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 (CCBRT) (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., as well as in South America and Europe. The system that has been most widely researched and adopted within U.S. organic production systems involves the fall sowing of winter cereal rye, followed by rye termination and sowing of soybean during the subsequent spring. The system, while not completely eliminating tillage, significantly reduces the number of tillage and cultivation passes in organic production. While needed in the late summer/early fall to prepare the seedbed for rye planting, tillage is not required 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, CCBRT requires no cultivation during the soybean production season; all weed management is achieved with the rye mulch.

In addition to serving as a weed management tool, CCBRT 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 improves water infiltration through the soil. CCBRT has been demonstrated to provide fuel and labor savings to the organic production system. Additionally, CCBRT can increase the soil microbial biomass in these systems.

Figures 1 and 2. CCBRT fields at the University of Wisconsin Agricultural Research Station, 2015.

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 cereal grain cover crop (such as cereal rye) 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 cereal 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 achieving adequate biomass of the cover crop. The dry biomass of the cover crop should be in the range of 8,000 – 10,000 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 ideally occur by September 15 through September 30. Figure 3 and Table 2 illustrate the impact of both cereal rye planting and termination dates, with earlier fall planting dates and later spring termination dates leading to higher biomass at termination.

Figure 3. Cereal rye cover crop biomass as influenced by year, planting date, and termination date. Cereal rye biomass increased with both earlier fall planting date and later spring termination. Figure from Nord et al., 2011.

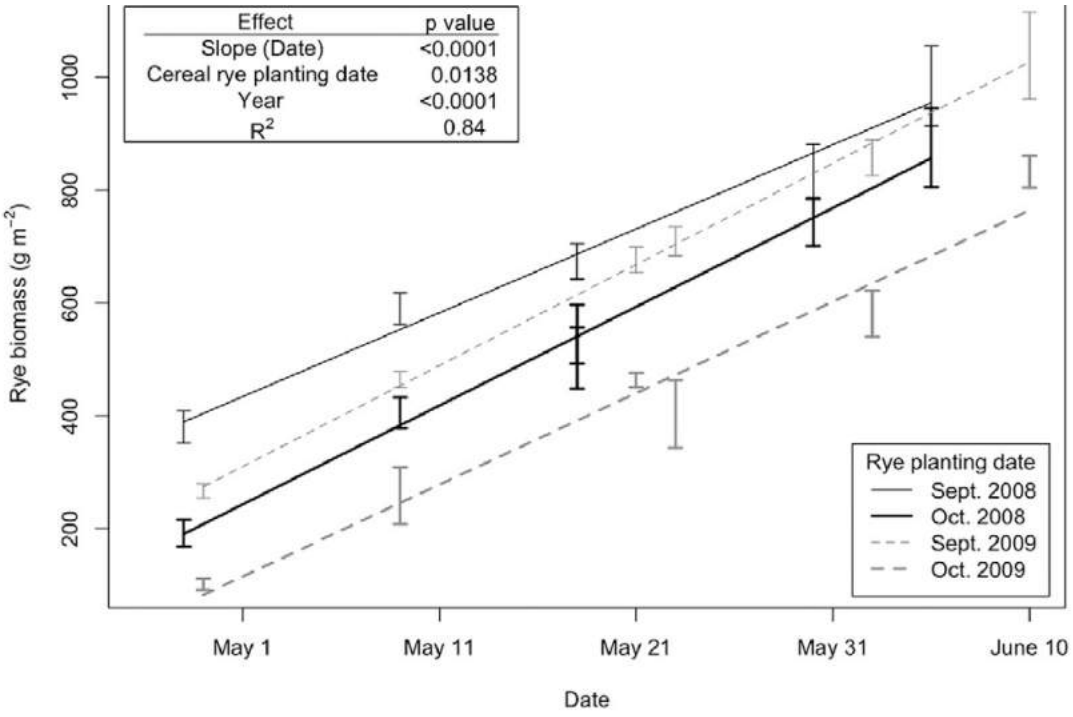

Table 2. Mean cover-crop biomass as influenced by cultivar, planting date, and termination date main effects, pooled across years. Mean comparison was performed by crop (planting and termination date pooled), planting date (crop and termination date pooled), and termination date (crop and planting date 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 of winter cereal grains do I need to produce good mulch?

Several species of winter cereal grains, including winter wheat, winter triticale, winter barley, and winter rye, have been evaluated to determine their performance in CCBRT in Wisconsin. Winter wheat and winter rye overwinter well in Wisconsin, and thus more reliably create a thick mulch biomass needed for effective weed control. Across 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.

Figure 4. Front-mounted roller-crimper used to terminate cover crops and to create mulches.

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. Other strategies of mowing can also be

employed, such as using a discbine mower followed by a teader that spreads windrows back out. 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.

Figures 5 and 6. CCBRT field at the University of Wisconsin Agricultural Research Station in Spooner, WI. Soybeans were planted on 30 inch rows in mid-May before the rye reached anthesis. At anthesis in early June, rye was terminated with a discbine mower followed by a teader that spread windrows throughout field.

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.

Figure 7. Cereal rye at anthesis. Note the anthers emerged from the cereal rye heads. Photo taken at the UW Arlington Agricultural Research Station in early June.

How do I plant the cash crop?

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 rates of soybean should be higher than in the typical organic system (approximately 225,000 seeds/ac or higher).

Figure 8. Adding weights to the planter can help ensure good seed-to-soil contact and good stand establishment.

Planting soybean into the standing rye cover crop prior to termination is also an option for farmers. This allows for an earlier planting date of soybean, which can be particularly advantageous in regions with shorter growing seasons. Soybean can be planted or drilled into the standing rye in mid-May, approximately 3-4 weeks prior to when the rye would reach anthesis. After the soybean reaches the V1-V2 stage, and the rye reaches anthesis, the rye can then be terminated either by rolling-crimping or mowing.

A word of caution, though – there is less replicated research on this technique in Wisconsin, although 2 years of data at Arlington, as well as farmer experience, demonstrates that this option has potential advantages. Timing of rye termination is dependent on two factors – soybean stage, which at V1/V2 allows for resilience against tractor and roller-crimper traffic, and rye stage, which must still be at anthesis to ensure effective termination. Termination of cereal rye may be less uniform using this technique.

Figure 9. Soybeans emerged through standing rye (planted mid-May at the UW Arlington Agricultural Research Station). Photo was taken right after termination with the roller-crimper in early June, with the crimping occurring over the emerged beans.

What kind of yields can I expect?

Yields of organic soybean using CCBRT have been competitive with, and in several years comparable to, typically managed organic soybeans with tillage, 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.

Table 3. Yields of CCBRT Soybeans at the UW-Madison Arlington Agricultural Research Station, 2009-2015.

	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
2015 (Silva)	55	60

Figure 10. Excellent weed control by rolled-crimped rye (left), compare to typical tilled/cultivated organic (right). Note the height difference of the soybean of each of the two treatments.

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

There are a couple of different options to incorporate CCBRT 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 CCBRT organic production

Weed population shifting to perennial weeds

As is true in conventional no-till production, reducing tillage using CCBRT can shift weed populations, increasing the proportion of difficult-to-manage, perennial weeds in the system. This becomes especially apparent when CCBRT 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 CCBRT in southern Wisconsin, hairy vetch has been more challenging to integrate into this system. To ensure a vigorous stand, hairy vetch needs to be planted in late August. Even with an early planting date, however, hairy vetch does not reach the correct stage of maturity for reliable termination (100% bloom/early pod set) until mid to late June, thus 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 winter survival of the crop in Wisconsin, although mixing Purple Prosperity with cereal rye may help increase winter survival. 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. In Wisconsin, 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. While typically tilled organic corn is seldom damaged, corn planted into cereal rye, or a cereal rye mix, is at risk. 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 CCBRT with cereal rye and corn, and less prevalent using the a pure vetch/corn system. Armyworm has not been an issue on the UW-Madison research plots using cereal rye/soybean CCBRT systems. Other research sites, such as the Rodale Institute in Pennsylvania, have observed issues with cutworms impacting corn stands in CCBRT.

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

Rye variety selection for organic no-till production:

https://www.youtube.com/watch?v=dCgyOcTUcK4

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.** Choose fields where you can get in early to plant a cover crop in the fall and 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.