

Effect of Compost Extracts on Organic Seed Germination and Reduction of Weed Seed Expression

1. Project Summary

Weeds are considered the number one obstacle for organic crop production for their early competition with crop seeds for water, space, light and nutrients especially in the first 20-30 days of crop growth. At Rodale Institute, preliminary test results showed that soil treated with anaerobically-prepared compost actually increased weed population by 7-10-fold when compared to those that received an aerobic treatment (Ingham, unpublished data). This was done on a very small scale. A new research project funded by OFRF has enabled a team at Rodale Institute to explore a proof of concept whether the use of aerobic compost extracts with varying dilutions and chemical and biological properties, would lead to reduction in weed seed germination without impacting crop seed germination under controlled conditions. Two compost piles C1 and C2 were prepared with varying rates of feedstock to encourage microbial diversity. Compost pile 1 was prepared with 30% brown (woodchip and straw), 50% green (leaf mulch) and 20% high nitrogen (N) (alfalfa) whereas, compost pile 2 was prepared with same feedstock components but at 50% brown, 30% green and 20% high nitrogen. Both C1 and C2 were analyzed for chemical and microbial diversity. Extract dilutions (1:3, 1:4, 1:5, 1:6, and 1:10 (w/v) were prepared from each. Ten seeds each of pigweed, giant foxtail, lambsquarter, bell pepper, tomato, cucumber, and basil were placed in petridishes, lined with Whatman filter paper #1, and received 10 ml of each dilution. Seeds were incubated for 5 days at 24 °C and compared to those in deionized water (DI) in randomized complete block (RCB) design with four replications. Compost 1 had higher EC (1.76 dS/m) and NO₃ level (390 mg/kg), and lower %C (36.69), %N (1.84) when compared to Compost 2 (1.38 dS/m, 307 mg/kg, 40.58, 1.91, respectively). Compost 1 had higher protozoa biomass than C2, whereas number of nematodes was higher in C2. With either C1 or C2 extract, an increase in dilution ratio from 1:3 to 1:10 resulted in significant and linear decrease in EC (2.1 to 0.98 dS/m; 1.74 to 0.96), %K₂O (0.062 to 0.027; 0.053 to 0.027) and NO₃ concentration (84.5 to 26.7 mg/kg; 61.3 to 26.9 mg/kg), respectively. Number of nematodes per ml in C2 extracts decreased as dilution ratio increased. There was a significant ($P = 0.013$) reduction in cucumber % seed germination from 100% to 93% at 1:3 dilution. Compost extracts impeded pepper seed germination to about 96% as compared to DI treatment. Compost 2 extracts significantly ($P = 0.0014$) reduced lambsquarter weed seed germination by 32% as compared to those in DI water. Compost with lower NO₃ levels, higher %C and number of nematodes has the potential to reduce weed seed germination without affecting crop seed germination.

2. Introduction to Topic

Weed management is considered the number one obstacle for organic crop production (OFRF 1999; Bond and Grundy 2001). Weeds from the start compete with crop seeds for water, space, light and nutrients (Dusky et al., 1988, Ozores-Hampton, 1998) and accumulate water and nutrients at a faster rate than many crop plants especially in the first 20-30 days of crop growth. Early competition has a far greater impact on crop yields than interactions later in the season (Teasdale and Cavigelli, 2003). Using compost as soil mulch (4 to 6 inch (10 to 15 cm)) can be most effective in weed suppression (Landis and Khadduri, 2008). However, composts may vary

in their chemical and biological components based on their method of preparation and when they are applied at this quantity can be expensive. Organic growers whether they grow vegetables, grains, herbs, berries, or native plants are constantly on the lookout for finding new technology that can reduce the severity of weed problems and yield losses. At Rodale Institute, preliminary test results showed that soil treated with anaerobically-prepared compost actually increased weed population by 7-10-fold when compared to those that received an aerobic treatment (Ingham, unpublished data). This was done on a very small scale. There is no published research data that show the effects of using compost extracts with varying chemical and biological components on crop seed germination and reduction of weed seed expression. If successful, such technology could be easily adopted and adapted for improving seed establishment in the greenhouse or in direct field seeding for any crop.

3. Objective Statement

The project proposal was submitted to OFRF to fund a two-year research project with the aim to conduct a research trial under controlled laboratory conditions in year one and at growers' field sites in year 2. Since OFRF supports projects on an annual basis, we were funded for year one. This project was undertaken to as a proof of concept for whether compost extracts could improve weed seed expression so as to reduce challenges faced by growers and ultimately, such technology, if proven, could increase adoption of biological tactics in their weed management systems.

Our specific objectives were to 1) build compost designed with varying chemical and biological components and asses their chemical and biological properties; 2) how would compost extracts with varying biological components and dilutions affect weed seed germination; and 3) how would compost extracts with varying biological components and dilutions affect crop seed germination rate?

4. Materials and Methods

This project design was created through lengthy discussions with organic growers in MD and PA and has garnered strong farmer/grower support, especially those who grow seasonal crops, grains, natives, and herbs for local and wholesale markets. We have tested compost extracts with varying dilutions on foxtail, pigweed, and lambsquarter weed seeds to simulate the major weeds that require better control, as identified by organic growers, and cucumber, tomato, basil, and pepper seeds as crops.

Compost Production

Upon receiving funding from OFRF, we gathered the feedstock material to build compost piles with varying rates to encourage a diverse microbial community. Compost pile 1 was prepared with 30% brown (woodchips and straw), 50% green (leaf mulch) and 20% high nitrogen (alfalfa), whereas, compost pile 2 was prepared with same feedstock components but at 50% brown, 30% green and 20% high nitrogen. The feedstock materials were mixed and layered into 3-ft (91.4 cm) tall compost bins made of 0.5 inch (1.27 cm) mesh galvanized hardware cloth (**Photos 1 and 2**).

The compost piles were monitored for moisture and temperature throughout the composting process (**Photo 3**). The compost in each bin was turned and mixed four times as temperatures increased beyond 131°F (55 °C) and below 170 °F (76.7 °C). After the 4th turn compost piles

never increased in temperature and stayed at about $76^{\circ}\text{F}\pm 2$ ($24.4\pm 1^{\circ}\text{C}$) for the next seven months to mature.

Upon maturity, each compost pile was sieved through 1-inch openings to remove large particles (**Photo 4**), mixed, and homogenized before it was used to prepare compost extract dilutions. It is important to note that the sieve was disinfected with diluted hypochlorous acid solution between the compost piles and bins were prewashed with same solution and different clean gloves were used for each compost pile. Bins of sifted compost were then moved to a clean storage space before compost extracts were prepared from C1 and C2.

Subsamples from each compost were sent to the Agricultural Analytical Services Laboratory (AASL) at Pennsylvania State University for chemical and Ward Laboratories, Inc., for microbial community analyses.

Compost Extract preparation

In the grant proposal, we proposed to test compost extract dilutions at 1:1, 1:2, 1:5, 1:10 and 1:20. However, before running all dilutions we did a preliminary test on the highest dilution rate (1:20) to learn whether we need to keep the proposed range or modify it. We found that at 1:20 dilution there was no beneficial effect on weed seed emergence. Consequently, we modified the range of dilutions based on the available amount of compost and ran compost extract dilutions at 1:3, 1:4, 1:5, 1:6, and 1:10 (w/v).

We used clean, disinfected brewing pouches filled with compost from either C1 or C2 and inserted into clean disinfected 5-gallon buckets and bubbled in deionized water (DI) for 24 hours (**Photo 5**). Extract dilutions were subsampled into clean bottles and sent on ice packs with overnight shipping to AASL lab for chemical analysis.

Incubation of weed and crop seeds

In a randomized complete block design (RCBD) with 4 replications, seeds of lambsquarter, pigweed, giant foxtail, tomato, cucumber, bell pepper, or basil were placed in petri-dishes, lined with Whatman filter paper # 1 and 10 ml of each dilution or DI and incubated for 5 days at 75.5°F (24°C) after which % germination was determined.

Statistical analysis

Data were analyzed by one way ANOVA in general linear model to test significance between treatments using Tukey's post hoc test and SAS 9.3 software.

5. Project Results

Chemical and biological properties of designed composts

Chemically: Electrical conductivity (EC) (1.76 dS/m) and nitrate ($\text{NO}_3\text{-N}$) level (390.69 mg/kg) in C1 were greater than in C2 (1.38 dS/m , 307.32 mg/kg , respectively) on dry weight basis (Table 1). C1 had a slightly lower C:N than C2, which it can be attributed to the higher percentage of green (leaf mulch) in C1.

Biologically: C1 had higher protozoa biomass than C2, whereas nematode number was higher in C2 (Table 1).

Table 1. Chemical and biological properties of composts.

Treatment [†]	pH	EC	C:N	NO ₃ -N (mg/kg)	Protozoa biomass (ng/g)	Nematode (#/g)
C 1	7.53	1.76	19.90	390.69	125.59	49.53
C 2	7.65	1.38	21.27	307.32	78.63	129.13

[†]C1: has 30% browns, 50% greens, 20% Hi N; C2: has 50% browns, 30% greens, 20% Hi N

Compost Extract dilutions:

- As dilution ratio increased from 1:3 to 1:10, EC and NO₃-N levels decreased in extracts (Table2).
- There was a significant ($P = 0.013$) reduction in cucumber seed germination percentage from 100% to 93% at 1:3 dilution (Fig. 1).
- Compost extracts impeded pepper seed germination by about 96% compared to DI water treatment.
- Compost 2 extracts significantly ($P = 0.0014$) reduced lambsquarter weed seed germination versus DI water (Fig. 2).

Table 2. Chemical properties of compost extracts.

Compost Extract Treatment	pH	EC (dS/m)	NO ₃ -N (mg/kg)
C1	7.93	2.12	85.55
1:3	7.64	1.81	65.97
1:4	7.84	1.64	59.71
1:5	7.96	1.31	44.56
1:6	7.98	0.98	27.65
1:10			
C2			
1:3	7.9	1.74	61.28
1:4	7.8	1.48	53.99
1:5	7.9	1.40	45.82
1:6	8.0	1.27	41.14
1:10	8.0	0.96	26.90

Fig. 1. Effect of compost extract dilutions 1:3, 1:4, 1:5, 1:6 and 1:10 on % germination of cucumber seeds

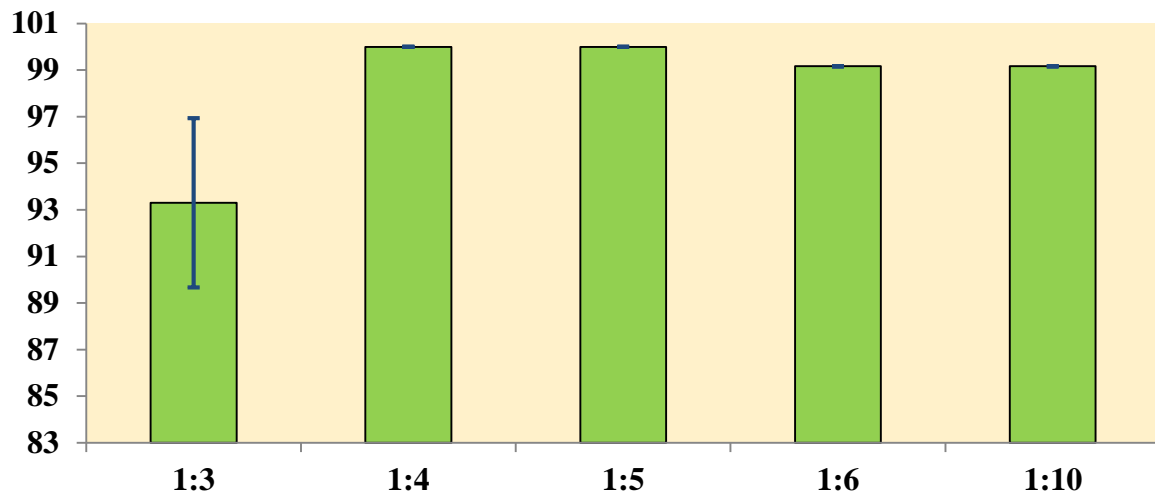
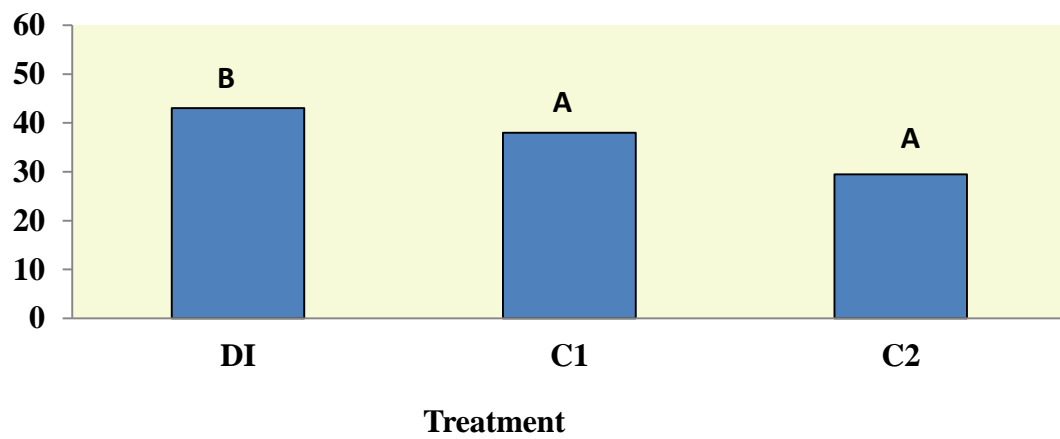


Fig. 2. Effect of extract treatment on % germination of lambsquarter seeds



6. Conclusions and Discussions

- Neither of the tested compost extracts in any tested dilution reduced pigweed or foxtail seed germination percentage.
- While common knowledge suggests that compost extracts could be useful to all crops, our research results showed that the tested compost extract dilutions did negatively impact germination percentage of pepper but not tomato, cucumber, or basil.
- However, our results showed that compost extract at 1:4 dilution, produced from designed compost 2 (higher percentage of brown or C:N) with lower NO₃-N levels and higher number of nematodes, has the potential to reduce lambsquarter seed germination percentage by 32% without affecting the germination of the tested seed crop species when compared to DI water.
- A follow up project is advised to test repetitive compost extract dilutions in potting media or sand while performing field studies as was described in the full two-year proposal. Several applications of these extracts on seeded weeds in soil/ potting media/sand may cause a compounding effect of suppression.

Recommendations for second year/ future project:

- In conjunction with the second-year project we propose to study the impact of using a solution of compost extract with herb extracts (since some are allelopathic) to enhance the additive effect of weed suppression.
- To identify the phytohormones, phenolic acids, and flavonoids in the compost extracts and in combination with herb extract to pin point the phytochemicals that are potentially involved in suppression or enhancement of weed and crop germination.

Problems encountered during the project period were related to delay in receiving a new incubator to run the incubation tests followed by a breakdown that required its maintenance before it became functioning properly.

7. Outreach

We placed the compost piles in a prominent location on Rodale Institute Research Farm for the many RI visitors attending workshops or field days or just touring to see. The compost research project was among several educational stops that took place during the annual Field Days at Rodale Institute. Dr. Zinati shared the project goal and objectives and the supportive funding agency. Many growers were happy to see such work being done at Rodale Institute. On October 25, 2014 and during a compost workshop, Dr. Zinati presented preliminary results to workshop attendees.

Another venue was used to disseminate the information to a larger audience was at the Mid-Atlantic Organic and Sustainable Services (MOSES) Research Forum, where results were

presented in a poster on February 27 and 28, 2015. This forum attracts many growers, professional educators, and students. The poster entitled “*Weed Suppression with Designed Compost Extracts*”, authored by G.Zinati, R. Moore, J. Moyer, and K. Nichols.

A web article has been compiled for internal revision and posting on Rodale Institute’s Website <http://rodaleinstitute.org/> soon.

8. References

Bond, W. and A. C. Grundy. 2001. Non-chemical weed management in organic farming systems. *Weed Research* 41: 383-405.

Dusky, J.A., W.M. Stall, and J.M. White. 1988. Evaluation of herbicides for weed control in Florida lettuce production. *Proc. Fla. State Hort. Soc.* 101:367–370.

Organic Farming Research Foundation. 1999. Final Results of the Third Biennial National Organic Farms' Survey. OFRF.

Ozores-Hampton, M. 1998. Compost as an alternative weed control method. *HortScience* 33:938-940.

Landis, T.D. and N. Khadduri. 2008. Composting applications in forest and conservation nurseries. *Forest Nursery Notes* pp.9-18. <http://www.rngr.net/publications/fnn/2008-summer/articles> accessed on November 12, 2012

Teasdale, J.R., and M.A. Cavigelli. 2003. Long-term organic farming systems research. ASA Organic Agriculture Symposium, Annual Meeting Abstracts CD-ROM, A08-teasdale370880-oral.

9. Addenda



Photo 1. Compost piles



Photo 2. Mix of Feedstock



Photo 3. Monitoring temperature



Photo 4. Sifting compost



Photo 5. Brewing pouch and 5-gallon brewing bucket

