Granting Agency:
USDA Natural Resources Conservation Service (NRCS), Virginia

Project Title:
Innovative Cropping Systems using Diverse Cover Crops & Manure Injection, Part II: On-Farm Dairy Manure Injection Trials

Grant Recipient:
Virginia No-Till Alliance (VANTAGE)

Other Key Project Partners:
- Virginia Cooperative Extension (VCE)
- Headwaters Soil & Water Conservation District (SWCD)
- VA Dept of Conservation & Recreation (DCR), Staunton Office

Project Timeline:
September 2012 to February 2017

Project Funding (for all parts):

NRCS Contribution:	$39,515
Recipient & Partner Match:	$41,850
Total:	$81,365

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Virginia Conservation Innovation Grant (CIG) Fact Sheet

VANTAGE Project Part II: Dairy Manure Injection Trials

Summary/Abstract: The overall purpose of this project was to demonstrate and promote innovative cover crops, dairy manure injection, and crop rotation for improved soil health in the Shenandoah Valley. Part II of the project, summarized below, involved comparing shallow, coulter-type dairy manure injection with traditional surface broadcasting in on-farm strip trials. Richard Fitzgerald, currently an independent consulting agronomist with Equity Ag, oversaw all aspects of Part II of this project in his former role as NRCS Shenandoah Valley Area Agronomist.

Figure 1: VA Tech's shallow, coulter-type slurry injector used in this demo project

Three replicated on-farm strip trials compared corn silage performance following two manure treatments: (1) traditional surface broadcasting plus sidedress nitrogen (N) fertilizer vs. (2) shallow subsurface injection with no sidedress N fertilizer. The trials consistently demonstrated that injecting manure allowed a significant reduction in supplemental N fertilizer with no loss in corn silage yield or quality. Consistent with previous VA Tech findings, the higher projected costs of injection were offset by the fertilizer savings. This project helped confirm that dairy manure injection in the Valley can generally "pay for itself" thanks to better crop recovery of manure N and lower fertilizer need.

The key obstacle to broader adoption of injection in the Valley is willingness by farmers and custom haulers to make the up-front investment in more expensive and complex injection equipment. This project gave a new group of such farmers and haulers positive, practical, first-hand experience with manure injection.

"Injection helps me make the most of my on-farm manure nutrients. I also think it will help me get more yield out of my more challenging soil types."
— Kevin Phillips, Farmer, Augusta County

Project Objectives

- Demonstrate and compare the impact of injection vs. traditional manure broadcasting on corn silage yield, quality, and production economics.
- Focus on farmer-managed plots to allow growers to gain direct experience with injection and to promote farmer-to-farmer information sharing.

Background / Justification

- The standard practice for spreading manure on no-till fields in the Shenandoah Valley is broadcast application with no incorporation. This results in odor issues and loss of manure N to the air through ammonia volatilization.
- Shallow, coulter-type manure injection can effectively place dairy slurry into the ground with minimal disturbance to soil and residue. VA Tech research has shown that, compared to broadcasting, such injection can virtually eliminate odors and typically doubles the amount of first-year plant-available N (PAN) that corn can recover from manure (see Reference 1).

About the Grant Recipient

VANTAGE is a farmer-led non-profit helping western VA growers optimize no-till systems through education and farmer-to-farmer information sharing. VANTAGE has chapters in Harrisonburg and Rocky Mount.

www.VANoTill.com

- Injection offers other potential benefits, including less risk of soluble phosphorous (P) runoff in no-till systems.
- On-farm testing in VA, including multiple years of injecting across hundreds of acres by Rockingham farmer Anthony Beery, has shown that coulter injectors are effective under real-life conditions on rocky Valley soils.
- Despite its promise, slurry injection has not caught on in the Valley. A fundamental goal of this project was to continue building interest in injection by working with new cooperators and by focusing on higher manure rates and higher amounts of recovered N.

Projected Benefits vs. Costs of Injection - A Closer Look

- Improved recovery of manure N through injection can significantly reduce the need for supplemental N fertilization of corn, thereby cutting fertilizer costs and potentially eliminating a sidedress fertilization pass.
- Eliminating sidedressing is very attractive to farmers with narrow-row corn highly vulnerable to traffic damage.
- Injectors are more expensive to buy and operate than broadcast spreaders.
- VA Tech analyzed the costs and benefits of injecting manure vs. broadcasting based on data collected by Anthony Beery. In that analysis with a slurry rate of 6,000 gal/ac, the added cost of injection was roughly offset by the savings from applying less fertilizer (see Reference 1).
- The above economic analysis depends on a key assumption—that the corn crop grown with injected manure and less fertilizer will perform as well as or better than the corn crop with broadcast manure and more fertilizer. Testing and demonstrating this "equal corn performance" assumption on high-yielding Valley corn silage fields was a core objective of this project.

Table 1. Average Manure Treatment Nutrient Application Rates *(all values in lb/acre)*

Treatment	Material applied	Application method	Total N Applied	Total PAN Applied*	Total P_2O_5 applied	Total K_2O applied
Broadcast manure	Dairy slurry (9,000 gal/ac)	Broadcast	170	63	50	185
	N fertilizer	Starter	40	40	0	0
	N fertilizer	Sidedress	70	70	0	0
	Total		**280**	**173**	**50**	**185**
Injected manure	Dairy slurry (9,000 gal/ac)	Injected	170	126	50	185
	N fertilizer	Starter	40	40	0	0
	Total		**210**	**166**	**50**	**185**

*PAN = predicted 1st-year plant-available N based on manure tests and VA nutrient management guidelines

Methods / Plan of Action

- Two cooperators conducted a total of three trials between 2012 and 2013.
- Each trial compared two corn fertilization strategies: (1) broadcast manure plus sidedress N vs. (2) injected manure with no sidedress N.
- A high slurry application rate of 9,000 gal/ac was selected in order to test the idea that injection could completely replace sidedress N fertilizer for corn.
- The goal was to apply similar amounts of predicted first-year PAN to each treatment. The target PAN rate was 170 lb/ac, the amount recommended in Virginia for a 23 ton/ac corn silage yield goal. See Table 1 for details.
- As Table 1 shows, a significant portion of the broadcast manure N was expected to volatilize after spreading. The 70 lb/ac sidedress following broadcasting was designed to replace this lost manure N and equalize PAN rates between the two treatments.
- Each treatment was replicated three times in each trial, resulting in a total of six strips per trial. Strips were sized to match the farmers' field equipment.
- Manure was injected using a demonstration tanker with Yetter coulter injectors provided by Dr. Rory Maguire of VA Tech (see Figure 1). All other field equipment was provided by cooperating farmers and manure haulers.

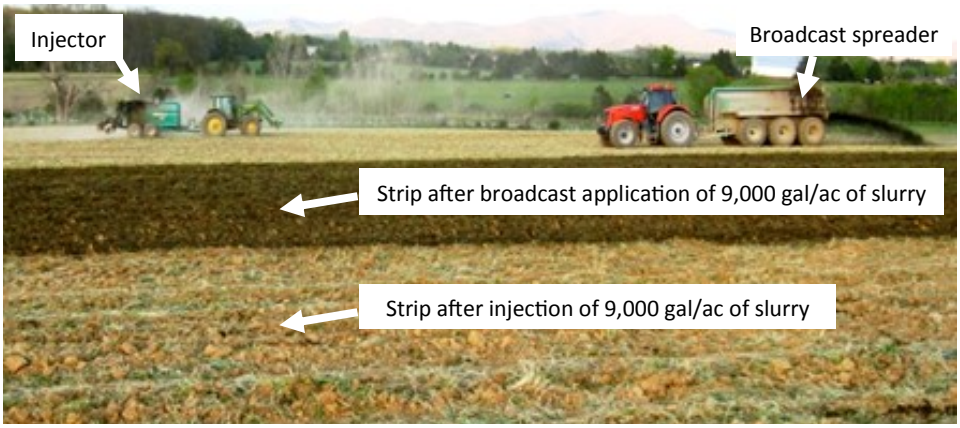


Figure 2. Application of manure treatments in alternating strips at Northpoint Farms.

- Soil samples were taken before and after manure application. The following two soil sampling protocols were compared in some of the injected strips: (a) standard soil sampling, in which cores were pulled randomly throughout the treated area and (b) targeted soil sampling, in which cores were pulled only from the injection zone in the treated area.
- Corn was harvested for silage. Yield for each strip was collected by weighing wagons or with a chopper-mounted yield monitor. Yields were adjusted to account for differences in silage moisture. Silage samples from each strip were sent for nutritional analysis.

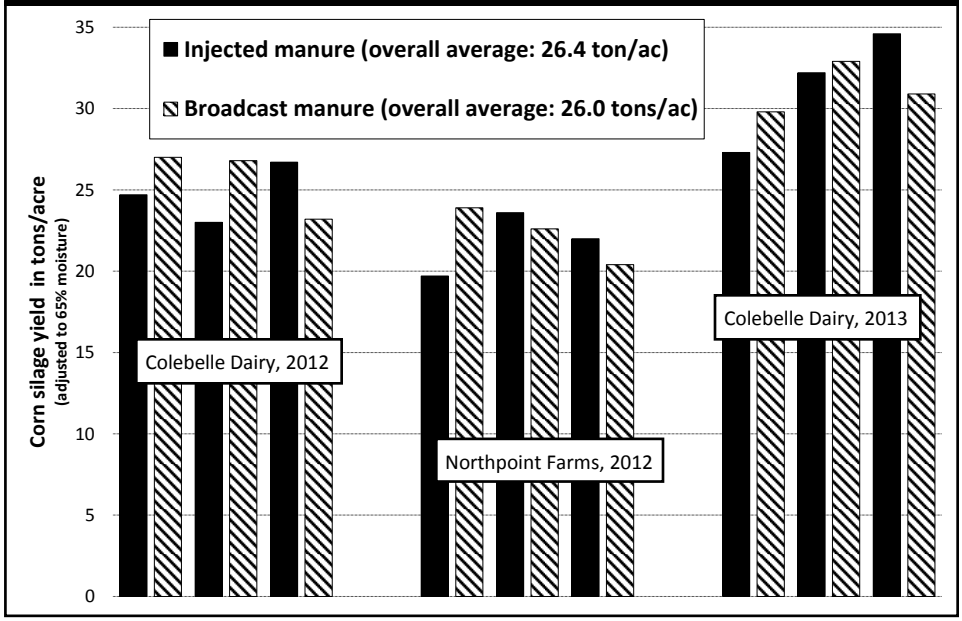
Cooperator Profiles

- Both cooperators are from Augusta County. Mr. Kyle Leonard owns and operates Colebelle Dairy, a 150-cow operation. Mr. Kevin Phillips owns and operates Northpoint Farms, Inc. with his three brothers. The Phillips family milks 900 cows at three facilities.
- Both cooperators grow high-yield, narrow-row silage corn and are eager to eliminate sidedress N applications.
- The two farmer collaborators contributed significant time and crop production resources to the project. Mr. Leonard's willingness to transport the VA Tech injection unit on the highway between sites was especially crucial.
- Other cooperators included two custom manure haulers. Mr. Lewis Horst of Shen Valley Customs injected at Northpoint. Mr. Linden Heatwole used his tanker to nurse (transfer manure to) the injector at Colebelle.

Results: Technical Findings

- High corn silage yields were achieved in all trials. Overall, there were no meaningful yield differences between manure treatments (see Figure 3).

Figure 3. Corn Silage Yields for All Replications, All Trials



- High corn silage quality was achieved in all trials. Overall, there were no meaningful quality differences between manure treatments (data not shown).
- The cost of slurry injection in this project was estimated at $65/ac, compared to $25/ac for broadcasting. Nursing the injector with a second tanker brought estimated injection costs to $75/ac. In summary, the added cost of injection compared to broadcasting was estimated at $40 to $50/ac per acre for this project.
- The farmer cooperators estimated that the total savings associated with the injection treatment, including 70 lb/ac less N fertilizer, no sidedress pass, and associated reduction in damage to corn, totaled at least $50 to $60 per acre.
- The assumption of equal corn performance between treatments held true. Therefore, it is reasonable to simply compare added injection costs ($40 to $50 per acre) vs. injection savings ($50 to $60 per acre). The conclusion: higher injection costs were roughly offset by savings on sidedress N fertilizer.
- Corn following injection generally had a more uniform green appearance compared to corn following broadcasting, indicating more consistent N supply.
- 9,000 gal/ac was about the highest rate that could be applied with the shallow coulter injector without compromising soil coverage of the injection slot.
- When soil testing after injection, it is important to sample only the injection slots. A sample taken randomly across the field will likely under-represent the fertility provided by injection.
- Mr. Leonard has fields near houses that he does not manure to avoid odor complaints. He tried injecting 6,000 gal/ac of slurry across one such field and observed no odors or complaints.

Results: Outreach Activities

- As a result of this project, a new group of Valley farmers and manure industry personnel have positive, practical, first-hand experience with slurry injection.
- Richard Fitzgerald explained the project and promoted injection at multiple events attended by a total of approximately 350 farmers, crop advisors, and conservation professionals. These

"With manure injection, my corn is more uniform down 1,000 feet of row"
— Kyle Leonard, Farmer, Augusta County

included a 2013 tour of the Colebelle plots hosted by Headwaters SWCD and the 2015 VANTAGE Winter Conference in Harrisonburg (see Reference 2).

Conclusions for Farmers

- Slurry injection works. Multiple Valley dairymen have used it for multiple years to grow high-yield, high-quality corn silage on plots and whole fields.
- Slurry injection allows you to use the N in your manure pit more efficiently, thereby cutting your corn fertilizer bill. In this project, 70 lb/ac sidedress N was eliminated following injection with no loss of corn silage yield or quality.
- Injection is most economical when the improved manure N recovery allows for total elimination of a sidedress N fertilizer application. This is most likely when manure rates are in the higher (6,000 to 9,000 gal/ac) range.
- Estimates of the added per-acre cost of injecting compared to broadcasting can vary. This project estimated a relatively high added cost of $40 to $50 per acre, in part because a high rate of manure was applied. Other studies (e.g., Reference 1) have assumed a lower per-acre cost. If you are considering investing in an injection rig, develop your own per-acre cost estimate. A key variable is the number of acres across which upfront and operating costs of injection will be divided.
- The fertilizer savings associated with injection usually offsets the added costs. That was the case in this project, despite conservative assumptions and a high estimated injection cost.
- Anthony Beery's experience indicates that the time required to inject can compare favorably with the time required for covering the same area with surface broadcasting, as long as a second nurse tanker can keep the injector supplied with slurry and minimize injector down-time. He found nursing was key when operating more than one mile from the pit.
- Across all VA trails to date, the fact that injected manure is concentrated in a narrow band every 30" across the field has posed no problem for corn nutrition. Corn roots quickly find the injection slots, proliferate in them, and take up nutrients through the season. Planter-applied starter helps corn grow until roots reach injection slots.
- Under typical conditions, injection can eliminate the smell and sight of manure during and after application.

Conclusions for Policymakers

- The majority of dairy slurry in the Valley is now spread by custom haulers. In addition, the cost of injection equipment must be spread across significant acres to be cost-competitive with broadcasting. For both reasons, increasing adoption of injection will depend heavily on Valley haulers, farmer cooperatives, or similar entities investing in injectors and nurse trucks. New incentives that promote injection should be aimed at these entities.
- By increasing crop recovery of manure N already on the farm, injection can play an important role in achieving P-based nutrient management and whole-farm nutrient balancing.

Figure 4. Field view after application of manure treatments to a standing cover crop prior to corn planting at Colebelle Dairy. The coulter injector was remarkably good at placing manure into the soil under large amounts of residue and vegetation.

This project is part of an NRCS initiative to promote greater implementation across Virginia of the "ring" of soil health management principles shown the diagram above.

References / For More Info

1. Manure Injection in No-till and Pasture Systems. Virginia Cooperative Extension (VCE), CSES Publication 22P pubs.ext.vt.edu/CSES/CSES-22/CSES-22-PDF.pdf
2. Live recording of Richard Fitzgerald's injection project summary presentation from 2015 VANTAGE Harrisonburg Winter Conference (20 minutes) http://www.offices.ext.vt.edu/shenandoah/programs/anr/CropandSoilEnvironmentalSciences/Benefits_of_Manure_Injection.mp4
3. VANTAGE website: www.VANoTill.com

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