IOWA SOYBEAN Association

RESEARCH CENTER FOR FARMING INNOVATION

ADVANCES IN COVER CROP MANAGEMENT

Funded in part by the soybean checkoff

Steps to INCREASE PROFITABILITY

Why Cover Crops?

Over the past five years there has been a large expansion of new knowledge related to crop management in cover crop systems. The purpose of this publication is to review this new knowledge to enable farmers to optimize cash crop yield while protecting natural resources.

Iowa farmers have many reasons for adopting cover crops in their operations.

The most common are as follows:

- ► **Reduce Erosion/Improve Soil Health**
- ► **Improve Nutrient Management**
- ► **Weed and Pest Management**
- ► **Yield Enhancement**
- ► **Livestock Grazing**

The key to optimizing profitability in cover crop systems is knowing what you want to achieve with clear goals in mind.

Reduce Erosion/Improve Soil Health

Cover crops are very effective in reducing erosion and building soil health. A mega-trend that farmers are facing in the United States is loss of farmland due to urban development. In Figure 1 is reported USDA census data on available farmland for the past 20 years. Note the large decline in available farmland over the past two decades due to government programs and urban development. With less farmland available, it stands to reason that we must place greater emphasis on protecting the productivity

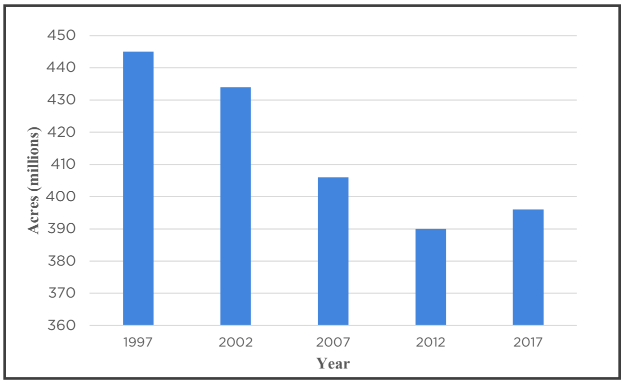


Figure 1. Loss of US Farmland to development over the past 20 years. National Agriculture and Statistics Service, 2017.

of existing farmland via reducing erosion and building soil health with cover crops.

Nutrient Management

A large threat to farmer profitability is nutrient loss via runoff, leaching or volatilization. Nitrogen is particularly susceptible to losses from leaching and volatilization. As an example, one of Iowa's crop districts loses, on average, 25 pounds of nitrogen per acre per year in leaching losses, according to private and public water sampling. This equates to 94 million pounds of nitrogen loss for one district. The loss comes at the cost of lost fertilizer value as well as extraneous costs of water quality impairment. Cover crops are an essential component of modern production systems as they minimize nutrient loss and protect water quality.

Recent research conducted by the Iowa Soybean Association (ISA) indicates tremendous potential for cover crops in manured cropping systems. Our results indicate significant reductions in nutrient losses coupled with an occasional yield advantage for the practice.

Weed and Pest Management

Crop protection companies are developing new, active ingredients to control herbicide resistant weeds, but these new product offerings will not be available for another 3-10 years. Should these active ingredients become products on the market, it will be essential to prevent and delay resistance to these chemistries. Through their weed suppressive capabilities, cover crops are an essential component of integrated weed management.

Recent research indicates cover crops can offer some suppression of soybean cyst nematode and sclerotinia stem rot (White Mold) in soybeans. Cover crops will provide stand-alone control of these diseases, but can be a valuable component of an integrated cropping system.

Yield Enhancement

Our goal at ISA is to develop management practices where there is a yield benefit for cover crops compared to conventional practices. There are two reasons we think this is possible. First, some research has shown greater soil water availability during reproductive stages for cover crop systems compared to no-cover crop systems. Cover cropped soils often have improved structure with greater water infiltration leading to deep soil profile replenishment. The second reason involves nitrogen. While cover crops sequester nitrogen during the early vegetative stages, new research indicates this nitrogen is released later during reproductive development. This slow release of nitrogen could be very important for maintaining yield in especially wet growing seasons where leaching and denitrification are prevalent.

Livestock Grazing

One of the most direct contributions of cover crops to profitability, is if farmers use the cover crop to graze livestock. Consider an operation where feed costs equate to $1.5 per cow per day. If the farmer is able to graze cover crops for 30 days in the spring, this equals $45/cow in feed production. Estimating this value on a per acre basis is difficult since it depends upon cover crop biomass and quality. One farmer estimates it requires one half to one acre of cover crops to feed a cow for a day.

New Ideas for Seeding Cover Crops

ISA Research Center for Farming Innovation (RCFI) is evaluating a unique approach to establish cover crops such as clovers, brassicas, and oats that require earlier seeding in the fall.

In this system, an unmanned aerial vehicle (UAV), would broadcast cover crop species that require early fall seeding into a standing crop. As UAV's fly lower to the ground, seeding of light seeded cover crops are less vulnerable to drift.

After harvest, the farmer could then drill a winter hardy grass species such as cereal rye or wheat to create a diverse cover crop stand.

What we hope to better understand in this system is the return on investment for more diverse species.

Table 1: Table 1. Cover Crop species ratings. Source: compiled by ISA from several sources and Iowa farmer experience. Abbreviations: E= excellent, VG= very good, G= good, F= fair.

	Species	Reduce Compaction	Control Erosion	Reduce Nutrient Losses	Build Soil Health	Suppress Weeds	Comments
Grasses	Wheat	G	E	VG	VG	E	Seed in fall, winter hardy.
	Cereal Rye	VG	E	E	E	E	Easiest cover crop to establish, use ahead of corn requires different management. Most winter hardy.
	Oats	G	VG	VG	VG	VG	Winter kill. Requires early fall seeding, not winter hardy.
	Triticale	VG	E	E	E	E	Believed to have less impact on corn cash crop compared to cereal rye. Winter hardy.
Brassicas	Radish	VG	VG	E	VG	E	Can be difficult to establish. Requires early fall seeding. Not winter hardy.
	Turnips	G	G	VG	G	VG	Can be difficult to establish. Requires early fall seeding. Not winter hardy. Good for grazing.
	Mustards	G	VG	G	VG	VG	Plant in early spring and terminate after planting or seed in early fall. Difficult to establish. Not winter hardy.
	Kale	G	G	VG	G	VG	Can be difficult to establish. Late summer to early fall seeding. Not winter hardy.
	Rapeseed	G	VG	VG	G	VG	Lower in cost, moderately winter hardy, adds diversity to cover crop system.
Legumes	Clovers	F	G	G	VG	F	Requires early fall seeding. Difficult to establish, can sometimes provide a yield advantage ahead of corn.
	Hairy Vetch	F	G	F	VG	G	Requires early fall seeding. Difficult to establish, can sometimes provide a yield advantage ahead of corn.
	Field Peas	F	F	F	G	F	Farmers experimenting with early spring field peas to provide nitrogen to corn crop.

Selecting Cover Crop Species for Your Farm

The cover crop seed industry provides a vast number of cover crop species. Choice of cover crop species depends upon your goals. Table 1 is a simplified list of cover crop species by goal. This list only contains species where Iowa farmers have had success.

Cover crop experts and seed suppliers often recommend that farmers plant blends of cover crops. Sometimes there is a yield advantage for the cash crop following cover crop mixes compared to planting a single species of cover crops.

However, many of the cover crop seed blends on the market contain cover crop species that require early fall establishment. If you are unable to seed these blends early in the fall, it is best to use single species cover crops that are cold tolerant such as cereal rye, triticale, or wheat. Late seeded brassicas and clovers rarely have enough time to establish much biomass and often do not over winter, leading to wasted input costs.

Cover Crop

ESTABLISHMENT

Achieving even emergence and good stand growth of cover crops can be challenging at first. There are currently four ways to seed cover crops: UAV, airplane or helicopter, ground application with high clearance machinery, drilling after harvest or in tandem with other field activities. Your choice of seeding methods depends upon the species you are seeding, cash crop harvest time, labor and equipment availability and weather. Here are some tips for improving stand establishment for each of these methods.

Unmanned Aerial Vehicle (UAV)

UAVs are the newest method of cover crop seed application. Cover crop seed applications can occur with a single or multiple UAVs in the same field (swarming) to speed up the process. This system is best suited for small-seeded cover crop species where application volumes are from 5 to 15 lbs/A. Costs for UAV cover crop application will vary due to several factors, however, standard costs for UAV application start at $150/hour. At average productivity, a UAV can apply cover crop at 12 acres/hour for a 10 lb/A application.

See Table 2 for average UAV productivity by pounds of seed applied. A 10 lb/A application equates to $12.50/A. As with any broadcast system, UAV seeding should occur near the time of rain events to improve cover crop seed germination. Some UAV's are equipped with larger seed tanks and this improves productivity.

Table 2. UAV cover crop productivity based upon rate of seeding.

LBS/ACRE	ACRES/HOUR
10	12
15	8
20	6
25	5
30	4
40	3

Airplane or Helicopter Applications

Airplane and helicopter applications of cover crop seed can be very successful, especially when seeding a relatively heavier cover crop seed such as cereal rye or wheat. Air applications sometimes struggle to apply seed blends of heavy and light seeded cover crops because wind patterns can carry the light seeded species off target. As with any broadcast application, airplane or helicopter applications should occur near rain events to optimize germination and stand establishment. Costs of airplane and helicopter applications vary widely based upon your location.

High Clearance Equipment

Applications of cover crop seed with high clearance equipment can sometimes be more affordable and offer improved spread patterns compared to airplanes. A potential drawback of high clearance applications is they can reduce narrow row soybean yields unless there are tramlines to follow.

Applications with Normally Occurring Field Operations

Some farmers have adapted their harvest machinery to spread cover crop seed during harvest by placing seeding boxes on the harvester. The cover crop seed is either spread at the header or behind the chaff spreader. While this system reduces fuel costs, some farmers find it difficult to manage harvest and seeding at the same time.

Other methods of applying cover crop seed during field operations include spreading seed during shallow vertical till operations and with strip till passes. Some strip till machines are equipped with fertilizer boxes that can be utilized to spread cover crop seed between the strip till rows.

Drilling After Harvest

One of the best methods to assure good cover crop establishment is to drill after harvest. In a normal corn-soybean rotation, waiting until after harvest to drill limits the cover crop species to winter hardy grasses, as brassicas and legumes generally won't have enough heat units to establish in the fall. In a corn silage system, drilling cover crop blends are a very good option. Some farmers are experimenting with growing earlier cash crop maturities to have time to establish a fall cover crop. This system is probably best where the farmer plans to graze the cover

Cash Crop Herbicide Carryover and Cover Crop Stand Establishment

Herbicides used to protect the cash crop can sometimes interfere with cover crop establishment. In wetter summers, the effects of carryover are lessened dramatically. Carryover risk is greatest in dry summers and for late applications.

The relative persistence and time of application of the herbicide also contributes to carryover risk. Of highest importance is establishing economic control of weeds in the cash crop. Once those are controlled, focus on tailoring your cover crop plans according to the relative species, herbicide risks, and weather.

The University of Missouri has conducted extensive research on the effects of carryover herbicides on cover crop stand establishment. Their ranking of species risk to cash crop herbicides is as follows with radishes being the most sensitive to herbicide carryover:

radish > peas > clover > wheat = oats > hairy vetch = cereal rye

The following soybean herbicides have the greatest risk of carryover risk to cover crops with late applications having the greatest risk to cover crop establishment:

fomesafen (Flexstar/Prefix), pyroxasulfone (Zidua), imazethapyr (Pursuit), acetochlor (Warrant), sulfentrazone (Authority products)

These corn herbicides have been shown to have the greatest risk on cover crop stand establishment:

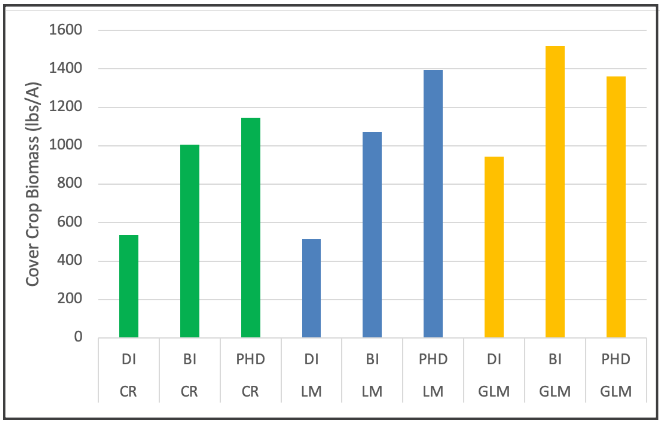
topramezone (Impact), mesotrione (Callisto, Halex GT, etc.) clopyralid (Stinger, SureStart), isoxaflutole (Balance Flexx), pyroxasulfone (Zidua, etc.)

crop to compensate the lost yield potential in an earlier maturing cash crop.

Results from a recent USDA study on methods of cover crop establishment illustrate the impacts of species selection and the interaction of species and seeding method. In this study researchers established three kinds of cover crops: cereal rye (CR), legume mix (LM) and a grass legume mix (GLM). These cover crops were established by three methods: drilled interseeded at corn growth stage of V5 (DI), broadcast interseeded at the dough stage (BI), and drilled soon after harvest (PHD). The amount of cover crop biomass for each treatment was measured at termination the following spring.

Results in terms of spring biomass for the species and establishment methods are shown in Figure 2. Note that for cereal rye (CR), drilling after harvest or broadcast interseeding at the corn dough stage were equally effective in providing ample biomass. Because cereal rye is relatively shade intolerant, it did not thrive under early season drill interseeding (DI). For the legume mix (LM), drill interseeding (DI) did not provide much biomass across the three years of the study. This mix did respond to broadcast interseeding (BI). While the post-harvest drilling (PHD) shows the highest biomass accumulation, this was not a stable establishment method as there was tremendous growth in only one out of three years. Similarly to the legume mix (LM), the grass legume mix (GLM) was best established by broadcast interseeding (BI) followed or post harvest drilling (PHD). In the grass legume mix that was drilled after harvest, grass species were much more dominant over legumes.

Figure 2. Spring cover crop biomass as affected by species selection and establishment method. Source: adapted from Agronomy Journal (2020) 112:4765-4774



Cover Crop Establishment Recommendations

Based upon this study and farmer experiences ISA makes the following recommendations regarding methods of cover crop establishment.

1. Broadcast interseed cover crops at the dough stage in corn and near leaf drop in soybeans. Best results occur with an inch of rain soon after seeding. If conditions are very dry, do not broadcast interseed.
2. Drill grass cover crops soon after harvest. In most falls, there will not be sufficient heat units for legume and broadleaf cover crops to establish. Legume and broadleaf cover crops need to be broadcast interseeded or drilled after corn silage to achieve adequate stands.

Terminating the COVER CROP

Farmers and experts differ on their strategies for terminating the cover crop. The following are guidelines ISA has developed based upon our research and input from experienced cover crop users. The key to optimum termination is to be flexible and change strategies according to weather.

Herbicide Termination 10-14 days Before Planting

This is a common recommendation and followed by some farmers to reduce the impact of cover crops on stand establishment and yield. However, there are some drawbacks for this strategy. In some years the amount of accumulated biomass from the cover crop can be very small under early termination. While a small cover crop can still add value in reducing erosion, the contribution to soil health will be very small. Another complication with very early cover crop termination is that cold temperatures can reduce activity of herbicides used to terminate the cover crop requiring higher rates or slow rates of desiccation. Finally, early termination can sometimes complicate the planting process as the slowly dying residue creates conditions where the soil stays wet longer.

Tillage Termination Before Planting

In systems that utilize manure, some farmers terminate their cover crop with tillage as they need to create a smooth seed bed from manure application traffic. While cover crops have been shown to be beneficial in this system, maximum benefits are achieved in letting the cover crop establish more biomass. Also, depending on the tillage operation, it may not be effective in fully terminating the cover crop.

Planting Green and Terminating Soon After Planting

In this strategy, no-till planting of corn or soybeans into growing cover crops, allows more time for cover crop biomass accumulation to suppress weeds and improve soil health. Generally, termination after planting occurs will ensure warmer temperatures compared to earlier terminations, improving consistency in chemical termination. Another advantage for planting green is that seed beds are often drier allowing for improved trafficability and cash crop stand establishment.

As with any system, there are downsides to planting green into living cover crop stands. Row units can sometimes plant at a shallower depth due to the accumulated biomass, meaning planting depth will need to be checked more frequently. The greatest risk in this system is if termination is delayed due to cold or rainy weather and the cover crop becomes too large, it can intercept sunlight from the emerging crop.

Adding tankmix herbicides such as saflufenacil (Sharpen) with glyphosate can speed up cover crop desiccation allowing more sunlight for cash crop seedlings. The herbicide paraquat (Gramoxone) can also provide rapid cereal rye desiccation when tankmixed with metribuzin or atrazine if the cover crop growing point is above the soil surface (between 6 to 8 inches tall). Carefully read and understand all herbicide labels when chemically terminating the cover crop.

Roller Crimping

Some Iowa farmers have good success in terminating the cover crop with machinery that flattens the cover crop on the soil surface. Sometimes these roller crimper devices are attached to a planter, or more commonly used in a separate operation. Roller crimping will not work well unless the cover crop is tall and the growing point is well above the soil surface. In roller crimping, you achieve maximum cover crop biomass, but the cash crop planting date can sometimes be delayed while waiting for the cover crop to get large enough for crimping.

Termination After Planting

To accumulate more biomass, some farmers will wait until a few weeks after planting to terminate the cover crop. In all of our research, we have seen significant cash crop yield losses associated with this practice.

Guidance on Cover Crop Termination Strategies

The table below contains ratings for various termination strategies by cover crop species. This table is not all inclusive of termination strategies and the Iowa Soybean Association does not endorse one herbicide strategy over another. Always carefully read herbicide product labels before application to avoid cash crop injury. Source: compilation of university weed science ratings along with farmer experiences. Abbreviations: E= excellent; G= good, may require additional control passes; F= Fair, may require additional control passes; P= poor; N= no control; "."= no data. Carefully read footnotes.

	Termination Method	Clover	Hairy Vetch	Radish	Rapeseed	Annual Ryegras	Cereal Rye	Wheat	Triticale	Oats
Non-Chemical Control	Winter Kill	N	N	E	N	N	N	N	N	E
	Roller Crimping	P	F	N	G	N	G	G	G	G
	Chisel plow1	G	G	E	E	G	E	E	E	E
	Vertical Tillage	P	P	P	P	P	P	P	P	P
Glyphosate and Tank Mixes	Ta	P	P	E	F	F	E	F	E	E
	Glyphosate (1.13 lb a.e.)2,3	F	F	E	E	G	E	G	E	E
	Glyphosate (0.75 lb a.e.) + 2,4-D Ester (1 pt)	G	E	E	F	P	E	E	E	E
	Glyphosate (0.75 lb a.e.) + dicamba (0.5 lb a.e.)	G	E	E	F	P	E	E	E	E
	Glyphosate (0.75 lb a.e.) + Sharpen (1 oz)4,5	F	P	E	P	F	E	E	E	E
	Glyphosate (1.13 lb a.e.) + Sharpen (1 oz)4,5	G	F	E	F	G	E	E	E	E
Paraquat and Tank Mixes	Gramoxone (2 pt)7	P	P	G	F	P	F	F	F	F
	Gramoxone (3 pt)7	F	F	G	G	F	G	G	G	G
Other Chemical Control	Select Max (clethodim) (16 oz)	N	N	N	N	G	E	E	E	E
	Dicamba (0.5 lb a.e.)	E	E	P	P	N	N	N	N	N
	Glufosinate (Liberty, Interline, etc.)	P	G	.	.	P	P	F	P	F

Footnotes:
1. Roller crimping works best with tall cover crops near or at flowering.
2. May require multiple passes.
3. Lower rate of glyphosate for smaller sized cover crops. Do not apply when nighttime temperatures are below 40˚ F. Always include 8.5 to 17 lbs AMS/A to improve consistency. Tankmixing with liquid fertilizer or other herbicides may reduce efficacy.
4. Higher rate of glyphosate improves consistency and speed of desiccation, especially for larger sized cover crops. Do not apply when nighttime temperatures are below 40˚ F. Always include 8.5 to 17 lbs AMS/A to improve consistency. Use higher rate when tankmixing with liquid fertilizer or other herbicides to help with antagonism.
5. Sharpen must be applied with methylated seed oil at 1% and AMS at 17 lbs/A. Carefully read label if tankmixing or layering other Group 15 (PPO inhibiter) herbicides with Sharpen.
6. Always add non-ionic surfactant (0.25%) or crop oil concentrate at 1%.
7. Clethodim desiccation will be slower than glyphosate. Avoid applications during colder weather.

Establishing the CASH CROP

Farmers know that planting is one of the most important operations on the farm. The goal of planting is to place seed at an even depth into moisture, spacing the seed as evenly as possible and closing the furrow to press out excess air in the seeding zone. Inability to achieve good stands with even emergence in cover crops and/or no-till production is the most common cause of yield loss in these systems. Experienced farmers and agronomists sometimes differ in their opinions on what it takes to set up a planter to optimize planting into cover crops. This largely stems from regional and climate differences as well as differences in soil types. It is very important for new cover crop users to find farmers in their area to discuss best practices for the Iowa soils they farm. The following is a general discussion of best practices.

Frequently Check Planting Depth

Both corn and soybean yield can be reduced dramatically by shallow planting. Farmers know what depth to place seed (1 to 1.5 inches for soybeans and 2 inches for corn), but during planting operations, monitors are sometimes inaccurate and an optimal planter setting for one field may need adjustment when entering a new field. **For this reason, one the highest returns on investment in farming is time spent checking planting depth.** This is very important in conventional systems and especially important in no-till or cover crop systems where residue can affect seed placement. One of the most successful cover crop farmers in the state has a hired employee run the planter while he/she checks planting depth.

Managing Residue

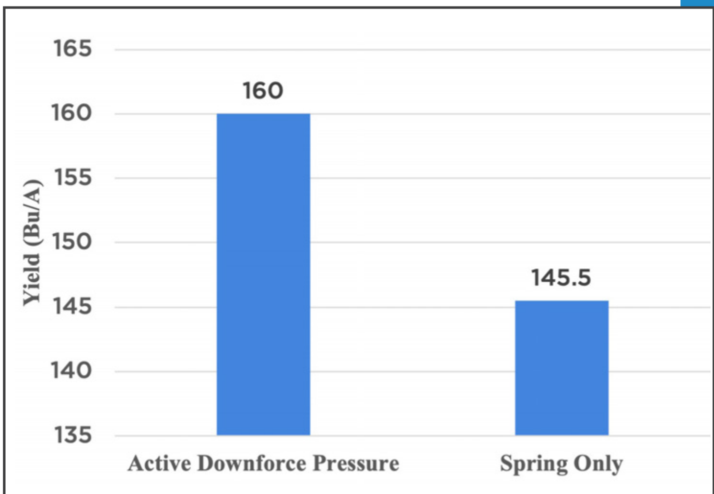
Cover crop and no-till systems require attention to residue management. Farmer preference differs widely across the state when it comes to best practices.

Some prefer to use no residue managers relying on sharp coulters to cut through the residue. Others prefer residue managers to move residue off the row and enable more control over planting depth. Currently there are so many designs of residue movers that it is impossible to determine the best styles from a research perspective. Determining the optimum residue management system will require discussions with successful farmers with your own testing and evaluations. What has been proven from research is there is likely a yield advantage to planting soybeans with a planter rather than a drill in no-till and cover crop systems as drills are often too light to optimize planting depth and often lack any system to manage residue.

Active Downforce Pressure

The equipment industry has developed several systems of active downforce where the planter adjusts down pressure in real time according to the field conditions. These systems require significant investment and, not surprisingly, farmers differ in their opinions on the need for this technology. ISA collaborated with HTS Ag to conduct a corn trial where two identical planter models were used in the same field. One of the planters was equipped with active downforce pressure while the other had only spring downforce pressure. This field was planted as no-till corn into soybean stubble across highly variable terrain. Results showed a 14.5 bu/A advantage for active downforce pressure in Figure 3.

Figure 3. Yield advantage for active downforce pressure in a no-till field in southwestern Iowa. Source: ISA Research research and HTS Ag.



Other trials and experiences have not shown this large of an advantage for active downforce systems. Where we see the largest advantage for these systems is where there are significant changes in terrain and soil types across the field. Uniform fields with similar soil types and slopes have shown smaller advantages to active downforce pressure.

SAME BUT DIFFERENT

WHILE SEEDING THE CASH CROP IN COVER CROP SYSTEMS INVOLVES THE SAME PRINCIPLES AS CONVENTIONAL PRODUCTION, IT CANNOT BE EMPHASIZED ENOUGH THAT YOUR STRATEGIES FOR ACHIEVING A GOOD STAND MUST BE DIFFERENT. SOMETIMES THESE DIFFERENT PRACTICES INVOLVE MORE INVESTMENT IN YOUR PLANTER. ONE SUCCESSFUL FARMER WHO HAS PROFITABLY ADOPTED COVER INVESTS SOME OF HIS COST SAVINGS FROM NOT TILLING IN ROUTINE PLANTER UPGRADES.

Alternative Ways to Manage Residue

Some farmers manage residue by adjusting and changing their planter settings. Others use precision seeding and strip-till cover crop systems. In these systems the farmer is overcoming planter limitations by creating no-residue zones across the field.

Precision Seeding the cover crop is drilled after harvest, but certain rows are plugged to leave a no-cover crop strip that matches the row units on the cash crop planter. For this system to work well, accurate guidance is needed to keep the cash crop planter in the unseeded zones. Interestingly, university studies have shown that cover crop biomass on a per acre basis is almost equal to broadcast seeding in a precision seeding approach. Note that in this system it is important to have the planter set up for no-till planting.

Strip-Till Cover Cropping is very popular with farmers in Iowa. In this system, cover crop seed is broadcast and then strip till passes are made after establishment. The lack of residue in the tilled zone creates less complication for the cash crop planter. This system is especially useful for poorly drained soils where there are concerns about soil temperature or moisture at planting time. An advantage for strip-till cover crops compared to systems where there is a uniform cover crop across the field is that the farmer can let the cover crop get larger before termination and it will not compete for sunlight, water and nutrients with the cash crop. Drawbacks to a strip-till cover crop system are costs of tillage and the potential for erosion on sloping land.

Precision Seeded Field where rows on the planter drill are plugged to allow for cash crop seeding.

Strip till cover crop system.

Managing Sidewall Compaction

Sidewall compaction is a problem in conventional, no-till, and cover crop systems alike. It occurs most often when heavy downforce pressure is required to place seed at the proper depth and when soils are wetter than optimum for planting. In conditions when the cover crop has been terminated weeks before planting, the soil can sometimes be wetter than in conventional systems. High downforce pressure coupled with wetter soils are key contributing factors to sidewall compaction that can reduce early vigor and stand in the early vegetative stages.

Figure 4 is an example of a farmer strategy where a spike tooth closing wheel fractured the sidewall allowing for improved seedling growth. In Figure 5 is a sidewall that shows some compaction as evidenced by the smearing of the sidewall.

There are several clever aftermarket parts that are reported to reduce sidewall compaction. Serrated openings discs are recommended by some experienced cover crop farmers, as they can reduce sidewall compaction through prevention. The serrated discs cut the reside more efficiently reducing friction in the seed trench. This serrated opening discs do not require special closing wheels to function well, as they prevent the problem by reducing friction. Another way some farmers manage sidewall compaction is with two smaller closing discs that fracture the sidewalls. This is standard equipment on some planters but can also be sourced as an after market attachment.

These are just a few examples of new planter technology becoming available. Unfortunately, finding the best technology for your farm will require careful, testing and evaluation as well as learning from the experiences of other farmers.

Figure 4. Closing wheel fractured the sidewall improving early season plant growth.

Figure 5. Example of a compacted sidewall as evidenced by the smearing.

Figure 6. Spike toothed closing wheel.

Figure 7. Serrated opening wheel.

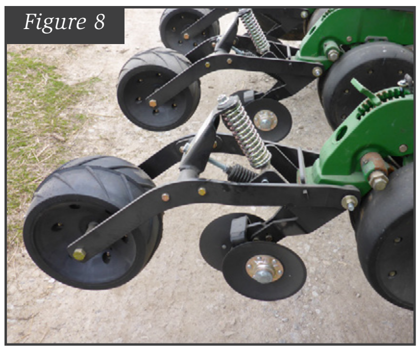


Figure 8. Two small disc closing wheels shatter sidewall compaction in this after market product.

Figure 9. Effect of cover crops on suppressing waterhemp. Left is a strip of no-cover crop. The right strip had cover crop. All herbicide programs equal. Source: AJ Blair

Managing Pests with COVER CROPS

Generally, cover crops reduce incidences of pests such as weeds and diseases, but in some cases production systems utilizing cover crops can encounter new pests. The following will describe where cover crops reduce and increase pest pressure.

One of the most consistent benefits for cover crops is in integrated weed management. Figure 9, above, is a field that was split between cover crops and no-cover crops. The strip to the right had a cereal rye cover crop whereas the strip on the left did not. The field was non-GMO seed production so the options for postemergence herbicides was much more limited than in standard production using herbicide traits.

In the scientific literature, it is well documented that cover crops reduce early season weed biomass and emergence by competing with weeds for light and from residue suppressing emergence. Reducing weed biomass is very important in modern production systems as they keep weeds in a more vulnerable stage longer allowing more time and flexibility for post-emergence weed control. However, cover crops should not be considered as a single weed management option. Weeds will still emerge in cover crop systems especially where cover crop biomass is limited.

Figure 10 is an example of how cereal rye can suppress giant ragweed, an important yield robbing weed in soybean and corn production. These results are adapted from a scientific publication where researchers measured weed density two weeks after the post-emergence herbicide application.

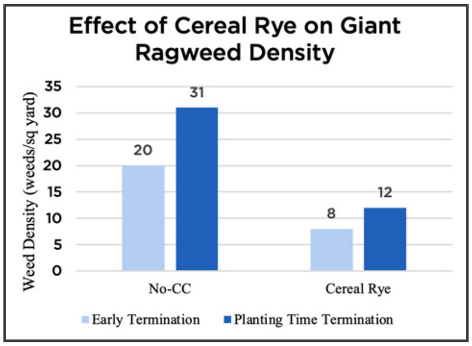
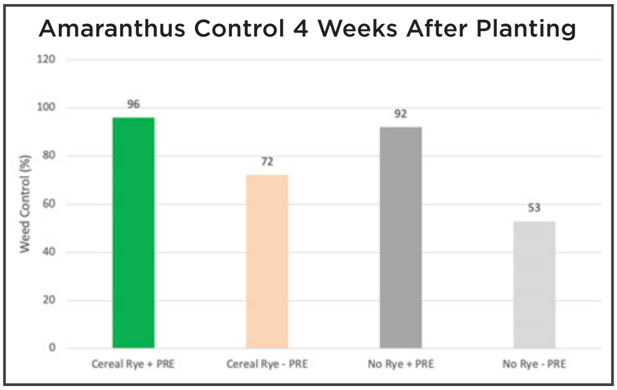


Figure 10. Effect of cereal rye on giant ragweed density 2-weeks after post-emergence herbicide application. Source: adapted from Weed Technology (2020) 34:787-793.

Figure 11. Effect of cover crop and pre-emergence herbicide on Palmer Amaranth control 4 weeks after planting. Adapted from Frontiers in Agronomy (2020) Vol. 2.



Do I still need a pre-emergence herbicide if I am using cover crops?

In some research data and farmer experience, the need for pre-emergence herbicides in cover crop systems is reduced. However, if your cover crop stands are thin or non-uniform a pre-emergence herbicide is justified as weeds will emerge in the barren spots.

In a recent study (Figure 11), scientists compared weed suppression by cover crops with and without at pre-emergence herbicide in soybeans. The weed in this study was Palmer Amaranth, a devastating weed related to waterhemp.

Note that including a pre-emergence herbicide with cereal rye cover crop improved weed control by 24% compared to cereal rye with no pre-emergence herbicide. Also note that cereal rye with no pre-emergence herbicide had 20% greater weed control compared to the no-cereal rye and no pre-emergence herbicide comparison.

If you forego a pre-emergence herbicide near planting, consider use of a residual herbicide with your first post-emergence herbicide application.

Can Cereal Rye Suppress White Mold (sclerotinia stem rot)?

White mold is a severe disease of soybeans that can reduce yields as much as 60% in some fields. Plant pathologists disagree about whether cereal rye has a role as an integrated component of white mold management.

In a recent study, researchers measured the effects of cereal rye residue on white mold apothecia (mushroom-like structure) emergence. These structures emit spores that infect flowers and stems, reducing yield. In Figure 12, note the dramatic reduction in the germination of apothecia in the presence of cereal rye residue. This reduction in apothecia correlated with significant reductions in emergence white mold infestation and increases in soybean yield. The presence of cereal rye created adverse conditions for spore release in this study, likely due to the dense mat of residue forming a barrier and preventing spores from reaching the flowers and stems.

Soybean White Mold

It is important to note that in this study, the cereal rye was allowed to reach anthesis and was terminated with a roller crimper. This likely does not reflect all farming conditions in Iowa. However, in some years cover crop biomass ahead of soybeans can be large creating a dense mat of residue. What is yet to be verified is how effective this mat will be in suppressing white mold. We foresee a cropping system where cover crops in combination with more tolerant genetics, reduced plant populations and fungicides will suppress more successfully than any single tactic alone.

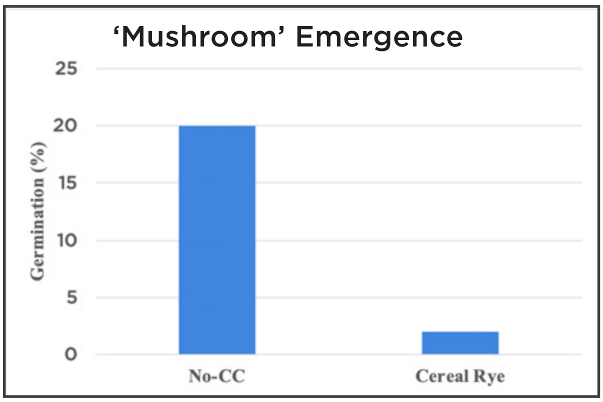


Figure 12. Activity of cereal rye on apothecia (mushroom) emergence. Source: Adapted from Renewable Ag. and Food Systems (2019) 35:599-607.

Does Cereal Rye Have a Role in Management of Soybean Cyst Nematode?

Whether cover crops have a role in an integrated system to manage Soybean Cyst Nematode (SCN) is currently a topic of debate among plant pathologists with some studies showing no changes in SCN populations after cover crops. However, a recent study conducted in North Dakota indicates that cereal rye, turnips, radishes, and clovers may have some role in suppressing populations. (Figure 13).

Note these cover crop species seemed to reduce SCN populations while soybeans (as expected) increased SCN populations. There is some evidence that mustard cover crops planted in the early spring and tilled into the soil before planting can have SCN suppressive activity, but this has never been studied in Iowa.

There is on-going research on the effects of cover crops on SCN populations. For now, our recommendation is to continue to manage SCN with an integrated approach which includes tolerant genetics and seed treatments and not to rely on cover crops as a sole management practice.

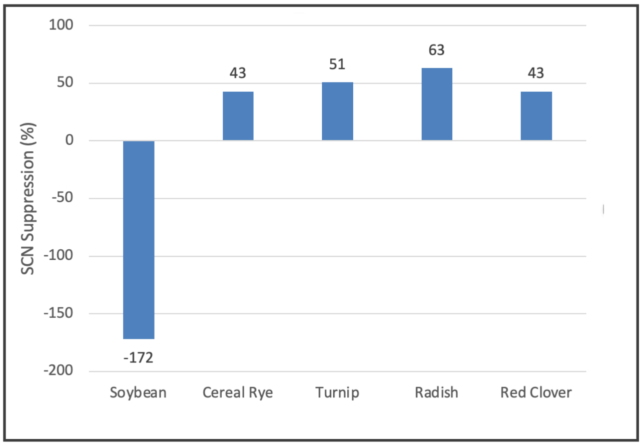


Figure 13. Effect of cover crops on soybean cyst nematode. Adapted from Plant Disease (2021) 105:764-769

Small Rodents and Slugs

In other states, there are occasional reports of extreme crop damage from small rodents and slugs associated with cover crops. The high amounts of residue create a more favorable environment for these pests.

Fortunately, in Iowa incidences of slugs defoliating soybean stands are rare. However slugs are difficult to control with only a few chemical options available. Some farmers in more southern states claim that eliminating insecticide seed treatments can reduce slug pressure, since these insecticides have activity on key slug predators.

Small rodent damage to crop stands does occur in Iowa. In most cases, these populations are small enough that they don't cause damage at economic thresholds. If populations of rodents are causing economic damage, then one time tillage could be beneficial.

Managing Soil Fertility in
COVER CROP SYSTEMS

One of the most overlooked components of production systems involving cover crops is soil fertility. Except for phosphorus, it is not well established whether cover crop systems need more or less nutrients to optimize yield. However, it is well understood that nutrient management in cover crop systems must be different from conventional systems to optimize crop yield.

Nitrogen: Research and farmer experience indicates that 30-50% of the corn crop's nitrogen need should be split applied in a cover crop system. This can occur as broadcast preplant, with starter at planting, or side dressed early (V2-V4 growth stage). The reason for this recommendation is illustrated in Figure 14, which is drawn from two studies. Scientists measured the amount of nitrate in the soil between the V6-V8 corn growth stages, a critical period for yield formation. The comparisons were cereal rye cover crop versus no-cover crop under conventional tillage. Note that the amount of nitrate in the soil was 2 to 4 times greater under a no-cover crop system compared to a cereal rye cover crop. The large amount of carbon in the roots and residue in the terminated cover crop increased the populations of soil microbes and fungi compared to the no cover treatment (data not shown). These soil microbes utilize nitrate in the soil for growth making it temporarily unavailable to the crop. These populations of microbes eventually die off, releasing the sequestered nitrogen back to the corn crop in about 4 to 6 weeks depending on rainfall and temperature. Therefore, we recommend early split nitrogen applications in corn following cover crops to overcome this early season nitrogen deficiency. Studies have shown the total amount of nitrogen supplied to the crop does not need to change in cover crop systems, rather it must be applied at different times.

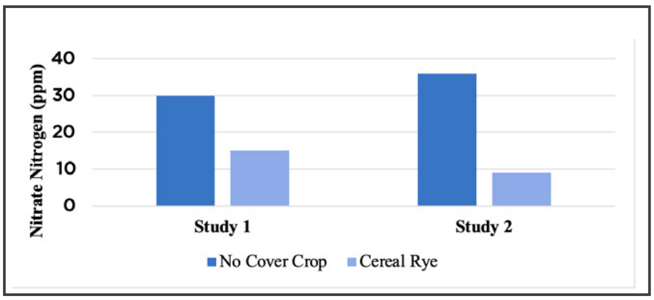
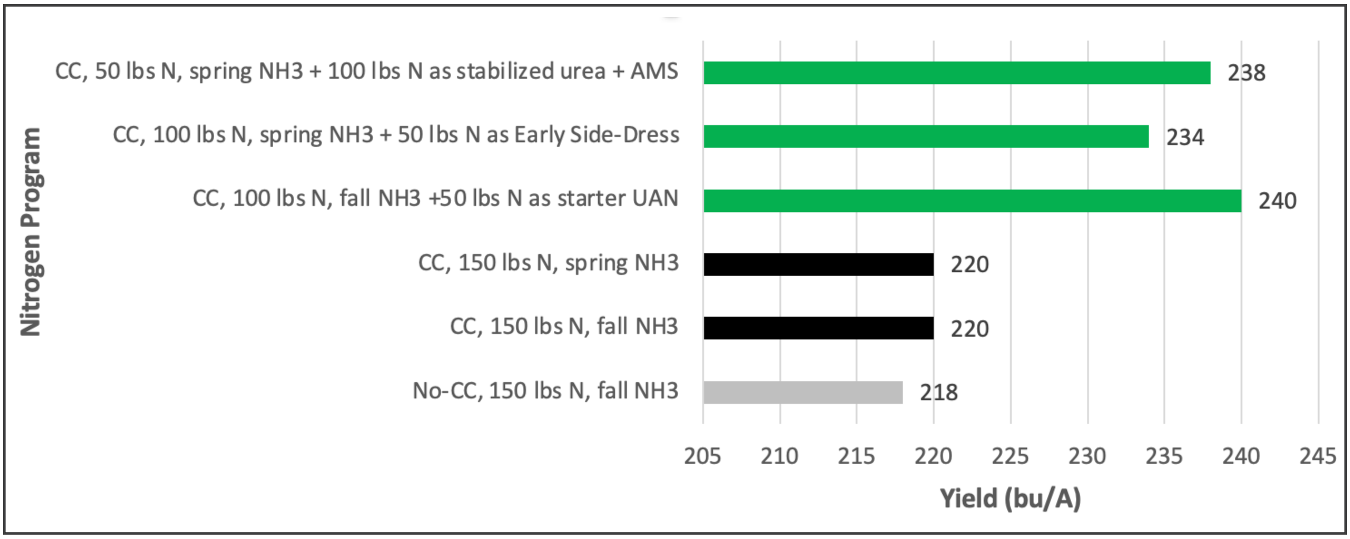


Figure 14. Effect of cereal rye cover crop on early season nitrogen availability. Sources: adapted from Soil Sci Soc Jrn 79:1482-1495 and Agron Jrn 111:1-11.

ISA tested this concept of split nitrogen applications in cover crop systems in both small plot and on-farm research. Yield results from the small-plot location are shown in Figure 15. All treatments had an equal nitrogen rate, only the source and time were changed. The lowest yielding plots were fall or spring applied ammonia with no early season nitrogen applications. All nitrogen management practices that included a fertilizer source that optimized early season nitrate availability yielded significantly more than the no-cover crops control.

Figure 15. Early season nitrogen management practices can increase corn yield in cover crop systems. Source: ISA small-plot research.



In on-farm research, we observed similar responses as in the small plot research. Figure 16 illustrates two cover crop fields where replicated strip trials compared a broadcast application of stabilized urea and ammonia sulfate immediately after planting versus a side dress application of ammonia at the V6 to V8 corn growth stage. Both treatments received identical rates of nitrogen, but with a different nitrogen source and timing of application. Note the yield increase for the post planting nitrogen application was 10 and 12 bu/A.

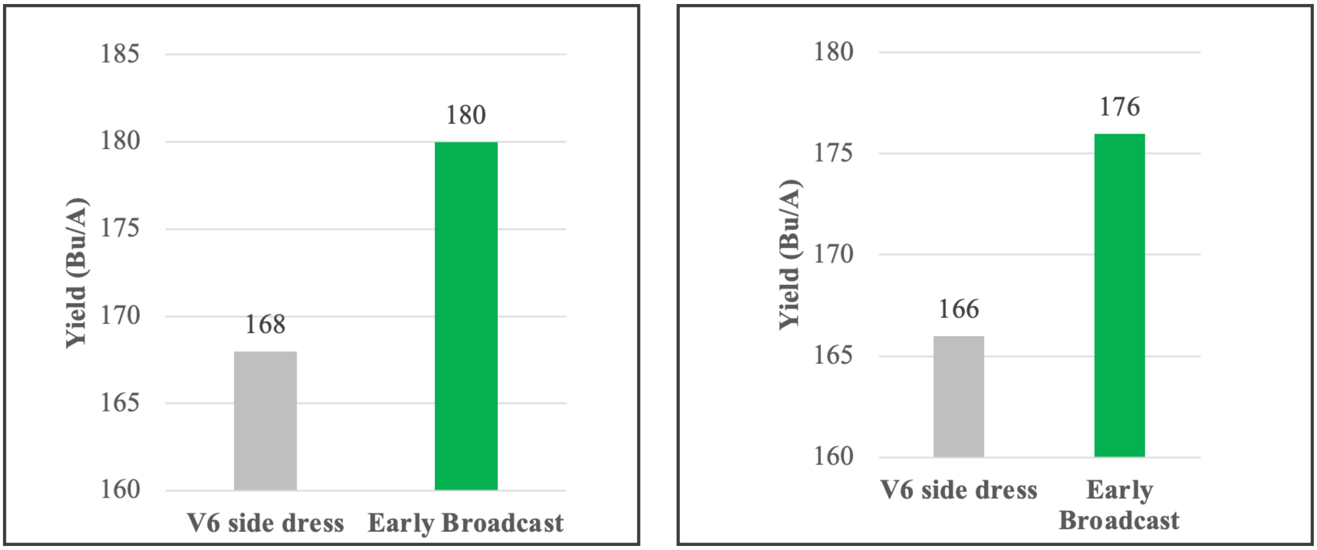


Figure 16. Corn response to early season nitrogen management following cover crops. Source: ISA on-farm research.

Nitrification Inhibitors in Broadcast UAN Applications

Broadcast applications of liquid nitrogen sources such as urea-ammonia-nitrate (UAN) before planting or with termination passes are popular with some farmers due to the convenience. High rates of UAN can sometimes antagonize glyphosate during termination passes, especially at high rates. A common recommendation is to not add more than 15 gallons per acre of UAN with the glyphosate in a burn-down or termination pass.

Broadcast UAN solutions are also vulnerable to nitrogen loss as the urea component can be denitrified into nitrogen gas and lost to crop production under high residue conditions. ISA evaluated the efficacy of urease inhibitors added to broadcast applications of UAN in small plot and on-farm research. In small plot location research, there was a 5-bushel yield advantage for a urease inhibitor added to broadcast UAN compared to UAN without an inhibitor. However, in five on-farm research locations there was no advantage. Whether a nitrification inhibitor will provide a yield advantage depends upon weather and the nitrogen rates applied. There is less advantage when using high rates of UAN compared to lower rates.

When Does Sequestered Nitrogen Become Available to the Crop?

Cover crops do an excellent job in sequestering nitrogen in the biomass and root biome making it less vulnerable to nitrogen losses. Less understood is the fate of this sequestered nitrogen during the entire growing season. Figure 17 shows data from a study where the researchers measured soil nitrate at various growth stages after cover crop termination in corn. Note that results are shown for conditions with wetter than normal and an average spring and summer. Soil nitrate levels during early corn development were likely limiting in the average spring, but with time the cover crop residue decayed and released significant nitrogen around tasseling (about 80 days after termination). For the wetter than normal spring, early season nitrate levels were likely not detrimental to early corn development and significantly more nitrogen was released compared to the average spring at 80 days after termination.

What this study means to farmers is that nitrogen sequestered by cover crops comes back into the cropping system around tasseling time. This serves as a slow-release mechanism for nitrogen resulting in more nitrogen available during grain filling. What farmers must manage is the early season deficits that occur and can reduce yield potential.

Phosphorus, Potassium, and Other Nutrients in a Cover Crop System.

There is some belief among some farmers that phosphorus and potassium become more available to the crop in a cover crop system. In our long-term cover crop research, we have seen no evidence of this effect. Phosphorus was significantly more available across sites in the cover crop comparison, but the difference was so small it would not make a difference in a fertilizer recommendation.

For this reason, we do not recommend reducing phosphorus and potassium inputs in a cover crop system. Sulfur is a mobile element and behaves similarly to nitrate in the soil. An area of ongoing research is to understand whether sulfur is immobilized in the cover crop in a similar fashion as nitrate. Until more research can be conducted, we recommend that farmers apply sulfur according to standard recommendations for conventional cropping systems.

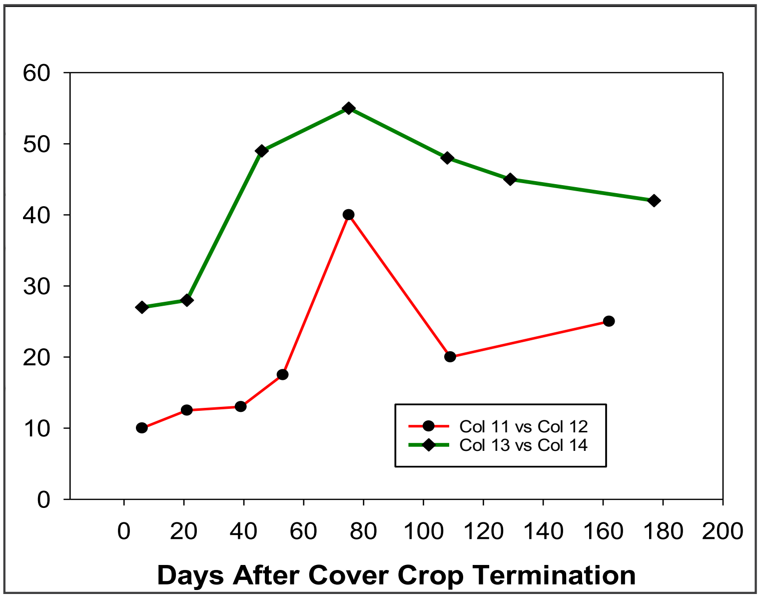


Figure 17. Fate of sequestered nitrogen in a cover crop system. Source: adapted from Soil Tillage Research (2020) 197104518

RESEARCH CENTER FOR FARMING INNOVATION

Putting it All Together, Recommended Cover Crop Systems

Soybean Cash Crop:

Drill after harvest or broadcast interseed at the corn dough stage. Do not broadcast interseed if the weather outlook is hot and dry, instead drill after harvest. Unless grazing, focus on cereal rye and avoid the expense of mixes. Allow the cover crop to reach a minimum of 8 to 12 inches before terminating. Use a pre-emergence herbicide unless cover crop biomass is large and evenly distributed across the field.

Corn Cash Crop:

Drill after harvest or broadcast interseed near the soybean leaf drop stage. Do not broadcast interseed if the weather outlook is hot and dry, instead drill after harvest. If broadcast interseeding, consider a broadleaf and grass mix, oats, or cereal rye. Allow the cover crop to reach a minimum of 8 to 12 inches before terminating. Check planter set up in the field, especially planting depth and trench closure. Apply 30-50% of the crops nitrogen needs as a split application with starter, broadcast or early side dress application.

Iowa Soybean Association
1255 SW Prairie Trail Pkwy., Ankeny, Iowa 50023
515-251-8640 | iasoybeans.com
Funded in part by the soybean checkoff