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Influence of biodynamic preparations on compost development and resultant compost extracts on wheat seedling growth

Jennifer R. Reeve [a,*], Lynne Carpenter-Boggs [b], John P. Reganold [b], Alan L. York [c], William F. Brinton [d]

[a] Plants, Soils, and Climate, 4820 Old Main Hill AGS 332, Logan, UT 84322, USA
[b] Department of Crop and Soil Sciences, 201 Johnson Hall, Washington State University, Pullman, WA 99164-6420, USA
[c] Wholistic Estate Management, 545 Catherine Court, Santa Rosa, CA 95409, USA
[d] Woods End Laboratories, Mount Vernon, Maine 04352, USA

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ABSTRACT

Biodynamic (BD) agriculture, a form of organic agriculture, includes the use of specially fermented preparations, but peer-reviewed studies on their efficacy are rare. Composting of a grape pomace and manure mixture was studied in two years (2002 and 2005) with and without the BD compost preparations. Water extracts of finished composts were then used to fertigate wheat seedlings, with and without added inorganic fertilizer. BD-treated mixtures had significantly greater dehydrogenase activity than did untreated (control) mixtures during composting, suggesting greater microbial activity in BD-treated compost. In both years there was a distinct compost effect on wheat shoot and root biomass irrespective of supplemental fertilizer. Shoot biomass was highest in all treatments receiving 1% compost extract. Wheat seedlings that received 1% compost extract in 2005 grew similar root and shoot biomass as fertilized seedlings, despite only containing 30% as much nitrogen as the fertilizer treatment. In both years seedlings that received fertilizer plus 1% compost extract produced 22–61% more shoot biomass and 40–66% more root biomass than seedlings that received fertilizer alone, even at higher rates. In 2002 a 1% extract of BD compost grew 7% taller wheat seedlings than did 1% extract of untreated compost. At 0.1% only BD extract grew taller plants than water, but in 2002 only. No effect on shoot or root biomass was seen at 0.1%. Our results support the use of compost extracts as fertilizer substitutes or supplements, testimonial reports on the growth promoting effects of compost extracts, and the occasional superiority of BD compost to untreated compost.

1. Introduction

Biodynamic (BD) agriculture was first presented as an alternative form of agriculture in 1924 by the Austrian philosopher Rudolf Steiner (Steiner, 1993). Since then it has gained considerable following, especially in Europe, Australia, New Zealand and India. Biodynamics shares much in common with organic methods of farming, including soil building, crop rotations, and composting. A key aspect of the BD method is the use of special preparations that are applied to the soil, crops and composts. The compost preparations consist of six fermented herbal substances (Table 1), which are added to compost piles at the rate of 5 g each to 1–13 mg of raw feedstock in order to promote the formation of a quality product (Koepf et al., 1990; Steiner, 1993). Proponents claim that these six preparations produce compost that develops faster with less loss of nitrogen, fewer odor problems, and greater nutrient holding capacity, by stimulating organisms present in the feedstocks (Koepf, 1993; Klett, 2006).

Many of the research reports supporting the efficacy of the BD preparations have appeared in non-refereed publications and in dissertations (Abele, 1973; Samaras, 1978; Spiess, 1978; König, 1988; Bachinger, 1996) and agency studies (Abele, 1978; Abele, 1987; Dewes and Ahrens, 1989). Recent peer-reviewed research showed that the compost preparations had a discernible effect on the finished product (Carpenter-Boggs et al., 2000). That is, BD compost maintained higher temperatures throughout the active composting stage, and finished BD compost contained 65% more nitrate, respired at a 10% lower rate, and had higher dehydrogenase enzyme activity than untreated compost; fatty acid analysis indicated that BD compost had a larger proportion of bacteria to fungi than the control compost (Carpenter-Boggs et al., 2000).

Boos et al. (1997) reported a trend towards higher initial temperature and lower respiration and ammonium in finished BD compost, indicating a faster decomposition process. Earlier research produced similar results with BD-treated compost having a narrower C:N ratio, more nitrate, greater cation exchange capacity,

* Corresponding author. Tel.: +1 435 797 3192.
E-mail address: jennifer.reeve@usu.edu (J.R. Reeve).

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Table 1
The main ingredients and recommended amounts of the biodynamic preparations used in up to 14 t compost.

Preparation	Main ingredient	Use	Unit volume (cm^3)	Unit mass (g)
502	Yarrow blossoms (*Achilliea millefoilium* L.)	Compost	15	1.1
503	Chamomile blossoms (*Matricata recutita* L.)	Compost	15	3.0
504	Stinging nettle shoots (*Urtica dioica* L.)	Compost	15	4.4
505	Oak bark (*Quercus robur* L.)	Compost	15	3.9
506	Dandelion flowers (*Taraxacum officinale* L.)	Compost	15	4.7
507	Valerian flower extract (*Valeriana officinalis* L.)	Compost	2	1.2

higher respiration rate and a more even and prolonged heating period (Heinze and Breda, 1978; Ahrens, 1984; von Wistinghausen, 1986).

Biodynamics has received attention from the wine industry in recent years with many notable winegrape growers, particularly in France and California, converting to biodynamic practices (Meunier, 2001; Walker, 2003; Nigro, 2007). Today, an estimated 1000 hectares of vineyards are certified biodynamic in the United States, with many more wine growers experimenting with the method (H.G. Courtney, 2008, The Josephine Porter Institute, personal communication). Organic winegrape production is also on the increase, particularly in California where pest and disease pressures are low relative to the more humid grape growing regions in the eastern and midwestern US. Certified organic grapes (all) accounted for 2.4% of total US grape acreage in 2005 (Economic Research Service, 2008).

Wine production creates considerable volumes of organic waste called grape pomace, which includes grape seeds, skins, and stems. Composting has become the obvious solution for pomace disposal for many wineries. The resulting compost is often used on site in the vineyards to increase soil organic matter, soil nutrients, water holding capacity and porosity (Brinton and York, 2003).

Composts may also be extracted with water at widely ranging ratios of 1:1 (dry w/w) (Hoitink et al., 1997) to 1:60 (dry w/w) (Scheuerell and Mahafee, 2004) to 1:800 (dry w/w) (Kelley et al., 2004). Such extracts are sometimes treated with additional ingredients and/or diluted before application (Scheuerell and Mahafee, 2004). The resulting extract or tea is applied to plants or soil for putative fertility or disease control benefits (Litterick et al., 2004). The compost tea industry, although small, is estimated to be growing at 25 percent per year (Carpenter-Boggs, 2005). Not only winegrape growers, but orchardists, vegetable farmers, and even golf course managers are showing interest in using compost extracts (Goldstein, 2005). Despite growing industry interest and use of these methods, neither on-farm composting of grape pomace nor the use of compost extracts has received adequate scientific attention (Goldstein, 2005).

The purpose of this study was, firstly, to test the effect of BD compost preparations on the quality of compost produced on a commercial California vineyard. Secondly, water extracts of finished BD-treated and non-treated pomace composts with and without added fertilizer were tested for effects on wheat seedling growth.

2. Methods

2.1. Composting procedures

Composting experiments were conducted on a commercial certified BD winegrape vineyard (McNab Ranch, Hopland, CA) with average annual precipitation of 114 cm. Feedstocks consisted of grape pomace and dairy manure with straw bedding, mixed and managed according to the vineyard's standard protocol. In March 2002, these materials were mixed 1:1 by volume for an initial approximate C:N ratio of 30:1 and divided into four windrows with height, width, and length of $1.5 \times 3.6 \times 12.1$ m. Two windrows were treated with the BD compost preparations (Table 1) purchased from the Josephine Porter Institute (Woolwine, VA) and two (controls) were not treated. The BD treatment consisted of 5 g of each preparation numbered 502 through 507, with each preparation placed in a separate hole bored 0.3 m into the pile according to standard BD practice (Koepf et al., 1990). One set was inserted for every 10 tons of material. Preparation 507, a liquid, was lightly sprayed over the entire pile.

Piles were turned with a front-end loader and compost samples were taken on days 0, 21, 55, 100 and 200. After turning, eight subsamples were taken along each side of the pile at a depth of 60–90 cm and thoroughly mixed together. Samples were stored at 4 °C prior to shipment to Woods End Laboratories (WEL, Mt. Vernon, ME) and Washington State University (WSU) for analyses. Temperatures were recorded in each pile at a depth of 90 cm every 4 h with a temperature data logger (Dickson, Addison, Illinois).

This procedure was repeated in March 2005 with a further four compost piles, with two reps for each treatment. Turning and sampling were carried out as above. Temperature in 2005 was measured twice weekly in eight places with a 90 cm probe (Rio Temp. Instruments, San Diego, CA). Daily temperature and rainfall data for the duration of each composting period were obtained from the UC Davis weather station located in Hopland CA, 3 miles south of McNab Ranch.

2.2. Chemical, physical, and biological analyses

The following analyses were carried out by WEL on 2002 samples. Compost samples were passed through a 10 mm sieve to remove any oversized material. Density was measured using TMECC Method 03.01-A (TMECC, 2002). Compost pH was measured according to EPA method 150.1 (Environmental Protection Agency, 1983). Total Kjeldahl nitrogen was measured using EPA method 351.3 (Environmental Protection Agency, 1983). Total carbon was measured by combustion at 550 °C. Organic matter was determined according to EPA method 160.4 (Environmental Protection Agency, 1983). Water holding capacity (WHC) was estimated by assigning an average of 300% WHC to the organic fraction and a 25% WHC to the ash (inorganic fraction) (method developed by W.F. Brinton, WEL). Respiration rate was determined by the alkaline trapping method 05.08 B (TMECC 2002) incubated at 34 °C. Total mineral nutrients P, K, Na, Ca, Mg were measured according to EPA Methods 202.1–265.3 (Environmental Protection Agency,1983). Analyses carried out by WEL in 2005 were bulk density, water holding capacity, and total mineral nutrients using methods above.

The remaining analyses were conducted at WSU. Moisture content on wet weight basis was determined by drying for 48 h at 65 °C. Ammonium–N and NO_3^--N were measured in 2002 in a filtered extract 0.1 M $MgSO_4$ using ion sensitive electrodes (ORION Research, Inc., Beverly, MA). In 2005, NH_4^+-N and NO_3^--N were measured in filtered extract of 1:5 (dry wt./vol) compost in 1 M KCl on a Lachat QuickCHem FIA + 8000 series autoanalyzer using the salycilate method for NH_4-N and the NH_4Cl_2 method for NO_3-N.