Integrated, Innovative Cropping Practices to Reduce Nitrogen, Phosphorus, and Sediment Losses from Cropland in the Shenandoah River Watershed

Final Report

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Executive Summary

Continuous no-till is a recognized best management practice that decreases N, P, and sediment loads from croplands. Reduction of sediment, N, and P from the approximately 137,000 acres of cropland in the Shenandoah River watershed of Virginia was the goal of this project. Continuous no-till and innovative practices such as injection of manure in no-till crop production systems and precision application of N fertilizers with real-time sensors, demonstrations and education programs, and development of a farmer to farmer mentoring program to assist growers with adopting continuous no-till were the methods to increase adoption of no-till in the region.

Rainfall simulations of injected versus surface broadcast (not incorporated) liquid dairy manure showed that over two years, injecting manure decreased total P loss by 51% compared to traditional surface applications. Total N loss in surface runoff was decreased by an average of 37% for injected manure versus surface broadcast over the two years of the demonstrations. Ammonia volatilization from surface broadcast manure applications averaged 34% of the ammonia in the manure while injected treatments lost on average only 3% of the ammonia. Cost analysis of an on-farm demonstration of manure injection on a commercial scale showed that acres per hour covered were similar to broadcast applications if a nurse tanker was used, but that the cost per acre was higher due to the reduction in acres covered per hour and increased equipment cost. Value of the captured ammonia N resulted in a cost approximately equal to surface broadcasting when calculating extra equipment costs. For custom haulers who use an acres-per-hour cost structure, injection of dairy manure may not be economically feasible. However, through cooperation with NRCS and the use of the information developed on this project, manure injection is now a best management practice for continuous no-till, and is eligible for $40/acre cost share payment.

Injection of urea-ammonium nitrate liquid fertilizer as a side-dress N application for corn showed that injection resulted in higher corn ear leaf N concentrations compared to the standard surface band application method but yields were not consistently increased. Ammonia volatilization losses from simulated injected N treatments compared to surface band applications in controlled laboratory conditions reduced ammonia volatilization greatly. Injection of side-dress N fertilizer in corn production is a practice that offers the potential for reducing N fertilizer requirements and ammonia volatilization losses to the atmosphere. However, additional equipment requirements and speed of application are drawbacks for many growers.

Whole farm nutrient budgets for two dairy farms showed that primary nutrient imports were in the form of feed and nutrient exports were in milk. Nutrient management plans as well as work with cattle nutritionists indicated that P imported in feed can be reduced to the extent that P is being used from soil reserves established with years of high manure applications. Whole farm nutrient budgets show how well farm nutrient flows are balanced and can be a useful tool to educate growers to make changes in their feed, manure, and fertilizer management practices.
The farmer-to-farmer mentoring program was established through the formation of the Virginia No-tillage Alliance (VANTAGE) and the holding of four major conferences with strong national and regional speakers that included many growers. The organization is now self-sustaining and additional chapters are being formed. In 2012 conferences were held in Harrisonburg, VA (Shenandoah River watershed 275 attendees), Franklin County (Blackwater, Roanoke River and Dan River Watershed, 100 attendees) and Dinwiddie county (James River and Roanoke River watersheds, 185 attendees). This group has served as a major focal point for growers deciding to implement no-till as they have had recommendations from respected growers as well as the educational programs and on-farm demonstrations associated with this project.

Surveys were sent to approximately 1200 growers in the Shenandoah River watershed at the beginning and near the end of the project. Two hundred ninety-five responses were received from the initial survey and three hundred eight responses were returned for the final survey. Initial surveys indicated that approximately 17% of the growers were using continuous no-till in agronomic crop production while for the final survey, 75% of the respondents were using no-till. Further surveys should be conducted to determine the validity of the large increase in growers indicating that they are using no-till, but the responses do confirm that the program has increased no-till adoption in the region. Growers also indicated that they were aware of the Virginia No-till Alliance and that this was a farmer based organization.
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Introduction

The Shenandoah River watershed (Fig. 1) in Virginia is home to 40% of Virginia’s dairy farms and approximately 900 poultry farms. These farms generate millions of dollars of economic activity and provide meat, milk, and eggs for hundreds of thousands of people. Thousands of tons of nutrients in feed ingredients are imported into the watershed each year and are retained in the region in manure. Approximately 137,700 acres of cropland are dedicated to corn, small grains, alfalfa and soybean production in the seven counties in the watershed. The Final 2006 305(b)/303(d) Water Quality Assessment Integrated Report showed that significant water quality impairments were occurring in the Shenandoah River watershed. The 2005 Tributary Strategies indicated that 31% of N, 51% of P, and 72% of sediment loadings were attributed to agricultural sources.

Corn, small grains, alfalfa and soybean are mainly used for feed to support dairy production in the region. These lands will continue to be cropped as long as farms continue to operate. The 2006 Virginia Department of Conservation and Recreation Land Use Survey indicated that approximately 43% of the cropland in the seven counties in the Shenandoah River watershed was conventionally tilled with conservation tillage practices on the remaining areas. However, observations at the time of this project proposal were that most of the “conservation tilled” acres were not in continuous no-till, but were disked and/or chisel plowed at various times during the crop rotation.

Figure 1. Project focus region: highlighted area includes Virginia counties where Shenandoah River Valley is located
Conversion of crop production to long-term continuous no-till offered opportunities for greater reductions in N, P and sediment losses as continuous no-till systems are known to increase water infiltration with concurrent reductions in runoff and sediment losses. Continuous no-till is also known to improve surface soil tilth through increasing soil organic matter levels.

While the benefits of continuous no-till are widely known in the scientific literature and by many growers, wide-spread adoption of continuous no-till crop production in the Shenandoah Valley had not occurred for various reasons. In particular, growers faced the decision to apply manure on the soil surface with no incorporation in a standard, no-till system, which exposed the manure to run-off and volatilization of nitrogen loss, or incorporate the manure by diskng which increased soil erosion potential. Also, real concerns existed about how to obtain optimum crop populations, most effectively apply supplemental nitrogen fertilizer for corn production, and how to manage weeds and pests such as slugs in continuous no-till production.

Our approach to the assisting growers to overcome the challenges of moving to continuous no-till was to identify real and/or perceived problems though a grower survey, develop demonstrations and educational activities to address the identified challenges, and develop a farmer to farmer mentoring program to share solutions. Most importantly we view the farmer to farmer mentoring program as an essential part of finding and sharing solutions that work for growers and to developing a sustainable program that would continue once our project ended. Our team also brought unique ideas and equipment to the program to determine if these ideas and equipment would work on Shenandoah Valley farms, and again be sustainable once the project ended.

This report covers various project activities including: (1) the evaluation and demonstration of manure injection as a unique solution to reducing manure runoff while maintaining continuous no-till; (2) real time sensing of variable rate N needs in corn production to optimum supplemental N rates for corn; (3) the formation and operation of the Virginia No-Tillage Alliance (VANTAGE); (4) educational events and activities during the project; (5) continuous no-till and cover crop demonstrations; (5) liquid N fertilizer injection demonstrations for optimizing supplemental nitrogen; (6) whole-farm nutrient budgets for two dairy farms; and (7) the initial and final grower surveys. In particular, these surveys show clearly that an intensive demonstration and education program that involves growers, extension, soil conservation personnel and agribusiness can make dramatic changes in practices that are known to reduce sediment and nutrient losses, and which growers will continue to use without continuing cost-share payments because the practices make the farm operation more efficient.
Innovative Crop Production Practices

Impact of Manure Injection on Nitrogen, Phosphorus, and Sediment Losses in Runoff

Nitrogen, phosphorus and sediment are the three main pollutants affecting the Chesapeake Bay, and losses of these from agricultural systems are affected by both tillage and manure application. No-till is a best management practice to prevent soil erosion as explained earlier, but this raises problems with manure management. If manure is left on the soil surface, ammonia is lost by volatilization and the nutrients are vulnerable to loss in runoff during storm events. Therefore manure injection needs to be incorporated into no-till systems. No-till injection of liquid dairy manure can be accomplished with equipment such as that available from the Yetter Equipment Co. (http://www.yetterco.com/prod_p_avenger.php) and Dawn Equipment Company, Inc. (http://www.dawnequipment.com/Strip-Till.html). These attachments allow high volume injection of manure with minimal soil and surface residue disturbance. In addition to no-till, where the soil is not tilled prior to planting, Chesapeake Bay Model also defines conventional and conservation tillage. This is based on crop residue cover, with <30% residue being conventional tillage, 30-70% being considered conservation tillage. Conservation tillage is more beneficial than conventional tillage, as the extra crop residue can help prevent soil erosion and associated sediment and nutrient losses.

Figure 2. Yetter liquid manure injector placing manure under the soil surface in no-till corn.
Rainfall Simulations to Measure Nutrient and Sediment Losses in Runoff

It makes sense that manure injection should decrease nutrient losses in runoff, as by getting manure under the soil surface it decreases the interaction between the manure and runoff water. A farm utilizing continuous no-till was identified for testing manure injection to decrease nutrient and sediment losses under simulated rainfall. The liquid dairy manure application treatments tested were (1) surface applied to no-till, (2) injected into no-till using Yetter injector implement, (3) surface applied then incorporated using conservation tillage with 30-70% of residue left on soil surface, and (4) surface applied then incorporated using conventional tillage with < 30% of residue left on soil surface after planting. NRCS methods were used for cover determination. All of these were conducted in triplicate and simulated rainfall was applied and runoff collected and analyzed using the National Phosphorus Research Project Protocols (http://www.sera17.ext.vt.edu/Documents/National_P_protocol.pdf)
Table 1. Nutrient and sediment in runoff in 2008 following liquid dairy manure (1) surface applied to no-till, (2) injected into no-till using Yetter Inc injector implement, (3) surface applied then incorporated using conservation tillage with 30-70% of residue left on soil surface, and (4) surface applied then incorporated using conventional tillage with < 30% of residue left on soil surface after planting. Values within a column followed by different letters are significantly different at the P<0.05 level.

<table>
<thead>
<tr>
<th></th>
<th>Dissolved P mg/L</th>
<th>Dissolved NO₃⁻ mg/L</th>
<th>Sediment g/L</th>
<th>Total P mg/L</th>
<th>Total N mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface</td>
<td>0.93 B</td>
<td>7.59 A</td>
<td>0.95 C</td>
<td>2.36 B</td>
<td>8.02 B</td>
</tr>
<tr>
<td>Injected</td>
<td>0.27 C</td>
<td>2.46 B</td>
<td>1.46 BC</td>
<td>1.79 B</td>
<td>7.60 B</td>
</tr>
<tr>
<td>Conservation</td>
<td>1.61 A</td>
<td>4.86 AB</td>
<td>3.56 A</td>
<td>8.43 A</td>
<td>28.42 A</td>
</tr>
<tr>
<td>Conventional</td>
<td>1.39 A</td>
<td>4.97 AB</td>
<td>3.11 AB</td>
<td>6.52 A</td>
<td>16.58 AB</td>
</tr>
</tbody>
</table>

Table 2. Nutrient and sediment in runoff in 2010 following liquid dairy manure (1) surface applied to no-till, (2) injected into no-till using Yetter Inc injector implement, (3) surface applied then incorporated using conservation tillage with 30-70% of residue left on soil surface, and (4) surface applied then incorporated using conventional tillage with < 30% of residue left on soil surface after planting. Values within a column followed by different letters are significantly different at the P<0.05 level.

<table>
<thead>
<tr>
<th></th>
<th>Dissolved P mg/L</th>
<th>Dissolved NO₃⁻ mg/L</th>
<th>Sediment g/L</th>
<th>Total P mg/L</th>
<th>Total N mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface</td>
<td>4.49 A</td>
<td>2.93 A</td>
<td>0.85 A</td>
<td>8.39 A</td>
<td>25.21 A</td>
</tr>
<tr>
<td>Injected</td>
<td>1.33 B</td>
<td>1.96 A</td>
<td>0.41 B</td>
<td>1.80 B</td>
<td>7.88 B</td>
</tr>
<tr>
<td>Conservation</td>
<td>1.18 B</td>
<td>1.46 A</td>
<td>0.72 A</td>
<td>2.81 B</td>
<td>11.18 B</td>
</tr>
<tr>
<td>Conventional</td>
<td>1.68 B</td>
<td>3.21 A</td>
<td>0.83 A</td>
<td>3.07 B</td>
<td>11.46 B</td>
</tr>
</tbody>
</table>

For both years that these studies were conducted, injection of manure dramatically decreased dissolved P in runoff, from 0.93 to 0.27 mg P/L in 2008 and from 4.49 to 1.33 mg P/L in 2010 (Tables 1 and 2). Dissolved P is the best measure of P that is immediately available to algae and other organisms in fresh water. However, the Chesapeake Bay Model reports total P losses, rather than dissolved P. In 2008, injecting manure and surface applying were statistically identical, although at 1.79 mg/L injecting manure was numerically 24% lower than the 2.36 mg/L for surface application. In 2010, manure injection substantially decreased total P loss, by 79%, from 8.39 to 1.80 mg/L. Therefore, when averaged over the two years, injecting manure decreased total P loss by 51% compared to traditional surface application. The total P loss from conservation and conventional tillage was statistically identical in both years, but was always greater than total P loss from injecting manure into no-till. This is because total P loss is closely tied to sediment loss in runoff, and no-till is known to decrease sediment loss. Looking at our data, the sediment loss from both conservation and conventional tillage was always
greater than the sediment loss from manure injection in no-till. This indicates that manure injection is a good way to reduce sediment and total P loss relative to any form of tillage.

Nitrate is the most immediately available form of N for crops and algae in freshwater systems. Differences in nitrate loss between our manure application treatments were not always significant, especially in 2010. However, nitrate loss from manure injection was always numerically lower than surface applications and this was significant in 2008. As for P, the Chesapeake Bay Model works on total N rather than plant available N or nitrate. Total N loss was always numerically less from manure injection than surface application, and this reduction in total N loss was dramatic in 2010. In 2010, manure injection decreased total N loss from 25.21 to 7.88 mg/L. **When averaged over both years, manure injection decreased total N loss in runoff by 37% relative to surface application to no-till.** Due to variability in the data, the total N loss from the conservation and conventional tillage was statistically identical. However, the total N loss from injecting manure into no-till was always numerically less than total N loss from conservation and conventional tillage and this was significant in 2008. The benefits of no-till were not always evident when manure was left on the soil surface. In 2010, there was greater total N loss from surface application of manure to no-till than for conservation and conventional tillage, although this was not the case in 2008.

**Manure injection and Ammonia Volatilization**

It is well known that a large proportion of ammonia in manure is lost to the atmosphere through volatilization. Studies in other states with different soils, climates and equipment have shown manure injection to decrease ammonia loss. This preserves N in soils for crop production, and prevent ammonia-N re-deposition, which is a source of N for the Chesapeake Bay. We conducted some direct measurements on ammonia volatilization from dairy manure to confirm that manure injection decreases ammonia volatilization under Virginia conditions. On average, only 3% of ammonia injected into no-till was lost through volatilization, while 34% was lost when the same manure was surface applied (Table 3). Surface application followed by incorporation with a heavy disk led to less ammonia loss than leaving manure on the surface, but this is obviously incompatible with no-till and means the benefits of no-till are not achieved. Values higher than 34% have been reported in other studies, and we would have lost more ammonia from our surface application if it had been warmer. However, our results again show the environmental and agronomic benefits of manure injection, as valuable N is maintained in the soil where it can be used by crops, rather than being lost from the agricultural system.
Table 3. Ammonia lost through volatilization following land application of dairy manure by a) surface application in no-till, b) injected into no-till, and c) surface applied then incorporated. Values followed by different letters are significantly different at the P<0.05 level.

<table>
<thead>
<tr>
<th>Replication</th>
<th>Surface applied</th>
<th>Injected</th>
<th>Incorporated</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>39</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>32</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td>34</td>
<td>4</td>
<td>26</td>
</tr>
<tr>
<td>4</td>
<td>31</td>
<td>3</td>
<td>19</td>
</tr>
<tr>
<td>Average</td>
<td>34A</td>
<td>3C</td>
<td>17B</td>
</tr>
</tbody>
</table>

Impact

A. Through cooperation with NRCS, there is now a cost share program to encourage farmers to utilize no-till. For farmers who develop a conservation plan with NRCS, manure injection is now an eligible best management practice. The payment is $40 per acre, which is more than enough to cover costs from our economic assessment with Anthony Beery.

B. Farmers in the Shenandoah Valley had previously not been aware of manure injection and therefore did not understand how the technology worked. We had a total of 50 educational events that reached several hundred stakeholders, including state and federal agencies, farmers and agribusiness.

C. As a result of our work, one farmer has purchased a large scale, 6000 gal manure injection unit:

The setup to inject manure conducted by farmer Anthony Beery on his dairy included the following. A Houle 6300 tanker was outfitted with a six row (30” centers) injection toolbar. A Farmstar pivoting toolbar was used as a base and a retractable toolbar was fabricated to narrow the unit for road travel. The injection units (Dawn 6000 series) were no till coulter style units with closing wheels. Mr Beery did his own research into different manure injection equipment and although more expensive, he thought the Dawn equipment was heavier and therefore more durable than the Yetter injector purchased for the field demonstrations. The initial manifold to split manure between the six injectors was a 6” pipe with center fill and 6 outlet fittings. However, Mr Beery was not satisfied that this manifold evenly split the manure between all six injectors, and he therefore used a second manifold to split the manure between the six injectors more evenly. The second manifold was a Farmstar hydraulically actuated manifold which served as a chopping/metering device. Additionally he installed an Envizio Pro GPS controller and flowmeter to enable precision application. As part of his involvement, he agreed to test out nursing his injector. This involves using a second tanker to ferry manure from the manure pit to the injector. This is financially advantageous, as the expensive injector can
continue injecting manure while a cheaper nurse truck spends time on the road. To achieve this he outfitted a 6000 gallon semi tanker with a Houle nurse boom to provide ability to nurse the spreader.

Figure 4. Photograph of the injection system purchased by Mr Beery.

Use of the injector

This was the first year in using this equipment and therefore he encountered various situations that caused delays and modification of the equipment.

1) The ship date in the injection units were delayed, which pushed back the completion date of the unit until the end of June. By that time he had already finished the bulk of the spring manure application, leaving only 45 acres open.

2) In the fall he encountered significant problems with plugging of the manifold with wood chips. Additionally he had difficulty getting uniform application from the manifold. After spending considerable time and effort trying to use the equipment, he decided to purchase a chopping/metering type manifold. Again the time lag to get and install the new equipment caused him to be beyond the window of time for most of the fall spreading.

3) Also, conversation with DEQ indicated that he would need to drop his application rate if the manure was injected in the fall. This drop in application rate was to meet his nutrient management plan, as injecting manure about doubles the plant available nitrogen, which cannot be over-applied in his nutrient management plan. This was not an acceptable option for him as he did not have enough acres to drop the rate per acre and still spread all the manure. This once again limited the number of acres available to inject.

4) Finally, because of the difficulties with plugging a concise estimate of application time was difficult to obtain on several fields.
However, we were still able to inject 45 acres in early summer 2011 ahead of sorghum and another 40 acres in fall ahead of small grain. He was able to gain some valuable information and experience that will help him in moving forward and injecting manure in spring in 2012. This is an important point, as it indicates that manure injection is continuing by a private farmer after completion of this project.

One of the important issues Mr Beery was asked to investigate was the economic comparison of surface applying manure relative to injecting it. He found that injecting manure can be done for a modest additional cost per acre, if the assumed amount of N can be recovered. When using a nurse tank and injecting, the application rate was very close to broadcast in acres per hour covered, however the cost per acre was higher. The net cost per acre when injecting without the nurse tank, after factoring in the captured N, was actually less than the broadcast cost. But the acres per hour covered drops over 20%. If the spreading window is large enough, injection can be done without the nurse unit. But typically, especially for custom operators, the fewer acres per hour are not acceptable as weather and other issues limit the available time to spread. Fields were about 1 mile from the dairy manure lagoon. A shorter distance would have made the nurse truck unnecessary, while a greater distance would have made it more important.

Table 4. Cost comparison of injected versus surface broadcast liquid dairy manure in 2011.

<table>
<thead>
<tr>
<th>Type</th>
<th>Gallons/ac.</th>
<th>Ac./hr.</th>
<th>Equipment cost/hr.</th>
<th>$/ac.</th>
<th>N recovery w/ injection</th>
<th>Cost/ac. less N</th>
<th>Net injection cost/ac.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadcast</td>
<td>6000</td>
<td>3.3</td>
<td>$105</td>
<td>$32</td>
<td>$0</td>
<td>$32</td>
<td>($9)</td>
</tr>
<tr>
<td>Injection w/o nursing</td>
<td>6000</td>
<td>2.6</td>
<td>$150</td>
<td>$58</td>
<td>$35</td>
<td>$23</td>
<td>($9)</td>
</tr>
<tr>
<td>Injection w/ nursing</td>
<td>6000</td>
<td>3.3</td>
<td>$255</td>
<td>$77</td>
<td>$35</td>
<td>$42</td>
<td>$10</td>
</tr>
</tbody>
</table>

*Equipment costs based on $105/hr. for broadcast/nursing, which is the local going rate. The $150/hr. for injection is what Mr Beery decided he would feel comfortable with if he was doing it for hire. The $255 is these two added together. All of these were based on equipment cost, depreciation and operator time.

*N recovered amount 50 lb/acre and valued at $.70/lb.
Practical notes made by Mr Beery that should help other adopters

1) We experienced minimal problems with the rocks that are in our fields. One issue encountered was that when the coulter would hit a rock, the pressure would cause the coulter to lose angle which then would affect the size of slot for injection. After upsizing some of the hardware on the unit, I believe we have remedied that situation.

2) A chopping manifold is preferred over a passive directional manifold to minimize plugging and ensure proper distribution.

3) The pivoting toolbar worked extremely well in providing limited turning ability while injecting.

4) Nursing capability is not beneficial on a cost basis unless the fields are some distance from the manure pit. Also a sizeable space to transfer into the spreader is helpful to facilitate maneuvering of the equipment.

5) We did not see any striping effect in any of the crops where the manure was injected, with the exception of one field. The field, which was drilled, was planted in triticale and radishes. The radishes germinated and grew much more prolifically in the injection slot. The triticale was consistent across the field. Other fields did not show this. Digging up some sorghum plants showed evidence of a concentration of roots growing into the injection slot.
6) In two different fields manure was broadcast and injected side by side. There was no visible difference in color in either growing crop where the manure was broadcast vs. injected.

7) Odor was minimized by manure injection but still noticeable.

8) Runoff potential is certainly decreased.

9) The GPS/flowmeter did an excellent job of metering flow while injecting at various speeds. Also the guidance feature is helpful especially in ground with significant cover.

10) Because of the flowmeter we noticed that the spreader while we thought it was full actually had 10-15% foam in it, effectively reducing the gallons per load. This could be significant when applying manure based on loads per acre, especially under strict mandated nutrient management allowances, where N would unknowingly be applied 10-15% less than intended.

Summary

Manure injection presents both difficulties and benefits. Increased out of pocket cost with more equipment to maintain and slower application rates is perhaps the most noticeable drawback. A narrower application swath in which more of the field is run over leading to increased compaction potential is another.

However, better utilization of on farm-produced nutrients, nitrogen in particular, is a significant benefit. This could potentially eliminate the need for side dressing N on corn. I hope to experiment with this in the coming year. Also a more precise and consistent application of the manure nutrients would seem to have benefits to the growing crop as well. The potential to increase organic matter levels in the soil over time through capturing more of the carbon in the manure may also be a benefit. Other considerations such as, possibly less damage to earthworm populations and fewer toxins on top of the soil in a no till environment, would be interesting questions to be pursued.

In conclusion, from our limited experience, I believe manure injection can be accomplished in the Shenandoah Valley and provide some added value to the farm. However, time and cost considerations have to be dealt with. Continuing to use this practice will no doubt help to determine that value to the farming operation.
Real time sensing of variable rate N needs.
Wade Thomason

GreenSeeker® demonstrations were conducted at locations in Augusta and Shenandoah Counties. These demonstrations compared sensor-based, variable rate side-dress N applications for corn to the standard uniform sidedress N application (Table 5). Fertilizer N applications at each demonstration site consisted of a sensor-based, variable N rate application, a fixed N rate based on standard recommendations (which will vary on a site-specific basis) and seven fixed rates to determine the optimum N rate at each location. The range of fixed rates was selected to encompass the standard recommended rate and included a 0-N treatment. Standard recommendations were generated at each site using procedures documented for Virginia corn production. The source and placement for the fertilizer treatments were urea ammonium nitrate (UAN, 30% N) applied in a surface band approximately 4 inches to the side of each corn row using drop nozzles or broadcast-applied in the wheat studies. Variable rate N applications were made to no-till corn crops using the RT200 GreenSeeker® system mounted on a Spra- Coupe 220 applicator with a 60-ft. boom. Six GreenSeeker sensors are equally spaced across the boom. Each sensor independently collects reflectance measurements from the crop canopy and communicates the readings to an onboard computer where an average Normalized Vegetative Index (NDVI) measurement is calculated. The onboard computer contains software that inputs the NDVI into the appropriate algorithm for wheat or corn then sends the prescribed N rate to the variable-rate controller. The GreenSeeker® sensors collect 60 readings per second and a new N rate is calculated once every second. At typical operating speeds of approximately 7 mph, an N rate change can occur every 10 ft as the applicator moves across the field. The range of rates that can be applied is affected by the nozzle selection. For these demonstrations, we used VariTarget® variable-rate nozzle (Spray Target Industries, Rosemount, MN). Based on a 30 inch nozzle spacing and intended operating speeds, these nozzles provided an application range of 10 to 97 gal/acre (33 to 315 lbs N/acre) at 15 to 100 psi of pressure.

Table 5. Production practices for GreenSeeker and small plot sidedress demonstration plots, 2008.

<table>
<thead>
<tr>
<th>Site</th>
<th>Hybrid</th>
<th>Population, plants/ac</th>
<th>Starter Fertilizer</th>
<th>Herbicides</th>
<th>Planting Date</th>
<th>Sidedress Date</th>
<th>Harvest Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Augusta</td>
<td>DEKALB 6787</td>
<td>31,000</td>
<td>40-0-0+1 qt/ac Zn</td>
<td>Pre-emerge: 3.2 qt/ac Harness, 1 qt/ac Princep, 1.4 qt/ac Roundup</td>
<td>5/21/2008</td>
<td>7/17/2008</td>
<td>8/26/2008</td>
</tr>
</tbody>
</table>

At maturity, sections of each plot, 2 rows by 10 feet long were hand harvested. In the case of the Shenandoah site, all ears in the harvest area were picked, husked and weighed.
Then a representative 6-ear subsample was dried and shelled to determine grain dry weight. Grain yields are reported on a 155 g kg\(^{-1}\) (15\%) moisture content basis. A grain subsample for moisture and test weight was collected from each 6-ear subsample and analyzed using a Dickey-John GAC2000 grain sampler (DICKEY-john, Auburn, IL). Grain protein was determined using a Dickey-John OmegAnalyzer G whole grain near infrared analyzer (DICKEY-john, Auburn, IL). The Augusta site was harvested for silage and, again, sections of each plot, 2 rows by 10 feet long were hand harvested. Stalks were cut at approximately 6 inches above soil height and entire plants weighed. A representative subsample of stalks was retained and dried to a constant weigh in a 60°C forced air oven to determine dry matter. Samples were then chopped using a chipper shredder to simulate silage harvest. These chopped samples were subjected to NIR analysis to determine forage quality, and this analysis was input into the MILK2006 program to generate relative forage “value” associated with the various treatments. At the Augusta location, no response of corn silage yield to increasing sidedress N rates was noted (Figure 6). Similarly, no difference in silage yield was observed in strip plots comparing the GreenSeeker variable rate sidedress application to no sidedress application (Figure 7). The manure applications provided adequate N for crop yields at this location. However an increase in silage quality (protein content) was demonstrated in response to sidedress N (Figure 8).

Figure 6. Response of corn silage yield to sidedress N, Augusta Co, 2008.
Figure 7. Strip plot silage yield response to injected (INJ) or surface applied (Surface) preplant manure and sidedress N (gs)

Figure 8. Milk per acre, estimated via the MILK2006 program for plots receiving injected (INF) or surface applied (Surface) preplant manure and sidedress N (gs)

At Shenandoah, corn grain yield did respond positively to increasing rates of sidedress (Figure 9). There was a linear increase in grain yield at sidedress rates up to 60 lb N/ac, but no further response. The average GreenSeeker recommended rate was 79 lb N/ac, which is 10 lb/ac less than the farmer selected rate of 89 lb N/ac at sidedress. In the large strip demonstration plots, sidedress comparisons were made between three sidedress application methods: (1) liquid UAN dribbled on the surface at a fixed rate; (2) liquid UAN injected using a Redball® unit at a fixed rate, and the GreenSeeker® variable rate dribbled on the surface. Each of these treatments was tested where preplant manure was injected or surface applied and not incorporated. The injected sidedress fixed rate yielded more than the GreenSeeker variable rate which yielded more than the surface applied fixed rate (Figure 10). The yield of the fixed rate, injected sidedress treatment was 174 and 168 bu/ac when manure was injected or surface applied, respectively. Injection of the
side-dress applied N produced higher yields with both surface and injected manure, indicating that this application method increased N fertilizer availability at this location.

Figure 9. Corn grain yield response to increasing sidedress N rates, Shenandoah, 2008

![Graph showing corn yield response to sidedress N rates]

Figure 10. Strip demonstration plot grain yield response to injected (INJ) or surface applied (Surface) preplant manure and sidedress N (gs), Shenandoah, 2008. Injected and surface treatments received a uniform sidedress rate of 89 lb N/ac as selected by the cooperator.

![Graph showing strip demonstration plot grain yield response]

These data will be merged with previous work in the Virginia Coastal Plain and will be provided for use in the Bay Model to determine the N reduction efficiency that should be given for precision N fertilizer application as well as injection of fertilizer N. Due to the cost of the Greenseeker® equipment, commercial applicators that can aggregate large areas will be the group that can provide the service at a reasonable cost, i.e. $8.00 per acre. While commercial applicators will be a major audience for the demonstration data, field days, presentations and fact sheets will target growers in order to illustrate the benefits of the variable rate N application as well as the benefits for injection of side-dress N application.
**Continuous No-Till and Cover Crops**

Cover Crops in Continuous No-Till Systems: I. Maximizing Nitrogen from Cover Crops.

Brian P. Jones

With commercial nitrogen prices projected to be at an all time high next year, and with increasingly strict regulations regarding organic sources of nitrogen (i.e. poultry litter) producers should seriously consider using some form of legume cover crop in their cropping system. The question is constantly asked, “Just how much nitrogen can I expect to get from these cover crops, and are they economically feasible if I have a restricted land base?”.

To help try and answer these questions, we began a project with a cooperator in the Mauzy area of Rockingham County last fall. We planted eight different cover crops or combinations, including: cereal rye, barley, crimson clover, common vetch, rye + vetch, rye + vetch + clover, rye + forage radish, and a control plot with no cover crop. We are also interested in figuring out the optimum time to kill these cover crops, and determining how effective the roller/crimper tool is for managing these cover crops. If you recall from previous issues of this newsletter, the roller/crimper is a tool designed to mechanically kill cover crops by rolling them flat and crimping their stems, thereby preventing the flow of water and nutrients and killing the plant. We have been conducting several field trials with this tool for the past two years, and this project will provide us with a replicated environment to further test this equipment. Using the roller/crimper (and herbicide if necessary), we killed each of the cover crop plots at three different growth stages. Following each kill, we planted corn which we will harvest for silage. Within each plot we are measuring the total soil nitrogen, soil organic matter and other soil nutrients. We are also measuring the amount of nitrogen in the cover crop at the time of killing, and the carbon: nitrogen ratio of the cover crop. As the corn crop matures, we are collecting plant nitrogen samples from the corn. The objective of all these measurements is to try and quantify how much the management and type of cover crop is affecting the available fertility for the corn crop. This project is still very much in the beginning stages, and our initial samples are being analyzed as I write this. However, I think that the photograph at left illustrates nicely what we are already seeing in the field.

The light green corn in the lower right is one of the plots where barley was planted. The darker corn in the upper left was planted after killing crimson clover. The literature
shows us that clover can contribute as much as 80 lbs of nitrogen to the following crop. Please stay tuned to later issues of this newsletter for updates as this study progresses.

Cover Crops in Continuous No-Till Systems: II. Do Cover Crops Pay?

Cover crops serve multiple beneficial roles in our cropping systems. The Virginia DCR offers incentive programs for producers interested in planting both cereal and legume cover crops. Even with these incentives, cover crop seed costs in 2008 have increased significantly, and lead many to wonder if cover crops do pay.

To try and answer this question, research was started in 2006 on a farm in northern Rockingham County. Eight different cover crop species were planted. These were killed on May 10, 2007, and corn for silage was planted. Cover crops were killed with herbicide and then rolled flat. Corn was no-tilled through the residue. We measured the biomass of the cover crops, the plant available nitrogen, and the carbon: nitrogen ratios of the cover crop species. We also measured the ear leaf N of the corn plant and the final corn silage yield. Plant available nitrogen (PAN) is the total amount of nitrogen that is available to the following crop, in this case corn silage.

We observed that PAN ranged from 16 lbs/acre with no cover to 152 lbs/acre with a mixture of rye and vetch (Table 1). Corn silage yield was also affected by cover crop species. 2007 was an exceptionally dry year in this part of the county, and thus our yields were somewhat lower than optimal. However, even with the dry weather, we were able to obtain yields of nearly 14 tons/acre simply by adding a legume cover crop into the system. When you look at overall profitability of using a cover crop, the advantage is clear. The total short-term profit from cover crops is shown in Table 3. These figures have already accounted for cover crop seed and establishment costs, and are a reflection of the value of the corn silage yield advantage combined with the additional nitrogen returned to the system. Do cover crops pay? I think the answer is undeniably yes.

Table 6. Total N available to corn from cover crops and the $ value of that N in 2007.

<table>
<thead>
<tr>
<th>Cover Crop</th>
<th>Total Plant Available N (PAN), lb acre(^1)</th>
<th>Value of PAN @ $0.90/lb N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rye</td>
<td>32.5</td>
<td>$29.21</td>
</tr>
<tr>
<td>Crimson Clover</td>
<td>108.6</td>
<td>$97.72</td>
</tr>
<tr>
<td>Hairy Vetch</td>
<td>87.1</td>
<td>$78.35</td>
</tr>
<tr>
<td>Rye+Vetch</td>
<td>152.9</td>
<td>$137.60</td>
</tr>
<tr>
<td>Rye+Vetch+Clover</td>
<td>130.2</td>
<td>$117.13</td>
</tr>
<tr>
<td>Rye+Tillage Radish</td>
<td>40.0</td>
<td>$35.97</td>
</tr>
<tr>
<td>No Cover</td>
<td>13.6</td>
<td>$14.60</td>
</tr>
</tbody>
</table>
Table 7. Corn silage yield following cover crops and the $ value of that corn silage after cover crop expenses

<table>
<thead>
<tr>
<th>Cover Crop</th>
<th>Corn Silage Yield @ 35% DM, ton ac⁻¹</th>
<th>Value of Corn Silage after Cover Crop Costs, $ acre⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rye</td>
<td>8.9</td>
<td>$218.16</td>
</tr>
<tr>
<td>Crimson Clover</td>
<td>13.8*</td>
<td>$355.76</td>
</tr>
<tr>
<td>Hairy Vetch</td>
<td>13.8*</td>
<td>$377.16</td>
</tr>
<tr>
<td>Rye+Vetch</td>
<td>10.6</td>
<td>$250.04</td>
</tr>
<tr>
<td>Rye+Vetch+Clover</td>
<td>14.5*</td>
<td>$370.49</td>
</tr>
<tr>
<td>Rye+Tillage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radish</td>
<td>13.0*</td>
<td>$306.33</td>
</tr>
<tr>
<td>No Cover</td>
<td>6.0</td>
<td>$179.69</td>
</tr>
</tbody>
</table>

Table 8. Total dollar profit of cover crop before corn silage in 2007.

<table>
<thead>
<tr>
<th>Cover Crop</th>
<th>Total Short-Term Profit from Cover Crops, $ acre⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rye</td>
<td>$247.37</td>
</tr>
<tr>
<td>Crimson Clover</td>
<td>$453.48</td>
</tr>
<tr>
<td>Hairy Vetch</td>
<td>$455.51</td>
</tr>
<tr>
<td>Rye+Vetch</td>
<td>$387.64</td>
</tr>
<tr>
<td>Rye+Vetch+Clover</td>
<td>$487.62</td>
</tr>
<tr>
<td>Rye+Tillage</td>
<td></td>
</tr>
<tr>
<td>Radish</td>
<td>$642.29</td>
</tr>
<tr>
<td>No Cover</td>
<td>$194.34</td>
</tr>
</tbody>
</table>
Liquid N Fertilizer Injection

Urea-containing fertilizers are a major N source in agricultural settings worldwide; unfortunately, N losses as volatilized ammonia (NH₃) from urea fertilizers can be relatively high compared to other N fertilizer sources (FAO/IFA. 2001. Global estimates of gaseous emissions NH₃, NO, and N₂O from agricultural lands. FAO and IFA. Rome, Italy.).


A proposed application method that places the fertilizer below plant residues into the mineral soil is the injection of urea-containing solutions. Currently, Urea Ammonium-Nitrate (UAN) solution is commonly placed as a band onto the surface of plant residues between rows in corn production as a sidedress application. Injection of UAN at this application time may increase N availability by reducing potential NH₃-N
losses and runoff N losses compared to the surface-banding method mentioned above. Therefore, 7 demonstration strip trials were established during the project within the Shenandoah River Valley. The demonstration sites were also associated with more detailed research taking place within the region and across the state at 15 other sites that sought to compare injection and surface-banding applications of UAN in no-tillage corn production, as well as a laboratory study that directly measured NH$_3$-N losses from UAN applied by these methods.

The demonstration strip trials were primarily used at educational events and field days to display innovative injection technology. Grain yield and ear leaf tissue N contents from these sites were summarized and presented at multiple events within the project region. Data from the more detailed research sites across the state was recently summarized, and will be presented at future regional and local educational meetings and field days.
Overall, the results from the research sites indicated that injection of UAN reduced the amount of N required to reach maximum yield or ear leaf tissue N content by 25 kg N ha\(^{-1}\) from 150 to 125 kg N ha\(^{-1}\) compared to surface-banding of UAN. The results also indicated this difference was inconsistently observed at each site, which signifies that in certain situations N losses from surface-banding UAN may be negligible. Injection of UAN was often found to increase ear leaf tissue N content compared to surface-banding applications at more sites than where differences in grain yield were observed. This is probably due to a longer period after UAN application for environmental factors (e.g. rainfall, temperatures) to mask the differences between application methods. This is another possible reason why injection of UAN did not consistently increase grain yield across sites compared to surface-banding.
Figure 12. Combined ear leaf tissue N content results from N responsive research sites. Regression analysis used to determine N rate where tissue N is at maximum.

Figure 13. Combined grain yield results from N responsive research sites. Regression analysis used to determine N rate where grain yield is at maximum.
Results from the laboratory study found that injection of UAN in various residue cover settings reduced NH$_3$-N losses to <1% of applied N. Ammonia-N losses from UAN surface applied onto bare soil, wheat stubble, and corn residue ranged from 15.3 to 32.5% of applied N. The highest NH$_3$-N losses were observed from UAN surface applied to corn residue, and NH$_3$-N losses from UAN surface applied to wheat stubble and bare soil were similar.

Figure 14. NH$_3$-N captured from surface-applied UAN at a rate of 75 kg N ha$^{-1}$.

Figure 15. NH$_3$-N captured from surface-applied UAN at a rate of 125 kg N ha$^{-1}$.
Overall, the results from the field research sites and the laboratory study indicate injection of UAN reduces the potential of NH$_3$-N losses and can reduce N requirements to meet maximum ear leaf tissue N contents and grain yields. Though injection of UAN did not consistently increase N availability at specific sites, it should be noted that N availability from surface-banding of UAN was never higher than injection application. Therefore, injection of UAN should be considered in N management practices by crop producers as an innovative application method that may reduce N inputs and has the potential to reduce environmental concerns associated with N movement into the atmosphere and surrounding environment.
Whole Farm Nutrient Budgets for Dairy Operations

Nutrient (nitrogen (N), phosphorus (P), and potassium (K)) flows at the farm-gate level were observed and recorded for two dairy operations (farms A and B) within the Shenandoah Valley over two 1-year periods. Both operations were conventional in the sense that a high portion of animal feed was purchased or brought onto the farm. Both farms also maintained a state certified nutrient management plan which limits manure applications to many fields by N or P limits. This is typical of many dairies in the region; therefore, information obtained from these farms can be applied to other similar operations. Farm input/output data was logged by the farm operator and items were sampled and analyzed for nutrient content if an N, P, and K amount was unknown. The final nutrient balance was completed using an excel-based template developed by Cornell University.

Farm A was located in New Market, VA. There were approximately 75 milking cows at any given time during the budget years. The farm consisted of 240 acres of tillable/usable land and 10 acres of unusable land. All usable land has manure applied to it at least one time a year. In the budget years, there was 94 acres of pasture land, 15 acres of alfalfa, 80 acres of corn, 10 acres of barley, and 41 acres of soybeans. All forage and crops (excluding soybeans) were kept on-farm. Manure application recommendations were N and P-based.

Most nutrients entering the farm over both years were in the form of feed with some additional fertilizer adding to the total. Milk was the greatest nutrient export of the operation. Table 1 lists all nutrient import/export general sources and amounts. In both balance years there were more N and K being imported onto the farm than being exported. This resulted in an excess of N in year 1 of 11 lb/usable acre and 6 lb/usable acre in year 2. Potassium was in excess of 15 lb/usable acre in year 1 and 6 lb/usable acre in year 2. Phosphorus (P) import/export was nearly balanced over both years with no significant excess or deficiency observed in the budget. These results suggest N- and P-based nutrient management plans are effective at limiting P excess at the farm level; therefore, reducing the chances of P build-up and runoff from fields. Excesses in N and K are common in whole farm nutrient balances. N has a high potential for environmental losses,

30
which means more N is required to be imported onto the farm than is being exported to cover these losses. The reason for excess K is probably due to reduced concern of environmental impacts and less intensive management of this nutrient in feed stock and plant systems.

Table 9. 1. Categorized import and export sources and nutrient amounts from Farm A.

<table>
<thead>
<tr>
<th>Category</th>
<th>N (tons per year)</th>
<th>P (lbs per usable acre)</th>
<th>K (tons per year)</th>
<th>P (lbs per usable acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed</td>
<td>5.31</td>
<td>7.64</td>
<td>0.88</td>
<td>1.29</td>
</tr>
<tr>
<td>Fertilizer</td>
<td>1.6</td>
<td>0.98</td>
<td>0</td>
<td>0.03</td>
</tr>
<tr>
<td>Animals</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>0.05</td>
<td>0.1</td>
<td>0.02</td>
<td>0.05</td>
</tr>
<tr>
<td><strong>Total Imports</strong></td>
<td><strong>6.96</strong></td>
<td><strong>8.72</strong></td>
<td><strong>1.31</strong></td>
<td><strong>3.47</strong></td>
</tr>
<tr>
<td>Milk</td>
<td>4.01</td>
<td>5</td>
<td>0.69</td>
<td>0.86</td>
</tr>
<tr>
<td>Animals</td>
<td>0.12</td>
<td>0.03</td>
<td>0</td>
<td>0.01</td>
</tr>
<tr>
<td>Crops</td>
<td>1.49</td>
<td>3.02</td>
<td>0.15</td>
<td>0.3</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total Export</strong></td>
<td><strong>5.62</strong></td>
<td><strong>8.02</strong></td>
<td><strong>1.16</strong></td>
<td><strong>1.71</strong></td>
</tr>
<tr>
<td><strong>Difference</strong></td>
<td><strong>1.34</strong></td>
<td><strong>0.7</strong></td>
<td><strong>0.15</strong></td>
<td><strong>0.74</strong></td>
</tr>
</tbody>
</table>

Farm B is located in Flat Rock, VA. There are approximately 70 milking cows on 213 acres of usable land. All usable land had manure spread on it at least one time during the budget year. Of the 213 usable acres, 20 acres was in alfalfa, 100 acres was in pasture, 12 acres was in hay, 27 acres was in corn, 27 acres was in rye, and 27 acres was in barley. Corn, rye, and barley were harvested for silage. Alfalfa and hay was baled and pasture land was grazed.

Nutrient import and export sources and amounts for the two balance years are displayed in table 2. Unlike farm A, farm B’s primary N import over both years was from fertilizer in the urea form with feed contributing a large portion of N as well. Most all P was provided by feed, and K was provided by a combination of feed and fertilizer. The primary nutrient export was from milk sale. In both years of the budget, P was being removed from the farm at a rate of 3 lb/usable acre in year 1 and 4 lb/usable acre in year...
2. Potassium in year 1 was found to be in excess of 5 lb/usable acre. In year 2 net removal of K was 9 lb/usable acre due to export of crops from the farm.

Table 10. Categorized import and export sources and nutrient amounts from Farm B.

<table>
<thead>
<tr>
<th>Category</th>
<th>Yr 1 N</th>
<th>Yr 1 P</th>
<th>Yr 1 K</th>
<th>Yr 2 N</th>
<th>Yr 2 P</th>
<th>Yr 2 K</th>
<th>Yr 1 N</th>
<th>Yr 1 P</th>
<th>Yr 1 K</th>
<th>Yr 2 N</th>
<th>Yr 2 P</th>
<th>Yr 2 K</th>
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<tbody>
<tr>
<td>Imports</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Feed</td>
<td>3.91</td>
<td>2.42</td>
<td>0.45</td>
<td>0.47</td>
<td>1.72</td>
<td>0.99</td>
<td>37</td>
<td>21</td>
<td>4</td>
<td>4</td>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td>Fertilizer</td>
<td>5.84</td>
<td>2.85</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.75</td>
<td>55</td>
<td>25</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7</td>
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<td>Animals</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>0.03</td>
<td>0.02</td>
<td>0</td>
<td>0</td>
<td>0.05</td>
<td>0.05</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total Imports</td>
<td>9.78</td>
<td>5.29</td>
<td>0.45</td>
<td>0.47</td>
<td>1.77</td>
<td>1.79</td>
<td>92</td>
<td>46</td>
<td>4</td>
<td>4</td>
<td>17</td>
<td>16</td>
</tr>
<tr>
<td>Exports</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk</td>
<td>3.74</td>
<td>3.18</td>
<td>0.67</td>
<td>0.57</td>
<td>1.19</td>
<td>1.01</td>
<td>35</td>
<td>28</td>
<td>6</td>
<td>5</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>Animals</td>
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<tr>
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<td>5.35</td>
<td>0.78</td>
<td>0.89</td>
<td>1.22</td>
<td>2.85</td>
<td>39</td>
<td>47</td>
<td>7</td>
<td>8</td>
<td>11</td>
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<tr>
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<td>-0.1</td>
<td>-0.3</td>
<td>-0.4</td>
<td>0.55</td>
<td>-1.1</td>
<td>53</td>
<td>-1</td>
<td>-3</td>
<td>-4</td>
<td>6</td>
<td>-9</td>
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</table>

Emphasis in recent years on N and P-based nutrient management plans and recommendations have visibly impacted the nutrient balance of both dairy operations. P import/export is nearly balanced at both farms. The purchased feed rations are high in crude protein or N and are limited in P. The livestock on both farms are more than likely receiving their P from ensiled crops grown on the property. These crops are tapping into high amounts of P built up in the soil from previous years and from P existing in spread manures; therefore, P fertilization from commercial sources is non-existent. The high protein feed rations may make it easier for N import/export to become unbalanced and over fertilization of N on fields more likely. Farm A operators have both herd nutritionists and soil fertility consultants to help maximize nutrient efficiency in both the livestock and the crops. This has helped to produce a system that is nearly balanced nutritionally; therefore, both environmentally and economically profitable. In the first
year of the budget, Farm B’s high use of commercial fertilizers created a large excess of N. The N balance when only considering feed and milk were similar between both farms, but farm B imported almost 4 times more commercial N fertilizer than farm A and does not have any substantial exports outside of the milk. This is a situation that is easily identified and corrected using whole farm nutrient budgeting.

The primary nutrient flows of both dairy systems were in the feed (import) and the milk (export). In both systems when the budget was restricted to just these two sources nutrient import/export was nearly balanced. Therefore, in theory, the amount of fertilizers imported onto the farm should supply nutrients lost through inefficiencies in the system. This information suggests that emphasis should be placed on manure management to reduce nutrient losses to the environment, accurately evaluating crop nutrient needs and soil nutrient supply, and reducing inefficiencies in cropping systems through innovative practices and technology.
Virginia No-Tillage Alliance (VANTAGE)

VANTAGE was organized in 2008 in the Shenandoah River Valley with the primary goal of promoting no-tillage crop production and to help farmers successfully implement no-till practices through shared ideas, technology, conservation, and education. The organization was developed to be farmer-run and farmer-oriented, and to serve as a place where those with years of no-till experience can share their knowledge with those new or emerging no-till producers.

Three capstone annual meetings have taken place, which have allowed for both state and nationally recognized no-till farmers and experts to attend as speakers. In addition to these speakers, the annual meeting allows for the presentation of the crop production research taking place in the region, access to local agribusinesses showcasing no-till products and equipment, and farmer-to-farmer forums where no-till producers can discuss problems and solutions in their implementation of no-tillage crop production.

The first annual meeting took place in February of 2009, and had nearly 300 farmers and agribusiness and agency representatives from all across the region attend. The keynote speaker for the event was Dr. Jill Clapperton, a world-renowned soil microbiologist from Montana. After Dr. Clapperton’s presentation, a panel of three Pennsylvania dairy farmers with over 100 years of no-till experience between them led a question and answer forum with the audience. Chris Lawrence, NRCS agronomist, then gave a very compelling demonstration of soil loss from no-till and continuously tilled soil using an innovative rainfall simulation unit. The first annual meeting closed with presentations given by Virginia’s top no-till farmers, David Hula and David Black. Both are known for the tremendous yields (over 300 bu/acre of corn) they are producing in no-till management. Overall, the meeting covered topics ranging from the importance of soil health, the impacts of residue cover on the soil, and discussion of many problems and solutions in no-tillage management.
The second annual meeting took place in February of 2010. Attendance was slightly less than the previous year; however, attendance was beyond expected since severe weather was observed in many areas within the region before and during the conference. Input from farmers during the year leading up to the event indicated an interest in no-till equipment set-up and cover crops. Therefore, two keynote speakers were selected for the event, Phil Needham and Steve Groff.

Phil Needham is well-known in the nation in no-till small grain production, and has given numerous presentations nationally and worldwide. He gave two presentations at the conference: optimizing equipment for no-till production and maximizing fertilizer use efficiency in no-till crop production. Steve Groff quickly gained national recognition with the showcasing of his farm and farming practices in multiple agricultural magazines. He has also been a pioneer in using cover crops in no-till systems. His presentation at the conference covered the implications of tillage radishes in no-till systems.

The second annual conference also included presentations from Roger and Brad Almeter, operators of a large dairy operation in western New York and are currently practicing zone-tillage on 1700 acres of cropland. Their presentation covered efficient manure management strategies in no-till. Also at the conference were numerous representatives from agribusinesses showcasing current no-tillage equipment and innovations. Overall, the conference included presentations on effective equipment set-up, fertilizer strategies, cover crops, and manure management in no-till systems.

The third annual VANTAGE meeting took place in February of 2011. For the first time this meeting included “break-out” sessions, which allowed for more presentations during the day and gave attendees exposure more exposure to information relevant to their no-tillage questions. Ed Winkle and Paul Jasa were the keynote speakers for the meeting. Ed Winkle is owner of HyMark consulting in Ohio, and he gave an introductory presentation on no-till systems and how to make them work and on alternative cover crops and cover crop management. Paul Jasa is an extension engineer for the University of Nebraska and is well-known in the Midwest for his information on no-till equipment. His presentations included optimizing no-till seeding equipment and managing soil structure, compaction, and water in no-till systems.
Presentations also given at the third annual conference included: fertility management for no-till systems with a focus on transitioning to high residue systems by Dr. Mark Alley, W.G. Wysor Professor of Agriculture at Virginia Tech; and, no-till vs. tilled erosion research results from North Carolina with a live rainfall simulator demonstration by Dr. Charlie Raczkowski, soil scientist and adjunct professor at North Carolina A&T, and Chris Lawrence, NRCS cropland agronomist. Two question and answer panels also took place at the meeting. The first was led by Dr. David Holshouser, associate professor at Virginia Tech; Ed Winkle; Tim French, Rockingham Cooperative; John Hoffman, Brinkley and Hurst; and Paul Jasa on successfully seeding soybeans into heavy residue in the Shenandoah River Valley. The second was a manure injection panel led by Richard Fitzgerald, NRCS agronomist; Dr. Rory Maguire, assistant professor at Virginia Tech; Anthony Beery, cooperating farm operator; and Lewis Horst, Shen Valley Customs. Also included at the third annual conference was a large trade show by agribusinesses focusing on no-tillage equipment and products.

The annual VANTAGE conference is a capstone event where attendees can have access to informative speakers and presentations; however, this is only a portion of the organization. Numerous field days and educational events throughout the Shenandoah River Valley are hosted or co-hosted by the organization during the year. These events present more detailed information on many components within no-tillage agriculture. The organization is also serving as a forum connecting both established and beginner no-till farmers.

Currently, there is no membership for VANTAGE and is open to the public; however, a future goal for the organization is to develop a membership system that includes additional benefits for members. These benefits may include: reduced registration, travel, and lodging fees for national no-till meetings; group travel to educational events outside of Virginia; a VANTAGE newsletter distributed at key agricultural times during the year; and more.
Educational Events and Publications

Major Conference and Meetings

Professional Crop Advisers of the Shenandoah River Valley. January 2010. Harrisonburg, VA 75 attendees. Presentations covered all aspects of continuous no-till and challenged these farm advisers to be pro-active in working with growers to utilize no-till and improved practices for fertilizer and manure management.

Third Annual Virginia No-tillage Alliance Conference—Feb. 8, 2011, Rockingham Co. Fairgrounds, Harrisonburg, VA. 265 farmers, government and industry personnel were in attendance. 1,150 individuals, agribusiness companies, and government offices were made aware of the meeting directly through mail, phone, or e-mail correspondence. Announcements of the meeting were published in 5 agribusiness newsletters and 2 local newspapers. Speakers from Nebraska, Ohio, North Carolina, and Virginia gave presentations ranging from fertility management in No-Till systems to optimizing planting equipment. Break-out sessions were added to this year’s meeting agenda to allow attendees more selection of information. The audio from each presentation was recorded. Recordings will be linked with the specific presentation and will be made available on the VANTAGE website (http://www.valleycrops.cses.vt.edu/VANTAGE/2011.html). A detailed agenda of the meeting was given to all attendees and included pertinent publications or a detailed summarization of each presentation (Agenda can be found on website listed above). Posters demonstrating the demonstrations and research being conducted in the Shenandoah Valley with results and recommendations were on display. Over 17 exhibitors were present to provide information and demonstrations on no-till equipment, products, and practices.

Planter and Drill Clinics — March 2011. 2 sessions were held, one in Augusta county and one in Rockingham Co. Demonstrated common problems with drills and planters that lead to low plant populations, less cover, and lowered yields with emphasis on how to correct these problems in practical, cost effective ways. 34 farmers attended.

Weed Management in Continuous No-till. March 2011. 2 sessions were held in Augusta and Page counties to review weed management strategies for maintaining productive continuous no-till. 45 attendees.

Second Annual Virginia No-till Alliance Conference. February, 2010. Harrisonburg, VA. Presentations by nationally known speakers from universities, USDA-ARS, and farmers on selected aspects of continuous no-till. 315 attendees.

Vantage manure injection discussion group—Nov., 2010, Dayton, VA. 15 industry and government personnel were in attendance for this adaptive management program. Reviewed the conservation and economic benefits to manure injection in continuous no-till production systems and discussed possible adaptive approaches needed in our demonstrations to develop greater adoption of manure injection by growers.
Slug Management: July, 2010. Tours were held of two sites to evaluate the effectiveness of slug bait in reducing crop damage in no-tillage management. Results from the study have been used in the development of presentations and fact sheets, and the procurement of a pilot cost-share program for the use of slug bait in no-till corn and soybeans within the Shenandoah watershed.


Building better cropping systems in Virginia---May, 2010, Mauzy, VA. 52 attendees.

Manure Management for the 21st Century and Variable Rate Technology---Jan., 2010, Verona, VA. 70 attendees. Professional crop advisors update. This meeting brought together individuals who work directly with growers on all aspects of crop production.

Farm Tour of Cover Crop Plots---Nov., 2010. 12 attendees. Demonstration of aerial seeded and replicated cover crop plots. This work is coordinated with NRCS and the Shenandoah Resource and Conservation District.

*Cover Crop Meeting held in Pennsylvania---Oct., 2010. Extensive information presented on topics specific to cover crop management in no-till hosted by Cover Crop Solutions. *Transportation, lodging, and registration fees were made available for VA farmers desiring to attend the meeting (40 VA attendees).

First Annual Virginia No-till Alliance Conference. Harrisonburg, VA. Presentations by nationally known speakers from universities, USDA-ARS, and farmers on selected aspects of continuous no-till. Local board of Virginia farmers elected to direct the program. 385 attendees. This was initiation of the farmer to farmer mentoring program.

**Demonstration and Study Sites**

Manure Injection: Three sites were established in the Spring of 2010 in Weyers Cave and Dayton, VA. All were harvested for silage in late Summer/early Fall of 2010 and results were summarized and disseminated to appropriate groups.

Farm scale demonstrations with manure injection both for individual farmers and for custom manure haulers was identified as the next necessary step in providing growers with information to adopt liquid dairy manure injection and thus maintain continuous no-till crop production. Meetings were held with interested farmers and custom manure haulers and agreements developed for one farmer to do a large scale demonstration, at least 100 acres, of manure injection, and for a custom manure hauler to do injection demonstrations on at least six farms. These demonstrations are being planned and the equipment put together for this to happen in spring 2011.
Cover Crop: A field scale demonstration site was established in Mauzy, VA and included a large selection and combination of cover crop types and varieties as well as varying management strategies. The site was included in a VANTAGE and NRCS/USDA field day. Corn was planted upon cover crop termination in the Spring of 2010. Varying rates of N were applied to the corn at sidedress. The plots were harvested for grain and results were summarized. Soil samples taken at intervals during the lifespan of both the cover crops and the corn were analyzed for nitrate. This information will help to identify the amount and timing of plant available N released into the soil system from cover crops, and will lead to enhanced cover crop and cash crop management by growers. A second cover crop site was established in Edinburg, VA. This site was established by aerial seeding and served as both a replicated study site and a demonstration site for a VANTAGE field day.

Liquid Nitrogen Injection: Two sites were established in Middlebrook and Stuarts Draft, VA. Urea Ammonium-Nitrate solution was used to fertilize corn at sidedress by surface or injection application. Nitrogen rates varied as to identify N rate responses in corn growth. Corn ear-leaf tissue samples, grain yield, and corn stalk nitrate samples were taken from each plot at each site. Results have been summarized and will be added to information gathered from sites established across VA over the last three years. This will enable proper UAN management recommendations to be developed and shared with growers for the purpose of enhancing N fertilizer use efficiency and reducing potential losses to ground and surface waters.

be the largest nutrient import with fertilizer trailing in a distant second. Milk was by far the largest nutrient export at both operations. Detailed results have been used to model nutrient flows to and from the operations, and have been used by the participating operations to identify inefficiencies in their nutrient management. Whole farm nutrient budgets have continued for a second budget year at both operations and will conclude April 15, 2011. These data will be shared with growers and advisers to improve awareness and opportunities for increasing nutrient use efficiencies and decreasing nutrient buildup on farms.

Demonstration and Development of Farmer to Farmer Mentoring – Activities Specific to Mr. Robert Clark, Extension Agent Senior

1. Scouted corn and soybean fields for slug damage in continuous no-till. Activities through mid July 2011 included the following:
   a. 3,083 acres of corn and soybean enrolled.
   b. 230 extra acres scouted during scouting season.
   c. 3,102 Total Acres scouted at this time, a few late plantings still need to be scouted.
   d. 211 acres either not planted or fields were disked.
   e. 244 of the 3,022 acres were authorized for slug bait.
   f. Installed three test plots to evaluate the benefit of controlling slugs either using slug bait or Lannate (an insecticide that is promoted as having the ability to kill slugs).
i. Bridgemont Farm: One corn plot that has both Lannate and slug bait treatments in replicated plots.
ii. Bridgemont Farm: a corn plot that is Lannate treated and not treated plots.
iii. County Farm: a soybean plot that is Slug Bait treated and not treated replicated plots.

2. Pit Fall Traps: This was an extra part of the project added on due to the wet conditions and late planting. After speaking to experts from Virginia Tech and Ohio University, we decided to put out pitfall traps to look for beneficials (bugs that eat slugs). The experts said ground beetles and spiders are two beneficials to look for. The pitfall traps were constructed by using a soil auger and placing a solo cup in the hole with a water soap mixture. All traps were placed in enrolled no till fields. The samples have been preserved and will be identified later in the year.

3. I am actively pursuing the potential of establishing a demonstration farm in Shenandoah County to promote and educate farmers about continuous no-till cropping systems.

4. Attended a Mid Atlantic Regional High Residue IMP Work Group meeting in Delaware. The meeting served as a technical update session and a meeting to establish priority goals for finding solutions to slug issues in no till cropping systems.

5. Secured a location for an on-farm research plot to study alternative cover crops for continuous no-till. Will work with Dr. Wade Thomason on these plots.

**Demonstration and Development of Farmer to Farmer Mentoring – Activities Specific to Mr. Matthew Yancey, Extension Agent**

1. Twenty farmer consultations to test nitrate levels in no-till corn fields on 97 fields.
2. Twelve farmer consultations to evaluate issues related to no-till row crop and forage management.
3. Four meetings discussing no-till crop establishment in soybean and corn, and manure injection technology, with 116 participants.
4. Presentation at High Residue Integrated Pest Management working group meeting in Newark, DE and paper written to support presentation.
5. Installation of seven on-farm field test plots analyzing nitrogen usage, cover crops, slug management, soybean production, and corn hybrid selection.

**Gaining Ground Video and Virginia No-till Alliance Logo**

1. Video completed and reviewed, video features farmers as part of the farmer to farmer mentoring objective of the project.
2. Collaboration with NRCS
3. Distribution of almost 5000 copies has occurred.
4. New logo for the Virginia No-till Alliance and the new website have been completed.
**Manure Injection Large-scale Demonstrations**

Two large scale, i.e. more than 100 acres, have been put in place by a large dairy farmer and a customer manure hauler. These demonstrations are being tracked for time of application, cost, and durability of equipment.

**Whole Farm Nutrient Budgets**

Two years of whole farm nutrient budgets for two farms has been completed and will be used during the winter meetings by extension and NRCS personnel.

**Farmer Surveys – Follow-up to Initial Survey**

Surveys were sent to over 1200 farmers to determine their adoption of continuous no-till practices. This was a follow-up survey to compare no-till adoption at the beginning of the project and near the end. The surveys have been summarized and information is available in his report.

**Winter Annual Conference 2012**

Planning for the winter 2012 conference has begun. Venue and lead speakers have been secured. Conference will be held at the Fairgrounds at Harrisonburg, same as in the past. Attendance has been between 250 and 400 in the past three years.

**Gaining Ground Video and Website**

Our project enabled Virginia Cooperative Extension to partner with the Natural Resource Conservation Service, the Virginia No-till Alliance, the Virginia Forage and Grasslands Council, the Shenandoah Resource Conservation and Development Council, the New River-Highlands Resource Conservation and Development Council and the Downstream Project to make and distribution the Gaining Ground Video and website.

http://www.gaininggroundvirginia.org/index.php/video/gaining-ground-successful-no-till-farmers-tell-their-stories/ The video is has farmers telling their views about continuous no-till, efficiency of production, and improvement in soil quality. Over 3000 copies have been distributed in Virginia.

Support was also provided to develop the Virginia No-till Alliance Website that can be found at http://virginianotill.com. This site contains links to publications and other resources and has been shown to be effective among our more innovative growers.

**Publications**


Shenandoah River Valley Crop Producer Surveys

Surveys sent to crop producers in the Shenandoah River Valley in spring of 2007 and winter of 2010 were used to develop effective methods of delivering information about cropping practices and technology to crop producers, and then to gauge the impact of programs, demonstrations, and research developed under this project on the farming practices utilized by these crop producers. The initial survey included questions that allowed us to determine the majority of cropping systems, tillage use, who producers receive their information from, and how they would prefer to receive their crop production information. The final survey was similar to the initial survey in that general crop production information was gathered, but was specified to only production during the period of the project. The final survey also included questions to estimate the effectiveness of the VANTAGE program and related educational events, as well as the current status of no-tillage crop production adoption in the area and what factors may be impeding the adoption of no-till.

Initial survey results represented 98,485 acres of corn, soybean, wheat, rye, barley, alfalfa, grass hay, and pasture from 295 responses (A breakdown of the acreage for each crop is given in Table 11). A majority of the responses (47%) were from Rockingham county, 30% from Augusta, 11% from Shenandoah, and 13% from Frederick, Page, Warren, and Clark counties combined. The responses indicated a majority (21%) of the row crops being grown are as continuous corn followed by either a winter cover crop or small grain silage. Only 5% of the respondents indicated they grow continuous corn without any winter cover crop or small grain silage. Corn/soybean or small grain/corn rotations represented 14% of the responses, where corn/soybean or small grain/alfalfa rotations represented 11% of the responses. The rest of the respondents indicated they grew either continuous pasture (24%) or continuous hay (22%).

Approximately 13% of the survey respondents who grow row crops indicated they “always” use some form of tillage. Of these, 3% always use a moldboard plow or chisel plow, 5% always use a disc, 3% always use a shallow surface tillage tool, and 2% always use a deep ripping implement. Tillage was used “sometimes” in the cropping
system by 60% of the respondents. Only 17% of the respondents indicated they used continuous no-tillage cropping systems.

Table 11. Initial survey crop acreage totals and by county.

<table>
<thead>
<tr>
<th>County</th>
<th>Corn</th>
<th>Soybean</th>
<th>Wheat</th>
<th>Rye</th>
<th>Alfalfa</th>
<th>Grass</th>
<th>Pasture</th>
<th>Other</th>
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<tbody>
<tr>
<td>Augusta</td>
<td>6967</td>
<td>1652</td>
<td>871</td>
<td>1731</td>
<td>1782</td>
<td>1862</td>
<td>5619</td>
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<td>3088</td>
<td>1706</td>
<td>2181</td>
<td>4860</td>
<td>7300</td>
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<tr>
<td>Shenandoah</td>
<td>2042</td>
<td>913</td>
<td>305</td>
<td>333</td>
<td>93</td>
<td>220</td>
<td>1975</td>
<td>3397</td>
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<tr>
<td>Frederick</td>
<td>1616</td>
<td>1100</td>
<td>242</td>
<td>166</td>
<td>40</td>
<td>167</td>
<td>1685</td>
<td>2132</td>
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<td>162</td>
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<td>1535</td>
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<tr>
<td>Warren</td>
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<td>0</td>
<td>75</td>
<td>75</td>
<td>0</td>
<td>182</td>
<td>222</td>
<td>417</td>
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<tr>
<td>Clark</td>
<td>1885</td>
<td>588</td>
<td>300</td>
<td>12</td>
<td>0</td>
<td>100</td>
<td>210</td>
<td>499</td>
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<tr>
<td>Total</td>
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<td>8213</td>
<td>2932</td>
<td>5439</td>
<td>3783</td>
<td>5147</td>
<td>16106</td>
<td>31147</td>
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<tr>
<td>Total (as %)</td>
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<td>3%</td>
<td>6%</td>
<td>4%</td>
<td>5%</td>
<td>16%</td>
<td>32%</td>
</tr>
</tbody>
</table>

Initial survey results indicate the most frequently used source of information for crop production was from seed, fertilizer, or crop protection advisors (54%). Virginia Cooperative Extension (VCE) agents accounted for 15% of responses, and 12% of respondents chose neighbors as their primary source of information. Less than 12% of respondents chose feed/nutrition advisors, DCR personnel, NRCS personnel, and Soil and Water Conservation Service personnel as their primary source of crop production information. Six percent of respondents chose “other” as their primary source of information.

A majority of respondents (49%) indicated they would prefer to receive crop production information as a hard-copy newsletter. Approximately, 25% preferred local meetings, 14% preferred field days/demonstrations, 6% preferred an e-mail newsletter, 3% preferred a website, and 2% preferred regional meetings.

From the initial survey results, we were able to outline the common crop production practices in the area of the project, where a majority of the production was taking place, and determined the most effective method in delivering information to producers. Since a key source of information was found to be from seed, fertilizer, and crop protection advisors a major emphasis was placed on train-the-trainer events and meetings.
Though 49% of respondents indicated they would prefer to receive crop production information as a hard-copy newsletter, the time requirement for the development and distribution of a newsletter was not feasible. However, many hard-copy publications from VCE were made available at a large majority of educational events and field days. Field days, demonstrations, and local meetings were determined to be the best option when informing area crop producers on innovative advancements in crop production, current research, and new equipment and methods for no-tillage production. A regional meeting was also determined to be beneficial since a larger venue and attendance would facilitate the appearance of nationally-known guest-speakers, more demonstrations of no-tillage equipment from manufacturers/dealers not in the region, the coverage of topics in no-tillage not typically reviewed at smaller meetings, and better government and industry personnel attendance.

Results from the final survey conducted in the winter of 2010 provided members of the project an opportunity to evaluate the performance of the educational programs and research developed for project. The number of respondents, counties, crops grown, and crop acreage represented in the final survey were very similar to the initial survey (Figure 16), therefore, we can infer that many of the differences between initial and final survey results may be directly related to the programs and research within this project.
The portion of the surveys that was of most interest to us was the amount of tillage and no-tillage management taking place in the project region. A major focus of this project was the introduction of innovative solutions to problems commonly associated with no-tillage management to crop producers; therefore, we expected to see a larger amount of final survey respondents indicate they are using no-tillage crop production compared to the initial survey. Results were well beyond expectations, where adoption of no-tillage management increased 58% from 17 to 75% of the crop acreage represented in the survey. This result was extremely positive for the programs developed for this project that had never been introduced in the region, such as train-the-trainer events and the VANTAGE organization.

Table 12. Percent of respondent farms in each county of the Shenandoah River Watershed and percent of respondent acres in corn, soybeans and small grain production for the initial and final surveys.

<table>
<thead>
<tr>
<th>County</th>
<th>Farm Location</th>
<th>Crop Acreage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial†</td>
<td>Final</td>
</tr>
<tr>
<td>Augusta</td>
<td>30 31</td>
<td>Corn 39 52</td>
</tr>
<tr>
<td>Clark</td>
<td>2 3</td>
<td>Soybeans 18 19</td>
</tr>
<tr>
<td>Frederick</td>
<td>4 2</td>
<td>Small Grains 39 29</td>
</tr>
<tr>
<td>Page</td>
<td>6 3</td>
<td></td>
</tr>
<tr>
<td>Rockingham</td>
<td>47 45</td>
<td></td>
</tr>
<tr>
<td>Shenandoah</td>
<td>11 14</td>
<td></td>
</tr>
<tr>
<td>Warren</td>
<td>1 2</td>
<td></td>
</tr>
</tbody>
</table>

†295 respondents to initial survey and 308 respondents to final survey

Adoption of no-tillage crop management during the project period was very high, but there were some respondents that indicated their continuous adoption was being impeded by specific problems. Approximately, 26% of these respondents indicated “getting a good stand” was major impediment, 19% were impeded by weed control, 16% were concerned with slugs, and 13% were limited by equipment costs. Concerns regarding disease management, insect management, soil compaction, fear of reduced yield, and “other” were selected by respondents; however, these make up only a combined 25% of all concerns selected by the respondents.
The final survey also included questions regarding the popularity and attendance of the project’s keystone organization, VANTAGE. Approximately, 42% of the respondents had heard of the VANTAGE program; however, only 14% of all respondents had attended a VANTAGE meeting. Optimistically, of those that had attended a VANTAGE meeting 90% indicated information from the meeting was a direct influence in their adoption or consideration in adoption of no-tillage management. The VANTAGE program was efficient at introducing crop producers to information that resulted in their adoption of no-tillage; however, it was apparent that the initial advertising strategy of the organization was not sufficient. This information has been very useful, and advertisements of the annual VANTAGE meeting were increased as a direct result.

Overall, the results from the initial and final surveys allowed the project members to develop effective strategies in delivering information on no-tillage management and innovations in crop production practices that are environmentally responsible and economically feasible. This was validated by the extraordinary increase in no-tillage management adoption during project. Results from the final survey has also allowed us to identify the concerns that producers have with no-tillage, and has led to more specific educational events and field days that recognize and provide possible solutions to these problems.