Conservation Innovation Grants

Final Report

June 2013

Title: Demonstration and Evaluation of Alternative Manure Management Techniques in Southern Idaho

Grantee Name: University of Idaho

Name of the principle investigator: Dr. Lide Chen

Timeframe covered by the report: September 2011- March 2013

Grant number: 69-3A75-11-188

Date of submission: 6/30/2013

Deliverables identified on the grant agreement:

A. Two field days showing: a) dairy manure vacuum collection and dairy manure on-farm composting and b) liquid dairy manure land injection via drag hoses.

B. Analysis of costs associated with the manure injection method.

C. Assessment of odor and NH_3 emissions from both the manure injection and surface broadcast fields for comparisons.

D. Development of an educational video demonstrating dairy manure vacuum collection, manure injection with drag hoses, and properly on-farm manure composting.

Table of Contents

Executive Summary

This proposal addressed 2011 CIG's primary priority areas of **Nutrient Management** and **Air Quality and Atmospheric Resource.** The goals of this project was to demonstrate, evaluate, and encourage the widespread adoption of vacuum dairy manure collection, proper composting, and land application via subsurface injection in Southern Idaho for mitigating odors and reducing manure nitrogen loses via ammonia volatilization. This was done via: 1). two field days held in Southern Idaho demonstrating vacuum/scraper dairy manure collection, composting, and manure land injection; 2). evaluation of odor and ammonia emissions from manure injection and surface broadcast fields; 3). analysis of costs associated with manure land application methods; and 4) development of educational materials including hand-outs for two field days, three sets of presentation materials, an educational video based on literature data, field evaluation results from this project, and analysis of costs associated with the demonstrated manure application methods.

The original time period projected for this project was one year. A No Cost Time Extension (NCTE) of six months was requested because the start time of this project did not match the manure injection application time. The approved NCTE let the manure application field day be held in later fall of 2012 which fit better into farmers' busy schedules and improved the field day attendance. With the NCTE, all the objectives of this project were successfully completed.

Customers that have benefited from this project and/or will benefit include dairy farmers, local communities, custom manure injection applicators, NRCS local/state staff, and extension personnel. The dairy farmers have learned and/or will learn about how the demonstrated techniques work, how they can save money by reducing the need for lagoon cleaning and reducing the quantity of N-fertilizers purchased, and how these techniques benefit the environment, leading to a good neighbor relationship. Wide adoption of these techniques improves air quality which benefits local communities. There is a potential market for custom manure injection application. The results of this project also benefit extension personnel for their extension activities.

The project funds were spent as anticipated. Field days, panel discussion, literature data combined with our field data (attendees' odor perceptions, olfactometry analysis, and passive

ammonia sampler data), cost analysis, and presentations were employed to demonstrate the alternative technologies in this project.

Quantifiable physical results from this project include two field days, two sets of hand-out materials pertaining to dairy manure collection, composting, and land application, three presentations at two national conferences, cost analysis results, odor and ammonia test results, and a video.

Our major recommendations include: 1) the manure injection technique can reduce odor and ammonia emissions compared with surface application, therefore, applying liquid dairy manure by subsurface injection could be recommended as one of the best management practices to control ammonia and odors, 2) carbon-rich materials such as straw should be introduced into on-farm dairy manure compost piles to increase the piles' C:N ratios leading to a good quality of mature compost and less odors during composting, and 3) field days are a good platform for both research and demonstrations of new techniques. Producer' collaboration and full participation are very important to make a CIG project success.

Introduction

This CIG project sought to demonstrate that dairy manure management techniques such as vacuum/scraper collection, direct injection, and proper on-farm composting methods, which have shown in other regions to effectively manage odors and manure nutrients, can be successfully adapted to Southern Idaho conditions. This project was a collaborative effort, drawing on the expertise of a team of extension specialists and an educator at University of Idaho. The project's success also relied heavily on the active participation of the farmers.

Here are brief descriptions of key personnel and their qualifications:

- Lide Chen, Extension Waste Management Engineer, has several years experience working on odor emission monitoring and manure treatment. He took part in two multi-state projects related to air emissions. He also participated in a couple of manure treatment projects with a goal of mitigating odor emissions. He has served as PI on a number of federal and industry funded projects.

- Howard Neibling, Extension Water Management Engineer, has 34 years experience in research and teaching/extension in soil and water conservation/management and irrigation water management. He has published a number of extension materials, developed two ASABE (American Society of Agricultural and Biological Engineers) Blue Ribbon videos, and averages 40-50 extension presentations per year to agricultural clientele and agency personnel in Idaho and surrounding states. He has considerable experience in construction and operation of innovative field research equipment.
- Wilson Gray, Extension Professor and Extension Economist, has many years experience in business management and analysis as related to livestock operations in Idaho and the western U.S. Currently, he works in cooperation with the Livestock Marketing Information Center, the Western Livestock Research & Extension Coalition, and the Western Extension Marketing Committee. Areas served include marketing alternatives and outlook, managerial use of technology including computers and information access for decision making, and FINPACK financial analysis.
- Mireille Chahine, Extension Dairy Specialist, has several years experience in dairy management and nutrient management. She has worked very closely with dairy owners and dairy employees to improve their management. She has considerable experience in conducting extension activities.
- Mario De Haro Marti, Extension Educator, has several years of experience working with dairy waste management, air emissions, odor control, and pollution prevention. He also is a reference in compost management in Southern Idaho. He has considerable experience in close contact with dairy producers.

This team worked together with participating farmers throughout the whole project and the objectives proposed in this project were fully fulfilled.

The project goals and objectives identified in this grant were as follows:

- The overall goal of this project was to demonstrate, evaluate, and encourage the widespread adoption of the vacuum/scraper dairy manure collection, proper composting, and land application via subsurface injection in Southern Idaho for mitigating odors and reducing manure nitrogen losses via ammonia volatilization.

- Specific objectives of the project were to:
  - Hold two field days in Southern Idaho demonstrating the vacuum/scraper manure collection, composting, and manure land injection;
  - Evaluate odor and ammonia emissions from manure injection and surface broadcast fields;
  - Analyze costs associated with the manure land application methods.
  - Develop an educational video to show how to use the demonstrated manure management techniques.

- The scope of the project tasks included: 1) develop field day handout materials, 2) identify and inform the field day target participants, 3) plan, organize and hold the field days, 4) evaluate odor and ammonia emissions from manure injection and surface broadcast fields, 5) analyze costs associated with the manure land application methods; 6) develop the educational video, and 6) showcase the project. More broadly, the project provided stakeholders opportunities for learning and exchanging opinions on new manure management techniques and sought to determine if these techniques, proven effective in other regions, offered potential solutions for addressing the challenges facing Idaho's dairy industry.

- This project was facilitated through relationships with individual dairies, a private environmental consultant, manure application equipment businesses, and academic partners. The project PIs worked closely with two dairy operations on planning and organizing field days including a panel discussion. An environmental consulting expert joined the project to add expertise in relating project results to potential solutions of several environmental issues common to Southern Idaho dairies. A manure application equipment dealer provided economic information for cost analysis. Custom manure application workers did the manure application demonstrations. A graduate student and USDA ARS scientists were involved in ammonia sampling and analyses. In addition, field day attendees and the Iowa State University Olfactometry Laboratory manager evaluated odors emitted from both the injection and surface broadcast fields.

- This project was funded through a 50% cost share with this CIG program. All PIs, cooperator farmers, and the manure application workers donated their time as cost share.

Background

Idaho has recently experienced rapid growth of the dairy industry. Dairy production currently stands as the single largest agricultural pursuit in Idaho. Currently, Idaho ranks as the third largest milk production state in the US. When this project was proposed, Idaho had roughly 530 dairy operations with 570,000 milk cows, with 54% of dairies and 73% of milk cows located in the Magic Valley in Southern Idaho. A number of dairies in the Magic Valley used flushing systems resulting in huge amount of lagoon water which is applied to crop lands near the lagoons via irrigation systems during the crop growing seasons. The volatilization of ammonia from the irrigated lands and lagoons is not only a loss of valuable nitrogen, but also degrades air quality. Concentrated dairy production in a limited area such as the Magic Valley has caused air and water quality concerns. Controlling odors and capturing nitrogen in dairy manure were (and are) big challenges facing the Idaho dairy industry.

While many dairy operations in Southern Idaho know the benefits of composting and compost their manure, only few of them follow a proper procedure in the composting process. Most of composting operators in Southern Idaho just simply put their N-rich manure together without introducing carbon-rich materials. With a low C:N ratio, much of the N within the compost piles is lost as ammonia or nitrous oxide gases resulted in undesired odors and loss of N-fertilizer value.

An alternative manure management method widely used in other areas was to vacuum or mechanically collect slurry dairy manure, followed by direct land application (manure injection via drag hoses or manure tankers) or composting, which provides more flexibility to handle manure year round. Although the manure direct injection and composting techniques have been proven in other regions such as Midwest to effectively manage odors and reduce nitrogen losses, they are relatively new to Idaho. This project was initiated to address the above mentioned challenges and 2011 CIG's primary priority areas of Nutrient Management and Air Quality and

Atmospheric Resource. It was our hope that successful completion of this project would promote adoption of the manure subsurface injection and proper on-farm manure composting.

The sectors which benefit from this project include both dairy producers and communities in the Magic Valley. Using the demonstrated techniques, dairy farms will save money on purchasing N-fertilizer and cleaning lagoons, and maintain good neighbor relationships, thus leading to a sustainable dairy industry. In addition, widely adaption of the demonstrated techniques will benefit the environment due to reduced emissions of odor and ammonia.

Natural resource issues addressed in this project include water conservation due to eliminating the use of flushing water, improved air quality due to reduced emissions of odor and ammonia, improved water quality due to reduced subsequent deposition of ammonia volatilized from lagoons and manure applied fields, and improved soils due to application of manure compost. There are no negative effects on the environment or community. For adapting these demonstrated techniques, there are initial costs for purchasing equipment. However, in the long term, the farms will benefit from the N-fertilizer value captured in soils and savings on cleaning their lagoons.

Review of methods

Innovative aspects of this project include the following:

- The subsurface injection method is an innovative approach to manure land application in Idaho. Currently, lagoon water is applied to crop lands via irrigation systems during the crop growing seasons. The irrigation systems can spread lagoon water over a large area quickly and efficiently. However, these systems tend to generate more odors and higher ammonia-N losses by elevating liquid manure high into the air during irrigation. Direct injection method takes place in early spring (before planting) and later in the fall (after harvesting). The manure direct injection incorporates manure directly beneath the soil surface and thus minimizes odor and ammonia emissions. The irrigation systems include traveling gun systems and center pivot systems while the injection method needs tractors, injectors, and drag hoses or manure tanks.

- The manure vacuum collection involves vacuum tanker truck or tractor towed tanker with vacuum units. The other most often used apparatus for mechanically collecting manure are tractor or skid steer ally scraper. Both the vacuum and scraper collection of manure are new to some dairy operations in Idaho and offer many benefits. They: 1) eliminate the need for flushing and requirements for large volumes of flush water leading to a considerable reduction in the volume of liquid manure produced, 2) are adaptable to barns with different size alley configurations suitable for almost every dairy operation, 3) can improve air quality by eliminating release of volatile compounds from flush water and large lagoons, 4) can handle high solid content manure, 5) provide a higher total solid content manure that can be transported more economically to application lands or other value added processing, and 6) vacuum collection users report less odor, flies, lower water use and cleaner cows.
- Introducing carbon-rich materials into dairy manure compost piles is a new concept to on-farm dairy manure composting operators in Southern Idaho. While many dairy producers in Idaho recognize the benefits of composting and compost their manure, only few of them follow a proper procedure in the composting process. Most of composting operators in Southern Idaho just simply put their N-rich manure together without introducing carbon-rich materials such as straw. With a low C:N ratio, much of the N within the compost piles is lost as ammonia or nitrous oxide gases resulting in undesired odors and loss of N-fertilizer value.

Comparison to existing practices:

- The manure subsurface injection method needs investment in equipment such as injectors, manure mixers, manure tanks or drag hoses compared with the irrigation method currently used. However, the new investment, in long run, will save money on cleaning lagoons and purchasing N-fertilizers. It was reported that irrigating with lagoon water seals soil surface, leading to lower water use efficiency and lower yields. In addition, the manure injection method has the above-mentioned environmental benefits.
- Comparing with manure flushing systems, the mechanical manure collection systems need extra labor and equipment input. The returns include both the environmental and economical benefits such as less odors, less water uses, lower manure transportation costs.

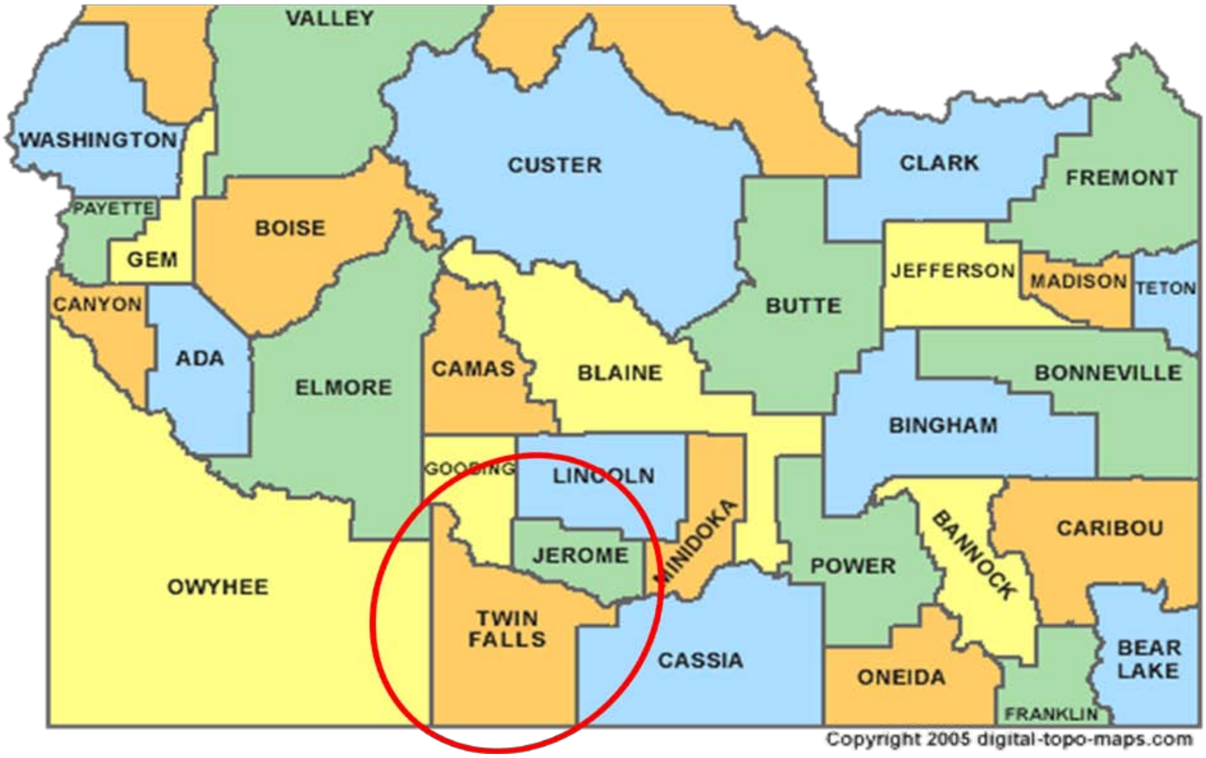
- The demonstrated proper composting needs a little extra time, labor, and money input for introducing straw into compost piles and turning the piles. There is no need of new equipment compared with the current composting practices. The extra benefits of introducing carbon-rich materials into compost piles are higher quality of mature compost and less odors during the composting process.

Schedule of events:

- October 2011 - April 2012: Initiated this project. A bunch of meetings were held to schedule and coordinate the two field days. Visited two cooperator dairy farms and manure field application operators to discuss this project. Conducted literature review regarding the demonstrated techniques. Manure application equipment dealers were contacted to request information regarding to economic analysis. Purchased sampling equipment for this project.
- May 2012 – August 2012: Prepared the first field day handout materials. Sent field day flyers to targeted participants. Advertized the field day event. Held the first field day focusing on manure collection and properly composting. During the field day, panel discussion pertaining to manure collection and composting was conducted among PIs, cooperator farmers, and field day attendees. Took raw videos during the first field day.
- September 2012 – November 2012: prepared the second field day handout materials. Sent field day flyers to targeted participants. Advertized the field day event. Held the second filed day focusing on manure injection application. During the field day, panel discussion pertaining to manure land application was conducted among PIs, cooperator farmers, and field day attendees. Also, field day attendees were invited to evaluate odors based on their odor perceptions. Odor and ammonia samples from the manure applied fields and background were collected and analyzed. Raw videos were taken during the second field day.
- December 2012 – March 2013: Costs associated with the manure land application methods were analyzed. Odor and ammonia data were evaluated. Prepared two manuscripts that were presented at a national Waste to Worth conference to showcase this project. Another presentation was prepared for the 2013 ASABE Annual International Conference will be held in Kansas City, MO in July. Prepared final report.

Map of project:

Two field days were held at two dairy farms. One was located in Jerome county and the other was located in Twin Falls county. The following map shows the two counties.



Summary of successes and failures:

This demonstration project mainly focused on holding two field days, evaluating odor and ammonia emissions, and cost analysis. Thanks to the team members' strong backgrounds and experiences in these areas we were able to well complete this project as proposed in the proposal. However, we had to request a NCTE for another 6 months to better accommodate the manure land application field day to local farmers schedules (thus improving the field day attendance) due to the start time of this project did not match the manure injection application time.

Quality Assurance

- Project site description: The odor and ammonia samples were collected from two sites where liquid manure was applied via both subsurface injection and surface broadcast methods. At each of the two sites, a square plot of approximately 3,600 m^2 in the western portion of the site was used for surface broadcast and the rest of the land was used for subsurface injection. The western portion of the site was chosen because the prevailing winds were from the north during the test period. The previous crop at the two sites was corn and both sites had been disked after harvest.

Manure applied to the two sites was from one of the cooperator dairies located in Buhl (belongs to Twin Falls county), Idaho. The dairy had approximately 3,500 milking cows managed in a free-stall and open-lot mix set-up, with about 60% of the cows housed in free stalls. Waste was flushed from feeding alleys and the milking parlor. The wastewater passed through solids removal equipment and basins and then into three lagoons in series. Manure used for the field tests was from the last lagoon, which had about 9 million gallons of manure at the beginning of the tests and its sludge had been not cleaned for 5 years.

The manure lagoon was agitated before and during application with a floating mixing pump. Manure was pumped from the lagoon directly to the application sites via drag hoses. The two manure application methods were demonstrated with the same equipment. Subsurface injection placed manure behind the equipment shanks in a band approximately 20 cm (8 inches) deep. Surface broadcast was realized by lifting the shanks above ground so manure was applied on the soil surface. Manure was applied from east to west and back again until the site was finished. The equipment shanks were lifted only when the equipment was in the designated 3,600 m^2 square plot for surface application.

- Sampling and sample analysis: After manure application in the sites, three towers, each 1.5 m high, were placed in a north-to-south orientation with approximately 15 m spacing. The middle tower was placed at the center of the manure surface applied plot. Three towers were placed in the manure subsurface injected field parallel to the ones in the manure surface broadcast plot and approximately 200 m apart to avoid or minimize cross-contamination between the two manure application methods. Another three towers were placed 50 m upwind (north) of the site. These towers were used for holding passive ammonia samplers.

Ogawa passive NH_3 samplers (Ogawa USA, Inc., Pompano Beach, Florida) were used to determine the time-averaged concentrations of NH_3 at each sampling location. The dissembled components of the passive samplers were thoroughly cleaned before use by rinsing with deionized water, soaking in a 1 M HCI bath, rinsing again with deionized water, and then air-drying in a clean hood. The sampler filters were prepared by saturating a clean filter with 100 µL of 2% citric acid and air-drying before assembling the samplers. Assembled samplers were then placed into airtight containers and transported to the fields for deployment. The prepared passive NH_3 samplers were installed on each tower at a height of 0.5 and 1 m to determine the NH_3 concentration at each location. The passive NH_3 samplers were changed approximately every 24 hours over a two-day period after manure application.

Immediately after collection in the fields, samplers were placed back into the airtight containers and then transported back to the University of Idaho Waste Management laboratory. The filters were removed from the samplers with clean forceps and transferred into 15-ml centrifuge tubes. The filters in each centrifuge tube were extracted with 5 ml 1 M KCI for 30 minutes on a reciprocating shaker. The extractant was filtered with 0.45 µm filter discs into 8 ml glass culture tubes. The filtered extractant was transported to the USDA Northwest Irrigation and Soils Research Laboratory (NWISRL) located in Kimberly, Idaho where it was analyzed for NH_4-N using a flow-injection analysis system (Quickchem 8500, Lachat Instruments, Milwaukee, WI) according to the system's operating procedure. Concentrations from passive samplers are time-average concentrations for the amount of time the sampler was exposed to the air and were calculated with the following equation:

$$\mathrm{NH_3\text{-}N}\left(\frac{mg}{m^3}\right) = 1000000\left(\frac{cm^3}{m^3}\right)\times \frac{NH_4-N\left(\frac{mg}{l}\right)\times extractant\ \ volume\ (l)}{deployed\ \ time\ (\mathrm{min})\times 31.1\frac{cm^3}{min}}$$

Where NH_4-N (mg/l) is the concentration of extracted NH_4-N and 31.1 (cm^3/min) is a constant used to calculate diffusion to the filter.

Air samples were collected from the first test site right after manure application using Tedlar® bags. One air sample was collected at 1 m above ground from each of the three towers located in the surface broadcast plot, subsurface injection, and background, respectively. A total of nine air samples were collected and then sent via UPS over-night service to Iowa State University Olfactometry Laboratory for odor analysis. A dynamic forced-choice olfactometer (AC'SCENT International Olfactometer; St. Croix Sensory, Inc. Stillwater, MN) was used to evaluate odor concentration based on ASTM E679-04 (ASTM, 2004) within 24 hours after collecting the air samples.

Nine field day attendees were also invited to evaluate odor emitted from the surface broadcast plot, subsurface injection field, and background, respectively using direct perception odor scoring cards. Each attendee was requested to circle one number from 0 (lowest odor perception) to 10 (highest odor perception) that matched his/her odor perception.

- Cost analysis: Cost analysis was carried out for four different manure land application systems. Cost calculations are based on 500 hours annual use for the tractor and 200 hours annual use for the injection system. Tractor operator labor is figured at $11.70/hour, diesel is figured at $4.00/gallon. Equipment costs were determined using the MACHCOST program from the University of Idaho's department of Agricultural Economics and Rural Sociology. The program is available on the AERS web page at http://www.cals.uidaho.edu/aers/r_software.htm. Equipment data was provided by John Smith at Smith Equipment Co. Rupert, ID 83350. Some machinery data was taken from "Costs of Owning and Operating Farm Machinery in the Pacific Northwest" PNW 346 available on line at: http://www.cals.uidaho.edu/edcomm/detail.asp?IDnum=559.

Findings

1. Odor and ammonia samples from the demonstrated fields showed there were statistical significances between subsurface injection and surface broadcast methods. The odor (33% reduction compared injection with broadcast) and ammonia (74% and 55% reduction with injection vs. broadcast from two fields, respectively) results together with literature data support the recommendation of wide adaption of manure injection method to reduce odor emission and capture more manure N in soils.
2. The estimated costs associated with subsurface injection were higher than surface broadcast mainly due to the need of larger tractor and lower operating speed. However, the higher costs could be compensated by the higher nitrogen fertilizer value captured in the soil by the subsurface injection method.
3. On-farm field days are a great tool to demonstrate and encourage the application of innovative techniques. They also can serve as a research platform, allowing collecting quality data. Farmers' collaboration and full participation during all phases of the project is very important.
4. Identifying progressive and pioneer producers that are already applying the innovative techniques or are willing to take the risk is important to develop this kind of on-farm experience. In general these individuals are also willing to share their knowledge, experience, and results with others to promote the adoption of such new techniques.
5. Having a producer hosting and presenting during the field day at their own facilities as opposed to a dedicated research facility stimulates others enthusiasm and helps creating a friendly environment for conversations and exchanges of ideas

Recommendations

These are summarized in the executive summary and are not reproduced here.

Appendices

A. Analysis of costs associated with manure land application methods
B. Field sample results
C. First field day hand-out materials
D. Second field day hand-out materials

Dairy Manure Land Application

Tank System with Broadcasting

While several models and capacities of tank broadcast systems are available this fact sheet summarizes probable costs of operation for a 7,400 gallon tank with a 2,000 gpm discharge rate and a 15 foot wide broadcast unit.

A 180 PTO HP tractor is needed to pull this unit at an average ground speed of 8 mph. Up to 10 acres per hour can be covered with the unit. The tank is discharged in approximately 4 minutes. Time and equipment to refill the tank is not included in these calculations.

University of Idaho
College of Agricultural and Life Sciences

	Wheel Tractor 185 HP 2W		Tank w/broadcast system		Tractor & Implement	
	$/hour	$/acre	$/hour	$/acre	$/hour	$/acre
Ownership Costs:						
Depreciation	19.89	1.95	36.16	3.55	56.05	5.50
Interest	13.76	1.35	18.84	1.85	32.60	3.20
Taxes, Housing, Insurance, License	2.36	0.23	1.62	0.16	3.98	0.39
Total Ownership Costs	**$36.01**	**$3.54**	**$56.62**	**$5.56**	**$92.63**	**$9.10**
Operating Costs:						
Repairs & Maintenance	5.75	0.57	77.56	7.62	83.32	8.19
Fuel	32.40	3.18	*	*	32.40	3.18
Lubricants	4.86	0.48	*	*	4.86	0.48
Total Operating Costs	**$43.01**	**$4.22**	**$77.56**	**$7.62**	**$120.57**	**$11.84**
Labor	12.87	1.26	0.00	0.00	12.87	1.26
Labor + Operating Costs	55.88	5.48	77.56	7.62	133.44	13.10
Total Cost	**$91.89**	**$9.02**	**$134.18**	**$13.18**	**$226.07**	**$22.20**

* Fuel and Lubricant Costs are assigned to the Power Unit.

Cost calculations are based on 500 hours annual use for the tractor and 200 hours annual use for the injection system. Tractor operator labor is figured at $11.70/hour, diesel is figured at $4.00/gallon.

Equipment costs were determined using the MACHCOST program from the University of Idaho's department of Agricultural Economics and Rural Sociology. The program is available on the AERS web page at http://www.cals.uidaho.edu/aers/r_software.htm

Equipment data was provided by John Smith at Smith Equipment Co. Rupert, ID 83350.

They can be reached at: www.smithequipment.biz

Some machinery data was taken from "Costs of Owning and Operating Farm Machinery in the Pacific Northwest" PNW 346 available on line at:
http://www.cals.uidaho.edu/edcomm/detail.asp?IDnum=559

Dairy Manure Land Application

Tank Injection Using Disk Injection

While several models and capacities of tank injector systems are available this fact sheet summarizes probable costs of operation for a 7,400 gallon tank with a 2,000 gpm discharge rate and a 12 foot wide disk injection unit.

A 215 PTO HP tractor is needed to pull this unit at an average ground speed of 7 mph. Up to 7 acres per hour can be covered with the unit. The tank is discharged in approximately 4 minutes. Time and equipment to refill the tank is not included in these calculations.

University of Idaho
College of Agricultural and Life Sciences

	Wheel Tractor 2 WD 215 HP		Tank w/ disk injection		Tractor & Implement	
	$/hour	$/acre	$/hour	$/acre	$/hour	$/acre
Ownership Costs:						
Depreciation	25.60	3.59	41.58	5.83	67.18	9.42
Interest	15.45	2.17	21.67	3.04	37.12	5.21
Taxes, Housing, Insurance, License	**$2.65**	**$ 0.37**	**$ 1.86**	**$ 0.26**	**$ 4.51**	**$ 0.63**
Total Ownership Costs	43.70	6.13	65.11	9.14	108.81	15.27
Operating Costs:						
Repairs & Maintenance	5.50	0.77	42.49	5.96	47.98	6.73
Fuel	37.68	5.29	*	*	37.68	5.29
Lubricants	**$5.65**	**$ 0.79**	*	*	**$ 5.65**	**$ 0.79**
Total Operating Costs	48.83	6.85	42.49	5.96	91.32	12.81
Labor	12.87	1.81	0.00	0.00	12.87	1.81
Labor + Operating Costs	61.70	8.66	42.49	5.96	104.19	14.62
Total Cost	**$105.40**	**$14.79**	**$107.60**	**$15.10**	**$213.00**	**$29.89**

* Fuel and Lubricant Costs are assigned to the Power Unit.

Cost calculations are based on 500 hours annual use for the tractor and 200 hours annual use for the injection system. Tractor operator labor is figured at $11.70/hour, diesel is figured at $4.00/gallon.

Equipment costs were determined using the MACHCOST program from the University of Idaho's department of Agricultural Economics and Rural Sociology. The program is available on the AERS web page at http://www.cals.uidaho.edu/aers/r_software.htm

Equipment data was provided by John Smith at Smith Equipment Co. Rupert, ID 83350.

They can be reached at: www.smithequipment.biz

Some machinery data was taken from "Costs of Owning and Operating Farm Machinery in the Pacific Northwest" PNW 346 available on line at:
http://www.cals.uidaho.edu/edcomm/detail.asp?IDnum=559

Dairy Manure Land Application

Tank Injection Using Knife Injection

While several models and capacities of tank injector systems are available this fact sheet summarizes probable costs of operation for a 7,400 gallon tank with a 2,000 gpm discharge rate and a 12 foot wide knife injection unit.

A 225 PTO HP tractor is needed to pull this unit at an average ground speed of 7 mph. Up to 7 acres per hour can be covered with the unit. The tank is discharged in approximately 4 minutes. Time and equipment to refill the tank is not included in these calculations.

University of Idaho
College of Agricultural and Life Sciences

	Wheel Tractor 2 WD 235 HP		Tank Injector w/knife injection		Tractor & Tank Unit	
	$/hour	$/acre	$/hour	$/acre	$/hour	$/acre
Ownership Costs:						
Depreciation	22.57	3.17	33.50	4.70	56.07	7.87
Interest	15.62	2.19	21.79	3.06	37.41	5.25
Taxes, Housing, Insurance, License	2.68	0.38	1.87	0.26	4.55	0.64
Total Ownership Costs	**$40.87**	**$ 5.73**	**$ 57.16**	**$ 8.02**	**$ 98.03**	**$ 13.75**
Operating Costs:						
Repairs & Maintenance	6.53	0.92	54.31	7.62	60.85	8.54
Fuel	41.16	5.78	*	*	41.16	5.78
Lubricants	6.17	0.87	*	*	6.17	0.87
Total Operating Costs	**$53.86**	**$ 7.56**	**$ 54.31**	**$ 7.62**	**$ 108.17**	**$ 15.18**
Labor	12.87	1.81	0.00	0.00	12.87	1.81
Labor + Operating Costs	66.73	9.37	54.31	7.62	121.04	16.99
Total Cost	**$107.60**	**$ 15.10**	**$ 111.47**	**$ 15.64**	**$ 219.07**	**$ 30.74**

* Fuel and Lubricant Costs are assigned to the Power Unit.

Cost calculations are based on 500 hours annual use for the tractor and 200 hours annual use for the injection system. Tractor operator labor is figured at $11.70/hour, diesel is figured at $4.00/gallon.

Equipment costs were determined using the MACHCOST program from the University of Idaho's department of Agricultural Economics and Rural Sociology. The program is available on the AERS web page at http://www.cals.uidaho.edu/aers/r_software.htm

Equipment data was provided by John Smith at Smith Equipment Co. Rupert, ID 83350.

They can be reached at: www.smithequipment.biz

Some machinery data was taken from "Costs of Owning and Operating Farm Machinery in the Pacific Northwest" PNW 346 available on line at:
http://www.cals.uidaho.edu/edcomm/detail.asp?IDnum=559

Dairy Manure Land Application

Drag Hose System with Knife Injection

While several models and capacities of drag hose systems are available this fact sheet summarizes probable costs of operation for a system utilizing 5,280 FT of 8 inch hose and 1,320 FT of 5 inch hose . The pump unit capacity is 1,500 gpm to a 16 foot knife injection unit.

A 250 PTO HP tractor is needed for the injection unit at an average ground speed of 3.5 mph. The lagoon pump is a 270 HP unit. Beyond 2 miles a booster pump would be necessary. Up to 4.75 acres per hour can be covered with the unit. Operation is continuous as no tank refill is needed.

University of Idaho
College of Agricultural and Life Sciences

	Wheel Tractor 250HP 4WD		Drag Hose w/knife injection		Lagoon Pump for drag hose system		Lagoon Pump, Tractor & Injection Unit	
	$/hour	$/acre	$/hour	$/acre	$/hour	$/acre	$/hour	$/acre
Ownership Costs:								
Depreciation	28.88	5.67	50.98	10.01	28.71	3.90	108.57	20.71
Interest	19.99	3.93	26.57	5.22	21.33	2.89	67.89	12.69
Taxes, Housing, Insurance, License	3.43	0.67	2.28	0.45	2.74	0.37	8.45	1.57
Total Ownership Costs	**$52.30**	**$10.27**	**$79.83**	**$15.68**	**$52.78**	**$7.16**	**$184.91**	**$34.97**
Operating Costs:								
Repairs & Maintenance	3.59	0.70	55.07	10.82	0.76	0.10	56.44	11.81
Fuel	43.80	8.60	*	*	47.32	6.42	91.12	15.64
Lubricants	6.57	1.29	*	*	7.10	0.96	13.67	2.34
Total Operating Costs	**$53.96**	**$10.60**	**$55.07**	**$10.82**	**$55.18**	**$7.49**	**$161.23**	**$29.81**
Labor	12.87	2.53	0.00	0.00	0.00	0.00	12.87	2.71
Labor + Operating Costs	66.83	13.13	55.07	10.82	55.18	7.49	174.10	32.52
Total Cost	**$119.13**	**$23.40**	**$134.90**	**$26.50**	**$107.96**	**$14.65**	**$359.01**	**$67.48**

* Fuel and Lubricant Costs are assigned to the Power Unit.

Cost calculations are based on 500 hours annual use for the tractor and 200 hours annual use for the injection system. Tractor operator labor is figured at $11.70/hour, diesel is figured at $4.00/gallon.

Equipment costs were determined using the MACHCOST program from the University of Idaho's department of Agricultural Economics and Rural Sociology. The program is available on the AERS web page at http://www.cals.uidaho.edu/aers/r_software.htm

Equipment data was provided by John Smith at Smith Equipment Co. Rupert, ID 83350.

They can be reached at: www.smithequipment.biz

Some machinery data was taken from "Costs of Owning and Operating Farm Machinery in the Pacific Northwest" PNW 346 available on line at: http://www.cals.uidaho.edu/edcomm/detail.asp?IDnum=559

REPRESENTATION: BG = Background; SA = Surface Application; IA = Injection application
UP = 1 m above ground; LW = 0.5 m above ground

Application Method	Height	Field	Day	NH3-N in the air (mg/m3)
BG	UP	1	1	0.18
BG	UP	1	1	0.22
BG	UP	1	1	0.38
BG	LW	1	1	0.16
BG	LW	1	1	0.13
BG	LW	1	1	0.20
SA	UP	1	1	0.91
SA	UP	1	1	0.97
SA	UP	1	1	0.77
SA	LW	1	1	1.98
SA	LW	1	1	1.45
SA	LW	1	1	1.37
IA	UP	1	1	0.18
IA	UP	1	1	0.21
IA	UP	1	1	0.21
IA	LW	1	1	0.30
IA	LW	1	1	0.17
IA	LW	1	1	0.28
BG	UP	1	2	0.14
BG	UP	1	2	0.18
BG	UP	1	2	0.14
BG	LW	1	2	0.14
BG	LW	1	2	0.15
BG	LW	1	2	0.16
SA	UP	1	2	0.45
SA	UP	1	2	0.62
SA	UP	1	2	0.72
SA	LW	1	2	1.72
SA	LW	1	2	0.90
SA	LW	1	2	0.79
IA	UP	1	2	0.28
IA	UP	1	2	0.38
IA	UP	1	2	0.34
IA	LW	1	2	0.25
IA	LW	1	2	0.33
IA	LW	1	2	0.31
BG	UP	2	1	0.56
BG	UP	2	1	0.31
BG	UP	2	1	0.35
BG	LW	2	1	0.30
BG	LW	2	1	0.23
BG	LW	2	1	0.36
SA	UP	2	1	0.59

SA	UP	2	1	0.69
SA	UP	2	1	0.46
SA	LW	2	1	1.53
SA	LW	2	1	0.60
SA	LW	2	1	0.78
IA	UP	2	1	0.32
IA	UP	2	1	0.30
IA	UP	2	1	0.35
IA	LW	2	1	0.22
IA	LW	2	1	0.27
IA	LW	2	1	0.22
BG	UP	2	2	0.15
BG	UP	2	2	0.16
BG	UP	2	2	0.14
BG	LW	2	2	0.13
BG	LW	2	2	0.17
BG	LW	2	2	0.24
SA	UP	2	2	0.35
SA	UP	2	2	0.39
SA	UP	2	2	0.33
SA	LW	2	2	0.60
SA	LW	2	2	0.52
SA	LW	2	2	0.42
IA	UP	2	2	0.23
IA	UP	2	2	0.41
IA	UP	2	2	0.24
IA	LW	2	2	0.24
IA	LW	2	2	0.20
IA	LW	2	2	0.22

Odor Results from Iowa State University of olfactometry Lab

Locations	Detection Threshold (OU/m^3)
Background	14
Background	51
Background	67
Injection field	62
Injection field	58
Injection field	62
Surface broadcast field	78
Surface broadcast field	87
Surface broadcast field	110

Attendee #	Location	Odor perception (from 0 (weakest) to 10 (strogest odor))
1	Injection	1
2	Injection	2
3	Injection	4
4	Injection	1
5	Injection	2
6	Injection	2
7	Injection	2
8	Injection	1
9	Injection	1
1	Broadcast	8
2	Broadcast	4
3	Broadcast	9
4	Broadcast	9
5	Broadcast	4
6	Broadcast	8
7	Broadcast	5
8	Broadcast	5
9	Broadcast	2
1	background	0
2	background	2
3	background	1
4	background	0
5	background	2
6	background	1
7	background	2
8	background	0
9	background	1

Dairy manure collection and composting field day

University of Idaho Extension

College of Agricultural and Life Sciences

Tuesday, July 24, 2012. From 2:00 to 5:00 p.m.

Project supported by USDA CIG (award identifying number: 69-3A75-11-188)

Objective: To demonstrate on-farm dairy manure collection techniques and how to couple them with proper composting techniques.

Dairy Manure Collection

Flush, vacuum, and scrape manure collection systems are commonly used on dairy farms. Each system has its own advantages and disadvantages. Vacuum truck or trailer and scrapers demonstrated today are being used in Idaho and other states in the USA. Benefits of manure collection using vacuum trucks and scrapers include (1) Eliminate the need for flushing and requirements for large volumes of flush water leading to less amount of liquid manure; (2) Adaptable to barns with different size and alley configurations; suitable for almost every dairy operation; (3) Can improve air quality by eliminating release of volatile compounds from flush water and large lagoons; (4) Can handle high solids content manure; (5) Provide a higher total solids content manure that can be transported more economically to application lands or other value added processing, like composting; (6) Vacuum collection users report less odor, flies, lower water use and cleaner cows.

On-farm Composting

What is compost and what is composting?

Compost is the product of the <u>controlled</u> biological decomposition of organic materials. More specifically, compost is the stable, humus-like product resulting from the aerobic biological decomposition of organic matter such as manure, straw, leaves, and food wastes under <u>regulated and optimized conditions</u> which ensure a faster process and the generation of quality compost.

Why composting?

On-farm composting provides many benefits. In general, finished compost is highly regarded for its ability to improve soils and enhance plant growth. It can reduce erosion, disease and weed germination while enhancing the nutrient and water retention capacity, tilt and overall productivity of the soil. Composting reduces the manure volume and moisture content, which allows the materials to be significantly more affordable to transport than raw manure. Composting converts the nitrogen (N) present in raw manure into a more stable form, which is released slowly over a period of years and thereby not lost to the environment. To achieve this N retention, proper Carbon (C) to N ratios (C:N) should be achieved in the initial mix. If the C:N ratio is too low (common problem on Idaho dairies) N is lost to the atmosphere as ammonia gas. Composting alleviates problems associated with ground and surface water contamination, reduces odor complaints and flies, and also reduces the cost of transportation and application to crop fields.

Common on-farm composting methods

Windrows and piles:

- Mechanically turned windrows or piles(most common method in Idaho) Passively aerated windrows or piles
- Forced aerated windrows or piles

Open bin composting:

- Mechanically turned
- Mechanically turned with forced aeration

In-vessel composting

- Rotating drums with or without forced aeration
- Bins and other enclosures (mostly with forced aeration)

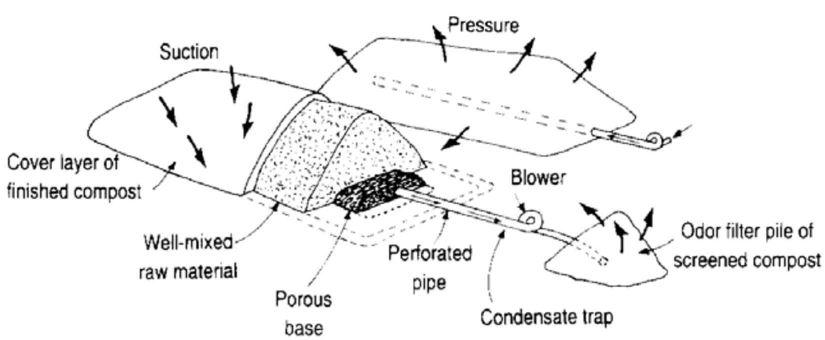
Common on-farm composting methods pictures (next page)

Windrows and piles:

Mechanically turned windrows or piles (most common method in Idaho)

Passively aerated windrows or piles

Forced aerated windrows or piles



Open bin composting:

Mechanically turned

In-vessel composting

Rotating drums with or without forced aeration

Bins and other enclosures (mostly with forced aeration)

Managing your on-farm composting

Composting is a microbial-driven process. Like other living creatures, microbes need the right environment to survive and thrive. For successful composting, microbes need nutritious “food”; suitable moisture, pH, temperature; and oxygen. The purpose of composting management is to create and maintain suitable conditions for microorganisms to thrive, thus leading to a quality compost product.

Recommended compost mix conditions for a quality compost product

Compost Mix	Reasonable Range	Preferred Range
Carbon to nitrogen ratio (C:N)	20:1 - 40:1	25:1-35:1
Moisture content	40%-70%	50%-60%
Oxygen concentration	>5%	>10%
Particle size	1/8-1 inch	varies
pH	5.5-9.0	6.5-8.0
Temperature	105-150	130-150

Common feedstocks and their characteristics.

Feedstock	Moisture content % (wet weight)	C:N (weight to weight)	Bulk density (pounds per cubic yard)
High in carbon			
Hay	8-10	15-30	
Corn stalks	12	60-70	32
Straw	5-20	40-150	50-400
Corn silage	65-68	40	
Fall leaves		30-80	100-300
Sawdust	20-60	200-700	350-450
Brush, wood chips		100-500	
ewspaper	3-8	400-800	200-250
Cardboard	8	500	250
Mixed paper		150-200	
High in nitrogen			
Dairy manure	80	5-25	1400
Poultry manure	20-40	5-15	1500
Hog manure	65-80	10-20	
Cull potatoes	70-80	18	1500
Vegetable wastes		10-20	
Coffee grounds		20	
Grass clippings		15-25	
Sewage sludge		9-25	

Source: Cooperband, L. 2002. The art and science of composting.

Typical ranges of test parameters in quality compost.

Test parameter	Range
pH	6.8-7.3
C:N ratio	10:1-15:1
EC (soluble salts) (1:5 v/v method)	0.35-0.64 dS/m (mmhos/cm)
Nitrogen	1.0-2.0% (by weight)
Phosphorus	0.6-0.9% (by weight)
Potassium	0.2-0.5% (by weight)
Moisture content	45-50% (by weight)
Organic matter	35-45% (by weight)
Particle size	passes 3/8" screen
Bulk density	900-1,000 lb/yd^3

Source: Warson. M. E. 2002.

Resources

Dairy Compost Production and Use in Idaho Series. Extension Current Information Series (CIS):
The Composting Process CIS 1179
On-Farm Composting Management CIS 1190
http://www.cals.uidaho.edu/edComm/catalog.asp (search for "composting").

On-Farm Composting Handbook. 1992. NRAES-54. Natural Resource, Agriculture, and Engineering Service. Cooperative Extension, PO Box 4557. Ithaca, New York. ISBN 0-935817-19-0.

National Engineering Handbook Part 651.Agricultural Waste Management Field Handbook (AWMFH).Chapter 10. 1996. It could be downloaded at: http://www.wsi.nrcs.usda.gov/products/W2Q/AWM/handbk.htm

US Composting Council http://compostingcouncil.org

Contact:

Lide Chen,lchen@uidaho.edu, 208-736-3615, University of Idaho Twin Falls Research & Extension Center.

Mario E. de Haro-Marti, mdeharo@uidaho.edu, 208-934-4417, University of Idaho Gooding Extension Office.

Howard Neibling, hneiblin@uidaho.edu, 208-423-6679, University of Idaho Kimberly Research & Extension Center.

Wilson Gray, wgray@uidaho.edu, 208-736-3622, University of Idaho Twin Falls Research & Extension Center.

Mireille Chahine, mchahine@uidaho.edu, 208-736-3609, University of Idaho Twin Falls Research & Extension Center.

Dairy Manure Land Application Field Day

University of Idaho Extension

College of Agricultural and Life Sciences

Tuesday, October 30, 2012. From 2:00 to 5:00 p.m.

Project supported by USDA CIG (award identifying number: 69-3A75-11-188)

Objective: To demonstrate manure land application with both the drag hose and manure tank injection techniques and manure mixing equipment.

Dairy Manure Land Application

Liquid dairy manure could be applied to lands via irrigation systems, land surface broadcast, and subsurface injection with drag hoses or manure tanks. Each application method has its own advantages and disadvantages. Liquid manure mixing, lagoon cleaning, and manure land subsurface injections demonstrated today are being used in Idaho and other states in the USA. Benefits of the demonstrated techniques include (1) Reducing ammonia (NH_3) and odor emissions from manure applied lands; (2) Reducing a loss of valuable nitrogen in manure, thus reducing fertilizer costs. More nitrogen fertilizer in the land could lead to yield increase. The nitrogen content of manure is an economic resource. Losing nitrogen to the atmosphere is like losing money; (3) Reducing concerns of air-drift pathogens associated with liquid manure applied via pivot irrigation systems; (4) Handling high solids content manure; (5) Removing lagoon solids, thus reducing odor emissions from lagoons and leading to less-frequent cleaning of lagoons, which reduces operational costs associated with manure handling systems.

Manure Mixing Equipment

A floating mixing pump and a remote controller (yellow)

A lagoon mixer driven by a tractor

A tractor with a rear-mounted tire pushes manure to the lagoon pump

Manure Land Application Equipment

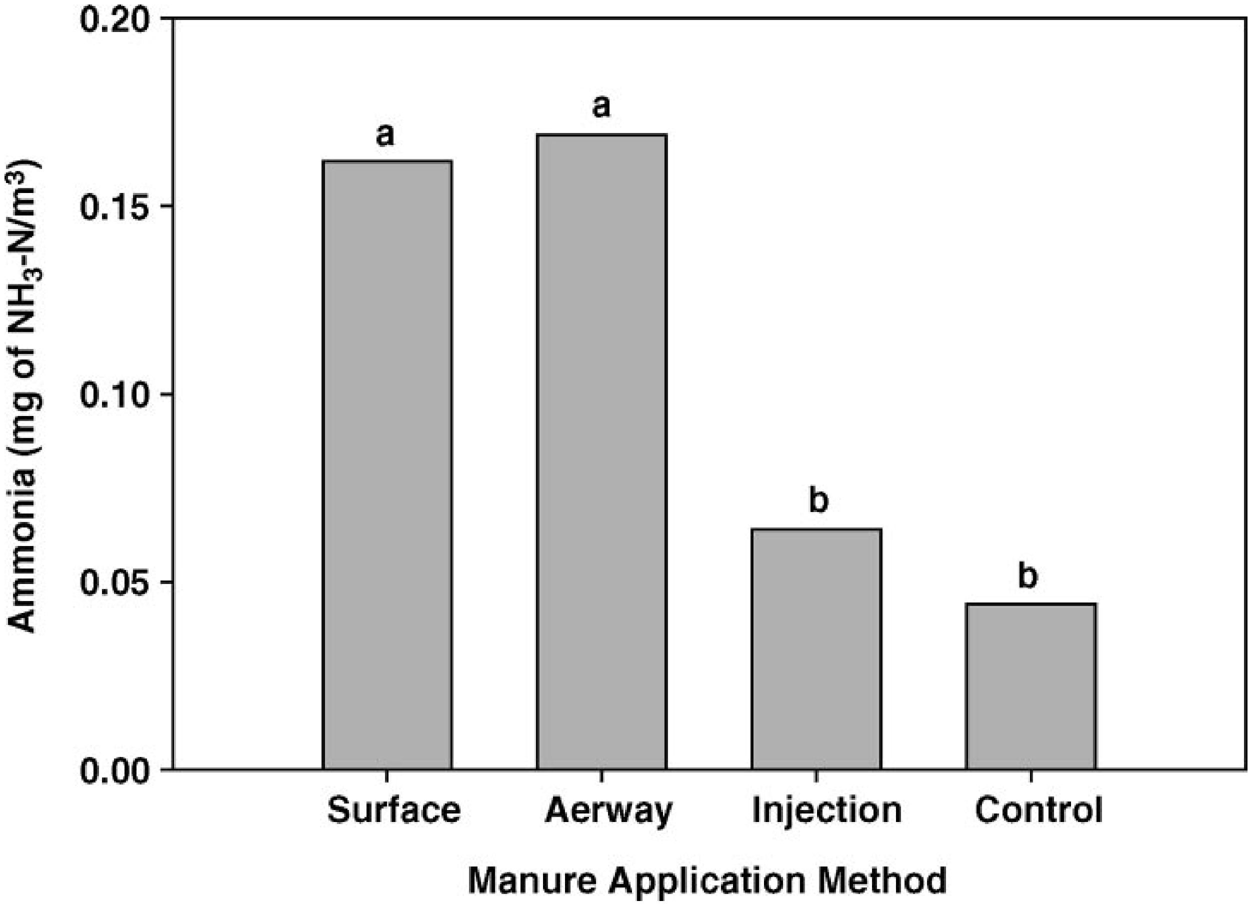
Surface broadcast with a manure tank

Surface broadcast with drag hoses

Subsurface manure injector with a manure tank

Subsurface injection with drag hoses

Ammonia Emission from Manure Applied Fields (Literature Data)



Ammonia concentrations for the manure application treatments averaged over two days at one meter height. [a,b]Treatments with the same letter are not statistically different at P=0.5. Leytem et al., 2009 reported there was a **67% decrease** in NH_3 concentration when liquid manure was applied by subsurface injection vs. surface or Aerway application.

Estimated Costs Associated with Manure Land Application (see Appendices)

Economics of liquid manure transport and land application (Literature Data)

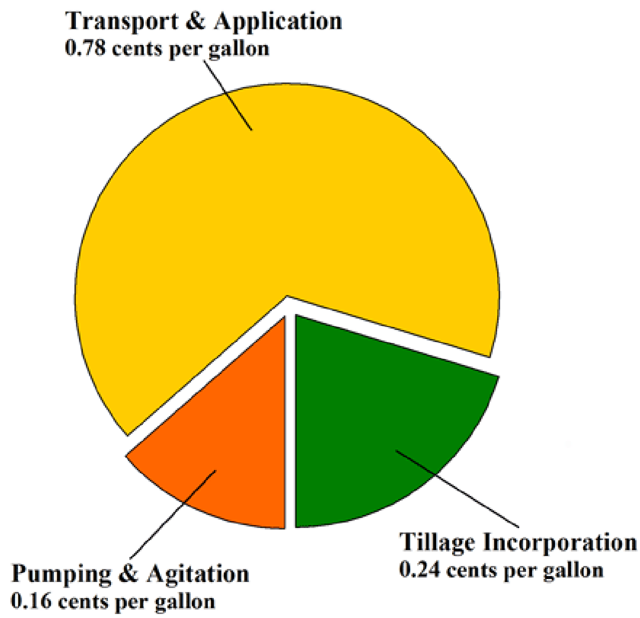


Figure 1: Manure pumping and agitation, transport, land application, and tillage incorporation costs for a 175-cow dairy. (https://www.msu.edu/user/mdr/vol16no4/liquid_manure.html)

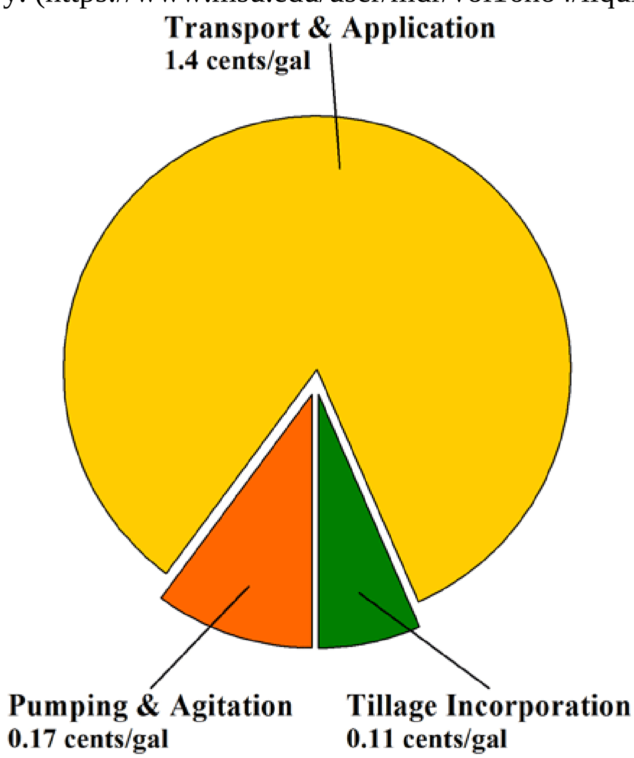


Figure 2: Manure pumping and agitation, transport, land application, and tillage incorporation costs for a 1400-cow dairy. (https://www.msu.edu/user/mdr/vol16no4/liquid_manure.html)

Contact:

Lide Chen, Waste Management Engineer, lchen@uidaho.edu, 208-736-3615, University of Idaho Twin Falls Research & Extension Center.

Mario E. de Haro-Marti, Extension Educator (Dairy/Livestock Environmental Education), mdeharo@uidaho.edu, 208-934-4417, University of Idaho Gooding Extension Office.

Wilson Gray, District Extension Economist, wgray@uidaho.edu, 208-736-3622, University of Idaho Twin Falls Research & Extension Center.

Howard Neibling, Water Management Engineer, hneiblin@uidaho.edu, 208-423-6679, University of Idaho Kimberly Research & Extension Center.

Mireille Chahine, Extension Dairy Specialist, mchahine@uidaho.edu, 208-736-3609, University of Idaho Twin Falls Research & Extension Center.