# Planting Green 101: Penn State Research Summary

**This article explains the “why” and “how” of planting green with corn and soybeans, including practical management recommendations based on results from 3 years of research across 5 locations in Pennsylvania.**

## Integrating no-till and cover crops requires informed management

The benefits of no-till have been well established, including reduced fuel consumption, reduced soil erosion, improved soil physical properties and soil quality, and improved water quality. We also know that some benefits of no-till are enhanced by planting cover crops, which provide additional benefits associated with living cover and roots such as weed suppression; beneficial arthropod habitat; increased soil organic matter, biological activity and structure; and nitrogen provision (legumes) or sequestration (non-legumes). However, integrating no-till + cover crops can complicate management, especially in the mid-Atlantic and northern Corn Belt. Both practices cool soil (this effect is even stronger when no-till and cover crops are used together), shortening the growing season for summer annual crops, as farmers wait longer in the spring for soil to warm up and dry out. Problems with stand establishment can then result from cooler, wetter soils, and interference from cover crop residue. Slugs, molluscan pests that eat crop seeds and defoliate young plants, are another common challenge associated with no-till and cover crops. Because they prefer moist and cool habitats, they thrive in systems without tillage that can bury eggs and warm-up and dry out soil. Recent research has also demonstrated that insecticide use can exacerbate slug populations. Neonicotinoid seed treatments are ubiquitous on corn and soybean and are used to control some secondary, early season insect pests. However, these insecticides provide no protection from slugs, but can injure or kill predatory insects when they feed on slugs exposed to the insecticide. Other pre-emptive insecticide applications, like pyrethroid sprays close to planting, can also reduce predatory insect activity. As a result, these pre-emptive insecticides practices can indirectly increase slug damage to crops because they limit the activity of predators of slugs.

## What is planting green, and why do people do it?

Planting green refers to planting cash crops into living cover crops instead of the more common practice of planting into desiccated cover crops killed with an herbicide a week or more beforehand (Figure 1). Some farmers in Pennsylvania report that they “plant green” (or “grow green”) to extend the soil conservation and soil health benefits of cover crops while mitigating the challenges of wet soil and slug damage associated with pairing cover crops with no-till. Planting green had not been extensively studied nor these claims quantified. So, at Penn State University we conducted a three-year study at five different locations in central and southeastern Pennsylvania to evaluate the effects on corn and soybean performance of “planting green” compared to preplant cover crop termination. In summary, over 14 site-years we measured no yield difference between soybeans planted green compared to soybeans planted into preplant-killed rye or triticale. In contrast, for more than half of our 12 site-years, grain yield of corn planted green was significantly lower or trended lower than corn planted into preplant-killed cover crops.

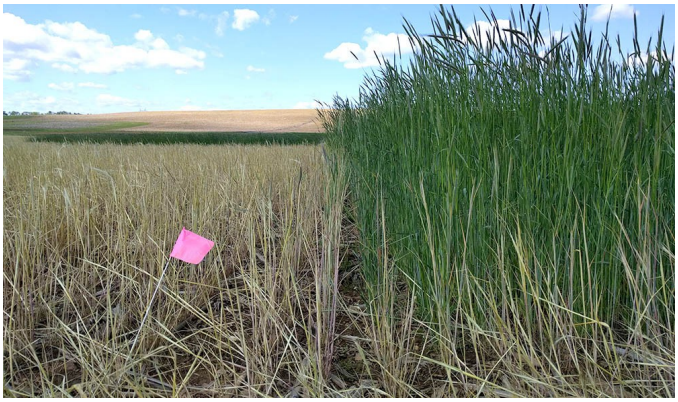

**Figure 1.** Cereal rye cover crop that was killed with glyphosate 3 weeks prior (left) and that will be killed after soybean planting (right) at Rock Springs.

## Cover crops for planting green

Cereal rye ( *Secale cereale* L.) is the most commonly used cover crop in the mid-Atlantic region, because of its ability to germinate and grow when planted late in autumn, over-winter, grow quickly in spring, sequester nitrogen, provide mulch for weed management, and ensile or be grazed for forage. We found that in central and southeastern Pennsylvania, rye biomass increased an average of 137% with an average of 15 days between preplant-kill and planting green. In addition to cereal rye, we evaluated no-till corn planted green into crimson clover ( *Trifolium incarnatum* L . ). Although our results varied, in the 6 site-years with crimson clover, the clover cover crop tended to dry out soil more than rye, and had tough stems and roots, making it more challenging for no-till corn establishment. Our research measured an 8% average decrease in corn population when it was no-till planted into crimson clover, regardless of termination timing in half the site-years compared to rye. In one site-year, planting into crimson clover compared to rye also increased insect damage (mostly from stink bugs) by 82%, regardless of termination timing. Because of these issues, across half the site years corn grain yield was on average 11% lower when planted green into crimson clover compared to preplant-killed clover, rye, or rye + clover mix. In addition, in central Pennsylvania, crimson clover winter survival is not consistent; it should be seeded no later than early September to ensure successful overwintering, making it less suitable for a summer annual crop rotation. In the mid-Atlantic region, additional research is still needed to help develop successful corn-crimson clover cover crop no-till management guidelines.

Some farmers have shown interest in using wheat instead of rye because seed can be less expensive, it matures more slowly in the spring, and is a shorter-statured plant than rye. Triticale’s development in the spring is intermediate to wheat and rye and has worked well for 2 of our 3 cooperating farmers. Further research is required to determine the feasibility and usefulness of other cover crop species and mixtures for planting green.

## Establishing the cover crop

Appropriate establishment dates for cover crops will depend on the species used (see the Penn State Agronomy Guide), crop rotation, and whether manure is applied in the fall. Cover crops can be drill-seeded, broadcast, or planted at various row spacings, depending on available equipment and grower preference. We evaluated drill-seeded cereal rye in 7.5 inch rows at 30, 60, and 120 lb/A preceding soybeans. When planted green, we found that in 5 of 6 site-years seeding rate did not significantly influence spring biomass when living rye remained until soybean planting. This was likely influenced by increased tillering at lower seeding rates (not measured in study) as well as rye planting date and N fertility. In one site year, we top-dressed the two low seeding rates with twice as much nitrogen (60 lb N/A) but the cereal rye produced biomass similar to the high seeding rates that used half as much N (30 lb N/A). Also, that site-year we established rye late (late October instead of late September), demonstrating that more spring nitrogen applied to rye can compensate for lower seeding rates and fall planting dates. However, too much N on small grain cover crops can result in excess biomass production, and in some cases lodging prior to termination, both of which interfere with the establishment of the subsequent cash crop. Therefore, if planting in September, we recommend reducing rye seeding rates to around 30 lb/A and either increasing the rye seeding rate or applying more fertility if planting is delayed into late October.

## Killing the cover crop

In no-till systems, the cover crop can be killed with an herbicide before or after cash crop planting. When a plant growth regulator (PGR) herbicide such as 2,4-D or dicamba is used, this can influence the timeline of cover crop termination and cash crop planting, particularly with soybeans, and may even prevent successful planting green options. Be sure to review herbicide-use guidelines for cover crop burndown prior to making any decisions about termination timing and cash crop planting. It is important to kill the cover crop completely, so it doesn't compete with the emerging cash crop for light, water and nutrients.

In 24/26 site-years (total for corn and soybean trials), we found that soil was 2-7.7% dryer when corn and soybeans were planted into green cover crops compared to preplant-killed cover crops. This may be beneficial in a wet year, providing better conditions for planting, and possibly allowing farmers to enter fields earlier for planting. In addition, despite the drier soil at planting, the larger mass of residue from late-killed cover crops compared to the preplant-killed cover crop decomposed more slowly over the growing season, and we measured moisture conservation, or wetter soil on average, later in the growing season.

Conversely, soil drying of living covers can be detrimental in a dry spring because the living, transpiring cover crop dries soil more than a cover crop terminated earlier in the season, and soil can become too dry for planting to optimum seed depth and subsequent crop germination. Therefore, planting green is not recommended in dry springs.

## Cash crop planting considerations

In addition to drying soil until termination, planting green also cools soil the entire growing season compared to preplant-killed cover crops. In our study at time of corn or soybean planting, soil planted green was 1.3-4.3■ cooler compared to planting into preplant-killed rye or triticale. Possibly due to the cooler soil, as well as reduced light and plant-available nutrients, corn and soybeans planted green emerged up to one week later than the preplant-killed treatment, and crop size and maturity visibly lagged the entire growing season. The seeds we used were not treated with fungicide or insecticides, though a fungicide may be helpful, especially in cool, wet springs, when diseases can be prevalent. To protect beneficial predator species, such as ground beetles (Carabidae), which are known to feed on slugs, we recommend using seed **without** neonicotinoid insecticides, unless planting into a field with known prior infestations of susceptible early-season insect pests.

## Equipment considerations

Planting green can be done successfully with most no-till planting equipment and does not necessarily require investment in special attachments. However, row cleaning, trash wheels, or residue management planter modification can help make cash crop planting more successful. In fact, planter attachments have been designed specifically for planting green by a Pennsylvania farmer, and Dawn Biologic sells the "ZRX" zone roller that have row cleaning disks and mini roller-crimpers or "residue managers" attached to the frame of the planter, allowing the user to roll/crimp/manage residue and plant in one pass (Figure 2). The need to roll or not is highly dependent on the cover crop seeding rate, row spacing, fertility, biomass and height and growth stage at time of termination, and grower experience and preference. However, we suggest rolling mature and/or high biomass cover crops, to minimize shading of the cash crop, which can cause spindly plants. We also suggest the use of aggressive row cleaners to help clear the furrow of residue to improve seed-soil contact and allow sunlight to access soil within a few inches of the cash crop row, to moderate the cooling effect of planting green. Some growers no-till drill soybeans into living cover, but for better stand establishment, we suggest using a planter, which allows greater precision. The key to successful planting green is to adjust for specific field conditions, and check planting depth and seed slot closure in the field several times regardless of equipment used.

**Figure 2.** Rolling cereal rye and planting soybeans green in the same pass at Rock Springs

## Nitrogen management considerations:

A fertility program should be unique to each field, depending on current soil-test values, manure nutrient analysis and application frequency, cover crop and cash crop species, and cover crop C:N ratio at termination. In one representative site-year, we measured a C:N ratio 30:1 for preplant-killed rye (12 days prior to planting) and 44:1 for rye killed at corn planting (planted green). Ratios of C:N greater than 25:1 typically result in immobilized nitrogen, or N that is unavailable for uptake by the cash crop, until microbes obtain sufficient nitrogen to consume the higher carbon material. Even legumes, which are higher in N than non-legumes, may immobilize N if their C:N ratio is above 25:1 at maturity. For this reason, we suggest a split-application of nitrogen, applying approximately one-third to one-half N at planting and the remainder as a side dressing. In addition to the presence of high C:N biomass at planting green, cooler and drier soil at cash crop planting can result in slowed nitrogen mineralization and less availability to the cash crop early in the growing season. Keep in mind that the rye residue will also release N as it is decomposed. For instance, the aboveground planted green rye (C:N of 44:1) produced more aboveground biomass than the preplant-killed rye, and the rye residues contained approximately 59 lb N/A and 41 lbN/A, respectively. Further research is needed to determine optimum N management for planting green.

## Pest management considerations:

Multiple farmers have communicated with us that planting green reduced slug damage on their cash crops. Our working hypothesis was that planting green provides good habitat for slug predators, and the living covers provide slugs an attractive alternative, which slugs eat rather than cash crop seeds and seedlings. We found mixed results in our study; depending on year and location, planting green significantly increased, decreased, or had no effect on slug damage on corn at V5. For soybeans, there was a significant reduction in slug damage in two of 14 site years when we planted green compared to preplant-killed cover, but no effect of planting green on soybean damage in the remaining 12 site-years (Figure 3). In two out of 12 corn site-years, armyworm outbreaks reached the economic threshold for both cover crop treatments in corn. Armyworm damage was lower in the planting green treatment at one site, but did not differ between treatments at the other site. So, we cannot conclude that planting green consistently reduces slug damage to corn and soybeans, or armyworm feeding on corn. We can conclude, however, that pest management is more complicated when planting green with fields requiring more scouting to detect possible pest problems.

**Figure 3.** Marsh slug next to a soybean seedling with slug damage at VE in Landisville PA. Planting green may provide alternative forage for slugs and habitat for slug predators.

To benefit from slug predators, one should plant cash crop seeds without neonicotinoid seed treatments, as research at Penn State has shown they do not control slugs but the neonicotinoids are toxic to ground beetles and other invertebrate predators that contribute to slug control.

## Economic considerations for planting green:

We have yet to complete an in-depth economic analysis of planting green. However, when paired with previous research, our 12 and 14 site-years of results for corn and soybeans, respectively, provide evidence of opportunities for cost savings for planting green compared to killing cover crops preplant. For example, planting green may reduce or eliminate the need for postemergence herbicide applications. Where we measured weed biomass, in 2 of 3 site-years, weed biomass was reduced by 64% compared to preplant-killed rye, although weed levels were well below economic threshold in both treatments. This cost savings could be increased if corn planters are adapted to spray a burndown herbicide and plant in the same pass, maximizing fuel and time savings. Using untreated seeds would also provide some savings, but these expenses would likely be offset by the need for more scouting in fields planted green. We also found that reducing rye seeding rate can result in comparable spring biomass, resulting in savings on seed costs.

Planting green could also offer other savings that are more difficult to quantify, such as preventing soil and nutrient loss from fields, resulting in less fertilizer usage over time. In addition to sequestering nutrients in living cover-crop tissue and slowly releasing them once desiccated as the cash crop needs them, planting green has strong potential to help build soil organic matter, which should help improve crop production. Unfortunately, these sorts of measurements were beyond the scope of our project.

## How should growers begin?

Prior to planting green, we recommend that growers first get comfortable with no-till + cover crop management. We also recommend that interested growers consult with others who have planted green with the climate, soils, and crops typical for your region. We suggest starting to plant green with soybeans before trying corn, as soybeans have indeterminant growth and our research showed that soybeans are highly adaptable to this practice. This legume crop also minimizes potential challenges with nitrogen tie-up by mature cover crops.

## In short, when planting green, we recommend:

- Reducing cover crop seeding rate, especially if applying manure.
- In a dry spring, killing cover crops one or more weeks before cash crop planting.
- Beginning planting green with soybeans instead of corn.
- Considering how much cover-crop biomass your equipment can handle, and rolling/crimping mature, high-biomass covers.
- Using aggressive row cleaners to start.
- Using a planter rather than a drill for establishing soybeans.
- Focusing on optimum planting depth.
- Paying attention to cover crop C:N ratio with species choice and crop maturity.
- Carefully attending to nitrogen management with corn, including at planting and sidedress N as needed.
- Scouting for early season pests and use of IPM to manage pests.
- Avoiding neonicotinoid seed treatments and pre-emptive insecticide sprays that can kill predators of insect and slug pests, which are allies in pest control.
- Consulting with farmers in your area whom have planted green successfully.

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Penn State College of Agricultural Sciences research and extension programs are funded in part by Pennsylvania counties, the Commonwealth of Pennsylvania, and the U.S. Department of Agriculture.