyses was done using SAS.

Results

Compost and compost tea analysis

The analyses yielded few surprising results. Both cattle manure compost and its extract had higher fecal colifonn counts, yet these were still low enough to fall within acceptable limits and were not detected in the crops tested.

Table 1. Chemical and biological characteristics of composts

Compost/ Compost extract	pH	E.C. (mS/cm)	NH_4+/ $N0_3$-	Total K (%)	Ca (%)	Na (%)	Total P (%)	Mg (%)	Total S (%)	Fecal coliforms (MPN/g)	Salmonella
Chicken manure compost	6.6	41.43	0.43	1.46	12.5	0.33	0.23	0.85	0.54	<3	none
Cattle manure compost	7.0	14.15	<0.02	0.88	0.82	0.12	0.53	0.31	0.18	930	none

Table 2. Chemical and biological characteristics of compost extracts.

Compost/ Compost extract	pH	E.C. (dS/cm)	Nitrate (mg/L)	Ca ppm	Mg ppm	Na	K	$S0_4$2	Fecal coliforms (CFU/100 ml)	Salmonella
Chicken extract	7.33	2.47	154	61.3	117	83.2	409	72.6	80	none
Cattle extract	7.57	0.51	3.01	9.13	7.86	17.7	130	1.17	3500	none

Strawberries

The number of berries harvested per harvest period varied between a low of 17 early in the season to 186 at peak harvest. There was a trend of greater berry yields with the application of cattle compost extract compared to the control and chicken compost extracts, although this difference was only significant at the 0. 10 alpha level and only at certain harvest dates (Figure 1).

Applications of cattle compost extract and water yielded similar berry weights but were often higher than the control. Berries treated with extracts from chicken manure compost generally yielded less than all other treatments. The percentage of berries with no surface rot was not significantly different among treatments, although in the first half of the harvest, the control plots generally had fewer healthy berries (class=0) compared to sprayed plots. Berries infected with *Botrytis* in any of the other disease classes were similar with application of compost extracts, water or no application at all.

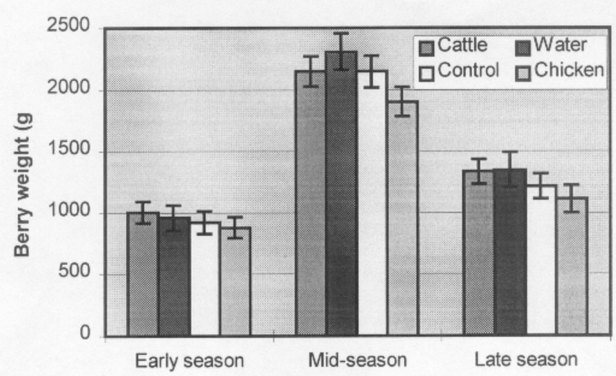

Figure 1. Strawberry weight from plots sprayed with cattle and chicken compost extracts, water and no application of sprays over a 1 month harvest period in 1999.

Lettuce

At every harvest, between 2 to 3 lettuce heads were harvested depending on the quantity required for markets. There was no consistent trend in either lettuce weight harvested (after trimming off diseased leaves) or in disease incidence with compost extract application. In fact, the control had higher average lettuce harvest weights compared to other treatments while plots sprayed with cattle compost extract had the lowest. ($F=2.66$, $P=0.05$) (Figure 2). In terms of time of application of composts, greenhouse application of extracts produced heavier lettuce heads with lower disease incidence compared to application only in the field or both in the field and in the greenhouse (Figure3). The type of compost extract and the time of application did not have an effect on any other variables measured for lettuce.

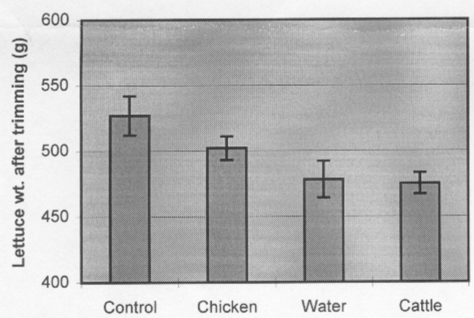

Figure 2. Lettuce head weights with compost extract and water application compared to control plots.

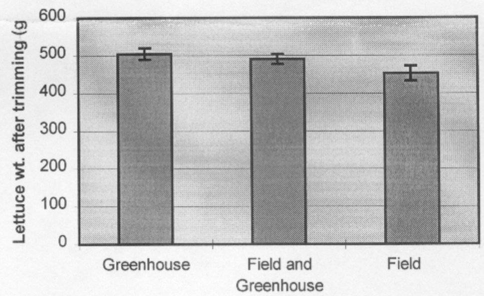

Figure 3. Lettuce head weights at different times of compost extract application.

Broccoli

Broccoli heads were harvested when they were of marketable size. This meant a range of 2 to 3 heads early in the season and 4-6 heads during peak harvest time. The effect of compost extract type and application time was analyzed over the entire broccoli harvest period and was also separated into and analyzed by 2 harvest dates, early and late. No significant differences were found with respect to compost extract type at any time yet there were interactions between compost type and application time. The application of cattle compost extract generally increased the weight of marketable heads compared to other treatments and the control (Figure 4). This was particularly true when cattle compost extract was applied in the field only (F=4.53, P=0.024).

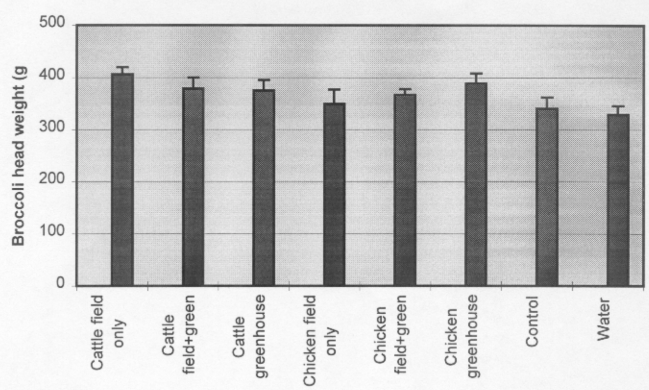

Figure 4. Effect of compost extract application and application time on broccoli head weight.

Both the control and the application of water resulted in lower average broccoli head weights. Similar effects of the cattle compost was observed for broccoli head diameter (F=3.05, P=0.07). The percentage of head rot was not significantly different among treatments, however, broccoli in control plots had a lower average percentage of rot (Table 3).

Table 3. Effect of compost types on broccoli head rot.

Compost type	Head rot (%)
Control	1.1 (0.6)
Cattle	2.0 (0.8)
Chicken	2.6 (0.8)
Water	5.5 (3.7)

There was no clear effect of time of compost extract application, yet applying the extracts only in the field or only in the greenhouse resulted in higher average head weight compared to application at both times (Table 3.). In contrast, head diameter was generally higher with application at both times.A significantly lower percentage of head rot was observed when extracts and water were only applied in the greenhouse (F=3.76, P=0.05).

Table 4. Effect of application time on broccoli head weight, diameter and percentage of head rot (standard error of the mean in brackets).

Application time	Broccoli head wt. (g)	Diameter (cm)	Percentage rot
Field only	390 (14)	15.7 (0.4)	3.6 (1)
Greenhouse only	383 (18)	15.7 (0.3)	0.6 (1)
Greenhouse and field	343 (14)	18.2 (2.8)	2.9 (1)

Leeks

The month before harvest and the harvest period of leek was distinctly wet. The extended periods of rain made extract application difficult and the crop was only sprayed when weather conditions allowed (8 times in October), rather than twice a week. Leeks were harvested over a period of a week (whenever there was a break in the rain). Approximately 30 leeks were harvested per plot. There were no significant differences in the various treatments in terms of leek weight after trimming diseased leaves. As seen with the other crops, the application of chicken compost extract generally resulted in lower leek weights (Figure 5). No other trends were observed in the incidence of disease with the different treatments.

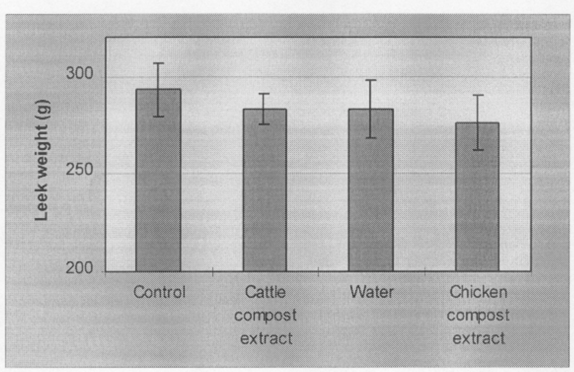

Figure 5. Effect of applied compost extracts and water on leek weights compared to control plots.

Microbiological analyses of plant leaves after compost extract application
Samples of broccoli and leek were sent away for microbiological analysis. No Salmonella was detected on any of these samples. Total and fecal coliforms were less than 3 MPN/g of broccoli and leek that received cattle compost extract while total and fecal coliforms were 3 and 43 MPN/g for broccoli and leek tissue sprayed with chicken compost extract, respectively.

Discussion of results
The effects of compost extract application were not consistent across all crops. Yet, some trends did emerge. Extracts from cattle manure compost were effective in increasing marketable number and weights of strawberries. The same extract also increased the weight of broccoli heads. Lettuce and leeks did not show any increased harvest weights or reduced disease incidence as a result of cattle compost extract application. Crops that received applications of chicken compost extracts had lower average harvest weights after diseased parts were removed, except for lettuce. It is possible that the chicken compost extract had some microorganisms associated with it or metabolites thereof that may have further contributed to disease progression or had some other negative effect on plant growth. It is also not clear why the cattle compost extract would have had a similar effect to water spray, unless after some storage time, the extract lost its 'potency' and had attributes more similar to the water treatment.

Disease incidence in strawberries and broccoli did not vary significantly among plots, yet compost applications often resulted in a greater average percentage of healthy crops compared to the control. This seems to indicate that there was some effect either related simply to the spraying of something liquid or to something associated with the extracts. Lettuce and leeks, however, did not show any clear response to compost extract application. Possibly, if compost extracts are effective as a result of an induced defense reaction of the plant as suggested by Samerski and Weltzien (1988), lettuce and leeks may be crops that are not readily induced in this way. This study also lends support to the idea that different crops respond different to extracts from a variety of sources (e.g. lettuce did not react to cattle extract as did the other crops).

The dilution of extracts in this study was 1:8 from the original compost; a recipe based on various research literature (Brinton, 1995; Cronin et al, 1996). It is possible that this was too dilute for a consistent, significant effect. In fact, researchers have found that dilutions of extracts can reduce disease inhibition dramatically (Cronin et al., 1996; Elad and Shtienberg, 1994). Compost extract incubation time also appears to be a variable in their effectiveness against disease. Urban and Trankner (1993) found that 24 hour extracts from horse and cattle manure composts effectively controlled gray mold in beans. Others, however, have only found disease suppression after an extraction period ranging from 7 to 14 days (Ketterer et al., 1992; Elad and Shtienberg, 1994). Some researchers suggest that compost extracts lose their efficacy if they are not used within about I week of preparation (Brinton et al, 1996). In this study, extracts were prepared in larger batches, extracted over a I week period and were used up to 3 weeks after preparation. It is possible that then that the mechanism responsible for inhibiting disease was much reduced as the compost extract 'aged'. This phenomenon seems to coincide with increased berry weights early on (when the extracts were freshly prepared) with cattle compost extract application; this was not evident later on.

There appears to be some controversy about how the extracts are prepared, anaerobically or aerobically. Cronin and coworkers (1996), for instance, found that anaerobically prepared extracts from spent mushroom substrate were much more effective in inhibiting apple scab than aerobically treated extracts. Weltzien (1991) and Brinton (1995) also promote the anaerobic method of compost extract preparation. These researchers suggest that the likely disease-suppressive effect is a result of a metabolite produced by anaerobic microorganisms in the extract (Cronin et al., 1996). In contrast, there is also evidence that indicates that aerobically produced compost extracts are much more effective (reviewed in Anonymous, 1996). Microbiological studies have also shown that aerobic microbes dominate compost extracts (Sackenheim, 1993 in Hoitink et al., 1997). The method used in this experiment was largely anaerobic with only occasional stirring during the extraction period. If, indeed, it is an aerobic microbial population that is responsible for disease suppression, then the extracts in this study would have been relatively ineffective.

Given that this growing season was unusually cool and wet, it is possible that populations of pathogens were favoured and could easily outcompete any beneficial organisms associated with the extracts. High pathogen populations could also be less impacted by inhibitory substances produced by organisms in the extracts.

The effectiveness of compost extracts appears to depend on many factors including method of preparation, extraction time, compost used and crop applied on. Consistency and maturity of the compost to be extracted are yet more variables. Evaluation is necessary on specific crops and specific disease organisms over a period of several years to account for year to year variations in weather which can significantly influence disease dynamics. We recommend that at least another season is required to follow up on these initial results and to focus on strawberries and broccoli. A repeat of the initial experiment is necessary but we also suggest incorporating another extract dilution, an aerobically prepared extract and the use of only 'fresh' compost extracts.

Extension activities

Several extension activities are planned to share the preliminary results with organic growers in NOOA and in the wider Okanagan region. The preliminary results will be discussed at one or two NOOA monthly meetings prior to the 2000 growing season. A discussion group (perhaps web based) will be started with BC organic growers in order to share experiences about compost teas and their effectiveness as a disease management tool. A small summary will also be prepared for the COABC (Certified Organic Associations of BC) AGM in February. Furthermore, an article on compost teas that includes the results of this study, will be submitted to a number of agricultural magazines in BC and in Canada (e.g. BC Grower, BC AgriDigest and Eco-Farm and Garden).

Acknowledgements

Special thanks go to Wildflight Farm for being instrumental in conceiving this project and in participating in it. We also appreciate the support of the North Okanagan Organic Association (NOOA). A final thanks to Lena Armstrong, the project's reliable and observant field assistant. This project was made possible by the Organic Farming Research Foundation and the contributions of Wildflight Farm.

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