Organic No-Till Planted Soybean Production

A guide for organic farmers in New York State

Contents

Foreword

Demand for certified organic food-grade soybeans for tofu production was a key driving force behind the early adoption of large-scale organic grain farming in New York in the 1990s. The soils and climate of western New York were ideal for growing select varieties of soybeans highly prized for making gourmet tofu in Japan. The strong demand and high price of these varieties of soybeans attracted the attention of several New York farmers in the Finger Lakes region. As these pioneering farmers figured out how to organically grow the high-quality, high-protein varieties that the market required, demand increased, as did the number of organic farmers, much to our delight.

In a typical New York organic grain crop rotation, soybeans are planted after corn and followed by a small grain like wheat or spelt. A cover crop of clover is seeded into the small grain to provide nitrogen and build organic matter. After several years of practicing variations of this rotation, and as organic grain markets evolved, it became apparent that soybeans are the least healthy part of the system.

The soils in western New York are gently sloped and moderately to highly erodible. Because soybeans produce little organic matter or residue, this can result in significant erosion during the winter following soybeans. Despite the best efforts of organic farmers to build healthy soils, erosion at this point in the rotation can undo much progress and good intentions. With any farming system, it is essential to evaluate success by more than yield alone. Instead, we must honestly consider all intentional and unintentional consequences. This includes the cost and impacts of purchased inputs, runoff into the surrounding environment, including water and air, the financial viability of the farm and the community; the health of the farmer and their customers; and the long-term soil health. When there are negative consequences to any system, the best and most sustainable approach is to redesign the system to prevent such impacts, rather than adopting Band-Aid approaches to mitigate.

In his book, *Cradle to Cradle*, Dr. William McDonough writes, "To design systems that are 'less bad' is to accept things as they are, and to believe that this is the best that humans can do. The ultimate failure of a 'less bad system' is the failure of the imagination to grasp an entirely different model." Dr. McDonough believes that we should install 'filters in the mind' to redesign systems to prevent rather than mitigate negative consequences.

Organic farmers and university researchers are leading the way in imagining and developing innovative agricultural systems that are firmly based on reduced tillage and increased soil health, using diverse crop rotation and improved agricultural techniques. Research at the Rodale Institute in Pennsylvania demonstrated that no-till planting soybeans directly into rolled rye could produce a healthy, high-yielding crop, effectively controlling weeds without the need for either cultivation or herbicides. While this was very promising, adapting such a creative agricultural concept to different local variables on different farms, latitudes, and environments, has been remarkably challenging. This has required the development of effective equipment, defining the timing, growth stage, best-adapted varieties, and techniques, and it has required the cooperation and hard work of many people.

As New York organic grain farmers, we deeply appreciate the commitment that Cornell University has made to supporting organic farmers, helping us understand and improve our techniques, conserve our soils, and ultimately improve the viability and health of our farms and our families.

Klaas & Mary-Howell Martens

Introduction

New York is an organic agriculture leader with 1,321 certified organic operations farming over 323,000 acres of land in 2019. New York ranked #2 in the United States in terms of acreage of certified organic field crops with 166,543 acres in 2019. Although corn silage and hay are grown on much of the cropland in New York, soybean production has increased dramatically over the past decade. For example, in 2018 over 330,000 acres of conventional soybeans were planted in New York, up from just 190,000 in 2005. In New York, organic soybean production increased considerably from 92 farms growing soybeans on 6,775 acres in 2008 to 146 farms growing soybean on 9,727 acres in 2016.

With this increase in organic soybean production, there has been a clear need for research on management strategies that optimize production. Organic row crop production often involves a number of soil tillage and mechanical cultivation practices to manage weeds. These operations require a large amount of labor and fuel and degrade soil health. Farmers and researchers in other states such as Pennsylvania, Maryland, North Carolina, and Wisconsin have been successful with rolled cover crop organic no-till soybean production. This production system has several key advantages and allows organic farmers to reduce labor, save fuel, and improve soil health. Over the past several years, our field research has shown that this production system can also perform well in New York State, especially in USDA plant hardiness zone 5 and warmer.

This guide aims to help farmers who are interested in using the rolled cover crop organic no-till soybean system. We start with an overview of soil health and organic management, and then outline the process of growing a cereal rye cover crop, terminating it with a roller-crimper, and no-till planting soybean into the residue. Despite clear benefits, this production system can be challenging, and further research and on-farm trials are still needed. The guidelines provided here are intended to facilitate the successful adoption of rolled cover crop organic no-till soybean production. However, interested farmers are encouraged to work with their local Cornell Cooperative Extension office and other farmers who have been successful with this system in the past.

Chapter 1
System Overview

No-till planting soybeans into rolled cereal rye (*Secale cereale*) can reduce soil erosion, improve soil health, and save farmers time in the spring. However, in order to be successful, farmers must plan ahead, use ecological knowledge of weeds and other pests, and be ready to adapt if needed. Specialized equipment may need to be purchased, and crop rotations and other aspects of the cropping system may need to be redesigned to optimize production.

Figure 1. Soybean seedlings in bare soil that washed out after a heavy rain (left) and soybean seedlings in a rolled cover crop (right).

Soil health is central to organic farming. Founders of organic agriculture, such as Albert Howard, advocated for building soil fertility and humus content. Similarly, the USDA National Organic Program's crop rotation practice standard states that organic farmers must "maintain or improve soil organic matter content." Despite this appreciation for soil, organic crop production often involves soil tillage and cultivation for weed management. These practices can have a negative effect on soil health, especially soil physical and biological properties. In addition to damaging structure and compacting the soil, tillage can harm soil organisms and facilitate the decomposition of soil organic matter.

How can organic farmers reduce tillage and suppress weeds? Using a rolled cover crop to create a weed suppressive mulch can be part of the answer. Researchers in the US, influenced by no-till pioneers in Brazil and Paraguay, developed the system discussed here. It provides many benefits over traditional tillage-based organic soybean production (Figure 1).

It is important to recognize that the successful organic farmers who are using the rolled cover crop system are still using soil tillage at other points in their crop rotation. Continuous no-till is an admirable goal for organic farmers, but weeds can quickly become unbearable in an organic crop rotation without any tillage. Thus, the rolled

cover crop organic no-till system is really a "rotational no-till" system, where farmers no-till plant soybean, but still use tillage prior to establishing other crops.

Save Time and Fuel

The rolled cover crop organic no-till soybean system reduces labor and fuel requirements because it requires fewer field activities than traditional tillage-based organic soybean production.

- Primary and secondary tillage (moldboard plowing, disking, harrowing) are shifted from the spring to the fall, reducing labor requirements and fuel during a season's hectic time. Note that tillage is still used to establish the cereal rye cover crop, but this occurs in late August or early September. Blind cultivation (tine weeding, rotary hoeing) after soybean planting is eliminated. The rolled cereal rye mulch eliminates those operations.

- Inter-row cultivation is also eliminated. However, in some cases, a high-residue cultivator can be used to rescue the soybean crop if weeds were able to emerge through the mulch, but this practice should not be considered routine for the rolled cover crop organic no-till soybean system.

- Rolling and planting can be done in a single pass if the tractor used for planting is equipped with a front-mounted 3-point hitch. In the example shown in Table 1, we assumed cereal rye termination and no-till soybean planting would co-occur in the rolled cover crop no-till planted soybean system, thus requiring the same amount of labor as planting soybean into tilled soil.

Table 1. Labor and fuel requirements in traditional tillage-based organic soybean production and the rolled cover crop no-till planted soybean system. When summed across all operations, 34% less labor and 26% less fuel was required in the rolled cover crop no-till planted soybean system compared with the tillage-based system.

		Labor		Fuel	
		Tillage	No-till Planted	Tillage	No-till Planted
Time	Field Activities	hours/acre		gallons/acre	
Fall	Moldboard plow	--	0.18	--	2.2
	Disc	0.08	0.08	0.7	0.7
	Cultipack	0.06	0.06	0.7	0.7
	Drill cereal rye cover crop	0.12	0.12	0.4	0.4
Spring	Moldboard plow	0.18	--	2.2	--
	Disc	0.08	--	0.7	--
	Cultipack	0.06	--	0.7	--
	Plant soybean	0.11	--	0.5	--
	No-till plant soybean	--	0.11	--	0.7
	Blind cultivation	0.04	--	0.2	--
Summer	Inter-row cultivation	0.10	--	0.4	--
	Inter-row cultivation	0.10	--	0.4	--
Fall	Combine soybean	0.19	0.19	1.8	1.8
	Total	**1.11**	**0.73**	**8.8**	**6.6**

Farmers who are interested in transitioning to the rolled cover crop organic no-till soybean system should consider the costs associated with purchasing a roller-crimper (e.g., $6,400 for 15-ft unit), and any other costs that they might incur such as purchasing a no-till planter, modifying equipment (e.g., front mounted 3-point hitch), and additional cover crop and soybean seed that they might not otherwise use.

Soil Health Benefits

Cover crops that are seeded in the fall and overwinter help to stabilize soil and provide living roots that sustain beneficial organisms in the soil. After terminating the cover crop with a roller-crimper, the soil surface is covered with a thick layer of mulch that remains rooted in place. This mulch protects soil from heavy rains that are common in the mid-summer.

Growing cereal rye uses a large amount of soil moisture and during wet years, this can be very beneficial as farmers can access and plant fields with cereal rye when it would normally be too wet to plant into tilled soil. However, during dry years, transpiration from cereal rye can deplete soil moisture, causing the soil to harden and making proper seed placement difficult. Monitoring soil moisture is very important when using cover crop rotational no-till practices. In 2016, 2018, and 2020, farmers in central New York experienced abnormally dry spring conditions, which resulted in lower yields in soybean that was no-till planted into rolled cereal rye than soybean planted into tilled soil.

After termination, the rolled rye mulch will maintain greater soil moisture levels by reducing evaporation from the soil surface (Figure 2). Compared to bare soil, mulch tends to increase water infiltration, which reduces runoff and increases soil water storage. Increased water storage can increase crop tolerance to short term drought conditions, which are expected to increase in frequency as a result of climate change.

Mulch keeps the soil cool early in the season, which can reduce some microbially mediated soil processes like mineralization. The cool soil may slow soybean growth compared to growth in tilled soil. In the coolest parts of New York, where only the shortest season soybeans can mature, soil temperatures under mulch may be too low for successful organic no-till production. In warmer parts of the state, mulch can play an important role in moderating temperature changes in the soil.

Effects on Soil Health

Reducing soil tillage and growing cover crops are two practices that are known to provide soil health benefits across different types of cropping systems. Managed together as part of the rolled cover crop organic no-till soybean system, they provide additional benefits. Unlike standard practices where cover crops are terminated early while cover crops are small, farmers strive to maximize cereal rye biomass production in organic no-till soybean, which increases the quantity of organic matter returned to the soil. Even with such high inputs of organic matter, changes in soil organic matter are difficult to detect over short periods. However, other indicators of soil health respond to changes in management practices faster. Previous research showed 23% greater soil respiration and a 63% increase in water infiltration in the rolled cover crop organic no-till system compared to a no cover crop system (Research Highlight 1, page 12).

Figure 2. The soil stays cool and moist under the soybean canopy and mulch cover.

Fitting into Crop Rotations

One of the main challenges with the rolled cover crop organic no-till planted soybean system is fitting it into existing crop rotations. In central New York, a common crop rotation for organic grain production is corn-soybean-wheat-red clover. However, there is not enough time to establish a good stand of cereal rye after corn grain is harvested in the fall, and similarly there is not enough time to plant wheat after no-till soybeans are harvested in the fall. Thus, expanded rotations that allow for early cereal rye seeding and do not require crop establishment in the fall after soybeans are harvested are ideal.

Several crops that are commonly grown in New York allow for early establishment of cereal rye. For example, small grains that are harvested in mid-summer provide plenty of time for cereal rye to be established early, which is important for maximizing ground cover and weed suppression. Other crops that could easily precede cereal rye seeding are summer annual forages such as sorghum sudangrass. Depending on the year, seeding after corn silage is harvested could also work well.

Soybeans that are no-till planted into rolled cereal rye tend to mature slightly later than soybeans that are planted into tilled soil, making fall seeding after harvest very challenging. Instead of winter small grains, spring-seeded crops such as spring wheat, spring triticale, oats, or peas may be a better option. Self-seeding cereal rye is another potential solution. Depending on the termination timing and efficacy of the roller-crimper, cereal rye can reseed, protect soil over the winter after soybean harvest, and be harvested for forage the following spring.

Adoption Strategy

To reduce risk, we suggest that farmers who are interested in no-till planting soybean into rolled cereal rye start with a small amount of acreage that is relatively weed-free at first. Then, as expertise increases, more soybean acreage can be converted to rolled cover crop management. As always, talking with farmers who are successfully using this system will increase the chances of success. Researchers and extension educators who have experience with rolled cover crop organic no-till soybean are also excellent resources.

Pest Considerations

One of the primary reasons why organic farmers use tillage is for weed suppression. Understanding how weeds are suppressed in the rolled cover crop no-till planted soybean system is an important first step toward successful production. Weed suppression can be enhanced with several cultural management practices, and some farmers have used high-residue cultivation to rescue soybean crops that are overrun with weeds.

Cereal rye competes with weeds for resources while it is actively growing in the fall and early spring. After the cereal rye is terminated, the mulch suppresses weeds by changing the conditions at the soil surface. Specifically weed seed germination is reduced because the cereal rye keeps the soil cooler and reduces light availability. If weed seeds do germinate, the mulch physically interferes with seedling growth. Mulch is more effective at suppressing annual weeds with small seeds. This is because the energy reserves (i.e., carbohydrates) in small seeds are easily exhausted. However, soybean, which has a relatively large seed size, can push through the mulch and emerge without exhausting its energy reserves. Cereal rye is also allelopathic, meaning that it produces chemicals that can inhibit the growth of weed seedlings. Note that cereal rye mulch does a poor job with suppressing weed species with large seeds and perennial weeds, such as hedge bindweed (*Calystegia sepium*) that emerges from rhizomes with large energy reserves.

One of the most problematic annual weeds that we have observed in the rolled cereal rye system is common ragweed (*Ambrosia artemisiifolia*). It is an early-emerging weed that has the ability to germinate and emerge under cereal rye before it is terminated (Figure 3). Common ragweed seedlings are not controlled by the roller-crimper and can push through the mulch after the cereal rye is terminated. Interestingly, common ragweed seedlings are often effectively killed by the coulter and planter units, leaving most common ragweed seedlings between rather than within the soybean row.

As discussed in other chapters, several cultural weed management practices can contribute to weed suppression in no-till planted soybean. Using an extended

crop rotation and avoiding weedy fields, especially those with large populations of perennial weeds, is important for effective weed management. Seeding cereal rye early (e.g., late August or early September) and at a high rate (e.g., 3 bu/acre) is also very helpful, especially for suppressing common ragweed. The other cultural management practice that is discussed in Chapter 4 is using a high soybean planting rate (e.g., >200,000 seeds/acre). High-residue cultivation can also be used to control weeds later in the growing season, but this should be used as a last resort if the main goals of using the rolled cereal rye system are to reduce labor and fuel while improving soil health.

Although cereal rye mulch can be effective at suppressing weeds, it can also attract slugs and a range of insect pests including black cutworm, true armyworm, and seed corn maggot. These pests are often more sporadic and thus scouting is important. In some cases, farmers might need to replant; however, depending on timing and seed availability that is not always feasible. More research is needed to develop management guidelines for insect pests in organic no-till planted soybean. Interestingly, research by Sarah Pethybridge in Geneva, NY, has shown that rolled cereal rye can suppress white mold in no-till planted soybean. Similar to weeds, the rolled cereal rye affects the microenvironment and interferes with the development of white mold.

Figure 3. Common ragweed (*Ambrosia artemisiifolia*) is one annual that is regularly a problem weed in no-till soybean fields.

Rolled rye is good for soybeans, not corn

Mulch from cereal rye contains relatively low levels of nitrogen, giving it a high C:N ratio. When cereal rye is rolled down and used as a surface mulch to cover the soil, microorganisms use the available carbon as an energy source while scavenging nitrogen to synthesize proteins and other nitrogen-containing organic compounds. This nitrogen immobilization process temporarily ties up nitrogen in microorganisms, reducing nitrogen availability in the soil. In contrast to soybeans, corn needs fairly high levels of available nitrogen for good yields. Corn does not fix its nitrogen from the air like soybean and other legumes. Thus, the low nitrogen levels in the soil from immobilization reduces the growth of young corn plants.

Some researchers and farmers have been successful with using the legume cover crop hairy vetch (*Vicia villosa*) instead of cereal rye for organic no-till corn. Mulch from hairy vetch has a lower C:N ratio and thus is more suitable for corn. However, hairy vetch residue decomposes faster than cereal rye residue, resulting in less effective weed suppression. Matching cover crop termination with cash crop planting is also more challenging when using hairy vetch. Mechanical termination with rolling is only consistently effective when the hairy vetch reaches the early pod stage, which is typically a few weeks later than typical organic corn planting dates. Corn is also much more population sensitive than soybean, and even minor stand reductions from poor seed placement and early season insect pests can have a large impact on corn yield. Because of these factors, using rolled hairy vetch for no-till planting organic corn can be more challenging than using cereal rye and soybean.

Timeline

Successful production starts more than a year before the soybean crop is harvested. Early cereal rye establishment is essential for maximizing ground cover and weed suppression, and timely cover crop termination is important for preventing cereal rye regrowth and seed production.

Late August - Early September

Cereal rye is seeded in late summer

March

Cereal rye protects the soil over winter

April - May

Cereal rye grows rapidly in the spring and can reach six feet tall.

Late May - Early June

Cereal rye is terminated with a roller at 50% anthesis.

Late May - Early June

Soybeans are no-till planted into the residue.

June

Soybean seedlings emerge and grow through the residue.

September - October

Mulch suppresses weed emergence until soybean canopy shades out weeds.

October - November

Soybeans are harvested in the early fall.

Farmer Feature: Gianforte Farm

Luke Gianforte grows 650 acres of certified organic crops with his father, Pete, on their farm in Cazenovia, NY. Most of their land has Honeoye clay-loam soil. They grow corn, small grains, and roughly 150-200 acres of soybeans for a tofu processing facility. The Gianfortes tried the rolled cereal rye no-till soybean system in 2009. That year, they purchased a roller-crimper, mounted it to the front of a tractor, and planted about five acres of no-till soybeans. However, several challenges led them to sell their roller-crimper in 2018 and go back to planting all of the soybeans into tilled soil.

One of the main issues was getting the cereal rye established on-time in the fall. Luke found it challenging to get a cereal rye crop planted early enough after harvesting corn for grain. One of the only ways to get the cereal rye established early was to follow a small grain, which is not as profitable. Another issue that led to Luke abandoning no-till planting was low soybean yields. The organic no-till soybean yields were not as good as the soybeans planted into tilled soil. In the traditionally tilled soybean fields, yields were never amazing, but they were solid and predictable from year to year within about five bushels. The reliability of the crop made it a staple in the rotation. However,

"It is challenging to fit into traditional organic grain production in New York, but I could see it working on some farms in some years."

- Luke Gianforte

growing soybeans using the rolled rye no-till system added more variability. Yields in the rolled cereal rye no-till fields were around half of what they were getting with planting soybean into tilled soil. Even considering the labor savings from reduced tillage and cultivation, the yield hit made it difficult to continue with no-till planting.

Low yields were thought to be due to planting soybean later than normal in the spring to accommodate effective mechanical termination of the cereal rye cover crop. Yield loss was also attributed to volunteer red clover that the cereal rye mulch could not suppress. After years of underseeding red clover in their small grains, Luke found that the population had built up in the soil seed bank. The clover would often out-compete the soybeans for space and nutrients, and it stayed tall, lush, and green at harvest time after the soybeans had dried down, making combining difficult.

Despite the challenges, Luke thinks the system could work well on some farms, like dairies that harvest corn for silage rather than grain, or on farms in areas with a slightly longer growing season.

Research Highlight 1: Trade-offs in Cereal Rye Management

In 2014-2015, an experiment was conducted in Aurora, NY that compared four different cereal rye-soybean management systems: 1) No cover crop - Bare soil was plowed before planting soybeans; 2) Ryelage - Cereal rye was harvested for forage before plowing and planting soybeans; 3) Plow down - Cereal rye was plowed under at the jointing stage before planting soybeans; and 4) Roll down - Soybeans were no-till planted into rolled cereal rye. Results show that soil health indicators, weed suppression, soybean yield, and profitability varied by management system (Table 2).

Compared to the 'No cover crop', the 'Roll down' system had higher soil respiration and sorptivity. Soil respiration is a measure of biological activity in the soil, whereas sorptivity is a measure of water infiltration and time before water runs off the soil surface. However, weed biomass was greater and soybean yield was lower in the 'Roll down' system compared to the other management systems. This experiment was repeated in 2015-2016, but because of extremely dry weather before and after planting, soybeans in the 'Roll down' system were stunted, and soybean yield was 43% lower than the 'No cover crop' system.

Table 2. Soil health indicators, weed biomass, and soybean performance across four cereal rye management strategies.

Measurement	No cover	Plow down	Ryelage	Roll down
Soil respiration (ppm CO_2/week)	1212	1238	1299	1496
Active carbon (ppm)	432	439	443	441
Potentially mineralizable nitrogen (ppm N/week)	4.8	3.8	3.6	4.9
Aggregate stability (%)	52	54	49	55
Water infiltration - sorptivity (in $min^{-0.5}$)	0.46	0.50	0.56	0.75
Cereal rye biomass (lbs/acre)	0	714	1468	3841
Weed biomass (lbs/acre)	34	39	40	466
Soybean density (plants/acre)	195,100	192,600	194,700	192,600
Soybean yield (bu/acre)	41	45	45	39
Return over variable costs ($/acre)	$720.34	$717.60	$732.09	$669.69

Chapter 1 Review

- The rolled cover crop organic no-till soybean system can reduce labor costs and fuel use while protecting soil from erosion and building soil health.
- Success requires advanced planning, proper equipment, and adaptive management.
- Soybeans can produce good yields, whereas organic no-till planted corn has not performed well.
- Fitting into existing rotations, soil moisture depletion before rolling in dry years, and early season insect pests are some of the main challenges.

Chapter 2

Cover Crop Establishment

In organic no-till planted soybean production, the cover crop replaces herbicides and mechanical cultivation for weed suppression. Because of the important role that the cover crop plays in this system, it should be managed carefully like a cash crop.

Field Selection

Organic no-till management should not be used in fields with large soil weed seed banks or heavy infestations of perennial weeds. Most farmers have a sense of how weedy their fields have been in the past. It is best to avoid problematic fields with abundant weeds, as there is greater potential for competition with soybean and yield loss.

Cover Crop Selection

Cereal rye is one of the most winter hardy, productive, and affordable cover crops available, making it the top choice of many farmers who use the rolled cover crop organic no-till soybean system. This versatile cover crop can be planted later than other cover crops. If needed, cereal rye can be harvested for forage at the flag-leaf or early boot stage or later when it is mature for grain and straw. Although other cereal cover crops such as barley and wheat can overwinter in New York, biomass production from these species is often lower than with cereal rye. Triticale is another cereal cover crop that has performed well in research trials. Desirable traits for cover crop selection include winter hardiness, high biomass production, early maturity, and lodging resistance. Although the cereal rye variety 'Aroostook' has been used in many research trials, other varieties of cereal rye as well as 'variety not stated' (VNS) cereal rye may be cheaper and easier to source.

Soil and Field Preparation

Cereal rye is known for its ability to scavenge nitrogen, and it is often used as a "catch crop" to prevent nitrogen from leaching over the winter. In most cases, applying nitrogen to fertilize the cereal rye cover crop is unnecessary and should be avoided, as excess soil fertility can increase weed competition, costs of production, and the likelihood of lodging. However, soil samples should be collected and tested, and any amendments (e.g., lime) or nutrients needed for successful soybean production (e.g., phosphorus and potassium) should be applied prior to soil tillage and seeding of cereal rye.

Before planting the cereal rye, primary and secondary tillage are recommended to establish a smooth, level soil surface, facilitating both cereal rye establishment in the fall and termination in the spring. Depending on a number of factors including the previous crop and surface residue, soil weed seed bank, presence of perennial weed species, and the need to incorporate soil amendments (e.g., lime, manure to increase soil P and K levels, etc.), soil should be moldboard plowed before planting cereal rye. Disking and cultipacking are useful to smooth out the field and improve the seedbed before planting the cereal rye. Flat and uniform conditions are ideal, as ridges can reduce the effectiveness of the roller-crimper when terminating the cereal rye cover crop. Another benefit is that the combine head can be dropped lower, which facilitates the harvest of soybean pods that are close to the soil surface.

Farmer Feature: Scheffler Farm

Eileen and Ed Scheffler own a 300-acre certified organic dairy in Groton, NY. They milked 50 cows until early 2019 when the herd was sold. The Schefflers sold bulk milk through the Organic Valley cooperative, and also had a small farm store where they sold beef, raw milk, and raw milk cheeses. In addition to corn, wheat, and sunflowers for on-farm biofuel use, Ed usually grows 30 acres of soybeans each year. In 2017, he participated in a rolled cereal rye organic no-till soybean trial on about 12 acres. The 12 acres were divided into two treatments: 1) traditional tillage-based management treatment and 2) a rolled cereal rye treatment.

Corn silage was harvested on September 28, 2016 and in early October, the field was moldboard plowed and cereal rye was seeded. Ed used 'Danko' cereal rye seed and drilled in two directions at a rate of 240 lbs/acre before cultipacking. The relatively late cereal rye seeding date may have contributed to the poor stand the following spring.

Unlike the dry conditions in the spring of 2016 and 2018, the spring of 2017 was very wet. Soil in the traditional tillage-based treatment was plowed early before the cereal rye elongated. On June 5, 2017, the cereal rye was rolled down in the no-till treatment. Soybeans were planted on June 12, 2017 by a neighboring farmer with a no-till planter. They planted bin-run Boyd soybeans that Ed had been saving himself at 210,000 seeds/acre in the tillage-based treatment and 336,000 seeds/acre in the no-till treatment. One problem was that the planter was equipped with a shoe for delivering liquid fertilizer, which caught the cereal rye residue and plugged up.

Figure 4. Pests decimated roughly 30% of the newly emerged soybean seedlings during the trial (left). Weed suppression from the cereal rye mulch was also poor (center), which resulted in low yields of no-till planted soybean (right).

"We have to concentrate on ways to save the soil, but we also must balance the economics."

- Ed Scheffler

The soybean crop did not establish well in the no-till treatment. Part of the poor establishment was due to pests, which reduced the emerged soybean population from 120,000 seedlings/acre to 70,000 seedlings/acre. Seedling damage was not a problem where the soil was tilled, as the emerged soybean population was only reduced slightly from 94,000 seedlings/acre to 91,000 seedlings/acre. Later in the season, weeds became problematic in the no-till treatment, especially common ragweed, broadleaf dock, and yellow nutsedge.

Cover crop biomass, weed biomass, and soybean yield were measured by hand using small sampling quadrats. According to those results the cover crop produced 4,660 lb/a of biomass. Weed biomass in the no-till treatment was 1,450 lb/acre but only 690 lb/acre in the tillage-based treatment where inter-row cultivation was used. Soybean yield was 26% lower in the no-till treatment compared with the traditional tillage-based treatment.

That summer, the Sheffler's farm experienced multiple extreme rain events. Even though the field where they planted the soybeans was very flat, heavy rain caused extensive soil erosion in the tillage-based treatment, but not the no-till treatment. Reflecting back on the experience, Ed says "We have to concentrate on ways to save the soil, but we also must balance the economics."

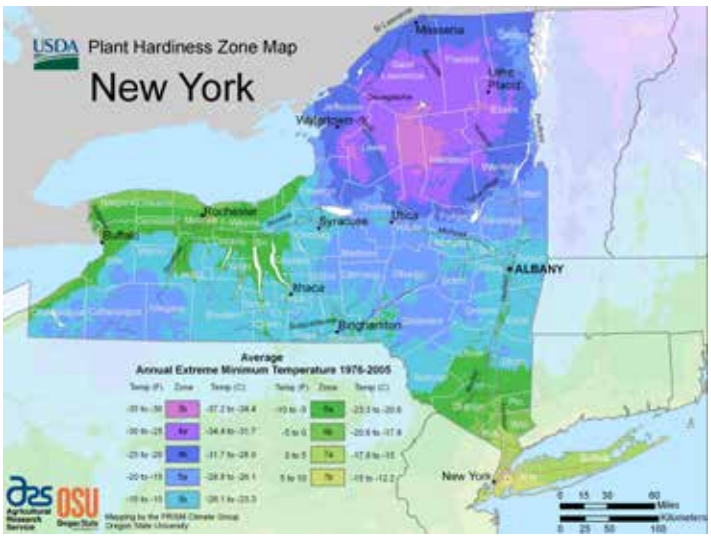
Cereal Rye Seeding Dates

Although cereal rye can be seeded later in the fall than any other cover crop, early seeding is essential for good weed suppression and successful soybean production. In most areas in New York, seeding after corn is harvested for grain will result in poor growth and insufficient weed suppression in the spring. In some cases, cereal rye can be seeded after corn is harvested for silage. However, seeding after a small grain such as wheat or a summer annual forage crop like sorghum sudangrass is harvested typically allows plenty of time for cereal rye seeding.

Cereal Rye Seeding Rates

A thick stand of cereal rye in the spring is important to help suppress early-emerging weeds. To accomplish this, cereal rye should be seeded at 2 to 4 bu/acre. Although doubling the cereal rye seeding rate from 1.5 bu/acre to 3 bu/acre may or may not increase biomass production, our past research shows greater shading, ground cover, and weed suppression at the higher seeding rate. Farmers seeding later in the fall (e.g., October) in a cooler part of the state (USDA Plant Hardiness zone 5) into a field where weeds might be a concern, should consider using a higher rate such as 3.5 or 4 bu/acre. However, farmers seeding early in the fall (e.g., late August or early September) in a warmer part of the state (USDA Plant Hardiness zone 6) into a field with relatively low weed populations, might save on seed costs by seeding at lower rates such as 2 or 2.5 bu/acre.

Figure 5. USDA Plant Hardiness Zone Map for New York, 2012. Agricultural Research Service, U.S. Department of Agriculture. Accessed from https://planthardiness.ars.usda.gov/



Cereal rye is different than ryegrass

Knowing the difference between cereal rye and ryegrass is important. Ryegrass is not suitable for no-till soybean as it does not produce as much biomass and is not susceptible to termination from rolling.

Cereal rye (*Secale cereale*) is also known as winter rye. This winter annual cover crop is sometimes grown as a forage or grain. It can grow up to six feet tall, and has a much larger seed than ryegrass (Figure 6).

Figure 6. Cereal rye seed.

Ryegrass is a general term used for annual or Italian ryegrass (*Lolium multiflorum*) and perennial ryegrass (*Lolium perenne*). Ryegrass is also used as both a cover crop and a forage crop. Its growth is shorter than cereal rye and has "glossy" leaves. The seed is also much smaller than cereal rye (Figure 7).

Figure 7. Ryegrass seed.

Figure 8. Ground cover on April 1 in plots where cereal rye was seeded on six dates in the fall as part of an experiment conducted in central Pennsylvania. Photo credit Steven Mirsky and Bill Curran.

Additional Considerations

In general, using a drill for seeding the cereal rye cover crop will result in better seed placement and establishment than broadcast seeding and thus should be used when possible. However, broadcast seeding can have several advantages including reduced labor requirements and more uniform seed distribution. One issue that has been observed with drill seeding is that soil can be exposed when rolling the cover crop in the same direction it was drill seeded. Although a small amount of exposed soil will not affect the ability of the mulch to protect the soil from erosion, weeds are almost certain to exploit these gaps and compete with the soybean crop.

In order to maximize soil coverage and weed suppression, cereal rye should be seeded perpendicular to the direction it will be rolled. In some cases, such as with long narrow fields where drilling cereal rye perpendicular to the direction it will be rolled is not feasible, farmers may choose to drill the cereal rye cover crop on a slight angle. Another alternative is to use a combination of broadcasting and drilling. Consider, for example, drilling 2 bu/acre and broadcasting another 1 bu/acre of cereal rye seed. The broadcasted cereal rye will fill in some of the space between rows, making for better weed suppression. Regardless of the exact methods that are used, it is important to test and calibrate equipment to the desired seeding rate.

Chapter 2 Review

- **The cereal rye cover crop operates as the primary form of weed management and should be carefully managed.**
- **Selecting a high-biomass producing cereal rye variety like Aroostook is helpful but may be more costly and difficult to source than VNS cereal rye.**
- **Complete and even ground cover is important for weed suppression.**
- **Use high-quality seed with good germination rates at a relatively high seeding rate of 2-4 bu/acre.**
- **Prepare a smooth seedbed to ensure consistent termination in the spring.**
- **Plant before the end of September to maximize growth and tillering.**

Chapter 3

Evaluating and Rolling

Spring is a critical time for organic no-till soybean production. Scouting fields both early in the spring and tracking soil moisture and weather conditions closer to soybean planting can help farmers identify and avoid problems.

Adaptive Management

In general, if cereal rye is seeded in late August or early September at 3 bu/acre the cover crop will produce up to 8,000 lbs/acre of biomass when it is rolled in spring. Although unlikely, problems with cereal rye can arise for a variety of reasons including poor seed quality, crop damage from geese, extreme cold temperatures, low soil fertility, and poor soil drainage. If such problems should arise, farmers should be prepared to change plans. Early spring and right before cover crop termination are two important timepoints for management decisions.

Early Spring Evaluation

Scouting fields and being prepared to use tillage if needed can pay dividends. The first check should be in early March to assess cereal rye ground cover. After greenup and just before jointing (i.e., stem elongation) you should not be able to see any soil between rows of cereal rye (Figure 9). If the stand is poor and soil is exposed, weeds will emerge and compete with the soybean crop. Cereal rye can easily be plowed prior to jointing, while it is still small and has a low C:N ratio. After the cereal rye grows tall, the stem lignifies making the vegetation difficult to incorporate. Cereal rye that is close to maturity has a high C:N ratio, which can cause nitrogen immobilization as it decomposes.

Early spring is also a great time to evaluate weed populations and assess the weediness of fields. If weeds are growing between rows of cereal rye, they will likely survive cover crop termination with the roller-crimper. Watch out for winter annual weeds (e.g., horseweed and purple deadnettle) and perennial weeds (e.g., Canada thistle, hedge bindweed, and red clover). Although a few weeds might not impact soybean yields, large infestations should be taken as a last warning not to use no-till practices. If weeds are abundant or the cover crop stand is thin or patchy, the cereal rye cover crop should be plowed under while it is still small. In this case, soybeans can still be planted or drilled and weeds can be managed using blind and inter-row cultivation.

Figure 9. A sparse stand of cereal rye such as this one will not provide adequate ground cover when rolled. Cereal rye stands like this should be plowed under.

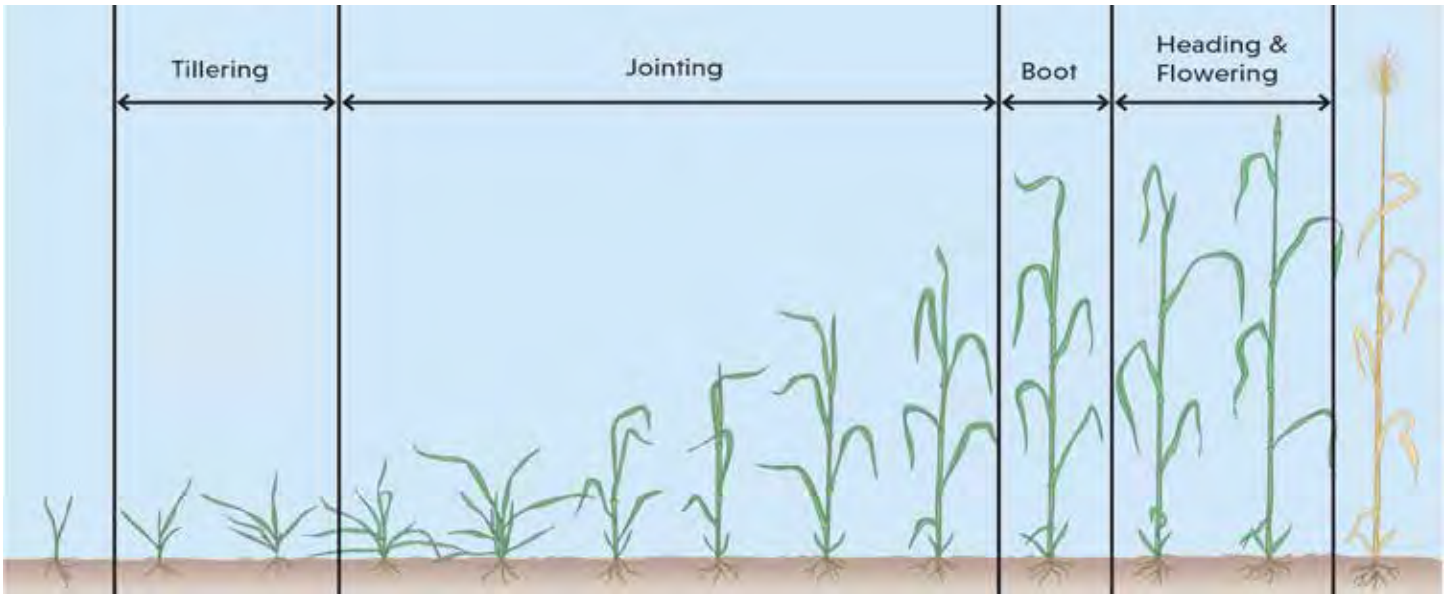


Figure 10. The Feekes scale is used to identify growing stages of cereal rye. Image modified and used with permission from Emerson Nafziger.

Figure 11. This cereal rye seedhead is at early anthesis and can be rolled within the next two days. Anthers begin to emerge from the center of the seedhead and then move outward.

Late Spring Evaluation

Before rolling the cover crop and no-till planting soybean seeds, it is important to evaluate soil moisture conditions and check the extended weather forecast. As the cereal rye crop grows taller and starts nearing anthesis, it uses a large amount of soil moisture. Depending on the weather conditions, this can be a benefit or a drawback to the system. Under very wet conditions, farmers can access their fields and plant soybean when neighboring tilled fields are too wet to drive over. However, under very dry conditions, such as those like we experienced in 2016 and 2018 in central New York, the cereal rye can use too much soil moisture. In addition to creating hard soil conditions and reducing the ability to achieve good seed-to-soil contact, dry conditions can reduce soybean germination and growth rate. Poor establishment and growth can leave the soybean crop susceptible to weed competition later in the season. If the soil is bone-dry and there is no rain in the extended forecast, farmers should wait and consider allowing the cereal rye to mature and harvesting it for grain.

Ready to Roll

Timing is critical for effective cover crop termination. Cereal rye should be rolled at anthesis when pollen is being shed from the inflorescence. If the cereal rye is rolled before the anthesis growth stage, the plants will likely bounce back and stand upright again after

Farmer Feature: Oechsner Farm

Thor Oechsner and Dan Gladstone farm roughly 1300 acres of certified organic land in Newfield, NY. They grow red clover for forage and seed, grain corn, winter wheat, spring wheat, buckwheat, and cereal rye. In 2018, the farm added soybeans to the rotation.

In fall of 2017 they selected a 20-acre field with a relatively low population of perennial weeds. They applied poultry manure at 1 ton/acre and moldboard plowed the field before seeding 'Danko' cereal rye in early September. To ensure good ground cover, they broadcast-seeded 1 bushel/acre and drilled another 2 bushels/acre before cultipacking the soil.

The spring of 2018 was unusually dry. Their stand of cereal rye was dense and virtually weed-free, but the ground was very hard when they were hoping to no-till plant the soybeans. It finally rained on June 14, softening the soil enough for planting. Later that day after the rain had stopped, they used a John Deere 1590 no-till grain drill to plant their soybeans on 7.5 inch row spacing. The variety was Blue River 12A2 (1.2 relative maturity group) and it was planted at a rate of 250,000 seeds/acre directly into standing cereal rye, which was then rolled immediately afterwards.

With extremely dry conditions before and after planting, the soybeans struggled well into August. Thor and Dan noticed that the no-till soybeans were about 2 weeks behind soybean they planted in a different field where the soil was plowed and inter-row cultivation was used. Although weed suppression from the rolled cereal rye was excellent, the soybean plants were yellowish and leggy, which was likely due to nitrogen tie-up by the cereal rye.

Starting in mid-August, weather conditions changed from dry to wet. Although the cereal rye mulch may have also helped reduce soil erosion from the excessive rain in late summer and fall, Thor and Dan thought it prevented the soil from drying out. It was January 15 before the ground had frozen, allowing the soybeans to be combined. What could have been a high-yielding crop ended up lodging under the weight of the rain and snow, and they lost roughly 85% of the crop. Dan did note that there were very few rocks to deal with during harvest - one of the advantages of eliminating inter-row cultivation.

Despite challenges with the dry spring and wet fall conditions, Thor and Dan thought the rolled cover crop no-till soybean system had good potential and noted that the system might be a way to "bank" soil health and fertility for following crops.

Figure 12. (opposite page) Chris Pelzer of the Cornell Organic Cropping Systems Lab worked with Thor to develop a plan and select appropriate seeding rates (left). Cereal rye mulch keeping the weeds at bay (top right). A weed-free field of mature soybeans is ready to harvest (bottom right).

"The way rolled rye no-till soybeans is going to pay for itself is not in better soybean yields, but in leaving the field in better condition for future crops."

- Dan Gladstone

Adaptive Management

Spring is a critical time for organic no-till soybean production. Scouting fields both early in the spring and tracking soil moisture and weather conditions closer to soybean planting can help farmers identify and avoid problems.

Prior to seeding:

Does the field have relatively low population of perennial weeds?

Yes

Proceed with seeding cereal rye in early September.

At greenup in spring:

Is the cereal rye stand uniform, dense, and weed-free?

No

Work on reducing weed populations.

Yes

Proceed with monitoring growth of cereal rye.

A few days before planting:

Is there adequate soil moisture and/or rain in the forecast?

Yes

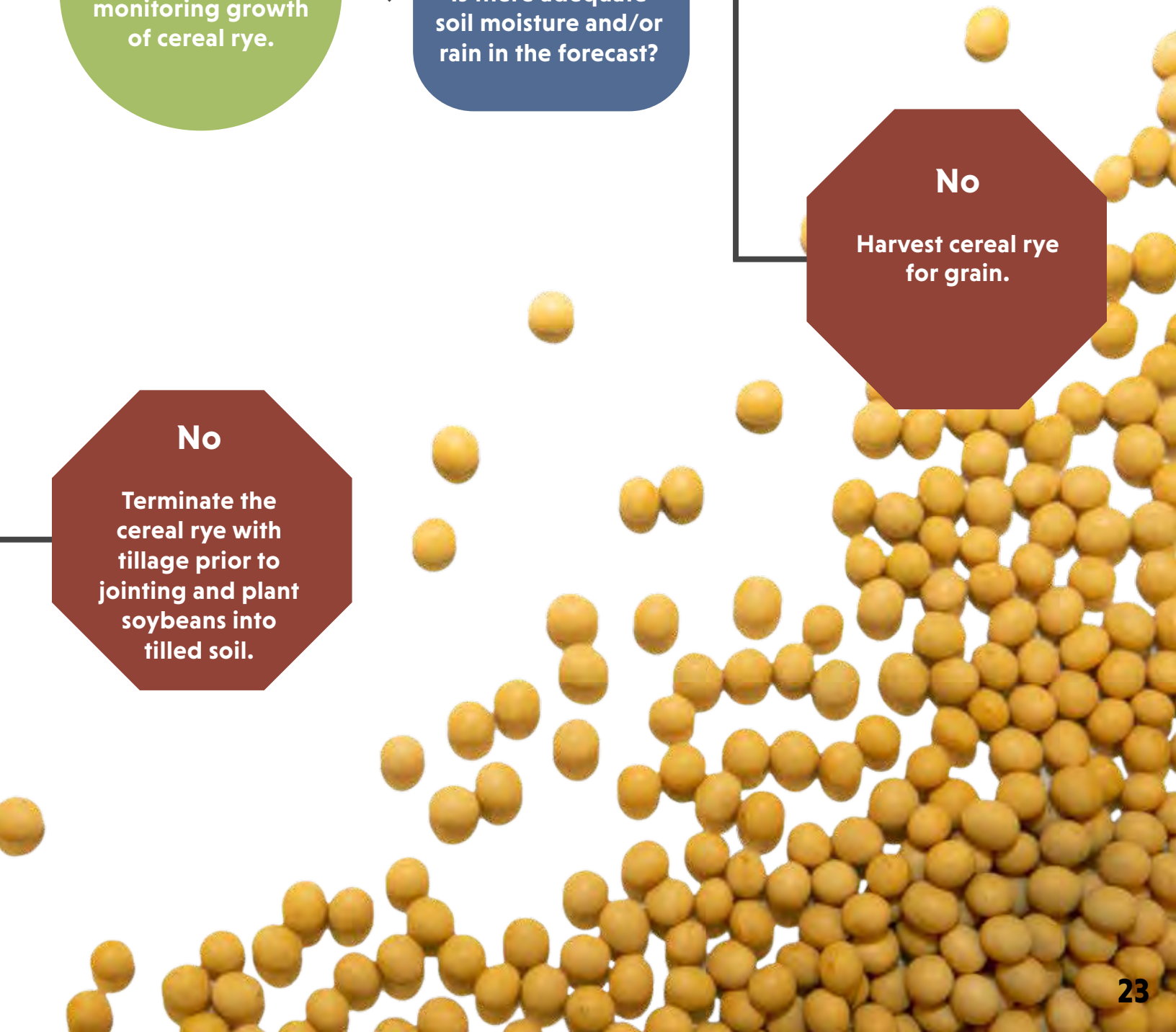
Proceed with rolling cover crop at anthesis and no-till planting soybeans.

No

Harvest cereal rye for grain.

No

Terminate the cereal rye with tillage prior to jointing and plant soybeans into tilled soil.



rolling. This should be avoided because the cereal rye can compete with soybean seedlings as they emerge, and the cereal rye that is not terminated can produce viable seed. There is also potential for seed production if the cereal rye cover crop is rolled after anthesis. Although soybean can be planted later than corn, delaying cereal rye termination and soybean planting too long will also reduce soybean yield.

Ideally cover crop termination and no-till soybean planting are done together in a single operation. This saves time and fuel compared to rolling and planting separately. For the 1-pass system, the roller-crimper is mounted to a front 3-point hitch. Note that rollers from I & J Manufacturing are built for either front or rear mounting, so before purchasing a new roller it is important to know if you will be using it on the front of your tractor for the 1-pass system or if you will be using it on the back 3-point hitch.

If the cereal rye cover crop was drilled, it can be beneficial to roll it down and no-till plant the soybean perpendicular to the direction in which it was drilled. Perpendicular rolling helps to maximize ground cover and weed suppression. If rolling in the same direction the cereal rye was drilled, there is potential for the soil to be exposed. If the cereal rye cover crop was broadcast seeded, the direction in which it is rolled is not important. More information on no-till drills and planters, and soybean agronomy will be covered in the next chapter.

Lodging

Because cereal rye can grow so tall, it is susceptible to lodging. It is not uncommon to see tall cereal rye lodge after a storm. Unfortunately, cereal rye that has lodged will not roll down uniformly in one direction and can negatively impact soybean emergence (Figure 13). No-till planting into lodged cereal rye is difficult as coulters often do not cut through the mulch, which disrupts soybean seed placement. If there is significant lodging, farmers should consider increasing the soybean planting rate and adding extra weight to the planter to facilitate seed placement. Even if the cereal rye is not lodged, problems can arise during rolling on windy days when the wind pushes the rye in different directions as it is being terminated. If possible, avoid rolling cereal rye on very windy days.

Rolling Equipment

Roller-crimpers are used to terminate the cereal rye cover crop in the spring before planting soybeans. Although some farmers have constructed their own roller-crimpers (blueprints are available from The Rodale Institute) most farmers who are using the rolled cover crop system have purchased their roller-crimpers from I & J Manufacturing in Gordonville, Pennsylvania. These Rodale-style rollers have blunted blades arranged in a chevron pattern that crimp the cover crop stems during rolling. Available in different sizes and configurations (e.g., front vs. rear mounted), rollers can be filled with water for additional weight (Figure 14).

Figure 13. Cereal rye that lodged before rolling (left). Poor soybean emergence where cereal rye lodged (right).

Rolling has several advantages over other ways to terminate cover crops. Rolling requires less diesel fuel and is faster than mowing. Mowing facilitates decomposition of the mulch, whereas mulch from rolled cover crops is more persistent and provides weed suppression for a longer period of time than mulch from cover crops that were mowed. Since the rolled stems are still anchored to their roots, they do not get raked and dragged through the field with planting equipment.

Figure 14. A roller-crimper in France with a reversable 3-point hitch that can be front or rear-mounted (top left). The blade on this front-mounted I & J roller-crimper is designed with a chevron pattern to minimize bouncing. The guard over the bearing prevents mulch residue from bunching up (bottom left). Rolling test strips in Penn Yan, NY. Adapters are available that allow attaching a roller-crimper to front loaders (right).

Chapter 3 Review

- Decision making in the spring requires scouting fields for soil coverage and weed populations, and tracking soil moisture.
- It may be more profitable to plow cereal rye under, harvest it for ryelage, or harvest it for grain.
- Roll the cereal rye cover crop perpendicular to the direction in which it was drilled when it reaches 50% anthesis.
- Use a roller-crimper and planter or drill that are the same width, so that rolling and planting can be done in one pass.

Chapter 4

No-till Planting Soybeans

Using appropriate equipment and avoiding extremely dry and hard soil conditions are important for successful establishment when no-till planting soybean into rolled cereal rye. To maximize yields, it is also important to use high-quality seed and a relatively high soybean seeding rate.

Planting Equipment

Compared to traditional tillage-based soybean production, where soybeans are planted into a clean seedbed, no-till planting into thick mulch can be challenging. In addition to the potential for dragging and clogging equipment, residue can inhibit seed furrow formation or be pushed into the furrow (i.e., hair pinning). Older no-till planters with shoe-type openers can rake residue and are not as effective as planters or drills with disk openers. Regardless of opener type, care should be taken to reduce the potential for residue to collect and drag through the field (Figure 15 (right)). The most important features of a no-till planter are:

- Heavy duty construction
- Double disc openers before the planting tube
- Seed-firmers behind the seed tube
- Heavy cast iron or toothed closing wheels

Figure 15. The fertilizer dispenser behind the ripple coulter on this planter (left) caught cereal rye residue while no-till planting soybean (right), which reduced mulch uniformity and interfered with seed placement.

Research Highlight 2: High Seeding Rates in Organic No-Till Soybeans

Soybean seeding rates were compared at two sites in 2014 and two sites in 2019. A food-grade variety was grown in 2014, and soybeans in that experiment were no-till planted into a cover crop mixture of rolled cereal rye, triticale, and barley. In 2019, a feed-grade variety was no-till planted into cereal rye. Soybeans were planted at five rates, up to 370,000 seeds/acre. High soybean seeding rates consistently had faster canopy closure, reduced weed abundance, and increased soybean yields. After considering seed costs and market prices for soybean, the economic optimum seeding rate was 250,600 and 270,800 seeds/acre for the food-grade soybeans in Aurora and Hurley, respectively, and 210,700 and 216,000 seeds/acre in the feed-grade soybeans in Aurora and Geneva, respectively. At those seeding rates, the food-grade soybean produced 40 and 52 bu/acre in Aurora and Hurley, respectively, and the feed-grade beans produced 56 and 48 bu/acre in Aurora and Geneva, respectively. Notably, results show that optimal seeding rates are substantially higher than the recommended rate for conventional soybean.

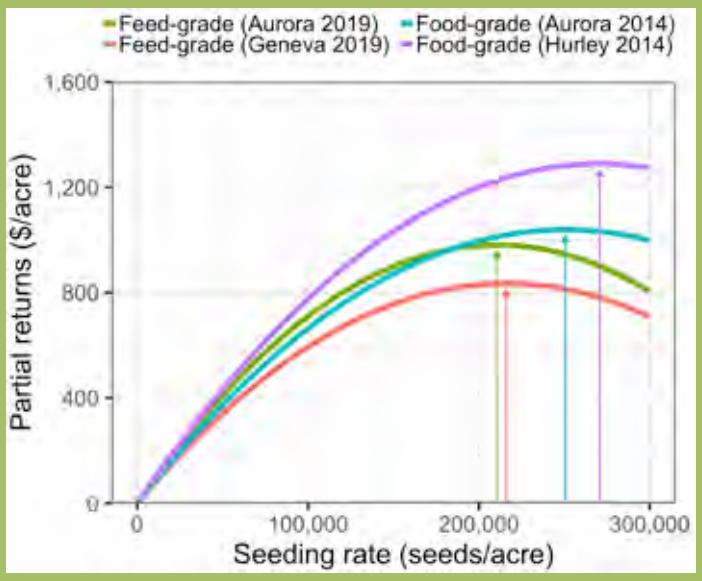


Figure 16. High soybean seeding rate are more profitable. Food-grade soybeans were 'IA 2053' (RM group 2.0) and feed-grade soybeans were 'Viking 0.1518N' (RM group 1.5). Seed cost was $49/bag and market prices were $0.47/lb for food-grade and $0.31/lb for feed-grade.

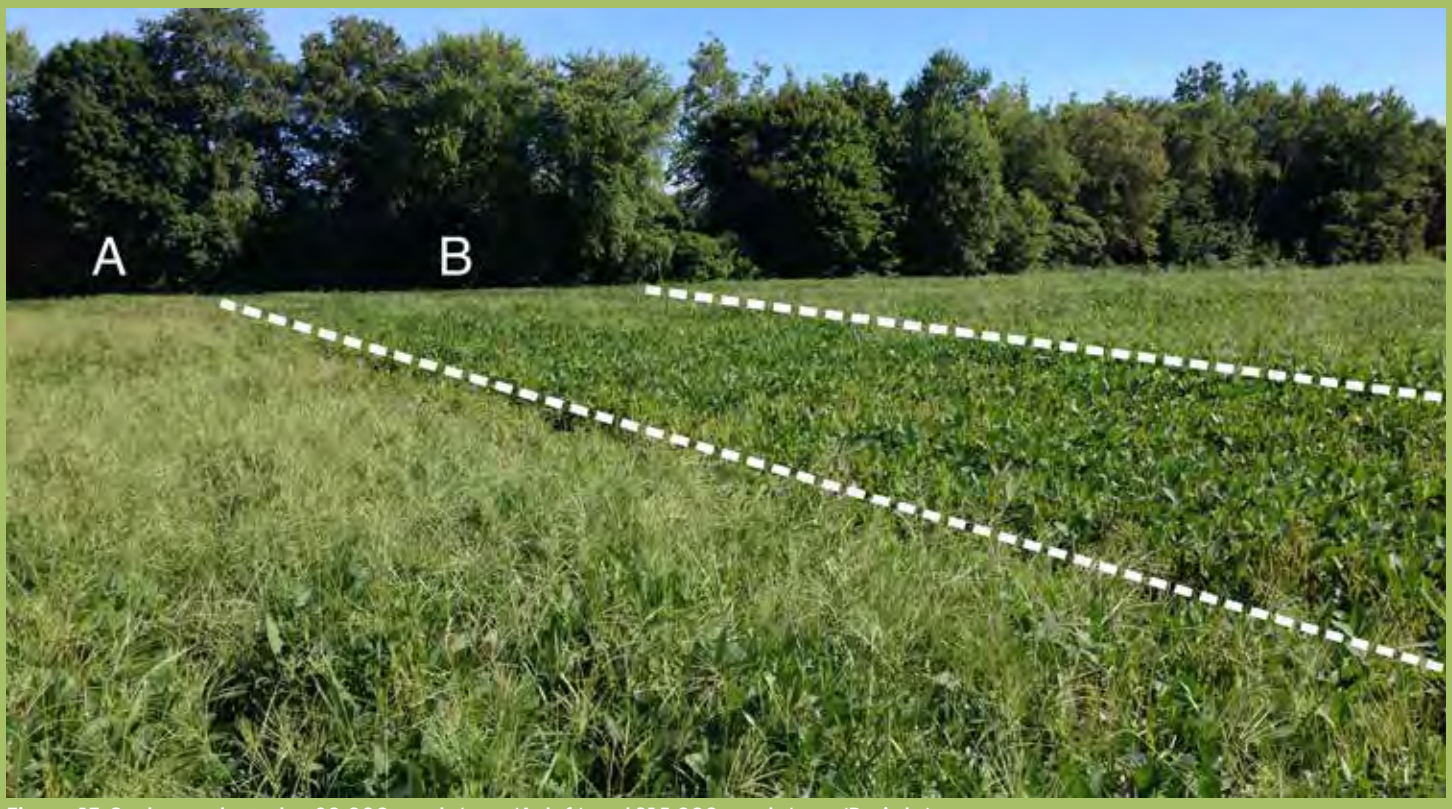


Figure 17. Soybean planted at 80,000 seeds/acre (A, left) and 315,000 seeds/acre (B, right).

Farmer Feature: Martens Farm

Klaas Martens farms with his family on over 1,600 acres of certified organic land in Penn Yan, New York. They have been farming organically since 1992 and are actively involved in the organic farming community. Situated on the western shore of Seneca Lake, their farm has Honeoye and Cayuga silt loam soils. In 2013, Klaas and his son, Peter, worked with Jeff Liebert to conduct an organic no-till planted soybean trial that compared the effects of three different cover crop species (cereal rye, triticale, and winter barley) and two cover crop termination dates on cover crop biomass, weed suppression, and soybean yield. Two varieties of each cover crop species were included in the experiment: 'Aroostook' and a variety-not-stated (VNS) cereal rye, 'TriCal 718' and 'TriCal 815' triticale, and 'McGregor' and 'Verdant' barley. All cover crops were seeded on September 16, 2013, at a density-based seeding rate of 2 bu/acre and then rolled the following spring on May 30, 2014 (early termination date) and June 5, 2014 (late termination date).

Before rolling, high cover crop biomass was recorded in all treatments, with over 8,000 lb/acre of cereal rye, 7,000 lb/acre of triticale, and 5,000 lb/acre of barley on May 30. In the week between the first and second termination dates, cover crop biomass increased between 500 and 1,000 lb/acre across the three cover crops.

Klaas, Peter, and Jeff no-till planted the soybeans ('Viking 2265', 2.2 relative maturity) on June 5 at a rate of 300,000 seeds/acre using an Esch No-Till 5507 drill. As the downward pressure was dispersed across 15 row units, some adjustments were needed to ensure good seed-to-soil contact through the thick cover crop mulch. Klaas and Peter added a spacer on the hitch to alter the angle of the drill, they removed the spacers from the hydraulic cylinders (one on each side), and they loaded 2,500 lb of additional weight to the drill to enhance the down pressure.

A negligible amount of cover crop stood back up (i.e., bounced back) after rolling, even at the earlier date. Weed biomass, measured on September 15, 2014, was lower in plots where cover crop biomass was higher. The winter barley produced the lowest amount of cover crop biomass and had the highest weed biomass out of all treatments. Quackgrass (*Elymus repens*) and common ragweed (*Ambrosia artemisiifolia*) were the two most common weed species across all treatments, though common ragweed populations were lower in plots that were rolled at the later date.

Despite differences in cover crop biomass and weed suppression, soybean yields did not differ and averaged 40 bu/acre across all treatments. Klaas was satisfied enough with the results of this trial to purchase his own roller-crimper and continue experimenting with rolled cover crop organic no-till planted soybean production. Increasing the number of acres under organic no-till planted soybean management each year since the trial, Klaas has recommended this approach to other farmers at conferences and grower meetings as a way to prevent erosion and improve soil health, while still maintaining profitable yields.

"I think the rolled no-till soybeans are a good example of a practice that has not been adopted as widely or as quickly as it should have been because it was being pushed mainly as a practice as opposed to it being introduced as a part of a farming system."

- Klaas Martens

Figure 18. Klaas Martens and Jeff Liebert survey some of the cover crop test strips at Klaas's farm in 2014 (top). A cereal rye cover crop being rolled for the variety trials (bottom left). Barley, triticale, and cereal rye were planted as part of this trial (bottom right).

Row Spacing

Organic soybean can be no-till planted with either a planter on 30-inch rows or a drill on 7.5-inch rows. Although both methods can be successful, there are trade-offs to consider when choosing to no-till drill or no-till plant soybeans. Weight per unit of surface area contact is one of the main determining factors affecting performance in the rolled cereal rye system. Compared to a no-till drill, a no-till planter set to 30-inch centers will typically provide superior seed placement since it will provide more down pressure per planting unit. Drills have their weight distributed across a greater area due to more planting units being in contact with soil, which reduces down pressure and seed placement through the mulch and into the soil. More consistent seed placement provides greater stand uniformity, increased shading, weed suppression, and ultimately higher yields.

Weed management is another important consideration when deciding between using a no-till planter or a no-till drill. With adequate seed placement, no-till drilling soybeans in 7.5-inch rows will often result in faster canopy closure, which can increase shading and weed suppression. However, soybeans that are no-till planted in 30-inch rows can be cultivated with a high-residue cultivator (Figure 19). Although there are different makes and models, high-residue cultivators typically have a narrow shank with wide sweeps positioned at a low-angle. This configuration allows the sweep to travel just under the soil surface, minimizing disturbance

Figure 19. High-residue cultivator.

Figure 20. A no-till planter with seed bags for additional weight.

of residue. Previous research has shown that weeds growing between 30-inch rows of soybean can easily be killed using high-residue cultivators. However, with proper field selection, good cereal rye growth, and high soybean seeding rates, weed competition should not be a major problem.

Equipment Components

Most planters and drills are not ready for the field right off the dealer lot and thus many farmers modify their equipment to suit their specific field conditions. Successful farmers who are no-till planting into rolled cereal rye have mainly focused their modifications on coulters and closing wheels. Sharp coulters are important for cutting through residue and loosening the soil for the seed furrow. Consider using a straight, bubble, or ripple coulter as these seem to work best for no-till planting soybean into cereal rye mulch. Wavy coulters should be avoided because they perform poorly in thick residue, which is mainly due to the weight being distributed across additional surface area.

Residue slicers are another option to consider if the leading coulter is not effective at cutting through the cover crop mulch. These add-ons consist of two rubber gauge wheels on either side of a coulter and hold the mulch in place as it is cut, providing a cleaner cut, reducing hair pinning, and preventing the mulch dragged along with the planter. While effective, residue slicers typically require an additional tool bar for mounting.

In conventional no-till production, row cleaners mounted to the front coulter are used to move residue away from the row and improve seed furrow formation and seed placement. However, row cleaners are not recommended for organic no-till production. Although row cleaners might improve seed placement, moving mulch away from the crop row leaves the soil exposed and susceptible to weed establishment, which can limit weed suppression in the crop row and reduce soybean yields.

The effectiveness of closing wheels varies by soil type, crop residues, and soil moisture conditions. Plastic and rubber wheels that are standard on many drills intended for use in traditionally tilled soil are not effective at closing the seed furrow in rolled cover crops, which can reduce seed-to-soil contact. No-till drills can be equipped with cast iron press wheels, which may do a better job than lighter plastic press wheels. On planters, a closing wheel that will "zip up" the furrow can be beneficial. The term "zipping" describes the action of both crumbling the sidewalls of the furrow while firming the soil at the same time (Figure 21).

Variety Selection and Seed Quality

As with traditional production, selecting the right soybean variety and using quality seed with a high germination rate is important in the rolled cover crop no-till system. In New York, most farmers plant varieties with early relative maturity ratings (i.e., maturity group 0-2). Compared to traditional tillage-based soybean production, soybeans are typically planted later in the spring and mature later in the fall in the rolled cover crop system. Depending on the crop rotation, farmers should consider planting an earlier variety than what would typically be planted in tilled soil. However, yield potential increases with maturity group. In addition to timing and yield considerations, insect and disease resistance should be considered when selecting an organic soybean variety for no-till planting, especially in fields with past problems with soybean aphids, soybean cyst nematodes, brown stem rot, or white mold. In addition to pest resistance, early vigor is an important trait for seedling emergence through mulch.

Seeding Rates

Organic farmers often use slightly higher seeding rates than conventional farmers, which can offset reductions in crop populations from pests and increase weed suppression from shading. Almost all conventional soybeans grown in New York have been genetically engineered to be resistant to the herbicide glyphosate. Effective weed suppression combined with relatively high seed costs have pushed conventional farmers to use lower seeding rates. However, our research has shown that high seeding rates are more profitable and help reduce weed problems in the rolled cover crop organic no-till soybean system (Research Highlight 2, page 27).

Soil Moisture at Planting

In years with above average rainfall in the spring, cereal rye can help dry out the soil and allow farmers to access fields that would otherwise be too wet to plant. Rolled cereal rye also acts as a protective barrier, reducing ruts and other tire damage to soil while keeping soil off of equipment. However, under dry conditions, cereal rye can reduce soil moisture and cause planting problems. In addition to hard soil that can prevent proper seed placement and seed-to-soil contact, soybean seedlings can suffer when soil moisture is low. In order to overcome planting problems associated with hard soil, some farmers have added additional weight to the planters to facilitate coulter penetration and seed placement. Another option is to wait for rain before no-till planting, which can make the soil softer and facilitate seed placement.

Figure 21. Gaguetine closing wheels crumble the soil while zipping the furrow shut.

Direction of Planting

One of the main benefits of the rolled cover crop no-till system is labor and fuel savings and being able to terminate the cover crop and no-till plant in a single pass. For farmers who can mount a roller on the front of their tractor, the direction of planting relative to the direction of rolling is not an issue. However, if rolling and planting are done in separate operations, it is important to match the direction of planting with the direction the cereal rye was rolled. This will ensure that mulch uniformly covers the soil surface. Poor seed placement and weed suppression problems can arise when no-till planting in the opposite direction the cereal rye was rolled.

Harvesting

After no-till planting, soybean emergence and seedling growth should be monitored. In some cases, replanting soybeans or an emergency crop might be warranted if there are severe reductions in the stand or stunted growth. However, under normal conditions, the crop should emerge and thrive. In previous research, soybeans that were no-till planted into rolled cereal rye often reached the yellow leaf stage about 1-2 weeks later than soybean planted into tilled soil. Slower dry down can delay harvest and the planting of winter cereal crops that might follow soybean in the crop rotation. One benefit is that there tend to be fewer rocks near the soil surface without inter-row cultivation, which can facilitate combine harvesting. Farmers have also reported smoother harvesting because of the combine header gliding on the cereal rye mulch.

Chapter 4 Review

- **Anticipate a slightly later planting date and slower dry down in the fall when selecting a soybean variety.**
- **Planting rate: 225,000-300,000 seeds/acre.**
- **If possible, roll the cereal rye perpendicular to the direction it was drilled.**
- **Use a no-till planter with a double disc opener and make sure components will not catch and rake mulch.**

Closing

Organic no-till crop production is still in its infancy, and management strategies, equipment, and knowledge are evolving rapidly.

Since starting this project, innovators have pushed forward with some exciting advances. For example, researchers in Wisconsin have shown yield advantages with no-till planting into cereal rye at the boot stage and then rolling cereal rye at anthesis after soybean seedlings have emerged. Advances in no-till planters have increased the consistency of seed placement. And organic farmers have more options for controlling weeds that break through the cover crop mulch, including inter-row rollers and mowers, as well as weed zappers that use electricity to kill weeds that are above the crop canopy. Additional performance improvements are expected from new cover crop varieties being developed specifically for organic no-till production and using decision support tools to optimize cover crop management.

Discussing all of the current efforts to improve organic no-till soybean production is beyond this guide's scope. Another shortcoming is that we are only at the beginning of developing the system of organic no-till production. More work is needed to go beyond the practice and achieve holistic systems management. Identifying and integrating other cover crop and cash crop combinations into a rotation as part of an extended sequence of no-till crops will be important for moving closer toward more regenerative and resilient agriculture. Simultaneously, research is needed to quantify the soil health benefits of rolled cover crops and understand how no-till planting into rolled cover crops can help farmers adapt to extreme weather and help mitigate climate change by sequestering carbon in the soil.

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