High Residue Conservation Tillage for Row Crops

Though CEFS does not currently have a formal conservation tillage unit, 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 "under ground" – reports on our work that focus on the rooting environment.

The purpose of conservation tillage research underway at CEFS is to seek ways of overcoming soil physical and chemical constraints to root growth and, consequently, yield. In other words, how do we create a soil environment in which crops can express their genetic potential as free as possible from stress? This is, in a nutshell, the fundamental concern of soil management. To counter stress in the plant rooting environment we must employ an integrated program addressing the problems of soil erosion, crusting, compaction, moisture retention and storage, carbon fixation, and fertility. Tillage, in our view, is a disruptive and energy-intensive task that should be limited to modifying the soil to alleviate productivity constraints in the rooting zone.

Our research group also looks for ways to reduce off-farm purchased inputs as far as may be practical without sacrificing productivity. On the other hand, we accept the fact that modern agriculture relies on a diverse array of technologies and approaches to be successful and, ultimately, it's the farmer who must decide upon the best mix. Our research may be described as adaptive, where no *modus operandi* is taboo provided it boosts productivity, quality, income, and is consistent with the principles of good land husbandry. In short, we are mavericks looking for answers wherever, and in whatever guise, they may be found.

Our focus over the past few seasons has been to evaluate the mechanical roller-crimper as a residue management tool concurrently at CEFS and at the Upper Piedmont Research Station (Figure 1).

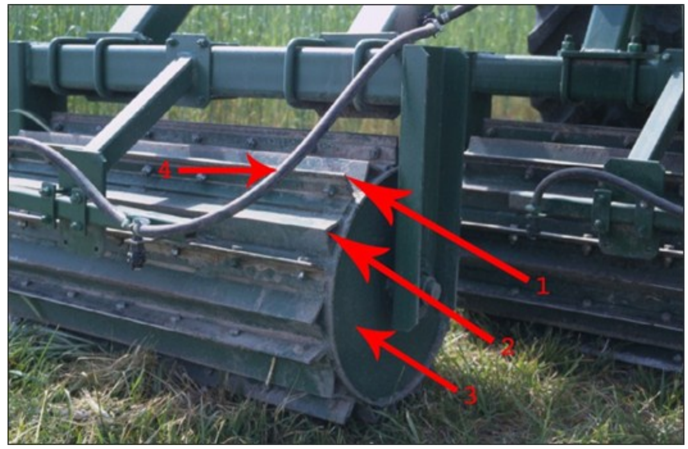

Figure 1. Mechanical roller-crimper built by Kelly Manufacturing Company (KMC), Tifton, GA. Arrows show principle parts of a roller: (1) crimper blade; (2) damping iron to reduce vibration; (3) drum roller w/end plug (not shown) allows user to fill drum with water to increase down pressure on crimper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

Mechanical rollers have long been used by farmers in Brazil, Argentina, and Paraguay to successfully manage high density cover crop residues in production systems using the guiding principles of 'zero' and 'minimum' tillage (Derpsch, 1998; Derpsch *et al*., 1991).

Basically, the roller-crimper uses the weight of a cylindrical roller to flatten and crimp standing cover crops, leaving a pressed, intact blanket of soil protective mulch oriented in the direction of planting. This has been termed *high-residue* conservation tillage (Lee et al, 2002; Reiter et al, 2002; Torbert et al, 2002). Although a precise definition of 'high-residue conservation tillage' has not been coined, it is defined herein as an agricultural production system consisting of: (1) limited or no-tillage; and (2) intensified production of crop and cover crop residues to maintain full soil cover prior to crop canopy closure. Initially, interest in the high residue concept was sparked by observations from soil nitrogen recovery studies with small grains at the Thompson Farm over the period 1999-2002. As happened, some of the small grain plots were left undisturbed, allowing the plants to mature and subsequently flop over and die. Wherever this had occurred, a perched canopy of dead residue covered the soil surface. Peering beneath this canopy one could see that few, if any, weeds had germinated as late as the first week of July. In contrast, plots where the small grain residue had been cut and removed were flush with weeds. The question arose: could this effect be duplicated in row crop production?

At about the same time, visits to Latin America by workers from the National Soil Dynamics Laboratory in Auburn, Alabama, brought home news of the use of residue rollers by farmers in Brazil. Prototype rollers were built and field tested in Alabama. Results were encouraging, but (at the time) limited in scope. These reports led to more questions: could residue rollers be used to create a closed canopy of residue on the soil surface? Would this canopy suppress early-season weeds *and* provide soil protection benefits at the same time?

The idea of high-residue conservation tillage itself is not new. Gardeners who use the deep-mulch method have been practicing high residue conservation tillage long before the invention of cover crop rollers. Our goal is to extend the deep mulch concept to address the problems of soil carbon loss, soil crusting and compaction, and reduction in the risk of short-term droughts in row crop production systems of the southeastern U.S. There's still much that is not known about the overall impact of high-residue conservation tillage systems on long-term soil moisture balance, fertility, weed, disease, and insect management. Following is a brief overview of the objectives, methods, and results with the mechanical roller in 2004. A detailed 2-year summary of this research is available here.

Objectives

The purpose of our current research is directed toward evaluating weed suppression, residue management, and soybean and cotton lint yield response a in high-residue conservation 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

Research was initiated in fall 2003 by establishing a small grain cover crop (rye cv. 'Abruzzi') at each of two sites with similar weed management histories, field C-9 (cotton) and field C-10 (soybean). Soil at both sites was nearly level, well-drained and moderately permeable Wickham sandy loam. Prior to rye growth termination, residue cover 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. Rye residue after one pass with the mechanical roller. Residue pressed on the surface and oriented in the direction of planting may aid growers in managing higher inputs of residue.

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 use, the drum was filled approximately ½ full of water via two threaded plugs installed on either end 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 then estimated 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. A randomized complete block design with four replications was used for statistical analysis of data in both trials.

Results

In 2004 cotton (Figures 3 and 4) and soybean (Figure 5) stands were successfully established in the rolled rye 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, yields for soybean and cotton lint in 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 an early establishment of weeds 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 management. Despite above-average rainfall during the growing season in 2004, sub-soiling a Wickham sandy loam combined with good weed management increased cotton lint yield nearly ½ bale per acre over no-till.

Interpretive Summary

Early results indicate that row crops can be adapted successfully to high residue conservation tillage systems using the mechanical cover crop roller. It appears that neither high residue density (2-3 tons/acre) nor residue orientation suppressed annual or seedling perennial weeds sufficiently to overcome the need for early-season weed management using herbicides, cultivation, or a combination of both. Overall, weed germination was encouraged by soil disturbance, 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 in rolled rye residue.

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

Figure 5. Soybean planted no-till in mechanically rolled rye.

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

A Final Note

High residue conservation tillage at CEFS represents a small but growing worldwide trend toward cropping intensification as a means of increasing yield and limiting opportunity for weeds by maximizing the period of residue-soil cover. Our group is working in tandem with farmers, researchers, and extension personnel throughout the southeastern U.S. 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 in high residue conservation tillage.

Alternative roller design is one critical area of work that has come under review by Kornecki *et. al*. (2005) at Auburn's Soil Dynamics Lab. As the photo gallery on page 5 shows there's a lot of inherent flexibility in the way mechanical rollers may be designed. However, the bottom line for roller design is two-fold (1) effectiveness of cover crop growth termination; and (2) efficiency in terms of managing greater input of residue without imposing greater time constraints on the grower. Experience is likely to point to no one particular design that fits all situations. Rather, growers are likely to adapt the roller to specific cover crop, cropping system, and field equipment situations.

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Further Reading

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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.

Detail of South American drum roller.

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