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Final Report to the Organic Farming Research Foundation

# Impact of Disease Suppressive Composts on Organic Vegetable Quality, Composition and Yield

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## Abstract

The goal of this research was to initiate studies on compost effects on severity of common soil borne diseases and to characterize changes plant growth due to improved nutrient availability and soil microbial activity with compost application in organic production systems. Composts were initially characterized for maturity using a commercially available compost maturity test kit. Results were compared to laboratory measures for compost suppressiveness. Preliminary results suggest that this kit may be a useful tool to assess suppressive quality after further testing. Four field experiments were conducted examining different compost effects on disease incidence and plant quality. Disease pressure was very low in field trials, despite selection of sites with historic disease problems. There was some evidence of reduced disease incidence and severity in composted treatments in one snap bean experiment conducted at a research station, but this was not organically managed and the data need to be confirmed by field scale trials. Plant stands did improve in trials using dairy manure based composts, but not poultry manure based composts. The moderate rates (2 to 15 T/A) of compost used did not increase soil microbial activity over the uncomposted controls, at a midseason sampling time. Higher rates may provide this type of increase, but may become economically unfeasible. Soil microbial activity levels were higher on an organic farm compared with several neighboring conventionally managed farms, suggesting that historic management was more important than a single application of compost. Two greenhouse disease bioassays compared commercially available compost materials for effects on plant growth and disease suppression. In the first study, composts were sterilized to eliminate microbial activity and isolate nutrient effects. The results for disease suppression in the first greenhouse study were inconclusive due to poor pathogen growth. However, two of the tested materials enhanced plant emergence rates and growth, particularly if compost microbial activity was intact (non-sterilized). A subsequent greenhouse assay focused on one poultry compost that had been previously shown to suppress *Rhizoctonia* root rot of beet. Low rates of this compost were not effective at reducing plant losses to this disease, under controlled conditions. It is suspected that this compost provided added fertility to increase growth of vigorous seedlings and thus result in higher yields in these plots.

# Introduction

Numerous root rot diseases are widely distributed and cause severe yield losses on many vegetable crops grown in New York State and the NE region of the USA, including beans, table beets, cabbage, peas, sweet corn, lettuce, carrots, onions, tomato, potato, several cucurbits and others (1 3). Control of these diseases has traditionally depended upon rotations and soil quality improvement strategies. One characteristic of compost which is receiving much attention in both research and grower publications is the observed suppression of soil-borne diseases in crops grown on compost-amended soils. Most previous published research has focused on use of composts in potting media for disease control on ornamentals (4,5). Several studies have explored control of vegetable diseases, including clubroot on Chinese cabbage, lettuce drop, Aphanomyces root rot of pea, Rhizoctonia root rot in bean and radish, Fusarium wilt of cucumbers, and Phytophthora crown rot of peppers (9, 11, 12). Many other examples likely exist but have not been reported in research literature. Although organic systems have been shown to have some degree of suppressive soils, use of spring-applied highly suppressive compost may decrease the severity of root rot diseases, particularly during cooler, wet weather characteristic of the Northeast.

Compost products may be particularly effective at suppression of damping-off seedling diseases caused by Pythium and Rhizoctonia (2, 5, 8). Pythium-rot (caused primarily by *Pythium ultimum* and few other low-temperature species) and Rhizoctoniarot (caused by *Rhizoctonia solani* and its sexual state, *Thanatephorus cucumefis)* diseases are among the most wide-spread and damaging diseases on all the vegetable crops grown in New York and the NE region. Depending on time of initial infections and the prevailing environmental conditions, symptoms of these diseases can be in the form of seed rot, damping-off, root rot, foliar blight, or pod rot. Seeds and young seedlings can be attacked and killed shortly after planting resulting in poor emergence and seedling establishment, or in older plants, rotting of fibrous rootlets reduces absorption of water and nutrients. However, most research on suppression of these two diseases have been based upon greenhouse studies and need verification in field experiments.

The primary mode of action for compost in disease suppression has been shown to be due to enhanced microbial biomass and activity that contributes to increased microbial antagonism to pathogens around plant roots. Disease suppressiveness of compost-amended soils may also be partially explained by enhanced nutrient supply and improved soil physical properties. Different compost types as well as different batches of one compost may vary in disease suppressiveness, and the suppressiveness of a batch may change over time (2,4,8). The degree of curing or compost maturity has been shown to be important to maximize suppressive benefits in other systems (2, 5, 8). Improperly or inadequately cured compost materials may lack disease suppressive qualities and depending on the carbon:nitrogen ratio, may also reduce plant available N in the soil, due to immobilization by soil microorganisms as the compost is further decomposed (3, 6). If immature compost materials are applied well ahead of planting, then further stabilization and decomposition will occur, preventing N immobilization. However, disease suppressiveness may be compromised, depending on time course for activity. There has been little research investigating the duration of effectiveness for field-applied compost to support microbial activity for disease biocontrol (2, 5). Prior to promoting the use of any compost material based upon disease suppressive quality, more baseline information on the duration and nature of the suppressiveness is required for growers to make sound management decisions.

Preliminary research in NY indicated that application of low rates (2 to 4 T/A) of composted poultry manure improved stands, root growth, decreased loss to root rot diseases, and increased yields of field-grown beets, sweet corn and beans, in conventionally managed production systems. The tested compost rates were much lower than those used in most previous research examining general compost effects in field systems. However, this compost supplied an additional 60 lb. of nitrogen per ton to the soil, which would be expected to influence crop quality and yield. The mode of action of low rates of compost has not been explored previously, but may include stimulation of microbial activity, suppression of soil-borne diseases and improved nutrient availability.

There are several biological and chemical indicators of compost maturity and suppressiveness (5, 6, 1 0), but these measurements require time and special equipment. A quick test has been developed for compost producers to test compost maturity, within a short time frame (Woods End Research Laboratory, Maine)(12). This test may also have some predictive value for ranking or comparing composts for disease suppressiveness, but this has not been tested. Such a tool may be very useful to both organic and conventional growers, for monitoring their own composts for optimal maturity to maximize most suppressiveness. If these on-farm composts are used for transplant production, compost age and suppressiveness could be optimized to prevent N immobilization and to enhance likelihood of healthy, vigorous seedling production.

Integrating compost into commercial vegetable production for disease suppression represents a long-term approach to enhance soil microbial activity and system resilience to disease pressure. As a preventative disease measure, it is expected that regular additions of suppressive compost will provide protective benefits that will accrue over multiple crops and seasons. The vegetable production system may influence the efficacy of suppressive composts. Organic producers have been very enthusiastic to learn about disease suppressive composts. In addition, these producers have also been targeted by compost producers with products labeled as suppressive. However, organic systems, which already use regular inputs of green plant and animal manures to enhance soil and organic matter quality, have been shown to have disease suppressive soils (5, 15). Thus, the addition of a highly suppressive compost may not further reduce disease incidence in these systems. Little information is available on the degree of suppressiveness of organically managed soils and there are no reports of changes in suppressiveness of these soils with addition of highly suppressive composts. The effect of these composts on organic systems needs to be investigated, so that growers may know what type of suppression could be expected on their farms and under what conditions these amendments would be most effective. These suppressive composts could also play an important role in organic transition, by 1) reducing severity of soilborne diseases, 2) providing a 'seed' crop of soil microorganisms, that assist in both suppression and nutrient cycling within the soil, and 3) providing plant essential nutrients early in the season, for crop establishment.

## Project Objectives

-Analyze several animal manure-based, organic-approved compost products for suppression of important soil-borne pathogens of vegetable crops in the Northeast

-Determine applicability of a farmer-based test kit for assessment of compost maturity to predict suppressiveness

-Evaluate compost effects on plant stand and crop composition

-Determine changes in microbial activity, disease suppressiveness and soil nitrate nitrogen of organically managed soils after addition of a compost

## Materials and Methods

*Compost materials and testing:*

Five compost products were selected for field and greenhouse experiments based upon organic grower collaborators' preferences. One compost was grower made and the rest were certified for use and commercially available (Table 1). The grower compost was animal manure and food waste based. The composts were analyzed for nutrient composition through the Cornell Nutrient Analysis Laboratories. Compost microbial activity was determined by measuring the rate of hydrolysis of fluorescein diacetate (FDA)(10), which has been correlated with compost disease suppressiveness (4, 5). In addition, compost maturity was estimated using a commercial test kit (Wood's End Lab "Solvita" Compost Maturity Test). This test kit provides an estimate of compost maturity based upon respiration rate, and ranks maturity from 1 (immature or raw, high rate of decomposition) to 8 (highly matured compost, like soil, ready for most uses) (Table 2). Results from the FDA hydrolysis and the test kit were compared to determine if the test kit could suggest a suppressive compost. Three additional composts were also evaluated for microbial activity using these two tests for this comparison, but these products were not used in on-farm trials.

*Field experiments:*

A total of three organic and four conventional farm and two research station trials were conducted to explore the impact of composts on soil microbial activity and disease suppression. Funding for the research on the conventional farms was supported through other grants, but some of the results have been incorporated into this report. Two greenhouse experiments were also conducted to explore seedling growth and disease suppression, under controlled conditions (described below). Sites were selected based upon historic problems with soil borne diseases, to examine compost effects on crop stand, tissue analysis and yield and soil nitrate levels. Rates of compost used at each site were based upon grower practices. No attempt was made to control for differences in nitrogen contribution of products, where more than one was evaluated, since the primary interest was on effect of compost on soil microbial activity. However, soil nitrate nitrogen was also determined to assess potential differences between composted and non-composted treatments.

Two of the cooperating organic farms were located in the southern region of New York (Tompkins and Tioga Counties). At one site, a grower-made compost ('A', Table 1) was applied, to one half of the plots at a rate of 15 T/A. Four rows of spinach were seeded into the plots after one week, on June 15. At the second site, a commercial dairy manure compost ('B', Table 1) was applied to one half of the plots at a rate of 2.5 T/A. Four rows of beans were seeded five days later, on 6/24/97. Plots at each site measured 12'x 15' and four replicates of a composted and non-composted control were used. Stand counts and leaf tissue samples were taken from eight feet of the middle two rows in each plot of the bean trial on 7/10/97 and from five feet of the middle two rows in the spinach trial on 7/3/97. Leaf samples were dried and analyzed for total nitrogen and mineral composition (Cornell ICP Laboratory). Soils were sampled from all plots on 7/16/97 and analyzed for nitrate levels and microbial activity (methods described below). No yield data was recorded from either trial, due to poor late season growth, unrelated to compost applications.

The third grower trial took place at an organic farm in western NY. Two commercial poultry compost products ('C', 'D', Table 1) were applied at a rate of 2 T/A, one week before seeding. Beets were seeded one week later into these plots on June 2. Stand counts and leaf tissue samples were taken July 8. Soils were sampled on three dates- June 2, July 7, and July 23, and analyzed for nitrate nitrogen concentrations. On June 2 and July 23, total microbial activity in the top 2 inches of soil was evaluated, using the same enzymatic assay applied to the composts (FDA hydrolysis).

On two conventionally managed research farms, the poultry compost 'C' (Table 1) was examined for effects on soilborne disease and yield. This product had previously been found to reduce levels of *Rhizoctonia* root rot on beets. To examine residual compost effects from previous years, a research site was identified that had received an application of this compost in 1996, at the Cornell Vegetable Research Farm in Freeville NY. In 1996, poultry compost 'C' had been applied to a 12- ft band (rate of 4 T/A) across the center of each plot, with control (non-composted) sections adjacent to either side of the band. In 1997, compost 'C' was applied to one half of the original band, at a rate of 4 T/A and mixed into the top 2 inches of soil. This design allowed replicated comparison of three treatments: a no compost control, 1996 compost application, and 1996+1997 compost applications. Snap beans were direct-seeded on June 10, across the entire experiment. Soils were sampled mid season (July) to determine microbial activity and soil nitrate concentrations. Snap beans were harvested August 11, and above ground biomass and bean yield were recorded. Roots were evaluated for disease severity using a 1 to 9 (9=severe root rot) scale (Abawi, personal communication). Naturally occurring pathogen populations provided the disease pressure in this experiment, as in the on-farm trials.

A third poultry compost trial was established at the Cornell Vegetable Research Farm in Geneva, NY. Poultry composts 'C' and 'D' were applied at 4 T/A and compared to a no compost control. These were the same composts used at the organic beet trial, but at twice the rate. Beets were seeded on June 12 and soil and tissue samples were taken on July 23. At harvest (September 27), final plant stand, yield and incidence of root rot were recorded.

*Soil nitrate nitrogen and microbial activity analysis.* On a soil sampling date, ten soil cores (8 inches deep) from each plot were taken. Additional cores of the top 2 inches were taken for microbial activity tests. Soil nitrate was extracted and analyzed using standard laboratory procedures (7) and results were represented as concentration of nitrate nitrogen in dry soil.

The microbial activity of soil and compost was estimated by the rate of enzymatic hydrolysis of fluorescein diacetate (FDA) by soil microorganisms (10). Soil or compost (.7 g fresh weight) was incubated in phosphate buffer for exactly 40 minutes. Enzymes present in the soil or compost cleave FDA to produce a yellow-green compound. The color intensity produced over the incubation period was compared to known concentrations of cleaved FDA to provide an estimate of the rate of microbial enzymatic activity. Results were presented as micrograms of FDA hydrolyzed per minute per gram dry weight of soil or compost (ug-min-l-g-1). Higher rates of microbial activity resulted in higher FDA hydrolysis values.

### *Greenhouse Disease Evaluations*

Three commercially available compost products-two poultry manure based (C, D) and one dairy manure based (E)- were screened for suppressiveness to *Pythium and Rhizoctonia* using a greenhouse disease bioassay. A rate equivalent to that used in field trials (4 T/A) was calculated to be 5% v/v compost:peat mix. Composts and the peat- based media were mixed thoroughly, and then subsamples were either autoclaved on three consecutive days (to kill media microorganisms) or held moist until beginning the bioassay. Sterilized composts allow isolation of compost nutrient or physical effects on plant growth and disease incidence. Both pathogens were grown on sterilized wheat kernels for 6 days, prior to commencing the trial. Just prior to seeding, the autoclaved and non-autoclaved soil media were inoculated with one of the pathogens, by grinding the infected wheat kernels in a food mill and dispersing evenly throughout the soil/compost mixes. Seeds of both cucumber and beets were sown into these mixes. Plant emergence, appearance and disease symptoms were recorded once per week. At the end of the 4-week experiment, plant fresh and dry weights (above ground portion only) were measured. Soil nitrate-N, microbial activity, soluble salts, and pH were also recorded at the end of the trial.

A second greenhouse experiment was conducted to evaluate the impact of two 'field-equivalent' rates of compost on beet germination and early growth. A soil mix (1:1 v/v peat:field soil) was amended with compost at two rates, equivalent to 2 or 4 T/A. No-compost mix was used for control. One half of the pots were inoculated with *Rhizoctonia* as described above. Ten beet seeds were placed in each pot and plant stand was recorded every two to three days for four weeks.

## Results and Discussion

Compost analyses

Compost analysis (Table 1) indicated that the tested products varied in both maturity and stability. Composts 'B' through 'E' were commercially produced. The composting process was carefully monitored in all cases, and uniformity of the products over several batches was high. The poultry compost 'C' had no carbon added during composting, as evidenced by the low C:N ratio and a strong ammonia smell to the product. However, the higher nutrient density of this compost (equivalent to a 3-4-5 NP-K fertilizer) and observed disease suppression in the field made this product appealing to both organic and conventional vegetable growers and fostered support for this research effort. Poultry compost 'D' did have added sawdust during production, no smell and had been cured for 3 months. Composts 'B'and 'E' were both dairy-manure based. Compost 'B' was purchased bagged product with little known about the production history or length of curing. Compost 'E' was widely used by NY organic growers. Results from testing this product in greenhouse studies are presented.

Nitrogen contributions from composts were not controlled in these studies. When added to field trials, the total nitrogen supplied by the composts were as follows: compost 'A' added at 15 T/A provided 840 lb N; compost 'B' supplied at 2 T/A provided 24 lb N; compost 'C' added at 2 or 4 T/A provided 244 or 488 lb N; and compost 'D' provided 80 or 160 lb N. Not all of this N was available to the crop; estimates of N availability within the first year of compost application will vary by the compost feed stock and maturity, and range from 5 to 50%. At this high end, composts are still considered immature or unstable, and may be better described as 'partially stabilized manure.'

Seven compost products were analyzed for microbial activity, using the FDA hydrolysis method, and results ranged from 2 to 18 ug-min$^{-1-}$g$^{-1}$ dry wt activity. The rate of FDA hydrolysis from composts would be expected to generally be higher than those found in soils. Research with peat based potting mixes suggested a minimum FDA rate 3.2 ug-min-l-g-1 dry wt for suppressiveness to *Pythium spp* (1). In the case of these composts, all but three could considered as potentially disease suppressive, provided this threshold would apply to straight compost as well. In potting mixes, the percentage of compost on a volume basis is generally less than 25%. Solvita test kit results for these composts ranged from 1 to 6. Based upon interpretation information provided with the kit (Table 2), none of the composts were considered 'finished'. Several were still very active and others were in the curing phase. In our studies, composts were grouped as either highly active (Solvita scores from 1 to 3) or approaching curing (score 5 to 6).

A comparison of results from microbial activity (FDA) and the Solvita Compost Maturity Test suggested that there may be potential to use the test kit to estimate suppressiveness (Figure 1). However, results from these studies were clustered in two ranges of the Solvita test. Additional comparisons of composts of different maturity are required. These results were very preliminary and also dependent on the good correlation between microbial activity as indicated by FDA and actual disease suppression in bioassays. Many additional compost products must be tested and disease bioassays are required to verify this correlation. Once a compost product is characterized for effects on various soil borne diseases, however, this kit may be useful to track both maturity and potential disease suppressiveness.

### Field compost-experiments.

*Plant stand, disease incidence and tissue analysis.* Late season disease pressure was very low in the on-farm trials, despite selection of fields with historical soil-borne disease problems. Evaluating crop stands provided a measure of early season disease pressure as well as seed-bed soil quality for crop emergence. Compost applications significantly increased plant stands in the spinach and bean. on-farm trials (Table 3). Although a low rate (2.5 T/A) of dairy manure compost 'B' was applied, stands of beans were improved by 25%. A low rate of poultry composts 'C' and 'D' did not improve stands of organic beets. When poultry compost 'C' was applied at a higher rate (4 T/A) to conventionally grown beets, stands were reduced compared to other treatments, suggesting potential salt damage.

Only the conventional bean experiment supported previous observations of reduced disease pressure with compost application in the field. A high rate (4 T/A) of poultry compost 'C' applied to conventionally managed beans did not affect plant stand significantly (Table 4). Previous applications of the same product from one year earlier also did not affect stand. However, the incidence of root rot in this experiment was significantly reduced by 1997 spring compost applications (Table 4).

Mid-season tissue analysis of spinach from the organic farm 'A'did indicate some statistically significant differences among composted and non-composted plots, however the actual relevance of these differences was minor (Table 3). There were no significant differences among treatments in the on-farm bean experiment. Beet tops were significantly higher in sodium in composted plots in both the on-farm and research station experiments. Beets respond positively to sodium applications, and historically sodium was applied to partially substitute for potassium fertilizers. Poultry composts contain higher sodium than other animal manure composts. At both the low (2 T/A) and high (4T/A) rates, sodium concentration in beet leaves was increased.

*Soil nitrate nitrogen and microbial activity levels.* Compost additions significantly increased midseason soil nitrate nitrogen measurements only at farm C, in organic beets (Table5). In this case, addition of the high N poultry compost 'C 'contributed to higher mid-season soil nitrate N concentrations, up to ten times the levels of other treatments. Differences in soil nitrate N among the treatments on this farm continued to later in the season (Figure 2). At the first sample date, there was no significant difference in soil nitrate N under the three treatments. By mid-season, soil nitrate levels under the control and compost 'D' treatments at this farm were low (3 to 5 lb/A) and may have become growth limiting. However, by the end of the season (soil sampling day 3), high levels of nitrate N were still detected under compost 'C', and could contribute to leaching losses of N from this treatment. The more stable poultry compost 'D' did not contribute to excess soil nitrate N.

Soil microbial activities at the midseason sampling date also were not affected by compost additions, except at farm A (Table 5). All composts had FDA values above a threshold of 3.2 ug-min$^{-1}$-

$g^{-1}$ suggested for suppressiveness (1) and were applied and incorporated into the surface 3 inches of soil. On organic farm C, soil samples were also taken on June 2 and analyzed for microbial activity. At this earlier planting date, differences were detected in microbial activity among the three treatments, but these were not statistically significant at levels desirable for research. Plots with no compost averaged 1.47 ug-min-l-g-1, those with high N poultry compost 'C' averaged 1.95 ug-$min^{-1}$-$g^{-1}$ and those with poultry compost 'D' averaged 1.54 ug-$min^{-1}$-$g^{-1}$. Microbial activity of soils were lower at mid season sampling date (Table 5). The low rates of compost applied may have been insufficient to result in a measurable increase in microbial activity at a midseason test of these soils.

Measurements of microbial activity were higher at all organically managed on-farm trials than at conventionally managed farms. On conventionally managed beet farms with the same soil type and within two miles of organic farm C, soil microbial activities ranged from .43 to .45 ug-$min^{-1}$-$g^{-1}$ as compared to .84 to .89 ug-$min^{-1}$-$g^{-1}$ on organic farm C, on the same sampling date. This observation of higher soil microbial activity under organic management systems compared to conventional systems has been previously reported (1 5).

*Crop yields.* Crop yields were only recorded for the two beet (Table 6) and the conventional bean experiments (Table 4). Marketable yields of beets were significantly higher under the high N poultry compost 'C 'on both farms. Above ground biomass was also higher. Yields in the conventional trial were twice those on the organic farm, however, twice the amount of compost was used at that site. Yield results correlated with the high soil nitrate N associated with this compost 'C'. The poultry compost 'D' also enhanced yields over the control in the research station trial. In beans receiving compost 'C' in 1997, plot yield and individual plant bean yield was significantly increased and total plant weight increased over the control and plots which had received compost in 1996 (Table 4). Despite the potential nutrient carryover from compost applied in 1996, there was no observed yield effect.

## Greenhouse Compost Trials

In the initial greenhouse experiment, attempts to establish a high population density of both *Pythium and Rhizoctonia* in the media tested in the greenhouse disease bioassay were unsuccessful. While there was some decreased growth of both beets and cucumbers in pathogen- inoculated soils, there was not the expected 50% reduction in plant number due to these damp-off diseases (Table 7). It is suspected that the wheat-cultured inoculum had too low a population density to adequately colonize the media within the short experimental duration.

However, the various compost treatments had significant effects on plant emergence rates and growth (Table 7). Two of the tested composts, one poultry ('D') and the other dairy manure ('E') based, enhanced plant emergence rates and growth, particularly if microbial activity was intact (non-sterilized). Both beets and cucumbers had similar final stand counts, but significantly higher fresh and dry weight in non-autoclaved 'D' or 'E' compost based media compared to autoclaved media and the no compost control. The effect of these two composts was particularly pronounced for cucumbers. The similar plant stands and fresh/dry weights among the autoclaved medias and the control indicated that release of phytotoxic compounds as a result of autoclaving was minimal. In addition, soluble salt levels and nitrate and ammonium-N concentrations did not vary among autoclaved and non-autoclaved mixes of these two composts, and the no-compost control (Table 8).

Those treatments containing poultry compost 'C' were phytotoxic to beet and cucumber growth, resulting in slower emergence rates, and lower stand counts, plant fresh and dry weights than other treatments. Sterilizing the media had no effect on crop response, unlike those observed for the other two composts. The poultry compost 'C' mixes had higher soluble salts and pH compared to other treatments (Table 8), which contributed to poor plant growth in these treatments.

Because of the observed reductions in *Rhizoctonia* root rot observed in the bean experiment and previous beet research, an additional greenhouse experiment was conducted to explored the effect of the high N poultry compost 'C' on beet emergence and disease resistance to *Rhizoctonia.* This poultry compost provided no reduction in disease incidence in these greenhouse studies (Figure 3). Greater disease losses were observed in compost amended treatments than in non-compost amended treatments. Over the 4 week study, total stand of beets was reduced by 25% in the control, non-compost treatments, as compared to 66% in the treatments receiving the lowest rate of compost. The higher level of compost (equivalent to 4 T/A field rates) reduced germination and plant stands over the experiment. Thus, it appears that this poultry compost product increased beet yield in field trials through a nutrient and not a disease suppressive effect.

## Summary

Understanding the impacts of compost applications for disease suppression will require several years of field study and careful characterization of compost quality. These studies represented initial work to begin exploring the effects of composts on soil borne diseases of field grown vegetables, under both organic and conventional management. Research to understand the complex ecology governing disease suppressiveness of composts is the focus of many research programs around the world. As more specific information comes available, development, quick tests for producers and growers to assess potential biocontrol of diseases with specific composts should become available. In these studies, a commercially available compost maturity test kit correlated well with laboratory measures of microbial activity in compost. This test could be used to determine general suppressiveness, once the results are verified through bioassay of composts with specific pathogens.

While disease pressure was low in field studies in this research, compost did affect soil fertility, plant emergence and stand, and tissue composition (with poultry compost). In these studies, plant populations were improved by additions of composts. Previous suppression of *Rhizoctonia* in beets by a poultry compost was associated with improved fertility of the crop and not actual disease suppression. Reduction in root rot of beans by this same poultry compost was also suspected to be primarily due to fertility. Differences in disease severity were not large (although statistically significant) and additional trials are needed to confirm this suppression, for this compost product, in various snap bean production areas and systems.

The low to moderate rates of compost additions used in these studies did not result in measurably higher soil microbial activity through the season. Soils on organic farms had general microbial activities that were higher than on neighboring conventional farms with the same soil type. This activity is affected by other factors including management and climate. It remains unknown if a specially tested or labeled 'disease suppressive" compost would benefit an organically managed field for disease reduction, given these higher background levels of soil microbial activity. Additional studies exploring higher rates of compost coupled with inoculations of organically managed fields with pathogens are required to test this theory. As more is learned about the ecology of compost induced disease suppression, specific types of composts may be recommended for managing diseases on organic and conventional vegetable farms.

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Table 1.Compost tested in greenhouse and field experiments, 1997.

| Compost | Description | pH | Moisture (%) | Organic matter (%) | Total (%) | N Total C (%) | C:N ratio |
|---|---|---|---|---|---|---|---|
| A | farm made, mixed | 4.80 | 70 | 81 | 2.8 | 39.5 | 14 |
| B | dairy manure, commercial | 7.82 | 6 | 14 | 0.6 | 8.6 | 14 |
| C | Poultry, no added carbon | 7.37 | 6 | 65 | 6.1 | 30.0 | 5 |
| D | Poultry, added sawdust | 8.77 | 4 | 78 | 2.0 | 28.7 | 14 |
| E | dairy manure, commercial | 7.82 | 30 | 36 | 1.5 | 11.8 | 14 |

Table 2. Interpretation guide provided with Solvita Compost Maturity Test Kit.
Information summarized from materials supplied by Wood's End Laboratory.

| Solvita Test Result | Approximate Stage of Composting Process |
|---|---|
| 1 | Fresh, raw compost; new mix; extremely high rate of decomposition; very odorous; high in volatile organic acids |
| 2 | Very active decomposition, moderately fresh compost; very high respiration rate; need intense aeration. |
| 3 | Active compost; young materials, high respiration rate; still needs intensive management. |
| 4 | Compost in medium active stage of decomposition; may be ready for curing. |
| 5 | Compost is moving past the active phase of decomposition; ready for curing-, reduced need for intensive management. |
| 6 | Aeration needs reduced; curing; significantly reduced management needed. |
| 7 | Well-matured, aged compost; cured; ready for most uses |
| 8 | Highly matured compost, well aged; like soil; ready for most uses. |

Table 3. Plant stand and tissue analysis from plants grown on composted and noncomposted plots. Farms A, B, and C were organically managed and farm D was a Cornell research farm.

| Farm | Crop | Treatment' | Plant stand[2] | Tissue analysis (%) 3 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | (num/ft) | N | P | K | Ca | Mg | Na (ppm) | Mn (ppm) |
| A | Spinach | Compost A | 2.9 a | 3.31 a | 0.54 a | 7.33 a | 1.25 a | 0.79 b | 306 a | 70 a |
| | | No compost | 1.9 b | 3.36 b | 0.50 b | 7.84 a | 1.36 a | 0. 91 a | 374 a | 66 a |
| B | Beans | Compost B | 5.3 a | 3.88 a | 0.34 a | 4.55 a | 2.55 a | 0.44 a | 78 a | 128 a |
| | | No compost | 3.9 b | 3.74 a | 0.33 a | 4.22 a | 2.62 a | 0.46 a | 72 a | 127 a |
| C | Beets | Compost C | 9.25 a | 3.46 a | 0.53 a | 8.93 a | 1.27 a | 1.53 a | 5862 a | 72 a |
| | | Compost D | 8.5 a | 2.84 a | 0.55 a | 8.48 a | 1.28 a | 1.4 a | 6222 a | 74 a |
| | | No compost | 10.5 a | 3. 01 a | 0.65 a | 8.99 a | 1.33 a | 1.44 a | 3724 b | 72 a |
| D | Beets | Compost C | 13.1 b | 4.32 a | 0.43 a | 5.05 b | 1.79 a | 1.1 a | 9163 a | 148 a |
| | | Compost D | 17.1 a | 3.72 b | 0. 41 a | 6.05 a | 1. 81a | 1.03 a | 9094 a | 136 a |
| | | No compost | 16.8 ab | 3.85 b | 0.38 a | 5.20 b | 1.99 a | 1.14 a | 5363 b | 149 a |

1 Spinach received 15 t/a compost and beans received 2.5 tons per acre. Beets on farm C received 2 T/A of each product and farm D received 4 T/A of each product. Control (no compost) treatments received no supplemental N on organic farms. On farm D, control treatments received 120 lb/A N as ammonium nitrate.

2 Numbers from same farm and in same column followed by the same letter are not significantly different at the 5% level.

3 Data for macronutrients is based upon a percent of dry matter or part per million for micronutrients. Analysis of other micronutrients indicated no significant differences among treatments.

Table 4. Productivity and disease rating of snap beans grown with or without poultry compost topdress in 1996 or 1997.

| Compost application year | Plant number (num/ft) | Plant biomass (lb/plot)[1] | Yield (lb/plot) | Yield/plant (oz)[2] | Disease rating[3] |
|---|---|---|---|---|---|
| None | 8.5 a | 9.5 a | 4.7 a | 1.45 b | 6.4 a |
| 1996 | 8.7 a | 9.9 a | 4.1 a | 1.27 b | 5.9 b |
| 1996 and 1997 | 7.7 a | 14.1 a | 6.3 a | 2.19 a | 4.1 c |

1 Average weight taken from 6 feet of harvested row and four replicates.
2 Means followed by same letter are not significantly different at the 5% level.
3 Average value from evaluation of all harvested plante. Bean root rot rating scale:
1=no visible symptoms, 9=>90% root and hypocotyl tissue affected with decay.

Table 5. Soil nitrate nitrogen and microbial activity levels at midseason sampling of composted and non-composted fields at four farms.

| Farm | Crop | Treatment[1] | Soil$NO_3$-N[2] (lb/a) | FDA[3] (ug/min/g) |
|---|---|---|---|---|
| A | Spinach | Compost a | 15 a[4] | 1.05 a |
| | | No compost | 15 a | 0.73 b |
| B | Beans | Compost b | 42 a | 1.12 a |
| | | No compost | 32 a | 0.99 a |
| C | Beets | Compost c | 31 a | 0.84 a |
| | | Compost d | 3 b | 0.88 a |
| | | No Compost | 5 b | 0.89 a |
| D | Beets | Compost c | 42 a | 0.54 a |
| | | Compost d | 28 a | 0.57 a |
| | | No Compost | 52 a | 0.57 a |

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1 Spinach received 15 T/A compost;beans received 2.5 T/A; beets on farm C received 2 T/A; beets on farm D received 4 T/A compost.

2 Farm A/spinach soil sampled 7/16/97; Farm B/bean soil sampled 7/23/97; Farm C/beet soil sampled 7/23/97; Farm D/beet soil sampled 7/23/97. Values for spinach and beans represent mean of 4 replicate samples, each comprised of 8 soil cores taken to an 8 inch depth. Beet soil nitrate values from mean of 3 replicates.

3 FDA values from surface 2 inches of soil. Values represent mean of 3 or 4 replicates.

4 Numbers in same group and column followed by the same letter are not significantly different at the 5% level.

Table 6. Marketable yield and above ground biomass from beets grown on composted and noncomposted soils, either organically (Farm C) or conventionally (Farm D).

| | Treatment[1] | Marketable yield (T/A) | Above ground biomass (T/A) |
|---|---|---|---|
| Farm C | No compost | 7.7 b[2] | 5.4 a |
| | Compost C | 10.4 a | 7.2 a |
| | Compost D | 8.9 ab | 6.6 a |
| Farm D | No compost | 14.0 c | 7.3 b |
| | Compost C | 19.1 a | 10.3 a |
| | Compost D | 16.3 b | 7.5 b |

1 Beets received 2 t/a compost of each compost product at farm C and T/A at farm D.
2 Numbers from the same farm and column followed by the same letter are not significantly different at the 5% level.

Table 7 . Greenhouse evaluation of 3 composts, either autoclaved or non-autoclaved, for effects on disease suppression, plant emergence and dry matter production.

| | | | | Beets | | Cucumbers | | |
|---|---|---|---|---|---|---|---|---|
| Treatment | Plant num.[1] | Fr.Wt[2] | Dry Wt | % Dry Wt | Plant num. | Fr. Wt | Dry Wt | % Dry Wt |
| <u>Compost</u> | | | | | | | | |
| Autoclave Compost'C' | 13.6 a | 5.4 a | 0.5 a | 11.5 b | 8.9 a | 15.4 a | 1.6 a | 1 1.0 c |
| Autoclave Compost'E' | 25.1 b | 41.1 b | 3.1 bc | 9.1 ab | 14.1 bc | 78.3 cd | 7.4 c | 9.6 b |
| Autoclave Compost'D' | 24.9 c | 37.5 b | 2.6 b | 7.0 a | 13.7 bc | 60.4 b | 5.8 b | 9.7 b |
| No Compost Control | 27.0 c | 43.9 b | 3.2 bc | 7.2 a | 14.2 bc | 71.9 bc | 6.9 bc | 9.8 b |
| Non-Autoclave Compost'C' | 19.5 c | 2.1 a | 0.2 a | 11.6 b | 12.7 b | 14.1 a | 1.5 a | 10.6 c |
| Non-Autoclave Compost'E' | 27.4 c | 63.1 c | 4.3 d | 6.8 a | 15.6 c | 89.0 de | 8.0 cd | 9.0 a |
| Non-Autoclave Compost'D' | 27.9 c | 54.9 c | 3.7 cd | 6.8 a | 15.8 c | 99.0 e | 9.2 d | 9.3 ab |
| <u>Pathogen</u> | | | | | | | | |
| No Pathogen | 23.5 z | 38.4 z | 2.65 z | 8.6 yz | 14.1 z | 64.9 z | 6.1 z | 9.8 z |
| Pythium | 24.1 z | 33.9 z | 2.49 z | 9.5 z | 13.8 z | 61.6 z | 5.9 z | 9.9 z |
| Rhizoctonia | 23.3 z | 23.4 z | 2.41 z | 7.7 y | 12.9 z | 57.0 z | 5.4 z | 9.8 z |

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1 Means among compost or pathogen treatments in the same column followed by the same letter are not significantly different at the 5% level.

2 Data presented in grams (28 g= 1 oz).

Table 8. Soluble salts, pH and microbial activity of peat-based greenhousemedia amended with 5% compost (v/v).

| Compost | Soluble salts[1,2] (dS/m) | pH | FDA (ug/min/g) |
|---|---|---|---|
| Autoclave Compost'C' | 1.78 b | 6.51 cd | 15.5 c |
| Autoclave Compost'E' | 0.94 a | 6.22 b | 5.5 b |
| Autoclave Compost'D' | 1.02 a | 6.44 c | 7.4 b |
| No Compost Control | 0.85 a | 5.93 a | 0.4 a |
| Non-Autoclave Compost'C' | 2.09 b | 6.65 d | 4.5 ab |
| Non-Autoclave Compost'E' | 0.95 a | 6.00 a | 0.4 a |
| Non-Autoclave Compost'D' | 0.94 a | 6.46 c | 1.2 ab |

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1 Means in same column followed by the same letter are not significantly different at the 5% level.
2 Soil soluble salt levels >1.75 are considered excessive for plant growth and development.

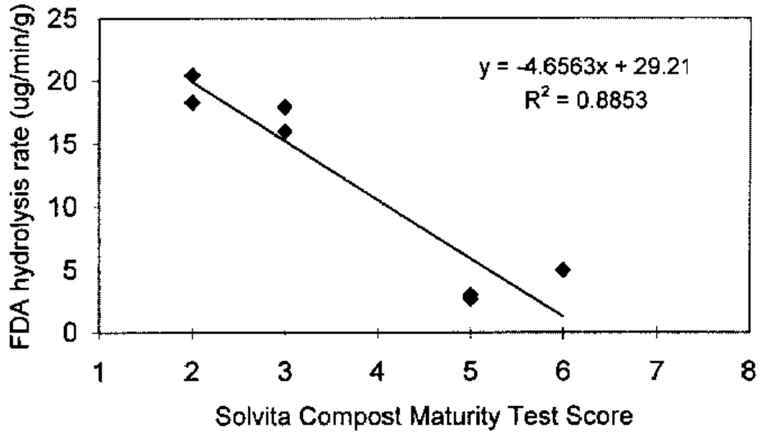

Figure 1. Correlation between FDA hydrolysis and Solvita Compost Maturity Test Kit measurements of compost maturity and microbial activity. Results represent mean of 2 replicates per compost. Seven composts were assessed.

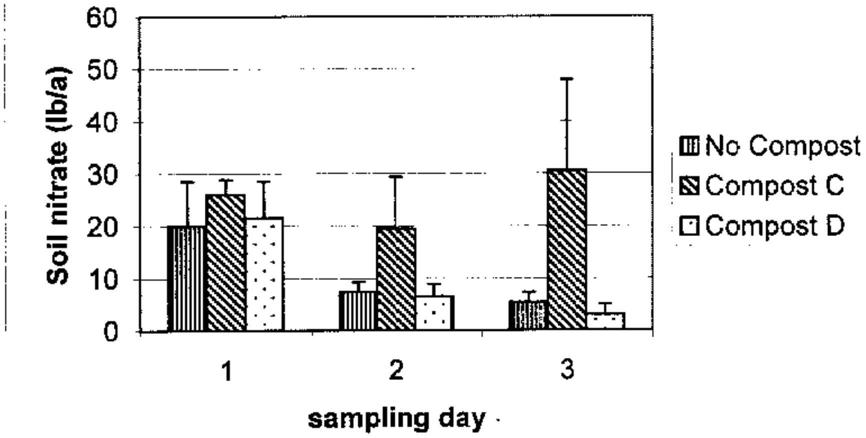

Figure 2: Soil nitrate nitrogen levels (lb/a) from three sample dates from soils amended with 2 poultry composts. Standard deviations represented by error bars. Sampling day 1 was June, 2, 1997, Day 2 was July 8, 1997, and Day 3 was July 22, 1997. Beets were harvested on July 30, 1997.

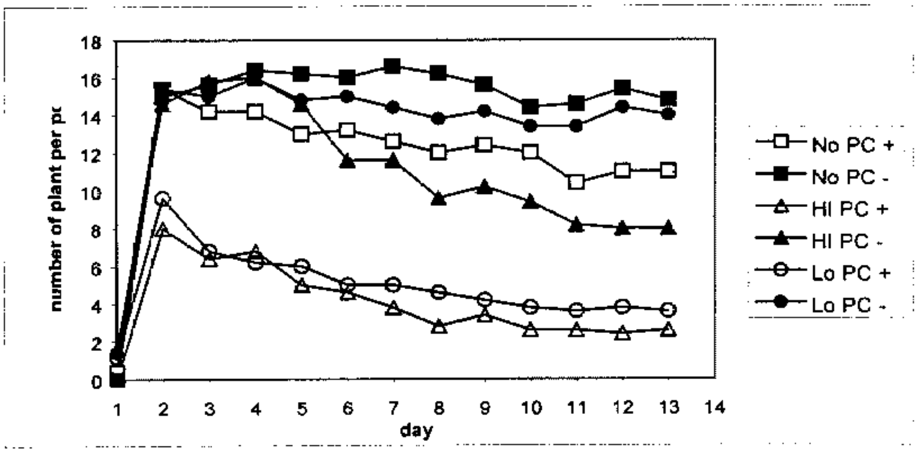

Figure 3. Effect of high rate (HI PC) and low rate (Lo PC) of poultry compost and inoculation (+ or -) with Rhizoctonia solani on beet emergence, under greenhouse conditions. Plant counts were taken every two to three days over a 4 week period.