High-Residue Conservation Tillage for Row Crops

Although the conservation tillage unit at the NCSU Thompson Farm is currently on hiatus, a dedicated group continues to dig into this critical area of research. We are busily engaged in tactical operations behind the wire, and this is the first installment of what we hope will become an intermittent series of dispatches from the "underground" – reports on augmenting the crop rooting environment.

Farmers are always looking for ways to protect their soil and knock back weeds without reaching for more tillage or more herbicides. Nevertheless, we accept that modern agriculture relies on a diverse array of technologies and approaches to be successful and that, ultimately, it's the farmer who must decide upon the best mix. Our research program may be described as adaptive, where no *modus operandi* is taboo provided it boosts productivity, quality, income, sustainability, and is consistent with the principles of good land husbandry. In short, we are mavericks looking for solutions wherever, and in whatever guise they may be found. At the Center for Environmental Farming Systems (CEFS), we think we may have found a low-tech solution that achieves these outcomes: the mechanical roller-crimper.

The idea isn't a new one. Farmers in Brazil, Argentina, and Paraguay have long used hand-built rollers to manage thick cover crops under "zero-till" and "minimum-till" farming (Derpsch, 1998; Derpsch *et al*., 1991). The concept is simple: a heavy cylindrical drum rolls over a standing cover crop, flattening and crimping the stalks so they die and lie down in a neat, unbroken mat pointing the way the next crop will be planted. That mat becomes a protective mulch blanket. The idea of using crop residue itself as the main soil -protection and weed suppression tool is what we're testing here in the Southeast.

We stumbled onto the idea almost by accident. Between 1999 and 2002, we were running nitrogen studies on small grains at the Thompson Farm, and some plots were simply left alone: no harvest, no cleanup. The grain matured, fell over, and died in place, leaving a thick, dried canopy on the soil surface. Out of curiosity, we looked underneath it in early July and found almost no weeds. Plots nearby, where the grain had been cut and cleared, were covered in them. That contrast raised an obvious question: could the same effect be reproduced deliberately, in row crops like corn, cotton, and soybeans?

Around the same time, researchers from the National Soil Dynamics Laboratory in Auburn, Alabama, came back from trips to Latin America having seen exactly this kind of residue management in practice. They built prototype rollers and tested them in Alabama fields, with promising if limited results. That work sharpened the question further: could a roller-crimper be used on purpose to build a weed-

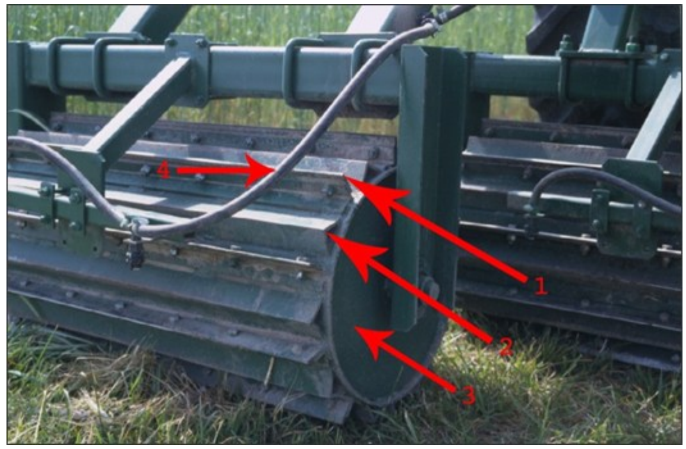

Figure 1. Mechanical roller-crimper built by Kelly Manufacturing Company (KMC), Tifton, GA. Arrows show principal parts of the roller: (1) crimper blade; (2) damping iron to reduce vibration; (3) drum roller w/end plug (not shown) allows user to fill drum with water to increase down pressure on crimper blade; (4) plumbing assembly to apply burndown herbicide.

suppressing residue shield — one that protects the soil at the same time it's smothering weeds?

Gardeners have known the value of a thick mulch layer for generations; what we're doing is essentially extending that same principle to full-scale row-crop agriculture. Our goal is to see whether this kind of high-residue, low-till system can also help with problems that go beyond weeds, like soil carbon loss, crusting, compaction, and the risk of short, dry spells during the growing season. However, there's still a lot we don't know about how intensified, full-season cropping might affect soil moisture, fertility, disease, and insect pressure over the long run.

What follows is a look at the goals, methods, and early results from NCSU's first mechanical roller trial in 2004, with a full two-year data summary available [here] for anyone who wants a deeper dive.

Objectives

The goals of this early-stage research were to evaluate weed suppression, residue management, and soybean and cotton lint yield response a in high-residue, low tillage system to test: (1) the physical effect of surface pressed, intact residue and residue orientation on early-season weed suppression using different weed control programs; (2) the relationship between residue decomposition and incident weed pressure; and (3) the effect of residue management on soybean and cotton stand establishment, growth, and yield.

Methods

The studies was conducted at the North Carolina Department of Agriculture Cherry Farm Unit in Goldsboro, NC. The cover crop plots were initiated in fall 2003 by drill-seeding a small grain winter annual grass (rye cv. 'Abruzzi') at two locations with similar weed management histories, field C-9 (cotton) and field C-10 (soybean). The soil at both sites was mapped as nearly level, well-drained and moderately permeable Wickham sandy loam. Prior to rye growth termination, residue cover density was estimated using 0.5 m^2 quadrats. Rye growth was terminated mechanically or with glyphosate at 1.75 L /ha, and the standing rye residue flattened using one pass of the roller-crimper (**Figure 2**). The mechanical roller was built to our specifications by the Kelly Manufacturing Company, Tifton, GA. in 2003.

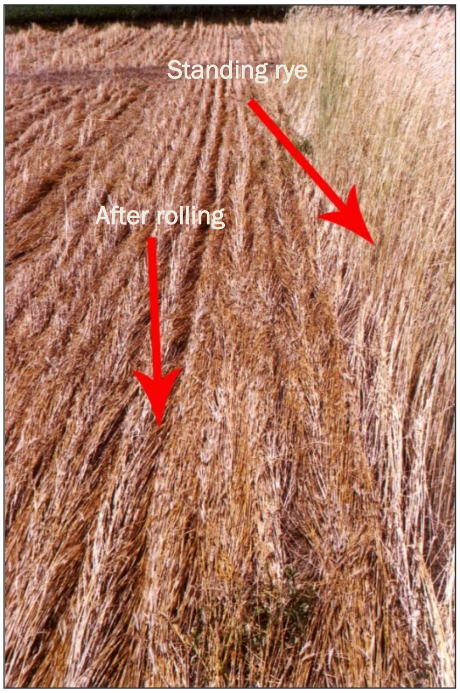

Figure 2. Winter annual rye cover crop after one pass with the KMC mechanical roller. Residue pressed on the surface and oriented in the direction of planting may aid growers in managing high density residue loads.

The roller drum was 46 cm in diameter x 203 cm wide. Crimper blades, consisting of mild steel angled 90° with dimensions of 0.635 cm in thickness x 5.7 cm height, were mounted 18 cm apart around the circumference of the drum. The drum was attached to the toolbar via parallel linkages, which in turn attached to the tractor via a category II 3-point hitch. Optional tank and spray brackets were included but not used in this application. Before rolling, the drum was filled approximately ½ full of water via two threaded plugs installed on either ends of the drum.

Full-season soybean (Pioneer 95B97) was planted on 14 May 2004 using a six-row John Deere Maximerge vacuum planter calibrated at 334,300 seeds ha^{-1} (8 seeds/ft) on 76-cm (30 inch) rows. Cotton (DP 451) was planted on 17 May 2004 using a four-row planter calibrated at 119,170 seeds ha^{-1} (3.5 seeds/ft) on 96-cm (38-inch) rows. Weed management programs included: (1) rye residue + no herbicide; (2) rye + glyphosate only for burndown; (3) rye + glyphosate + pre-emergent herbicide; (4) rye + glyphosate + pre + post emergent herbicide. All plots were planted no-till except in cotton, where a rip-strip treatment was included. A clean-till treatment and one no-till treatment that excluded the roller, was used for comparison in both trials.

Weed counts were taken at planting and at 2 and 4 weeks post-emergence at three points alone a diagonal transect in each plot. Total weed biomass was measured at lay-by. Residue decomposition was evaluated by placing folded, intact residue in 2-mm nylon mesh bags at rates equivalent to field conditions and retrieved at 2, 4,6, 8, and 16 weeks after planting. Plots were also sampled for soil moisture to 45 cm deep in the untrafficked interrow. A randomized complete block design with four replications was used for statistical analysis of the weed counts, biomass, soil moisture, and yield data in both trials.

Results

In 2004, cotton (**Figure 3** and **Figure 4**) and soybean (**Figure 5**) were successfully established in the rolled cover crop residue. Stands for both crops were reduced in the rolled residue mainly due to lifting of the planter's gauge wheels in places where the residue was unevenly distributed. Rye residue production averaged 4.97 Mg/ha (4,420 lbs/acre) in cotton and 7.01 Mg/ha (6,253 lbs/acre) in soybeans. Mechanical rolling alone was not as effective at terminating rye growth as glyphosate. When good weed management was achieved, soybean and cotton lint yields in the rolled treatments were about equal to conventional clean-till. However, reducing herbicide inputs resulted in a yield penalty. Weed surveys conducted at two and four weeks after planting showed early establishment of several important weed species where herbicide inputs were either reduced or eliminated despite a lack of soil disturbance and heavy mulch cover.

Decomposition of the rye residue followed an exponential decay function with approximately 70% of the original residue decomposed at 16 weeks after planting.

Overall, highest lint yield was obtained by rolling and ripping combined with pre-and post-emergence weed control. Despite above-average rainfall during the growing season in 2004, sub-soiling a Wickham sandy loam combined with weed control increased cotton lint yield by nearly ½ bale per acre over no-tillage alone.

Interpretive Summary

Early results indicate that row crops can be adapted successfully to high residue conservation tillage systems using the mechanical cover crop roller. We found that neither high residue density (2-3 tons/acre) nor residue orientation suppressed annual or seedling perennial weeds enough to counter the need for supplementary early-season herbicide application, or cultivation, or some combination, for weed management. Overall, weed germination was encouraged wherever the ground was disturbed, including such minor breaches caused by wheel traffic and row markers. As shown in **Figure 6**, it's difficult to completely avoid soil and residue disturbance even under so-called 'zero tillage' conditions.

Figure 3. No-till cotton directly planted in rolled rye residue.

Figure 4. Strip-tilled cotton, early post-emergence in mechanically rolled rye residue.

Figure 5. Soybean directly planted in mechanically rolled rye.

Figure 6. Weed germination in the furrow cut by Maximerge row marker.

A Final Note

High-residue, low tillage represents a small but growing worldwide trend toward cropping intensification to cultivate yield gains while reducing in-season weed pressure by extending the period of soil mulch cover. Our group is working in tandem with farmers, researchers, and extension personnel throughout the southeastern USA who recognize the benefit of squeezing pests off the production stage using innovative management approaches. When it comes to tinkering, farmers often lead the way (NRCS, 2002). Scientists and technical staff at places such as the National Soil Dynamics Lab in Auburn, Alabama, Rodale Institute, and the Natural Resource Conservation Service (NRCS) also are forging ahead with high-residue conservation tillage research.

Alternative roller design is one critical area of work that has been scrutinized by Kornecki *et. al*. (2005) at Auburn's Soil Dynamics Lab. As the photo gallery on page 5 reveals, mechanical rollers come in a lot of different designs, and that's by design. There's no single "right" way to build one. But every version is built around the same two goals: killing off the cover crop effectively, and handling a heavy load of residue without adding extra work for the farmer. In practice, that means no one roller design is likely to fit every situation. Instead, growers will probably end up adapting the tool to match their own cover crops, cropping systems, and equipment.

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Further Reading

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Torbert, H.A., J.T. Ingram, J.T. Ingram Jr., and R. Ingram. 2002. High-Residue Conservation Tillage System for Cotton Production: A Farmer's Perspective. *Ibid.*

Early drum-type roller built by NSDL, Auburn, AL.

Open blade Buffalo stalk chopper modified by Steve Groff, Cedar Meadow Farm, Lancaster County, PA.

Push roller for small farm or garden.

Larger open-blade chopper; inset: ground view of unit chopper.

South American drum roller.

South American drum roller detail.

Inset photo courtesy of Seth Dabney, USDA-ARS Sedimentation Lab, Oxford, MS.