

# Improving the Success of Interseeding Cover Crops in Corn

**Interseeding cover crops in corn is a promising management practice that could improve the adoption of cover crops where they have not been feasible before. As with any new practice, to improve the odds of success, some attention to management is necessary. In this factsheet, we share some of the practices that can improve the potential of interseeding cover crops based on our work and the observations in the literature.**

## Field Selection

Successful interseeding is a function of the relationship of the cover crop to the corn crop and its management. The ideal management probably varies a bit from region to region and field to field. The competitiveness of the corn crop and the degree of heat and drought stress in a region will impact the potential for success, fall biomass accumulation and potential interseeding management.

Our general recommendation is to target interseeding at the V5 to V7 stage of corn. At this stage, the potential for injury from short residual preemergence herbicides is reduced and the timing is good for sidedress N. Postemergent glyphosate or glufosinate (Liberty) could also be applied at this time if necessary to control escaped weeds prior to cover crop emergence. In most areas, we have been successful with this approach and have achieved respectable cover crop establishment. The amount of cover crop biomass accumulation in the fall will depend on a number of factors including cover crop species, corn hybrid maturity as well as planting and harvest dates, corn grain vs. silage, and soil fertility management.

The success of interseeding in our work and in others have shown that factors such as plant population, timing of interseeding and hybrid maturity can affect the successful establishment and cover crop growth in the fall. These factors should be adjusted if need be, to improve interseeding success in a particular area.

We have had reasonable success with corn populations up to 32,000 per acre with our typical recommendations. Others have found that reducing plant populations to 22,000 to 26,000 will improve establishment and increase the fall cover crop biomass. However, in most cases we don't want to be reducing corn populations to the extent that we will be impacting yield or profitability. Using hybrids or targeting fields where moderate corn populations would work is one management strategy to consider.

Earlier interseeding from V3-V5 has been successful in Canada and has increased establishment and cover crop biomass in the fall. This may be necessary in environments where the corn crop is too competitive for later interseeding. We have not evaluated interseeding prior to V5 corn and do have some concern for potential cover crop competition with corn. We suggest doing some experimentation on your farm in smaller fields or plots and testing which tactics work best for you. We have had some success with interseedings at later stages such as V8 but these are best targeted to fields with less competitive corn.

In more competitive environments, there could be benefit for earlier maturity hybrids. Often, these are shorter statured with earlier dry down and harvest. This will allow better light penetration in early fall and promote cover crop growth and development. Changes in hybrid maturity should be considered only if they are part of a whole farm management plan and not if they impact profitability. Often reduced drying costs, earlier harvest, improved prices and residual effects of cover cropping can offset modest yield penalties associated with earlier hybrids.

# Cover Crop Interseeder Herbicide/Weed Management Guidelines

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Interseeding cover crops will impact the weed management strategies in a field since some herbicides can impact the establishment of the cover crops. Fields with lots of weeds or with certain herbicide resistant weeds may not be good candidates for interseeding as these may require longer residual herbicides or multiple postemergence applications.

Over the last five years, we have evaluated some residual broadleaf and grass herbicides in corn for use with interseeding. The following information is based on these observations and lists our current recommendations for some herbicides that 1.) Will likely be a problem; 2.) Some that can be problematic particularly at full rates; and 3.) Some that are compatible with interseeded cover crops. Our goal is to provide recommendations that carry minimal risk for cover crop herbicide injury.

Our basic approach with herbicides and interseeding has been to use a no or short residual burndown herbicide or tillage followed by a glyphosate or glufosinate (Liberty) application prior to interseeding. The ability to use residual herbicides is a function of the type of cover crop being interseeded. When interseeding multiple species that include grasses, legumes, and Brassicas such as forage radish, then residual herbicide options are fewer. Single species cover crop (e.g. grass or legume) can allow greater herbicide choice (Table 1).

For corn that is not Roundup Ready or Liberty Link, similar preemergence programs can be used, but POST herbicide options do not include glyphosate or Liberty. The herbicides listed in Table 2 have limited residual activity and/or tolerance to grasses, legumes or Brassica species. These foliar herbicides must be applied prior to interseeding when weeds are small. This will generally be 3 to 5 weeks after corn planting and a week or more prior to interseeding. In organic systems, a combination of tillage and cultivation is used for weed control and herbicide impacts on cover crops are not a concern. If grazing of the cover crop is planned, most corn herbicides allow grazing of corn stalks although there is nothing on the herbicide labels concerning interseeded cover crops. Table 2.2-18 in the 2015/16 Penn State Agronomy Guide lists herbicide grazing restrictions for corn.

We have had limited experience and less success interseeding in soybean. Full-season soybean is very competitive and it is difficult for interseeded cover crops to survive the intense shading when soybeans develop a closed canopy. Planting shorter-season varieties that are not as tall, planting soybeans a little later in the season such as in June or as double-crop soybean after a winter cereal in regions where this is common can allow for greater interseeding success. Residual soybean herbicides present the same concern for the success of the cover crop as corn herbicides. We have not tested residual soybean herbicides and interseeded cover crops, but provide the following guidelines based on our herbicide experience (Table 3).

## Species selection

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The ideal species for interseeding are those that are cool season, somewhat drought and shade tolerant and relatively easy to establish. These have mostly included annual ryegrass, and red and crimson clovers (See Table 4).

Annual ryegrasses are available as true annuals or Italian ryegrasses. The annual ryegrass are less expensive, and sometimes produce a bit more biomass, but they can head out in the fall and are more subject to winterkill. The Italian ryegrasses don't head out and often have superior winter hardiness. Most of our research has utilized annual ryegrass and we have less experience with Italian ryegrass. We suggest seeding ryegrass at 15 to 20 pounds per acre as a single species or 10-15 pounds per acre in a mix with clover.

Of the clovers, medium red clover has been the most successful in our research. It is fairly shade tolerant, has good winter hardiness and is less expensive than some other clovers. Be sure to properly inoculate legumes. Seed medium red clover at 8 to 10 pounds per acre as a single species or 5-8 pounds per acre in a mix with ryegrass.

An alternative to medium red clover is crimson clover. It often produces a bit more biomass in the fall after interseeding, but is subject to winterkill in Pennsylvania and North. Seed crimson clover at rates of 10-15 pounds per acre as a single species or 8-12 pounds per acre in a mix with ryegrass.

We have evaluated orchardgrass, Kentucky bluegrass, perennial ryegrass, tall fescue, and several other legumes such as hairy vetch, ladino clover, and yellow blossom sweet clover. Orchardgrass has worked fairly well and is more winter hardy than the ryegrass, while the other grasses have not been successful. We have had mixed results with hairy vetch and the other clovers have not been successful.

Cover Crop	Injury likely Active ingredient	Injury likely Key Products	Injury possible Active ingredient	Injury possible Key Products	Injury unlikely Active ingredient	Injury unlikely Key Products
Grass	atrazine (>1lb), nicosulfuron, pyroxasulfone, simazine, s-metolachlor, tembotrione, topramezone	Atrazine, others, Accent, Steadfast, Zidua, Anthem, Simazine, Dual, others, Capreno/Laudis, Armezon/Impact	acetochlor atrazine (<1 lb), dimethenamid, isoxaflutole, metribuzin, pendimethalin	Harness, Degree, Atrazine, Outlook, Balance, Corvus, Metribuzin, Prowl	clopyralid, dicamba, flumetsulam, halosulfuron, mesotrione, rimsulfuron, safluenacil	Stinger, Hornet, Banvel/Clarity, Python, Hornet, Permit, Callisto, Resolve, Basis, Sharpen
Legume	atrazine (>1 lb), clopyralid, Flumetsulam, Halosulfuron, Isoxaflutole, Mesotrione, pyoxasulfone, Simazine, Tembotrione, Topramezone	Atrazine, Stinger, Hornet, Python, Hornet, Permit, Corvus/Balance Callisto, Zidua, Anthem, Simazine, Capreno/Laudis, Armezon/Impact	acetochlor, atrazine (<1 lb), dicamba (PRE), dimethenmid, metribuzin, pendimethalin, s-metolachlor	Harness, Degree, Atrazine, Banvel/Clarity, Outlook, Metribuzin, Prowl, Dual, others	rimsulfuron, safluenacil	Resolve, Basis, Sharpen
Brassica	atrazine (>1 lb), Flumetsulam, halosulfuron, isoxaflutole, mesotrione, simazine	Atrazine, Python, Hornet, Permit, Balance/Corvus, Callisto, Simazine	atrazine (< 1lb), metribuzin, pendimethalin, pyroxasulfone, tembotrione, topramezone	Atrazine, Metribuzin, Prowl, Zidua, Anthem, Capreno/Laudis, Armezon/Impact	acetochlor, clopyralid, dimethenamid, dicamba (PRE), pendimethalin, rimsulfuron, saflufenacil, s-metolachlor	Harness, Degree, Stinger, Hornet, Outlook, Banvel/Clarity, Prowl, Resolve/Basis, Sharpen, Dual, others
Grass/ legume/ Brassica mix	atrazine (>1 lb), clopyralid, flumetsulam halosulfuron, isoxaflutole, mesotrione, nicosulfuron, pyoxasulfone, simazine, s-metolachlor, tembotrione, topramezone	Atrazine, Stinger, Python, Permit, Corvus/Balance, Callisto, Accent, Zidua, Simazine, Dual, others, Capreno/Laudis, Armezon/Impact	acetochlor, atrazine (<1 lb), dicamba (PRE), dimethenamid, metribuzin, pendimethalin, tembotrione, topramezone	Harness, Degree, Atrazine, Banvel/Clarity, Outlook, Metribuzin, Prowl, Capreno/Laudis, Armezon/Impact	rimsulfuron, safluenacil	Resolve, Basis, Sharpen

Table 1. The likelihood of herbicide injury to grasses, legumes, brassica species or mixtures when inter-seeded 5 to 7 weeks after corn planting. Injury likely indicates these herbicides should not be used when interseeding sensitive cover crop species. Injury possible indicates that there is potential to use these herbicides, but some injury may occur. Use these herbicides as setup programs (1/2 - 2/3X) prior to post herbicides. Herbicides in the Injury unlikely category can be used at normal (1X) rates and should allow safe establishment of specified cover crop species. This table does not list all products that contain these active ingredients.

Tolerant cover crops	Active ingredient	Trade name
Grasses	bentazon	Basagran
Grasses	bromoxynil	Buctril
Grasses	carfentrazone	Aim
Grasses	dicamba	Clarity/Banvel/Status
Grasses	flumetsulam + clopyralid	Hornet
Grasses	fluthiacet	Cadet
Grasses	glufosinate	Liberty
Grasses	glyphosate	Roundup or other glyphosates
Grasses	halosulfuron	Permit
Grasses	halosulfuron + dicamba	Yukon
Grasses	mesotrione	Callisto
Grasses	rimsulfuron + thifensulfuron	Resolve Q
Grasses	thifensulfuron	Harmony
Legumes or Brassica species	bentazon	Basagran
Legumes or Brassica species	bromoxynil	Buctril
Legumes or Brassica species	carfentrazone	Aim
Legumes or Brassica species	fluthiacet	Cadet
Legumes or Brassica species	glufosinate	Liberty
Legumes or Brassica species	glyphosate	Roundup or other glyphosates
Legumes or Brassica species	thifensulfuron	Harmony
Grasses + Legumes or Brassica species	bentazon	Basagran
Grasses + Legumes or Brassica species	bromoxynil	Buctril
Grasses + Legumes or Brassica species	carfentrazone	Aim
Grasses + Legumes or Brassica species	fluthiacet	Cadet
Grasses + Legumes or Brassica species	glufosinate	Liberty
Grasses + Legumes or Brassica species	glyphosate	Roundup or other glyphosates
Grasses + Legumes or Brassica species	thifensulfuron	Harmony

Table 2. Postemergence corn herbicides that have short residual activity or cover crop tolerance. Herbicides must be applied prior to interseeding cover crops

Active ingredient	Trade names	Grasses	Legumes	Brassica species
chlorimuron	Classic, Canopy, Envive, etc.	OK	No	No
clethodim	Select	OK	OK	OK
cloransulam	FirstRate	OK	No	No
flumioxazin	Valor	OK	No	No
fomesafen	Flexstar, Reflex	OK	No	No
imazamox	Raptor	?	OK	No
imazethapyr	Pursuit	No	OK	No
quizalofop	Assure, Targa	No	OK	OK
sulfentrazone	Authority	OK	No	No

Table 3. Suitability of residual soybean herbicides for interseeded cover crops. Herbicides must be applied prior to cover crop interseeding.

Seeding Type	Species	Pounds/acre
Single Species	Annual ryegrass	15-20
Single Species	Other grasses (e.g. orchardgrass)	15-20
Single Species	Medium red clover	8-10
Single Species	Crimson clover	10-15
Single Species	Daikon radish	5
In Mixtures	Annual ryegrass	10-15
In Mixtures	Medium red clover	5-8
In Mixtures	Crimson clover	8-12
In Mixtures	Daikon radish	3-5

Table 4. Suggested seeding rates for interseeding cover crops on a per acre basis. These are the species we have experience with. Other species may also be suitable, but we have not tested them.

Another species we have evaluated is forage or Daikon radish. Seeding rates of 3 to 5 pounds with ryegrass have been effective. The radish will not produce the large roots in the interseeded crop situation but can produce some biomass and taproots to complement the grass.

Often mixtures of the clovers and ryegrass do well and radish can be added to the mix. Mixtures provide diversity and the potential benefits that come along with multiple species. A typical ryegrass /clover/radish mixture would include about 12 pounds of ryegrass, 8 pounds of red clover and 3 pounds radish. We are using a mixture of annual ryegrass (10 lb) and orchardgrass (10 lb), radish (3 lb), plus or minus a red or crimson clover (5 lb) in some trials.

## Fertilization

In general we have fertilized interseeded corn crops similarly to other corn crops. Concentrated applications of UAN dribbled over cover crop rows could cause some cover crop seedling mortality or stimulate the cover crops in some cases. Side dressing between every other row could exacerbate these effects and result in heavy cover crop growth in every other row, especially in a less competitive corn crop. Side dressing with the interseeder machine or another apparatus that could apply the N near the base of the corn plants could minimize these effects.

## Harvesting Impacts

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The silage harvest process can damage the interseeded cover crop but often it will quickly recover and within two weeks with good growing conditions, it should look good again. If conditions are wet at harvest with soil compaction from large trucks and choppers, some permanent damage can occur. When harvesting for grain, try to avoid tactics that would smother the cover crop. Operate the combine a bit higher to avoid shredding the stalks, while still harvesting the grain. Avoid mowing the corn stalks after harvest as this could smother the cover crop with corn stover. Instead consider leaving a high stubble in the field to reduce the stover on top of the cover crop.

## Cover Crop Termination

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Most cover crops are fairly easy to control in a burndown program as long as you pay attention to detail. There are a few species that may require special consideration. In general, most programs begin with glyphosate, which tends to be more consistent than paraquat (Gramoxone). Liberty has a narrow fit, mostly for horseweed/marestail control, but does not add much for cover crops. Herbicide effectiveness ratings for some common cover crops are provided in Table 5. Here are some considerations as you get into the field this year.

Guidelines for glyphosate. All cover crops should be actively growing and capable of intercepting the herbicide spray (e.g. not covered with crop residue). Remember to use a sufficient rate, which generally ranges from 0.75 lb ae to 1.5 lb ae/acre. The 22 fl. oz rate of Roundup or 32 fl. oz rate of Credit, Rascal, Clearout, etc. = 0.75 lb. In general, application alone in good quality water along with appropriate adjuvants (surfactant + AMS) is best and reducing the carrier volume to 10 gal/acre can increase activity. Do not add 28 or 32% UAN or other fluid fertilizers to the spray tank. If the water source has a high pH (8 or greater), consider adding an acidifying agent to the spray solution. Avoid tank mixing with higher-rate (> 0.25 lb) clay-based herbicides (WDG, WG, DF, DG, F) like atrazine, simazine, and metribuzin. Other herbicides such as 2,4-D, dicamba, clopyralid, Balance or Corvus, Resolve or Basis Blend, etc. are OK.

### Annual ryegrass

Annual ryegrass continues to be somewhat challenging to control. Glyphosate is the preferred herbicide and paraquat (Gramoxone) does not provide consistent control. Application during sunny warm days is best and cloudy weather will slow activity. Under cool conditions, it may take 2 to 3 weeks to kill the ryegrass and a second application may be necessary. Previous research suggests that small ryegrass is easier to control, but mild air temperatures 1 to 2 days before, during, and 1 to 2 days after application are likely more important. Apply glyphosate at 1.25 to 1.5 lb ae/acre following the guidelines provided previously.

### Hairy vetch, red clover, and crimson clover

For control of clover or other legume cover crops, glyphosate alone will not kill most legumes, but it is useful in mixture with other herbicides. Gramoxone alone is also not very effective on legumes and should be mixed with atrazine or metribuzin for increased performance. Dicamba (Banvel/Clarity) is one of the best herbicides for control of legume cover crops. It is often a necessary tank-mix partner with glyphosate for control of red or white clover. A 2,4-D ester formulation will effectively control hairy vetch and field peas. I am less familiar with crimson clover control and unsure if 2,4-D is adequate or dicamba is necessary. Both 2,4-D ester and dicamba can be tank-mixed with glyphosate without loss in activity and can be used in corn. Use a minimum of 12 fl. oz/acre of Banvel or Clarity or 2,4-D ester tank-mixed with glyphosate. For corn, apply dicamba or 2,4-D ester 7 to 14 days before planting or 3 to 5 days after planting for greater crop safety and plant corn at least 1.5 inches deep. Clopyralid is also effective on legumes and is a component of several corn herbicides. Dicamba and clopyralid are not suitable for soybean and 2,4-D ester (1 pt) must be applied at least 7 days ahead of soybean planting. Clopyralid can persist up to 12 months and injure legumes.

## Nutrient Requirements of Succeeding Crop

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We are still working to develop recommendations for corn following an interseeded crop. There should be some effect on the N requirement for corn following a well-established clover or clover grass cover crop. Following clover interseeded into wheat, this is often about 50 pounds per acre. Following a ryegrass crop, there could be some benefit if the grass was manured over the winter. Our recommendation in the Penn State Agronomy Guide is to increase the N contribution from an overwinter manure application from 20% of the manure N without a cover crop to 45% contribution with a cover crop not harvested for forage.

Without a manured cover crop, there is potential for some N immobilization from a grass cover crop like ryegrass and in this case, there may not be much N contribution from the cover crop to the succeeding corn crop. In the longer term, ryegrass should improve soil organic matter and reduce the need for N. In the short term, it may be good to maintain current N rates and also strive for some N at planting to offset any potential immobilization issues.

	<b>Rate* (lb/acre)</b>	<b>Annual ryegrass</b>	<b>Winter rye</b>	<b>Winter wheat</b>	<b>Crimson clover</b>	<b>Red clover</b>	<b>White clover</b>	<b>Hairy vetch</b>
2,4-D ester	0.5	N	N	N	8+	8	6	9
2,4-D ester	1	N	N	N	9	9	7	10
Atrazine	1.0	6	6	6	7	6	6	7
Atrazine	2.0	7	7	7	8	7	7	8
Clopyralid	0.25	N	N	N	9	9	9	9
Dicamba	0.5	N	N	N	9	9	9	9
Glyphosate	0.75	8	9	9	7	7	6	7
Glyphosate	1.5	9	9	9	8	7+	7	8
Glyphosate +2,4-D ester	0.75 + 0.5	8	9	9	10	8	8	10
Glyphosate +dicamba	0.75 + 0.5	8	9	9	10	9	9	10
Paraquat	0.5	6	7	8	7	7	7	7
Paraquat	0.75	6	8	8+	8	8	7	8
Paraquat + Atrazine or Metribuzin	0.5 + 1 or 0.25	7	8+	8+	9	8+	7	9

Table 5. Effectiveness of herbicides for control of common cover crops (based on Penn State research or our best guess). Control ratings: 10 = 95-100%; 9 = 85-95%; 8 = 75-85%; 7 = 65-75%; 6 = 55-65%; and N = less than 55%.

\*0.75 lb Glyphosate = 32 fl. oz of a 41% glyphosate; 0.5 lb paraquat = 2 pt Gramoxone SL; Clopyralid is a component of Stinger, Hornet, and Surestart/Tripleflex.

## Authors

Prepared by Greg Roth, Bill Curran, John Wallace, Department of Plant Science, Penn State University, Matthew Ryan, Soil and Crop Sciences Section, Cornell University and Steven Mirsky, Sustainable Ag Systems Laboratory, USDA-ARS (5/8/2015).

## Contact Information

### William Curran

Professor of Weed Science

[wcurran@psu.edu](mailto:wcurran@psu.edu)

814-863-1014

### Greg Roth

Professor of Agronomy

[gwr@psu.edu](mailto:gwr@psu.edu)

814-863-7043

**extension.psu.edu**

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