Organic Cover Crop-Based Rotational Reduced-Till Production: Making it Work for Wisconsin Farmers

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What is organic cover crop-based rotational reduced-tillage?

Cover crop-based rotational reduced-till production (CCRNT) (often referred to as organic no-till) is a production technique that involves the establishment of a cover crop, the mechanical termination of the cover crop at specific growth stages, and the seeding of a cash crop directly into the resulting mulch. This technique has been adapted to work in many of the row crop production regions in the U.S. and Canada, as well as in South America. The system that has been most widely researched and adapted to U.S. organic production systems involves the fall sowing of winter cereal rye, followed by rye termination and sowing of soybean the following spring. The system, while not allowing for a completely no-till organic system, significantly reduces the tillage and cultivation passes in the organic system, particularly in the soybean phase. While tillage does need to occur in the late summer/early fall to prepare the seedbed for rye planting, tillage does not need to occur in the spring prior to soybean planting. Additionally, while a typical organic soybean field may require approximately 3-5 cultivation events using tine weeders, rotary hoes, or row cultivators, this technique requires no cultivation during the production season; all weed management is achieved through the rye mulch itself.

CCRNT has multiple agroecosystem benefits. Cover crops provide the benefit of improving soil health, tilth, and water holding capacity. With a cover crop on the field throughout the fall, winter and spring, soil is protected against the erosion. The presence of the cover crop and its associated root biomass improve water infiltration through the soil. CCRNT has been demonstrated to impart fuel and labor savings to the organic production system. Additionally, CCRNT can increase the soil microbial biomass in these systems.

Establishing the cover crop

In the organic cropping systems of Wisconsin, the most common way to integrate CCBRT into row crop rotations involves the establishment of a winter rye cereal grain cover crop in the fall, the overwintering of the cover crop through the following spring, and the termination of the cover crop and planting of the soybean cash crop in the late spring. The cover crop must be planted in the fall earlier than a farmer might typically plant a rye cover crop in order to ensure adequate rye biomass at crimping, which, in turn, ensures adequate weed suppression. In addition to an earlier planting date, a heavier seeding rate of rye (3 bu/ac) also contributes to adequate biomass of the cover crop. The dry biomass of the cover crop should be in the range of 9,000 lbs/ac in order to create a thick mulch that provides a physical barrier during early crop growth to prevent sunlight

from reaching the soil surface and prevent weed seeds from germinating. To achieve this, planting of a cereal grain cover crop (including cereal rye) should occur by September 15 through September 30.

Photographs of 2015 CCRNT soybean fields planted into cereal rye (photos by Erin Silva)

Cereal rye cover crop biomass as influenced by year, planting date, and termination date. Rye biomass increased with later termination. Figure from Nord et al., 2011.

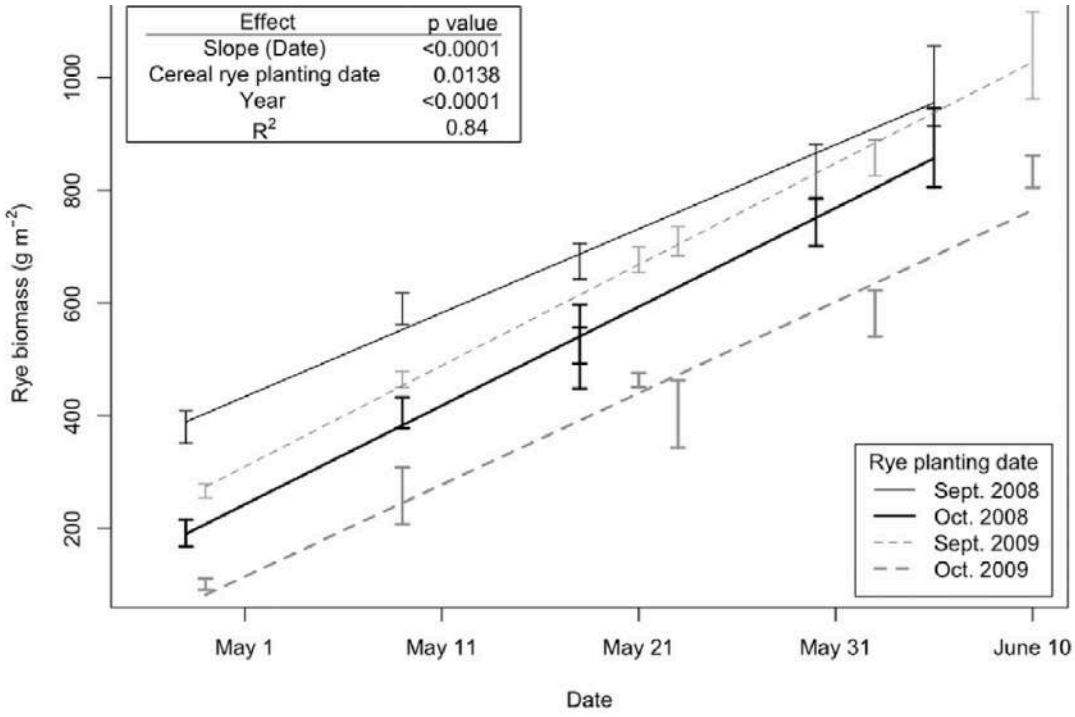

Figure 1. Front-mounted roller-crimper used to terminate cover crops and to create mulches.

Table 2. Mean cover-crop biomass as influenced by cultivar, planting date, and termination date main effects, pooled across years. Mean comparison was performed by crop (planting and termination date pooled), planting date (crop and termination date pooled), and termination date (crop and planting date pooled) independently, with different lowercase letters indicating significant differences ($P < 0.05$) using the Tukey–Kramer method.

Treatment	Biomass
	kg ha^{-1}
Crop	
Aroostook	7,259a
Wheeler	6,508b
Rye/hairy vetch	6,876ab
Planting date	
August 25	7,880a
September 5	7,904a
September 15	7,161b
September 25	7,016b
October 5	6,260c
October 15	5,066d
Termination date	
May 1	4,051a
May 10	5,809b
May 20	7,599c
May 30	10,066d

Table taken from Mirsky et al., 2011

Which species do I need to produce good mulch?

Several species of small grains, including winter wheat, winter triticale, winter barley, and winter rye, have been evaluated to determine their performance in CCRNT in Wisconsin. Winter wheat and winter rye more reliably overwinter in Wisconsin, and thus more reliably create a thick mulch biomass needed for effective weed control. Even with comparable biomass production, winter (cereal) rye consistently provides better weed suppression as compared to other small grain species, potentially due to allelopathic suppression of weeds. Of the varieties of cereal rye available, 'Aroostook' may provide an advantage as it mature of one to two weeks before of other rye varieties.

How can I terminate the cover crop?

Cover crops can be terminated with roller-crimpers and mowers. Several models of roller-crimpers have been designed, with modifications in size, weight, and other design factors. Typically, the roller-crimper is a ground-driven, hollow cylindrical drum with welded blades that crimps as well as rolls the cover crop. The drum can be filled with water to provide extra weight to the roller; depending on the width of the roller, weight of the unit can exceed 1000 lbs. The blades allow for "crimping", or crushing, the stem, which more effectively terminates the crop without completely slicing the plants. The Rodale Institute's version of the roller-crimper has been designed with these blades welded on the drum in a chevron pattern, which helps prevent the crimper from bouncing across the field and leads to more consistent termination across the field. Plans for this design can be found on the Rodale website www.rodaleinstitute.org/our-work/organic-no-till/no-till-rollercrimper-plans. I&J Manufacturing (Gap, PA) commercially manufactures the Rodale Institute design in various widths.

Termination of the cover crop can also be accomplished by mowing the cover crop when the cover crop reaches the growth stage of anthesis. A sickle-bar mower (versus a rotary type mower) works well for this purpose, as it lays the stems down onto the ground in a parallel pattern. As with the case of crimping, this allows for the planting disks to run parallel to the direction of cereal grin cover crop stalks, which requires less cutting of the residue than might need to occur otherwise. Generally, though, mowing the cover crops (rather than crimping them) leads to less even residue distribution onto the ground, creating gaps where sunlight can reach the soil surface and weed seeds can germinate.

Termination of the cover crop must occur at a very specific stage of cereal grain growth – at anthesis (flowering). The growth stage of anthesis corresponds with Zadok's growth stage 61 and can be easily observed in the field when pollen is visible on the cereal grain heads. Crimping before or after this growth stage poses the risk of cover crop regrowth after termination. Termination of the cover crop (either by rolling/crimping or sickle-bar mowing) should occur perpendicular to the direction of cover crop seeding in order to achieve the best ground cover by the mulch and elimination of sunlight from reaching the soil surface.

How do I need to modify my equipment?

Depending on spring conditions, soil conditions at planting may be wetter or drier than a neighboring typical tilled organic field. While the small grain mulch can serve to maintain soil moisture after it fully senesces approximately 2-3 weeks after termination, prior to this time, while it is still actively growing, the cover crop can remove moisture from the soil profile. This can be particularly an issue during drier springs; however, this can be an advantage in wetter springs, where excessive soil moisture can impact timely tillage and cultivation in organic systems, decreasing yields due to inadequate weed management. If the soil is very dry at the target planting date, it is best to wait until after rain to plant the cash crop in order to ensure seed-to-soil contact and seed germination.

It pays to take the time to adjust and/or your equipment to ensure optimal performance using this system. No-till drills and conservation planters can both work in this system; while the no-till drill set on 7.5 inch rows allows for quicker canopy cover, the wider 30 inch row spacing allows for a mid-season cultivation if weeds to break through the mulch and begin to be an issue. There also is some evidence that using a conservation planters may allow for more precision placement of the seed, creating a better stand of soybean. Seeding rate of soybean should target 225,000 seeds/ac.

Adding weights to the planter can help ensure good seed-to-soil contact and good stand establishment

What kind of yields can I expect?

Yields of organic soybean using CCRNT have been competitive with, and in several years comparable to, typically managed organic soybeans, reaching over 50 bu/ac. To reduce risk and best establish field conditions to reach these yields, it is critical to follow the guidelines outlined in this document: choosing fields with low perennial weed pressure; appropriate cover crop planting date at the correct seeding rate; termination of cover crop at the appropriate growth stage; re-adjusting plans if an early season cover crop assessment indicates poor cover crop overwintering; and adjusting/modifying planting equipment to ensure a good cash crop stand.

Yields of CCRNT Soybeans at the UW-Madison Arlington Agricultural Research Station

	Till (bu/ac)	**Cover Crop No-Till (bu/ac)**
2009 (Silva)	47	30
2008/2009 (Bernstein)	54	43
2011 (Silva)	52	53
2012 (Silva)		Crop failure due to drought
2013 (Silva)	50	45
2014 (Silva)	47	44

Figure 4. Excellent weed control by rolled-crimped rye (left), but mediocre weed control in typical tilled/cultivated organic (right). Note the height difference of the soybean of each of the two treatments.

How do I fit CCRNT in my crop rotation in Wisconsin?

There are a couple of different options to incorporate CCRNT in Wisconsin's organic crop rotations. The easiest options are available for livestock producers who grow silage corn and alfalfa; a potential rotation would be 3 years of alfalfa – silage corn – fall seeding of rye/soybeans – spring planted cereal grain (e.g., oats) - alfalfa. Another potential rotation, without alfalfa, could be corn – spring planted small grain (oats) – fall-seeded rye/soybeans – corn. The key is to proceed the rye/soybean phase with a cash crop that can be harvested in time to allow for a late September seeding of the rye.

Challenges observed with CCRNT organic production

Weed population shifting to perennial weeds

As is true in conventional no-till production, reducing tillage using CCRNT can shift weed populations, increasing the proportion of difficult-to-manage, perennial weeds in the system. This becomes especially apparent when CCRNT is used for more than a 2 to 3 year period (medium-term continuous no-till). Strategic tillage and diversified rotations,

particularly the inclusion of an alfalfa phase, can help reduce the risk of building up perennial weed populations in the field.

Problems with using hairy vetch

Whereas cereal rye is well adapted to the CCRNT in southern Wisconsin, hairy vetch has been more challenging. To ensure a vigorous stand, hairy vetch needs to be planted in late summer. Despite a early planting date, however, hairy vetch reaches the correct stage of maturity for reliable termination (100% bloom/early pod set) later than cereal grain cover crops, necessitating a late-June planting date of the cash crop. While there are some earlier maturing vetch varieties on the market (e.g., 'Purple Prosperity'), these varieties unfortunately do not have the winter-hardiness required for reliable over-wintering of the crop. Additionally, hairy vetch, due to incomplete termination and the presence of hard seed, can persist in a field, potentially becoming a weed issue.

Insect pests

Certain early season insect pests can be attracted to decaying cover crop residue and cause issues with stand establishment. We have particularly experienced issues with armyworms (*Pseudaletia unipuncta).* Armyworm primarily feeds on plants in the grass family, although they can attack some legumes and other plants in the absence of their preferred food source. Conventionally tilled corn is seldom damaged. First generation larvae active from mid-May to mid-June, can cause extensive defoliation to small corn plants, the same time of rolling/crimping and corn planting. This risk is particularly increased when trying to use CCRNT with cereal rye and corn, and less prevalent using the vetch/corn system. Armyworm has not been an issue on the UW-Madison research plots using cereal rye/soybean CCRNT systems. Other research sites, such as the Rodale Institute in Pennsylvania, have observed issues with cutworms impacting corn stands in CCRNT as well.

References:

Nord, E.A., W. S. Curran, D. A. Mortensen, S. B. Mirsky, and B. P. Jones 2011. Integrating Multiple Tactics for Managing Weeds in High Residue No-Till Soybean. Agron. J. 103:1542–1551.

Mirsky,S.B., W.S.Curran, D.M.Mortensen, M.R.Ryan, and D.L.Shumway. 2011. Timing of Cover-Crop Management Effects on Weed Suppression in No-Till Planted Soybean using a Roller-Crimpers. WeedScience 59:380–389.

YouTube Videos by Dr. Silva:

Using a roller-crimper for no-till organic soybeans:
https://www.youtube.com/watch?v=Aiocr_icrfw

Advances in organic no-till production in Wisconsin:
https://www.youtube.com/watch?v=UtxH4CJa-jk

No-till Organic Tips

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1. **Start small.** Organic no-till is a significant change for many organic farmers and conventional no-tillers alike. Try it out on a small scale to minimize risk.

2. **Choose wisely.** Select cover crops that are moderately priced, easily established, highly productive, and easy to kill. Choose fields with appropriate weed pressure – avoid perennial weeds.

3. **Don't skimp.** Get cover crops in the ground on time (cereal rye: mid-September to early-October) and at recommended seeding rates (3 bu/ac for cereal grains). Successful weed suppression requires a dense mat of cover crop residues.

4. **Alter planting strategies for cash crop**. Bump up the seeding rate of soybean (225,000 seeds per acre). Be sure to spend time setting the depth of the planter appropriately. Add extra weight to equipment if needed.

5. **Stay sharp.** Keep equipment in good shape. To plant through thick residue, planting equipment must be maintained in top condition. Invest the time needed to modify and adjust planting equipment.

6. **Plan ahead.** Due to the central role of cover crops in this system, planning must start far in advance of a given main-season crop. Order your seed and strategize how it will fit into your rotation in order to ensure an early planting date.

7. **Be flexible.** If the cover crop looks less-than-ideal in spring, be ready with a "Plan B". Re-assess the stand in late-April/early May – if the rye stand looks skimpy in certain areas of the field, incorporate those as a green manure and go with a typical weed management strategy.

7. **Be creative.** Organic no-till will need to be adapted to each farm's climate, soils, equipment, and resources. But with the principles in hand, many solutions are possible.