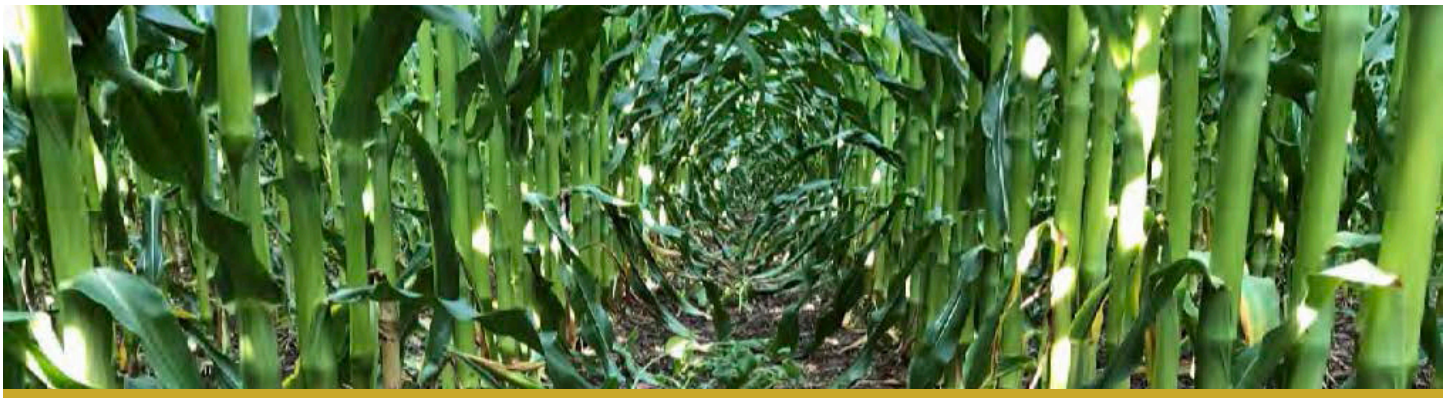
Sustainable Chesapeake



Demonstrating an Innovative Commercial-Scale Roller/crimper for High-Biomass Cover Crop Termination

Background:

My goals for this project were to improve soil structure, reduce chemical and fertilizer inputs, and preserve soil moisture by using a roller/crimper to terminate high biomass rye cover crops. I had tried a chevron style roller before and found it completely useless when rolling covers with hopes of laying covers down flat and terminating them. I first learned about the USDA Agricultural Research Service's roller/crimper, designed by Ted Kornecki and Corey Kichler, at a USDA-funded regional cover crop conference in North Carolina in July of 2016. I was impressed by the roller/crimper's ability to terminate cover crops without herbicides, laying it down flat where it created a mulch that covered the soil surface.

In 2017, I worked with Ted and Corey to conduct field trials on Cedar Plains Farm using a 6-ft. roller/crimper (three gang crimper) prototype. I was very pleased with the results and assembled a team to help secure funding to design, build, and evaluate a 30-ft roller/crimper prototype with hopes that the technology would benefit my cover cropping system and be useful for other commercial grain farms in the region. I worked with Sustainable Chesapeake, a non-profit that works with farmers to expand adoption of conservation practices, and applied for a $75,000 grant from the Virginia Natural Resources Service Conservation Innovation Grant program for the project. The project team also included Dr. Ted Kornecki and Corey Kichler (USDA Agricultural Research Service), my agronomist (Tim Woodward, Tellus Agronomics), Dr. Michael Flessner and Cynthia Sias (Virginia Tech), and Keith Balderson, Chris Lawrence, Lydia Fitzgerald, Dwight Forrester, and Debbie Bullock (Virginia Natural Resources Conservation Service).

FINAL REPORT BY

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Roller/crimper Design and Performance Evaluation

In the winter of 2019/2020, Ted Kornecki and Corey Kichler redesigned the roller/crimper to commercial scale (12-row, 30 ft.) roller/crimper similar to the dimensions of planters used on my farm and others in the region. I received the roller/crimper on a flatbed on May 6th, 2020 and put it together in a few days (figure 1). I began rolling May 13th and while I was able to use the roller/crimper to terminate cover crops on 274 acres in the spring of 2020 and 438 acres in the spring of 2021, there were multiple mechanical issues.

Figure 1. Fully assembled roller/crimper (2020)

Unfortunately, the double gang, straight bar configuration and the spring tension generated so much aggressive down force that some of the equipment's components couldn't handle the strain. The main frame was extremely heavy duty and other than a few alignment concerns, held together fine. Everything else broke: bolts, tension rods, 2 x 2 tubing welds, all of the rod welds on every crimping drum (these broke multiple times), all of the torsion connections broke (and required re-engineering), all of the crimping drums continually slid in their bearing holders and either fell out, or if caught in time, needed to be realigned. I had poly plates fabricated to help reduce rod wear and breakage. In addition to mechanical failures, cover crop wrapping around the crimping drums, especially at the bearings was a major problem (figure 2).

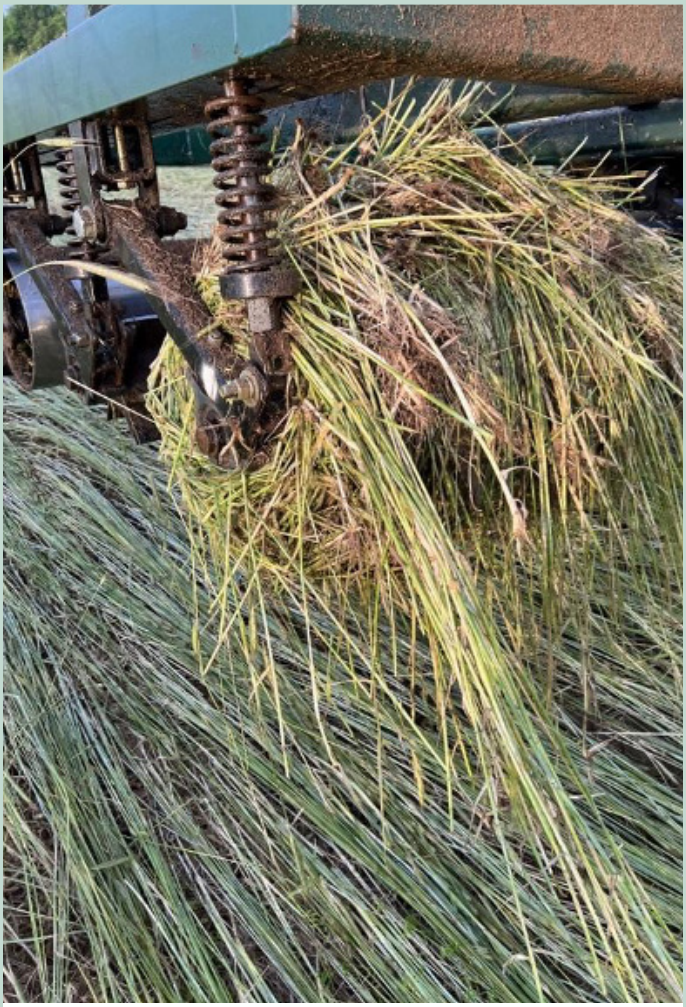

Figure 2. Crimping against the grain and on angled ends causes severe wrapping that required extensive downtime to address.

In the first and second year, the roller/crimper was a 4-hour machine: use it for 4 hours and work on it for 4 hours. It was extremely difficult and time consuming to operate. Since I rolled before planting, my farming operation was impacted greatly by the continued breakdowns of this implement.

In the winter of 2021 and 2022, I worked with Corey and Ted to re-design the roller/crimper with a staggered bar pattern on the crimping drum. Before, the straight bars created a tremendous vibration force.

Figure 2 cont.

After Corey's redesign, I took it to a local fabrication shop where they reconfigured the straight bar pattern to a three staggered bar pattern, which reduced the force on the equipment. This change improved the durability of the machine tenfold and allowed me to roll cover crops on 511 acres in the spring of 2022 with no breakdowns. There were stresses and some reworking needs to be done, but the redesign helped considerably.

While the last round of design and repairs improved performance, my conclusion is that the equipment still needs work before it is ready for commercial use. For example:

- The width of the machine (18.5 ft) makes transport on roadways in my area extremely difficult (figure 3).
- The hydraulic distribution was very uneven making pick up and lowering unpredictable.
- Wrapping of cereal rye stems is a major concern. With this design, you cannot roll against the grain or severe wrapping can occur, especially if wet or on an angled row end. GPS is required to get the rolling and planting to match up as it needs to.
- I couldn't turn with the roller on the ground as the crimping drums would become misaligned in their bearing hangers or fall out of the bearing hangers that hold them in place. I had to carefully lift the main frame and each wing up when turning around to prevent wrapping and alignment issues.
- Because of the hydraulic unevenness and the downward tilt of the wings, the implement can wrap with material or dig into the ground at each turn.
- Standing rye could not be crimped in between each section, as they are all joined in a straight line. I have tried multiple deflectors but nothing has solved this problem. As a result, strips of rye were left standing in the field.
- Row cleaners, in my opinion, are necessary if planting after 6ft tall rye has been rolled by this machine. Soybean cotyledons had difficulty getting above the rolled material and struggled to grow well. Row cleaners are a huge issue, especially on end units, if they go against the grain. Severe wrapping and premature bearing failure occurred.

Figure 3. With an 18.5 ft width, travel on narrow country roads was difficult and dangerous.

Although there were multiple design problems, I was able to successfully roll cover crops (figure 4a, 4b, and 4c). This solid roller in front and the two gang crimping drum roller configuration did successfully lay all cover crops down flat and in the case of 6ft tall rye, kept it down by terminating growth. Flat cover crop is soft to plant into and can help increase row unit ride quality, thus increasing planter performance.

Figure 4a. Ideal outcome for roller/crimper used to terminate high biomass rye. This total combined equipment alignment was difficult to achieve.

Figure 4 b. Roller/crimper used to terminate 6 ft tall, high biomass rye prior to planting.

Fig. 4c. Corn emerging from rolled rye.

Field Trials

Given improvements made to the equipment in the last year of the project, I worked with the project team to conduct field trials to answer the following questions:

- What are the weed suppression benefits of managing spring cover crops with a roller/crimper prior to planting? Does rolling cover crop prior to planting reduce the need for herbicide application?
- What impact does the timing of rolling have on crop emergence, stand, and overall production?
- What effect does high-biomass rolled rye cover crop have on the temperature and moisture retention of the soil?
- What is the impact that cover crops and the use of a roller/crimper to manage cover crops have on crop emergence efficiency?
- What effect does rolled vetch have on the soil temperature, soil moisture retention, and crop productivity?

After only one year of implementation, I don't have definitive results from the field trials to report. However, I think additional field trials would help me and other farmers better understand opportunities and drawbacks with rolling cover crops.

Lessons Learned

When I first decided to go this route of rolling/crimping cover crops, I had imagined the ease of rolling (and hopefully killing) my covers and planting into them directly afterwards (which I already knew I could do). Easy. Turns out there is more to consider when planning for rolling cover crops:

Consistency across the field. Cover crop stand consistency across the field is a priority for maximizing the benefits of cover crops. Inconsistent cover crop stands result in inconsistent weed distribution, soil moisture, and nitrogen availability, and ultimately lead to inconsistency in the cash crop. The establishment and consistency of cover crops needs to be a high priority if one is to expect to gain full value from a cover crop. Treat it as you would any cash crop that you grow. A hole or weak spot in your cover is no different from the economic loss you feel with a weak spot in your cash crop. There is a price to pay with not giving it your full attention.

High biomass rye and weed control. Established in the fall, tall high biomass rye provided weed control in the late fall and winter, reducing weed growth and overall pressure. I went into the spring in a much better position than fields with no cover. Without the high biomass rye, the fields have well-established weeds that can quickly overtake us in the spring.

Importance of planting on time. A program that is too complicated can interfere with planting. All of the energy/time I used in getting our rolling and planting to match up and the delays of unwrapping and adjusting our equipment took too much time away from the main focus, planting. Rolling and then planting takes time and people, both of which can be in short supply.

Cover crops genetics matter. I have been growing Wrens Abruzzi rye (6ft tall) for years and thought there was only one variety of Abruzzi rye and what I had was the correct/only option. Because of my lack of focus on the details of the Abruzzi rye (it was "just" cover crop) I did not really consider the maturity of the rye or how that might play into my management. I found out that our rye pollinated too early and when I was ready to plant, viable rye seeds were already in the fields and the roller-crimper could not kill them. There was way too much volunteer rye in the fields. This was a problem.

Timing of rolling high biomass rye. My best stands were achieved when planting directly into standing, green rye cover crops. The jury is still out on rolling vetch ahead of planting corn, but for rye ahead of soybeans, I observed the following:

- I have previously used a less aggressive chevron roller before planting and the cover crop bounced right back.
- Rolling directly after planting soybeans compacted the soil and reduced seed emergence — especially with this roller/crimper. However, planting into standing rye and then rolling when beans are small (by the first trifoliate leaf stage — within 21 days of emergence) was also problematic: this aggressive roller/crimper decreased the stand by 20%.
- Once rye was rolled down, the small weeds were covered but not completely shaded out which allowed them to slowly grow. This eventually led to undesirable weed pressure later on.
- Letting cover crops (vetch, rye) go longer (to flowering stage, just before seed production) improved biomass and weed prevention benefits.

Timing of rolling vetch cover crops.

- The roller/crimper may not be needed for planting corn into vetch (figure 5). Even with roller/crimper, the vetch came back up — especially if planting was delayed (e.g., due to weather). Taller vetch (like 3 ft) should probably be rolled to help with evenness of planting mat/ride quality and potentially aid in the uptake of chemicals to help kill cover but with shorter vetch, rolling is hit or miss.
- Planting green: In the future, my plan is to plant into vetch (rolled and not rolled dependent on stand), then spray herbicide soon after corn is planted so the corn can emerge through the vetch.

Figure 5. Rolling vetch before planting.

Rolling soybeans. I tried planting soybeans directly into the standing rye, and then rolled the cover crop after the soybeans emerged (2nd and 3rd trifoliate) with the goal of promoting branching and growth. It took a while for the soybeans to recover, and they did not grow as tall, but they branched out leading to more internodes, more flowers, and more soybean pods. Planting into rye and then rolling after the soybeans emerged increased biomass from the cover crop and improved weed control and other benefits. This also expanded the planting window. Good biomass from the rye reduced weed pressure in this field, allowing me to eliminate pre-emergence weed control. After rolling, I waited for weeds to be exposed and then applied one application of herbicide before the soybean crop developed a good canopy. The high biomass of rye suppressed weeds early on and the soybean canopy suppressed weeds later in the season.

Timing of herbicide application. I don't have a silver bullet that gets me completely away from herbicides, but I have been able to reduce herbicides using a holistic approach that includes high biomass cover crops.

- The key was to spray herbicides before bean canopy prevented access to the weeds and before the weeds got too large. Weeds are more vulnerable to herbicides when they are younger.
- Killing cover crops early in the season when weather conditions aren't ideal can be problematic. For example, some herbicides don't work well below 50 degrees F. In my opinion, you are asking a lot from a residual herbicide if you expect it to get to the soil through a dense, high biomass cover crop, especially if sprayed under cool, cloudy conditions with little to no rainfall in the days that follow.
- The roller/crimper may have made some weed problems worse. Marestail (Horseweed) was severely damaged by the roller/crimper. But, like the soybeans, the damage led the plant to branch more and instinctively become stronger, which, in turn, made it harder to kill.
- Weeds damaged by the roller/crimper also recovered and were a problem later in the growing season.
- I now plan to plant soybeans into standing rye first, then roll the rye with a chevron roller shortly after soybean emergence. I'll wait for the weeds to be exposed, and then hit them with herbicide while the weeds are still small and before the cash crop canopies.

Using row cleaners and precision now seems like a hindrance more than a necessity. Why complicate this process? Some drawbacks of row cleaners include:

- Row cleaners are a breeding ground for weeds and lead to loss of soil moisture and can cause erosion. If you get a heavy rain after using a row cleaner, you have created a trench for rainwater to pool in. Soil erosion can build up on top of soybean seeds and compromise emergence or wash seeds out of the ground in sloped fields.
- With no row cleaners, I have ease of planting, I have a perfect stand, the beans aren't held back by the rye at all. If anything, planting directly into standing, green cover crops promotes the bean to grow taller a little bit early than it would otherwise.

Nitrogen management. Well-established hairy vetch cover crops provided significant nitrogen savings. With the price of nitrogen hovering around $1/pound, any available nitrogen from the vetch is highly cost effective. With high nitrogen costs, terminating hairy vetch too early can reduce nitrogen available later in the season. Alternatively, the breakdown of high biomass rye tends to hinder the release of available nitrogen to the following corn crop.

Combination small grain/legume cover crop. Mixed vetch (20 lbs) with wheat (1 bushel) performed well. It was nice to see a healthy green beautiful field throughout the year, instead of a skimpy, non-noticeable stand of vetch in the fall. My plan, much like Paul Davis (a well-respected farmer in my area), is to terminate the small grain (wheat) in the spring to maximize the benefit of grass in the fall for nitrogen scavenging and erosion control, which will allow the vetch to take off in the spring (March/April) and sequester nitrogen for the following corn crop. This approach avoids a yield drag when planting after a small grain. Dr. Flessner suggests that early termination of the small grain before it gets really lignified may improve the rate of decay and release of nitrogen in the spring. A good wheat stand will also serve as protection for vetch during winter cold snaps. This approach also maximizes weed control benefits.

Small grain will grow thick in the fall and prevent winter weed emergence, and high biomass in the spring will provide further weed control and allow the vetch to grow with less weed competition.

In conclusion, working with this roller/crimper and all of the supporting people that have helped by giving me guidance and latitude, I am now thinking the following: rather than focusing on any specific piece of equipment, I need to think about each field holistically and work with nature and my cover crops. I am now more focused on the importance of cover crop variety and maturity, planting when I want to, reducing chemicals when the opportunity presents itself, and adjusting when they are not. I am thinking it isn't necessarily about killing cover crops, but more damaging the covers at the end of their life cycle and allowing my crops to come through the covers while using the cover crop benefits as long as possible. With this approach, my weed program is now tailored to each specific field and subsequent weed populations and pressure.

Acknowledgements

Dr. Ted Kornecki and Corey Kichler with USDA Agricultural Research Service provided the inspiration for this project and the design for the commercial-scale roller/crimper. Tim Woodward, with Tellus Agronomics, has been my agronomic consultant for almost ten years. He provided a high level of expertise for the project and led efforts to collect and analyze field trial data. Drew Marsh, is my farm employee/mechanic and was in charge of equipment repair, welding, and fabrication for this project. Dr. Michael Flessner with Virginia Tech and Cynthia Sias (graduate student) helped collect field trial data. Keith Balderson, Chris Lawrence, Lydia Fitzgerald, Dwight Forrester, and Debbie Bullock (Virginia Natural Resources Conservation Service) provided guidance and support throughout this effort. Chris Lawrence encouraged me to apply to the Conservation Innovation Grant program to fund this project. Kristen Hughes Evans and Virginia (Ginna) Morris with Sustainable Chesapeake helped me to secure funding for this project and provided grant coordination and administration. Dr. Elizabeth Hodges helped to edit this report and Liza Bliss provided graphic design.

Cedar Plains Farm

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Funding for the project was provided by the Conservation Innovation Grant program through the Virginia Natural Resources Conservation Service. Matching funds were provided through Cedar Plains Farm, LLC, Sustainable Chesapeake, The Keith Campbell Foundation for the Environment, and the Virginia Environmental Endowment.