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Nitrogen Release and Disease Suppressive Activity of Four Compost Amendments on Three Vegetable Farms

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Abstract

Plant and animal byproducts can replenish soil organic matter, supply nutrients, and influence disease incidence on vegetable farms. However, amendment composition and site-specific soil and climatic factors that are not well understood affect these processes, making management challenging. In this project, repeated applications of four amendments are being evaluated on three organic vegetable farms in Indiana and Ohio. Preliminary results indicate that both farm and amendment type alter nitrogen availability and pest incidence in cabbage and winter squash. Ongoing analyses will determine how resident soil microbial communities are influencing these processes, improving our understanding of the role of soil microbes and amendments in crop productivity. Results are expected to increase the practice of on-farm research and help organic farmers improve nutrient and disease management on their farms.

Background

Healthy soil is the foundation of sustainable crop production. Characteristics of a healthy soil include: good structure to facilitate water infiltration and plant root growth, a storehouse of nutrients released throughout the growing season, and a diverse and active soil microbial community that cycle nutrients and help plants withstand biotic and abiotic stress. To maintain soil health on intensively managed vegetable farms, growers must continuously replenish soil organic matter. Animal and plant byproducts are well known for their potential to contribute soil organic matter as well as supply nutrients on organic farms. In some cases, amending soil with these byproducts has also been found to suppress soilborne (Hoitink et al., 1997) and foliar diseases (Rotenberg et al., 2005). However, effectively meeting crop fertility needs with these amendments is challenging, and their application does not always result in pathogen suppression. Animal and plant byproducts must mineralize before nutrients are available for crop uptake, but the rate at which nutrients are released can vary substantially. The carbon to nitrogen (C:N) ratio is one factor that influences nutrient release, though site-specific factors such as moisture and tillage also have an effect. Consequently, timing nutrient release with critical periods of crop nutrient uptake can be difficult. The amount and rate of nutrient release, particularly N, could also influence disease severity in vegetable crops and may be one factor contributing to variation in the disease suppressive activity of these amendments. Changes in the composition and activity of resident soil microbes and induction of latent resistance mechanisms in plants are other factors that could contribute to the disease-suppressive activity of these amendments. Carefully designed on-farm experiments that track nutrient release from these amendments will help organic vegetable growers improve nutrient management on their farms. Such studies will also help

identify factors that influence the disease suppressive activity of these amendments allowing growers to better manage diseases on their farms. The specific objectives of this project are to: 1). identify soil amendments that improve soil health, provide plant available nutrients during periods of critical nutrient uptake, and increase crop productivity on organic vegetable farms; 2). determine how resident soil microbial communities interact with soil amendments to regulate nutrient cycling and disease suppressive activity; and 3). demonstrate and increase the practice of on-farm research.

Methods

A three-year trial was initiated in spring 2013 to quantify effects of repeated applications of four organic fertility amendments (Table 1) on three vegetable farms (LIFE Farm, Martinsville, IN; EcOhio Farm, Mason OH; and, Feel Good Farm, Sheridan, IN). The experiments are arranged in a randomized complete block design with four replicates on each farm. Amendment application rates are based on nitrogen needs of the crop in each year, assuming 50% of the N would become available for plant uptake during the current growing season. The chemical composition of the carbon compounds in the amendments was determined using ^{13}C -TMAH thermochemolysis. Vegetable crops grown in the trial include: cabbage (*Brassica oleracea* cv. Red Express, 2013), squash (*Cucurbita pepo* cv. Sweet reba, 2014), and tomato (*Solanum lycopersicum*, cv. to be determined, 2015). A winter cover crop mixture of cereal rye (*Secale cereale* L.) 75% and hairy vetch (*Vicia villosa*) 25% was planted following each vegetable harvest. Vegetable crops were evaluated for stand establishment, disease severity, leaf nutrients, and yield and fruit size. Soil samples were collected three times during each growing season and once each fall. Soil samples were analyzed for soil nutrients, labile soil carbon, microbial activity, microbial community diversity, and pathogen suppressive activity. Field days were held at one farm in each year to discuss on-farm research methodology, and share results of these trials.

Table 1. Soil amendments applied annually in three on-farm trials.

Product (N, P, K)	Rate Applied 2013 (lb/A)	Rate Applied 2014 (lb/A)
Fertrell (3-4-3) Bainbridge, PA	8,000	6,000
Nature Safe (8-5-5) Cold Spring, KY	3,000	2,250
Verdanta EcoVita (7-5-10) Bioworks, Victor, NY	3,430	2,570
Vermicompost (1.2-2-1) Nature's Way, Seymore, IN + Fertrell (3-4-3)	10,000+4,000	7,500+3,000

Results to Date

During the 2013 growing-season N availability varied among farms and amendments, with the largest differences observed shortly after transplanting. At that time, plant available N averaged across the three farms was higher with Nature Safe and Verdanta than with Fertrell or Vermicompost +Fertrell (Table 2). Early season plant vigor averaged across the farms was lower with Verdanta than with the other amendments, and leaf N was lower with Verdanta than with Vermicompost+Fertrell (Table 2). Cabbage yield across the three farms was not affected by the amendments (Table 2), however at EcOhio farm, yield was greater with the Verdanta than the vermicompost+Fertrell amendment (data not shown). EcOhio and LIFE produced more marketable heads and had higher leaf N content (10.4 and 9.8 heads; 4.8 and 4.7% N, respectively) than Feel Good Farm (4.0 and 3.7% N).

Disease incidence during the 2013 growing season also varied among farms and amendments. *Rhizoctonia* crown and stem rot and *pythium* root rot caused significant stand loss at Feel Good Farm, but no effect of soil amendment on these diseases was observed (data not shown). Black rot (*Xanthomonas campestris* pv *campestris*) occurred at all locations. When averaged across EcOhio and LIFE farms, black rot was worst with Vermicompost+Fertrell, least with Verdanta, and intermediate with Fertrell and Nature Safe by the end of the growing season (Figure 1). Throughout the season black rot was worse at EcOhio than LIFE. At Feel Good Farm soil amendments did not affect black rot.

Preliminary results of the 2014 growing-season indicate that leaf chlorophyll, which is commonly used to estimate leaf N, varied among farms and amendments (data not shown). Leaf chlorophyll was greatest at EcOhio, intermediate at LIFE, and lowest at Feel Good Farm. When averaged across farms, leaf chlorophyll was greater with Nature Safe than Verdanta and Fertrell. Squash yield was greater at LIFE than EcOhio, but there was no difference between the amendments. Squash was not harvested at Feel Good Farm due to significant damage by flooding.

Table 2. Plant available soil N (NH₄⁺/NO₃⁻) following transplant, and seedling vigor, leaf N content and marketable head number and weight of cabbage in 2013 on three farms.

Treatment	Soil N (lb./A)	Plant Vigor (1=low; 9=high)	Leaf N (%)	Marketable Heads	
				(no/plot) ¹	(lb./hd)
Fertrell	106 b	5.3 a	4.3 bct	9.0	0.87
Nature Safe	191 a	5.2 a	4.6 a	8.5	0.93
Verdante	163 a	4.6 b	4.5 ab	7.6	0.93
Vermicompost + Fertrell	101 b	5.0 a	4.2 c	7.1	0.93

¹Harvested area = 26 X 6 ft/plot; 279.2 plots/A. †Means within columns followed by different letters differ significantly at P<0.05 according to Fisher's Protected LSD.

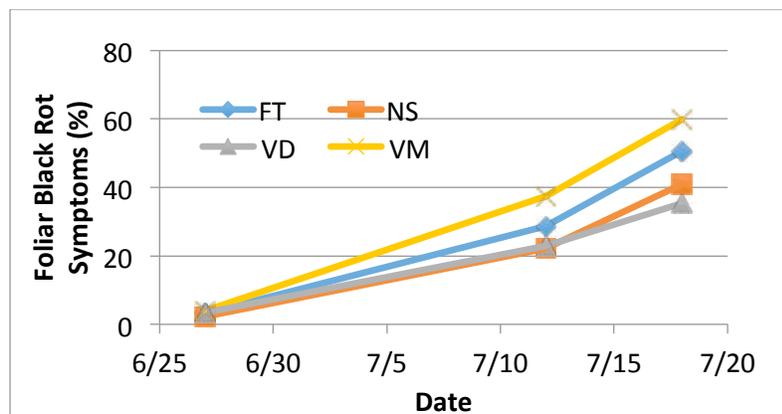


Figure 1. Black rot at EcoHio and LIFE Farms following Fertrell (FT), Nature Safe (NS), Verdante (VD), and Vermicompost + Fertrell (VM) soil amendments.

Pest severity during the 2014 growing-season also varied among farms and amendments (data not shown). Symptoms of Silverleaf whitefly (*Bemisia argentifolli*), an insect pest rarely seen in Indiana, was evident at both LIFE and Feel Good Farms, but not EcOhio. When averaged across the two farms with symptoms, silverleaf severity was worse with Nature Safe than Verdanta. Powdery mildew, caused by several pathogens including *Podosphaera xanthii*, was also evident

at all three farms. Early in the growing season, powdery mildew was worst at EcOhio, intermediate at LIFE, and lowest at Feel Good Farm. When averaged across farms, powdery mildew was greater with Fertrell than the other three amendments. At harvest, powdery mildew was worse at EcOhio than LIFE, and when averaged across these two farms, damage was greater with Nature Safe and Vermicompost+Fertrell than Fertrell. General symptoms of wilt, insect damage and leaf browning were greater at EcOhio than LIFE, and downy mildew (*Pseudoperonospora cubensis*) was greater at LIFE than EcOhio, though there were no effects of amendment. Preliminary results of pathogen bioassays in soil collected from LIFE farm with *Rhizoctonia solani*, a soilborne pathogen that causes damping off, indicate that infection was greater with Nature Safe than the other amendments.

Practical Implications

The trials show that two organic fertilizers containing the same percent nitrogen won't necessarily supply that nitrogen to the soil or crop at the same rate. Growers need to evaluate fertilizers on a case-by-case basis, and re-evaluate application rates and timings when switching to a new product. A resource that may be helpful in this regard is the Organic Fertilizer and Cover Crop Calculator from Oregon State University (smallfarms.oregonstate.edu/calculator). The calculator has not been validated for conditions in the Eastern United States, but it provides a starting point that is better than nothing.

This research shows that organic fertilizers can affect disease incidence and severity, but because we don't yet know how to predict what the effect will be, it is difficult to make a useful recommendation. For particularly problematic diseases, growers may find it worthwhile to make careful observations and/or establish trials on their farms to further knowledge about these effects.

Future Directions

These results indicate that site-specific soil and climatic factors as well as amendment characteristics influence nutrient release and disease severity on organic vegetable farms. Differences in nitrogen availability have previously been related to disease severity, either increasing or decreasing severity depending on the disease, and chemical composition of N compounds in soil. Ongoing analyses will determine how resident soil microbial communities contribute to these dynamics, increasing our understanding of the role of soil microbes and organic amendments in soil and plant health.

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Note

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