COMPOSTING OF DAIRY MANURE AND GRAPE VINE PRUNINGS USING THREE DIFFERENT COMPOSTING TECHNIQUES

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ABSTRACT

Composting agricultural waste is an acceptable and wide spread used technique. Most manures, including dairy manure, don't have the proper carbon to nitrogen ratio (C:N) for composting without the loss of nitrogen as ammonia during the composting process. The grape vine industry uses mostly burning as a technique to dispose of their carbon rich annual prunings. This project demonstrated the effects of increasing the C:N content of dairy manures using grape vine prunings. A nitrogen loss reduction (8.63 lb N/Ton) was observed on compost windrows with carbon enhanced mixes as compared to just dairy manure mix. Compounds' concentrations that usually limit compost application rates (e.g. P, K, salts) were also reduced in the final product when grape prunings were added to the initial mix. The project demonstrated the feasibility of using composting as a Best Management Practice to reduce or eliminate the annual burning of grape production. Additional benefits and disadvantages of considered composting techniques are discussed.

INTRODUCTION

The dairy industry is the number one revenue commodity in Idaho. Idaho is ranked third in milk production in the nation, having more than 578,000 dairy cows distributed in approximately 550 dairy operations (Idaho State Department of Agriculture, 2013). Considering each cow produces approximately 148 lbs of manure daily (feces and urine, not counting bedding; Lorimor et. al, 2000), this translates into 1.28 million ton monthly of manure production. On-farm composting of manure is one Best Management Practice (BMP) available to dairy producers. As a waste management practice, composting reduces the volume of composted waste between 35 to 50%, which allows the materials to be significantly more affordable to transport than raw wastes. Composting converts the N present in the raw manure into a more stable form, which is released slowly over a period of years and thereby not totally lost to the environment. Composting alleviates problems associated with ground and surface water contamination and also reduces odor complaints (Rink, et al., 1992; Eileen, et al., 1993). Even though during the manure handling and composting process between 50 to 70% of the nitrogen can be lost as ammonia, different techniques can be used to increase nitrogen retention (reducing losses as ammonia), and one of the simplest techniques is to fine tune the Carbon to Nitrogen ratio (C:N) as close as possible to 30 to 1 (C:N= 30:1) or more. Most of the time, manures from dairies and other livestock operations don't have the proper ratio to be composted efficiently in a direct way. Since manures are richer in nitrogen (C:N ratios below 18:1) and usual bedding consist of straw (C:N 60 to 90), a great proportion of the available nitrogen is lost as ammonia due to the lack of carbon to balance the composting process. In addition, the loss of ammonia from manures reduces the nutrient value of the manure and generates local and regional pollution. This lack of carbon also results in a lower grade compost that can carry high concentrations of salts, potassium (K), and phosphorous (P).

Grape producers, on the other hand, have an excess of a carbon rich waste (prunings). Composting of prunings by themselves is not a very successful technique since their low moisture content and C:N ratio (around 80:1) make the degradation process slow and high temperatures necessary to kill pathogens are often not reached. The grape industry in Idaho ranks fourth among Idaho fruit crops. There are 1,800 acres in production yielding 3,400 tons of grapes from 70 vineyards. In order to select fruiting wood, maintain vine shape and form, and regulate the number of buds retained per vine for current and sustainable yield and quality of grapes, an annual dormant pruning practice is necessary. The amount of pruning residue vary according to the type of grape cultivar, pruning techniques, and production method, and they can range from 0.4 to 2.8 tons per acre (Wang and Schuchardt, 2010; Mužík et. al., 2007). Currently, Idaho vineyards could be pruning approximately 1,000 to 4,000 tons of residue canes a year (reported industry calculations estimate around 2,500 ton/year) with no set practice for disposal or recycling. The most used practice to dispose of these residues in Idaho, open burning, generates air pollutants including carbon dioxide, soot (carbon particles), Particulate Matter (PM), and other gaseous emissions that pollute the air in the surrounding areas and dramatically increase the carbon footprint of the Idaho table grape and wine industries. Other agricultural producers including berries and various types of orchards face similar problems with the disposal of their annual pruning wastes. This project explored the combined composting of waste from the dairy and grape industries and demonstrated different composting techniques to offer agricultural producers' alternatives according to their size and equipment availability. The program researched the possibility of reducing the loss of nitrogen during the composting process, showcased how to eliminate the burning of annual prunings, and highlighted how bringing together different industries to treat their waste can have a positive impact for the environment.

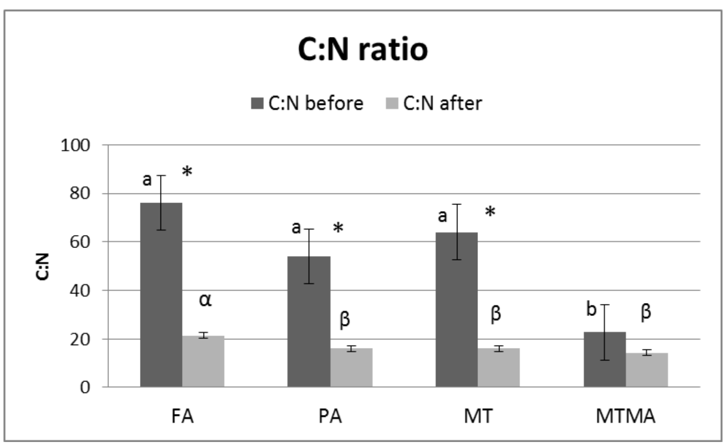
MATERIALS AND METHODS

This on-farm research and demonstration study was located at a vineyard in Emmett, Idaho. Manure stockpiled after one season's corral cleaning was provided by a local 800 cows open lot dairy. Grape prunings from the previous season were grinded using a hammer grinder (Vermeer HG 200. Pella, IA). Compost feedstock mixture was calculated using a compost spreadsheet calculator (WSU-Puyallup Compost Mixture Calculator, version 1.1. Puyallup, WA). The C:N ratio for the ground vine prunings was 79:1, so additional carbon to reach approximately C:N 40:1, following organic standards requirements, was added using straw and wood sawdust from the county fair and horse stable. Dairy manure C:N was 11:1. Moisture was adjusted by adding canal water to reach approximately 50% to 60% moisture on the initial mix. Three composting methods were tested using the described feedstock mix. The methods used were forced aerated (FA), passive aerated (PA), and mechanically turned (MT) compost. In all cases three replications per system were made. In addition, three replications of just dairy manure as it came from the dairy with some straw added to simulate dairy operations (C:N 20:1 but no prunings or other carbon added) were built using the mechanically turned system (MTMA). All compost systems were actively composted for four months or more; following specific recommended procedures for each system (e.g. at least five turns on the mechanically turned system). Mechanically turned windrows were turned using a skidder or small tractor. Temperatures were registered daily by the farmer for approximately 30 days in the aerated system and 10 days after each turning on the mechanically turned systems using a compost thermometer (Reotemp, Heavy duty compost thermometer. San Diego, CA). Complete manure/compost nutrient lab analyses were performed for each windrow at the beginning (compost feedstock mix) and at the end of the study after compost screening. ANOVA and contrast on lab data were performed using SAS 9.3 (SAS Institute, Cary, NC).

RESULTS AND DISCUSION

Temperature is one of the parameters monitored to control the composting process and to evaluate if pathogen reduction/destruction has been achieved during the composting process. The standard is to follow the U.S. Environmental Protection Agency (USEPA) Process to Further Reduce Pathogens (PFRP) which establishes a combination of temperature (131°F), time (e.g. five days for mechanically turned systems), and how many times that temperature should be reached (e.g. five times for the same systems), as a minimum (USEPA, 2013). In this trial, the FA system didn't reach PFRP. The FA composting process was incomplete due to the lack of moisture in the initial mix. Forcing air through the system requires higher initial moisture that we couldn't achieve in that system due to insufficient water supply at the moment of building those windrows. Other studies conducted by the author using FA with similar feedstock had reached PFRP without problems. All the PA windrows and the MT windrows with enhanced carbon mix (containing prunings) reached PFRP. All the MT windrows with just dairy manure and some straw (MTMA) didn't reach PFRP.

Initial feedstock mix C:N was significantly higher on the carbon enhanced windrows as expected (FA, PA, and MT), but the final C:N ratio on the compost was not significantly different among most systems and between the enhanced mix and the just manure mix (Figure 1). FA system is the only one with a difference at the end, possible due to the incomplete composting of the mix due to the lack of moisture. The reduction on the C:N between the initial mix and the final compost was significant on all systems on the C enhanced windrows, but not significant in the just manure mix.

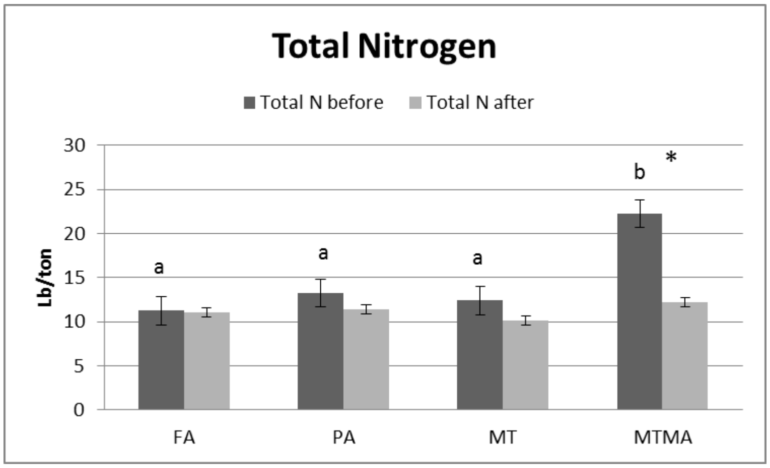


a,b Means on initial feedstock mix, values with different superscripts differ ($p<0.05$)

α, β Means on final compost, values with different superscripts differ ($p<0.05$)

Figure 1. Carbon to Nitrogen ratio

As expected, the initial mix total nitrogen (TN) was significantly lower on the carbon enhanced windrows compared to the just manure windrows (Figure 2). Total nitrogen on the finished compost had no significant difference among all the systems. The difference between the initial mix and final compost TN wasn't significant among carbon enhanced windrows, but highly significant in net values (10.08 lb/ton of N on dry weight basis) and statistically (p<0.0001) on the just manure windrows. This difference on TN, coupled with the no significant difference in C:N, suggests the loss of nitrogen as ammonia during the composting process on the windrows made of just manure. Net nitrogen loss is significantly lower in the carbon enhanced windrows (1.45 lb/ton average).

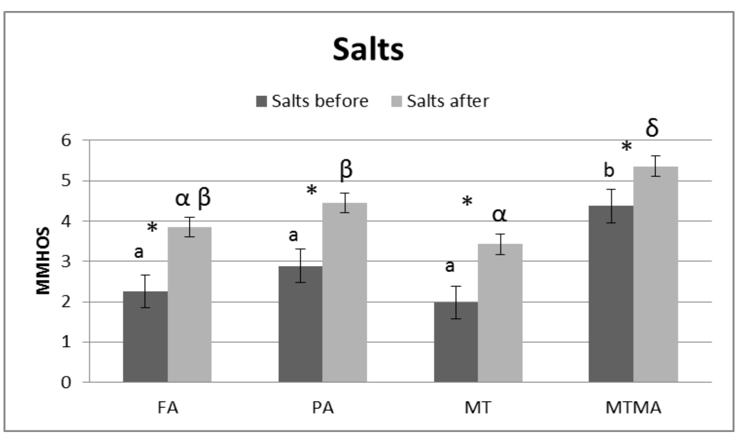


a,b Means on initial feedstock mix, values with different superscripts differ (p<0.05)

* Means the difference between initial and final values is significant (p<0.05)

Figure 2. Total nitrogen

Salt concentration (mmhos/cm) differences between initial mixes and final compost was significant in all windrows, with higher values in the final compost as expected due to the concentration effect that composting volume reduction has (Figure 3). Salt concentrations in the just manure windrows was significantly higher due to the dilution effect that adding carbon on the initial mix has on the carbon enhanced mix (lower manure mass per initial mix unit). Similar dilution trends were observed for P, K, and micronutrients. Carrying this dilution effect on the final compost can be beneficial when land applying compost since application rates can be increased, increasing the nitrogen and carbon content of the application (desirable conditions) by the time the limiting components in our soils (usually P, K, or salts) are reached.



a,b Means on initial feedstock mix, values with different superscripts differ (p<0.05)

α, β Means on final compost, values with different superscripts differ (p<0.05)

Figure 3. Salts

Screening of the carbon enhanced windrows generated a refuse (bigger size material from the screen) containing pieces of carbonous material (grape prunings) that can be used as mulch to control weeds on the vineyard or other vegetal production units. When PFRP is achieved (as it was in the PA and MT systems), plant pathogens in that mulch can be considered absent or inhibited, and the mulch will be usable on the same or similar plant species.

CONCLUSIONS

Composting of grape prunings is a viable alternative to the annual burning used by the majority of producers. Following the proper techniques, three methods are available to producers for composting, giving them flexibility on the process according to their size, equipment, and labor availability. Adding grape prunings and other carbonous materials to increase the C:N ratio of dairy manures at the moment of composting has many benefits including the reduction of ammonia emissions, the retention of that nitrogen in the compost, and the dilution of application limiting components such as P, K, and salts, which can allow higher application rates of compost. This project demonstrated that composting of dairy and potentially other livestock manures mixed with woody wastes from the grape industry or similar agricultural products is not only feasible but beneficial for both industries. Further research is necessary to determine how different carbon and animal manures sources, especially harder woods, will affect the composting process and the final product.

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