Sustainable Chesapeake

Virginia Subsurface Application of Manure (SAM) Initiative

Background:

Poultry litter is highly regarded as a fertilizer resource and used by farmers as an organic fertilizer throughout the country. Typically, poultry litter is spread on the soil surface, where the plant-available nitrogen component is vulnerable to volatilization. Also, nitrogen and phosphorus associated with surface-applied poultry litter can be washed off of farm fields by rain. Low-disturbance poultry litter injection compatible with no-till production places poultry litter nutrients below the soil surface, in the root zone where they are needed by growing crops. Compared to no-till systems where manure is surface applied, low disturbance injection reduces stratification of nutrients in the top few inches of the soil, increasing plant availability and reducing risk of loss to surface waters. Injection also prevents fine poultry litter dust drifting in the wind behind the application equipment, which typically happens with surface spreaders. Significant reduction in odor has also been reported where poultry litter is injected rather than surface applied.

However, injecting dry poultry litter is technically challenging. While commercial-scale technologies that can inject liquid manure are widely available on the market and used on farms throughout the region, there are no commercially available technologies that can inject poultry litter. Material handling issues present significant barriers to the development of injection technologies: poultry litter does not “flow” well, it is not homogeneous with respect to moisture content or particle size, and it can include things like rocks and trash that can clog injectors.

Given the potential environmental and agronomic benefits of injection, land grant university researchers are leading efforts to develop commercial-scale poultry litter injection technologies. Prototype units suitable for field trials and research (Subsurfers) have also been developed. Initially, these prototype units experienced significant performance challenges. In the Subsurfer owned by Virginia Tech, problems included overheating of hydraulic oil, tunneling of poultry litter over augers, augers not turning with full load of litter, and bending/ breaking of augers with long term use.

In anticipation of the eventual development of commercial-scale poultry litter injection technologies, the purpose of the Virginia Subsurface Application of Manure (SAM) project was to improve performance of Virginia Tech’s Subsurfer and use it to conduct field trials with results shared through outreach and education events to lay the foundation for expanded adoption of poultry litter injection in the Shenandoah Valley region and elsewhere in the Chesapeake Bay watershed.

The project team included: Dr. Rory Maguire and Doug Horn (Virginia Tech), Richard Fitzgerald, Lydia Fitzgerald, Megan Comfort, and Chris Lawrence (Virginia Natural Resources Conservation Service), Jimmy Crosby (Cros-B-Crest Farms), Mike and Susan Phillips (Valley View Farm), and Kristen Hughes Evans and Ginna Morris (Sustainable Chesapeake).

Poultry Litter Injector Equipment Modification

Based on the recommendation of partners, the project team contracted with a well-respected local machinist with decades of experience in agricultural equipment fabrication, Mr. Kenneth Knicely. Over the first several years of the project, Mr. Knicely worked to improve performance of the Subsurfer. He addressed multiple design problems as follows:

Overheating of the hydraulic oil. Mr. Knicely determined that overheating was caused by plumbing the hydraulic pumps in series. As a result of this and undersized hydraulic hoses, the oil pressure was 2,100 PSI when the augers were turning with the injector empty. This compares to a maximum pump pressure capacity of 2,200 PSI. Therefore, most of the 70HP from the tractor PTO was going to building excessive pressure and to the oil overheating, leaving little remaining oil pressure to turn the augers.

To address this problem, he installed a splitter that applied oil to the pumps individually. There were also two, 20 gallon per minute pumps funneled through the T-Jet controller that had a maximum capacity of 30 gallons per minute. Additionally, the original 14 ft. long augers were cut down to 30 in., and a drag chain was installed to supply litter to the shortened augers at the front of the injector.

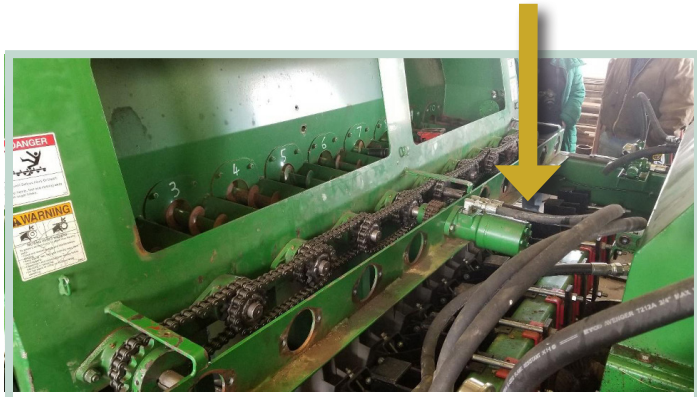

Photo above: Arrow indicates the one remaining hydraulic motor which turns all 10 shortened augers, via the newly installed chains attached to the front of each auger. Previously there were 10 of these hydraulic pumps plumbed in series, which caused excessive hydraulic pressure and overheating of the hydraulic oil. Under the old system the hydraulic pressure was an excessive 2,100 psi with no litter in the bed, with only the one pump it is estimated to be a much more reasonable 300 psi.

Because of these modifications, only one hydraulic motor is needed to turn all 10 of the shortened 30 in. augers. With the reduced hydraulic oil flow for only one pump instead of 10, the current ¼ - ½ inch hydraulic hoses were sufficiently sized. Hydraulic oil flow now requires one of the 20 GPM pumps to turn the augers, and one to move the drag chain.

Photo above: The 14 ft. augers required excessive hydraulic power to function effectively. The augers have been cut down to about 30 in. at the front of the bed of the injector to maintain their metering and grinding functionality, while a drag chain was installed to do the majority of the litter movement with minimum energy (photo below).

Photo above: Drag chains move litter from the back of the Subsurfer to the augers in the front.

Inconsistent Delivery of Poultry Litter to Augers. Instead of augers, drag chains were installed to move the litter from the bed of the Subsurfer to the injectors. Drag chains normally move forward in the bed of manure spreaders, then back underneath the spreader. However, this is not possible with the structure under the current Subsurfer. Therefore, the drag chain moves back about 8 in. *above* the chain that is moving forward. This has the added benefits of helping to break up any lumps in the poultry litter, and preventing buildup of litter at the front of the injector if the chain is moving litter faster than the augers. The drag chain overlaps most of the 30 in. augers, preventing any tunneling of the litter above them.

Technical Performance

Early performance evaluations were conducted in partnership with Kenneth Knicely and Jimmy Crosby (Cros-B-Crest Farm). In the last year of the project, field trials were hosted by Mike and Susan Phillips, owners of Valley View Farm.

Early performance evaluation identified issues with the drag chain performance. After additional repairs, the Subsurfer is working to inject poultry litter and mechanical flow issues have been addressed. However, there are still technical difficulties related to controlling the flow rate of litter. Specifically, keeping the application rate consistent across the field is a challenge. The auger speed control system did not work properly. At start-up, a steady flow of litter was delivered to the augers. However, once the front quarter of the hopper was below the top chain, litter was delivered to the augers in surges, resulting in inconsistent application across the fields, with some areas receiving too much litter and others receiving little to none.

While the discharge mechanism for delivery to each disk opener has proved to be very effective and efficient, re-design is needed to ensure a consistent delivery of poultry litter to the injection mechanism.

Partners also noted that technical performance with the Subsurfer is dependent on the litter's moisture content, consistency and the amount of foreign matter (non-litter objects like trash, rocks, etc.).

Poultry litter injection on Mr. Kenny Knicely's farm.

Field Trials

The purpose of the field trials was to determine how injected litter compared with broadcast litter and commercial fertilizer with respect two goals:

- Increasing biomass of tall fescue used to extend grazing timeframe for cattle through the winter months.
- Increase plant-available nitrogen available to corn through injection in the fall to mixed species cover crops.

Despite the performance challenges, the project team was able to use the Subsurfer to inject litter into tall fescue in the fall of 2021 and into a mixed species cover crop prior to spring planting in the spring of 2022. Additionally, given that the design of the Subsurfer for injecting the litter into the soil and covering the seed functions much like a no-till drill, Mike Phillips and Megan Comfort experimented with mixing cover crop seed with poultry litter prior to injection. They recognized that injecting cover crop seed and litter in one pass would save time, fuel, equipment wear and tear, and compaction. Care was taken to mix the seed and litter together to achieve a two bushel per acre seeding rate of Triticale with 2 ton of litter per acre.

Aerial view of field plots installed at Valley View Farm.

Field Trial Observations:

With only one year of data, the project team is still in the early phases of data collection and planning to conduct additional field trials in the coming years. However, the team has observed the following:

- Ammonia toxicity was not a concern with litter and seed mixed prior to injection.
- The germination of the fall crop seed mixed with the litter was not negatively affected from the addition to or mixing with the seed, however, the team does recognize that typical no-till drills are designed with 7-in. centers, while the injectors are on 10 in. centers, raising the question about cover crop stand coverage compared to drilled or broadcast seeding.
- Nitrogen implications:
  - Injected litter provided approximately 50 units of plant-available nitrogen and was enough to support good fall and winter growth with Triticale tiller counts exceeding 100 tiller per square ft. at growth stage 25.
  - Tissue sampling at growth stage 30 indicated a 40-60 lb. nitrogen need for the injected litter.
  - Pre-sidedress nitrate tests indicated a need for 70 pounds of side-dress nitrogen. The corn responded immediately after the nitrogen application.
- Stockpiled poultry litter stored in a poultry shed and "aged" for 3-4 months had the best consistency and maximized performance of the Subsurfer. The Subsurfer is currently very sensitive to higher moisture litter. This is a challenge for any design. Poultry litter injectors need to be able to handle litter in the 20-35% moisture range. Using poultry litter is also a concern, as this material is not uniform in particle size. Letting litter age in a static pile in the storage shed helps to address consistency concerns.

Mike Phillips demonstrating corn productivity after poultry litter injection.

Outreach:

Mike and Susan Phillips hosted a field day event at Valley View Farm on May 5, 2022. Attended by 150-160 farmers, conservation professionals, and local students, the field day featured liquid injection and showcased field trials with the poultry litter injector, as well as soil health and grazing system demonstrations.

Mike Phillips and Megan Comfort also spoke with a local Ruritan Club about the project. Many in the audience were farmers; they appreciated the potential for reduced odor and drifts associated with surface-applied litter and encourage Phillips and Comfort to continue this work.

Additionally, Sustainable Chesapeake coordinated with the Delmarva Land and Litter Collaborative to host a webinar featuring land grant university partners working to develop a commercial scale poultry litter injector on February 25, 2022.

Members of the project team at the May 5, 2022 field day event featuring poultry litter injection field trials. From left to right, Kristen Saacke Blunk (Sustainable Chesapeake Board Member), Richard Fitzgerald (Virginia Natural Resources Conservation Service), Doug Horn (Virginia Cooperative Extension), Kristen Hughes Evans (Sustainable Chesapeake), Megan Comfort (Virginia Natural Resources Conservation Service) and Mike Phillips (Valley View Farm).

Next Steps:

The project team is enthusiastic about the role poultry litter injection technologies can play in making small farming operations more sustainable. Litter injection provides opportunities for improving soil health and water quality, and reducing input costs. To achieve these goals, the team recommends the following:

- Prioritizing support for land grant university research and development efforts with the goal of developing a poultry litter injection system feasible for commercial use.
- Rather than investments in the existing Subsurfer, which has structural flaws that limit additional improvements, the team is enthusiastic about building or acquiring a Subsurfer that can be used to continue field trials at Valley View Farm in the coming years.
- Additional field trials replicated over multiple years will produce more concrete, quantitative numbers on injection vs broadcast– yields, nitrogen dynamics and commercial fertilizer requirements. To date, the team has little data to support recommendations for application via poultry litter.
- Determining whether injection will allow for more flexibility in the timing of poultry litter application to stockpile tall fescue. Usually, manure is applied to tall fescue in early August, but this time of year can be very hot and dry. Injection might allow for application during unfavorable weather conditions. Injection should also increase the window of time you can apply litter and prevent environmental losses.
- The team also sees opportunities in developing both commercial and small-farm (or research-scale) systems that achieve multiple agronomic goals in addition to poultry litter, such cover crop planting, lime application, and spraying. Smaller and commercial-scale systems that serve multiple agronomic goals may offer another path for expanded adoption of poultry litter injection. Note that the current subsurfer coulter spacing is 9-10 inches, which is wider than most drills. Spacing should be considered with future engineering options to achieve a broadest use of the equipment.
- Additional research on whether injecting litter can improve nitrogen mineralization estimates is valued by the project team. Because injected litter is less vulnerable to weather variability than surface applied litter, nitrogen release may be more predictable.
- Additional research on the value of shifting planting dates for summer crops and subsequent impacts on nitrogen use efficiency, pest pressure, and profitability are of interest. The team recognizes that this practice would keep the soil covered longer through the year, with more living roots, adding more surface residue without negative effects to final corn or soybean yield. Actively growing roots would occur 365 days with the delayed planting of corn. Heavy residue from the corn stalks would armor the soil through the winter, in preparation for early planted soybeans. This would allow a better window to get the mixed species cover crops established and provide an opportunity for increased growth that can be used as “feed” for livestock and soil microbes.

- The team recognizes that a holistic approach is needed to achieve small farm sustainability goals and envisions Valley View Farm as a center for innovation and education in the Shenandoah Valley. The Phillips have opened their farm as a living learning laboratory for small farms to nearby high schools and universities and are enthusiastic about hosting future field trials to evaluate the agronomic benefits of poultry litter injection in a cropping system designed to maximize soil health, productivity, and farm profit.

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Leadership from Jimmy Crosby (Cros-B-Crest Farm) and Mike Phillips (Valley View Farm) has been critical to the success of this project. Dr. Rory Maguire with Virginia Tech worked closely with Mr. Kenneth Knicely to improve performance of the Subsurfer, and Doug Horn, with Virginia Cooperative Extension, helped to inform equipment modification and establish field trials. Richard Fitzgerald, a nutrient management planner with the Natural Resources Conservation Service, helped with field trials and nutrient management analysis. Lydia Fitzgerald, Chris Lawrence, Debbie Bullock, and Alan Hawkins with the Virginia Natural Resources Conservation Service have provided guidance, oversight, and have helped Sustainable Chesapeake successfully administer this grant. The project team also appreciates the leadership and guidance from Dr. Josh McGrath in helping to inform equipment modifications and for leading land grant university efforts to develop a commercial scale poultry litter injector.

Valley View Farms

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