Interseeding Cover Crops into Corn

Relay cropping to plant cover crops using new technologies

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The Interseeder is an exciting technology recently released by Interseeder Technologies, LLC and trialed by Penn State University to fine-tune the cover crop mixes that can be used in various regions. Essentially a no-till drill, the Interseeder plants a cover crop into standing corn at V5 to V7 stage, creating a more updated and effective version of the traditional technique of broadcasting a winter cover crop into corn at last cultivation which is still utilized by some organic farmers. This maturity stage falls just after the critical weed free period, when corn would be most sensitive to competition from weeds (or an interseeded crop).

Interseeding corn at V6 stage

Broadcasting is still frequently done, sometimes using an air seeder or in organic farming scenarios with a seed spinner mounted on the back of a cultivator, but higher seeding rates must be used, and success is highly dependent on sufficient rainfall very close to the time of seeding, either before or after. Broadcasting is also much more effective on tilled than no-till soil. Some of the seed may also land in the leaf whorl. It is chosen for its ease and the lack of expense and equipment needed, but drilling the seed in with the Interseeder achieves better seed placement into moisture, and better seed-to-soil contact, especially in no-till corn ground.

Interseeding provides a flexible and innovative way to fit cover crops into the rotation, whether the farm is large or small scale, organic or conventional, conventional tillage or no-till.

Closing wheels and N application tube - latest design components of Interseeder

Researchers at Penn State continue to examine the delicate balance between corn and cover crop to be sure that a) the cover crop does not introduce too much competition into the corn and b) the corn does not threaten the eventual thriving of the winter cover crop. They are looking at earlier seeding of the cover crop (at the corn's V3-V4 stage) as well as shortening the corn's maturity to allow for better light penetration and greater cover crop growth in the fall. "Often, reduced drying costs, earlier harvest, improved prices, and residual effects of cover cropping can offset modest yield penalties associated with earlier hybrids," explains Penn State Extension.

Getting more of the benefits of cover crops

Most interseeded cover crops will give you nutrient credits for your following year's corn, but exact amounts depend on the species you use, in what proportions, your management practices, and ultimately the weather effect on growing conditions of both the corn and interseeded cover crop. Legumes fix a good portion of a following corn crop's nitrogen needs if they are allowed to grow to bloom in the spring (if not harvested for forage). Grasses can more than double the value of winter manure applications by uptaking nutrients before they leach. However, depending on maturity stage, grasses may also immobilize some nitrogen, making it available later as they decompose.

Being able to double-crop with a winter cover crop despite timing constraints also gives you the full benefits of ground cover, including erosion prevention, added soil organic matter and other factors contributing to soil health, and winter annual weed suppression.

By acting as a "break crop", adding diversity in the rotation, the cover crop can also improve yields in corn after corn systems.

Interseeding can be more economical than a typical cover crop planting, since it can be combined with another operation across the field (usually N sidedressing) and/or a post emergent herbicide application.

Interrow Seeder Unit

Weed Management

Avoid choosing fields for interseeding with pre-existing weed management problems.

Residual herbicides can be problematic for interseeded cover crops. The basic approach to weed management is to use a no- or short-residual (shorter half-life) burndown herbicide, or tillage followed by glyphosate or glufosinate prior to the interseeding. The interseeding occurs about 3-5 weeks after corn planting. Research is ongoing about the most appropriate herbicides to use in a rotation

with interseeded cover crops. Non-residual programs based on glyphosate and glufosinate are the best bet until we have more experience.

Species

The best species are cool season annuals or perennials, somewhat drought and shade tolerant, and easy to establish.

Among grasses, **annual and Italian ryegrasses** are the most common. Although ryegrass is one of the most successful cover crops for interseeding, it can also be challenging to kill in the spring.

Medium red clover is the most widely used legume, not only for interseeding but for its traditional relay cropping predecessors – broadcasting in corn at last cultivation and frost-seeding into a small grain in late winter.

On many organic farms, medium red clover broadcast at last cultivation has become standard.

Crimson clover has also had success, although it's more prone to winter-kill in more northern regions. As an annual, it typically grows more fall and early spring biomass compared to medium red clover.

That being said, endless combinations of cover crops can be used in the Interseeder context, and many factors decide their success -

- Crop Physiology
- Planting date
- Seeding rate
- Seeding depth
- Seed-to-soil contact
- Soil moisture
- Amount of sunlight through the corn canopy

Interseeded cover crop mix, Union County, PA, October 2014

Annual ryegrass and medium red clover have been two of the most consistently successful crops for interseeding.

King's AgriSeeds and Penn State have advocated using mixes of about 3-5 species. **King's Broadcaster Mix** is our primary commercial mix that is Interseeder-ready (contains Annual Ryegrass, Crimson Clover, Common Medium Red Clover, Daikon Radish, and Yellow Blossom Sweetclover).

The **original mix for the PSU interseeder project** has also performed quite well, and it contains Green Spirit Italian Ryegrass, 3-Way Clover (Red Clover, Ladino White Clover, Yellow Blossom Sweetclover). It performed quite well in the 2011-2012 PSU Short-lived trials under the name "King's Mix."

Blends		Cut 1	Cut 2	Cut 3	Total
King's Mix	Italian Ryegrass/ clovers	2.56	2.02	1.95	**6.53**
Tritcale plus	Triticale (815@66%+33% ARG)	3.20	1.98	1.35	**6.53**
Bristol	Radish/Rootmax	1.61	2.52	1.46	**5.59**
Indy Blend	Radish/Rootmax/Crimson Clover	2.18	1.96	1.31	**5.45**

Annual ryegrass cover crop after corn harvest in fall

Penn State On-Farm Research Trials (about 12 locations each in 2013 and 2014)

Treatment	Species	Rate (Lbs/A)
Untreated	No cover crop	0
Grass	Annual ryegrass	20
Legumes Mix	Med. Red Clover, Crimson Clover, Hairy Vetch	10+20+15
Legumes + Grass	Annual ryegrass, Med. Red Clover, Crimson Clover, Hairy Vetch	10+5+10+7.5
Grass + Radish (2014 only)	Annual ryegrass, Radish	10+5

Harvest

Most of Penn State's research has been done on corn for grain, although corn for silage will be evaluated more. There may be more short-term damage to the cover crop in a silage harvest situation, but it can usually recover as long as the field wasn't too wet at the time of harvest. For grain harvest, the biggest problem can be smothering from the residue, so be sure to set the combine high so there is no stalk shredding, and avoid mowing stalks to prevent damage to the cover crop.

Conclusions

Penn State's research findings include –

- Interseeding has the most success when the corn is at V5-V6 stage

- Annual ryegrass is the most successful grass; legume establishment is more variable
- Corn yield is mostly unaffected by the interseeding operation
- Effect of the interseeded cover crops on second year corn is still under evaluation

Key Aspects of Early Season Interseeding

- Seed cover crops at V6 stage for corn
- After critical weed-free period for corn
- Previous tests indicate that when timed right, there are minimal or no impact on yields

Latest Interseeder Version Design Components

- Drill units between rows
- Liquid N stream can be applied adjacent to corn row
- Herbicide can be applied under corn canopy
- Assist wheels to carry weight
- Ground drive
- Loading platform
- Conversion to complete Drill Unit
- Hitch for towing
- Commercialized by Interseeder Technologies, LLC - http://interseedertech.com/

Interseeded Cover Crops CIG (Conservation Innovation Grant) Summary:

- After two years, fairly high level of successful establishment
- About 70% in 2013 and 90% in 2014 in over 70 trials

Challenges:

- Geographic limitations - better in the North? (prefers cooler and heavier soils; provides good answer to short growing season)
- Identifying suitable species and varieties – **annual ryegrass and medium red clover are consistently two of the best**
- Soil residual herbicides can be problematic – but often necessary to manage HR (Herbicide Resistant) weeds
- Timely cover crop control the subsequent year

*There are many ways to **apply** cover crops into the rotation. We are doing that with various equipment applications both on the small and large scale. We are doing it both on organic and conventional farms, both in conventional tillage systems and in no-till systems. Keys to successful application that we need to understand are: cover crop physiology; planting date, seeding rate, seed depth, seed to soil contact considerations and soil moisture factors. From an Ag-Engineering point of view we need to understand how to utilize the right equipment to get these cover crop seeds established in various rotations and cropping systems including a relay-crop type scenario.*

Dave Wilson, Research Agronomist, 2004

That was a statement made years ago, and the same fundamentals hold true today in the Interseeder context.

Crimson clover 4 weeks after interseeding

Red clover in fall prior to corn harvest

Annual ryegrass

Orchardgrass

Red Clover

Hairy Vetch

Franklin Co. 2013 Interseeding. Photo taken Spring 2014

The older method of using broadcasting on an organic farm

Below is a list of cover crop mixes that have been used with the interseeder and/or for broadcasting at last cultivation on organic farms or conventional farms that may use cultivation. We have put various mixes together for different farms which had different goals and requirements for their particular seeding mix. The King's Broadcaster mix currently is the primary commercial mix that King's has for this type of application, which works very well both interseeded and broadcasted.

Dave Wilson's "original mix" for the PSU Interseeder Project			
# of crops or mixes	**Crop or mix**	**Percentage of Mix by Weight**	**At 30 lbs./acre Seeding Rate (lbs. of each crop in the mix)**
1	Green Spirit Italian Ryegrass	67.00	20.1
2	King's Three-way clover mix	18.00	5.4
3	Crimson Clover-'Dixie'	15.00	4.5
	Totals→	**100.00**	**30.0**

King's Broadcaster Mix Broadcast 25-30 lbs./acre, Interseed at 20-25 lbs./acre			
# of crops	**Crop**	**Percentage of Mix by Weight**	**At 25 lbs./acre Seeding Rate (lbs. of each crop in the mix)**
1	Annual Ryegrass	40.00	10.0
2	Crimson Clover-'Dixie'	30.00	7.5
3	Medium Red Clover "VNS"	15.00	3.75
4	Daikon Radish	10.00	2.5
5	Yellow Blossom Sweet Clover	4.00	1.0
	Inert	1.00	0.25
	Totals→	**100.00**	**25.0**

Mix used by PSU in 2014 at several farm locations this was used at Jim Biddle's farm, Williamsburg, Blair County, PA			
# of crops	**Crop**	**Percentage of Mix by Weight**	**At 32.5 lbs./acre Seeding Rate (lbs. of each crop in the mix)**
1	Annual Ryegrass	30.77	10.0
2	Crimson Clover-'Dixie'	30.77	10.0
3	Hairy Vetch "VNS"	23.08	7.5
4	Medium Red Clover "VNS"	15.38	5.0
	Totals→	**100.00**	**32.5**

Mix recommended by Dave Wilson for Kirby Reichert's organic farmer request who wanted Medium Red & White Clover with Radish Broadcast 25 to 30 lbs./acre, Interseed 20 to 25 lbs./acre			
# of crops	**Crop**	**Percentage of Mix by Weight**	**At 25 lbs./acre Seeding Rate (lbs. of each crop in the mix)**
1	Annual Ryegrass	60.00	15.0
2	Medium Red Clover "VNS"	25.00	6.25
3	Ladino White Clover "VNS"	10.00	2.5
4	Daikon Radish	5.00	1.25
	Totals→	**100.00**	**25.0**

Mix used by organic farmers at last cultivation Mix #1 Broadcast at 30 to 35 lbs./acre, Interseed at 25-30 lbs./acre			
# of crops or mixes	**Crop or mix**	**Percentage of Mix by Weight**	**At 30 lbs./acre Seeding Rate (lbs. of each crop in the mix)**
1	Green Spirit Italian Ryegrass or Annual Ryegrass	50.00	15.0
2	Crimson Clover-'Dixie'	36.70	11.0
3	Medium Red Clover "VNS"	13.30	4.0
	Totals→	**100.00**	**30.0**

Mix used by organic farmers at last cultivation Mix #2 Broadcast at 30 to 35 lbs./acre, Interseed at 25-30 lbs./acre			
# of crops or mixes	**Crop or mix**	**Percentage of Mix by Weight**	**At 30 lbs./acre Seeding Rate (lbs. of each crop in the mix)**
1	Green Spirit Italian Ryegrass or Annual Ryegrass	50.00	15.0
2	Crimson Clover-'Dixie'	36.70	11.0
3	Mammoth Red Clover	13.30	4.0
	Totals→	**100.00**	**30.0**

Mix used by organic farmers at last cultivation Mix #3 Broadcast at 30 to 35 lbs./acre, Interseed at 25-30 lbs./acre			
# of crops or mixes	**Crop or mix**	**Percentage of Mix by Weight**	**At 30 lbs./acre Seeding Rate (lbs. of each crop in the mix)**
1	Green Spirit Italian Ryegrass or Annual Ryegrass	50.00	15.0
2	Crimson Clover-'Dixie'	36.70	11.0
3	Mammoth Red Clover	6.65	2.0
4	Medium Red Clover "VNS"	6.65	2.0
	Totals→	**100.00**	**30.0**

Economic Ryegrass/Red Clover Mix Broadcast at 30 to 35 lbs./acre, Interseed at 25-30 lbs./acre			
# of crops	**Crop**	**Percentage of Mix by Weight**	**At 30 lbs./acre Seeding Rate (lbs. of each crop in the mix)**
1	Annual Ryegrass	68.00	20.4
2	Medium Red Clover "VNS"	32.00	9.6
	Totals→	**100.00**	**30.0**

All Around Mix, Strong ryegrass component Broadcast at 25 to 30 lbs./acre, Interseed at 20-25 lbs./acre			
# of crops or mixes	**Crop or mix**	**Percentage of Mix by Weight**	**At 30 lbs./acre Seeding Rate (lbs. of each crop in the mix)**
1	Green Spirit Italian Ryegrass or Annual Ryegrass	70.00	21.0
2	Daikon Radish	9.00	2.70
3	Berseem Clover c.v. 'Balady'	14.60	4.38
4	Winter Rape (Barsica or Dwarf Essex)	6.40	1.92
	Totals→	**100.00**	**30.0**

3 formulas used for Annual Ryegrass, Crimson Clover & Medium Red Clover Amounts of each have been varied by different farms for desired amount of clover or ryegrass			
# of crops	**Crop**	**Percentage of Mix by Weight**	**At 27 lbs./acre Seeding Rate (lbs. of each crop in the mix)**
1	Annual Ryegrass	55.56	15.0
2	Crimson Clover	22.22	6.0
3	Medium Red Clover "VNS"	22.22	6.0
	Totals →	**100.00**	**27.0**
# of crops	**Crop**	**Percentage of Mix by Weight**	**At 35 lbs./acre Seeding Rate (lbs. of each crop in the mix)**
1	Annual Ryegrass	51.40	18.0
2	Crimson Clover	34.30	12.0
3	Medium Red Clover VNS	14.30	5.0
	Totals →	**100.00**	**35.0**
# of crops	**Crop**	**Percentage of Mix by Weight**	**At 40 lbs./acre Seeding Rate (lbs. of each crop in the mix)**
1	Annual Ryegrass	50.00	20.0
2	Crimson Clover	37.50	15.0
3	Medium Red Clover "VNS"	12.50	5.0
	Totals →	**100.00**	**40.0**

Cornell Mix for 'SCOTTI' Project **(Transitioning to Organic Project using interseeder) (NY, PA, MD)** **Interseed at 45 to 50 lbs./acre** Planted at Jim Biddle's farm, Williamsburg, PA - King's strip #4			
# of crops	**Crop**	**Percentage of Mix by Weight**	**At 45 lbs./acre Seeding Rate (lbs. of each crop in the mix)**
1	Huron Winter Cereal Rye	50.84	22.878
2	Annual Ryegrass	25.42	11.439
3	Hairy Vetch "VNS"	13.58	6.111
4	Medium Red Clover "VNS"	10.16	4.572
	Totals→	**100.00**	**45.0**

CONCEPT MIXES

King's Concept mix #1 ADBBD **Ryegrass, Radish, Clover, Rape** **Broadcast at 25 to 30 lbs./acre, Interseed at 20 to 25 lbs./acre** Planted at Jim Biddle's Farm, Williamsburg, PA 6/18/15 - King's demo strip #3			
# of crops	**Crop**	**Percentage of Mix by Weight**	**At 25 lbs./acre Seeding Rate (lbs. of each crop in the mix)**
1	**A**nnual Ryegrass	63.81	15.95
2	**D**aikon Radish	13.41	3.35
3	**B**erseem Clover c.v. 'Balady'	10.68	2.67
4	**B**alansa Clover c.v. 'Fixation'	8.10	2.025
5	**D**warf Essex Rape	4.00	1.0
	Totals→	**100.00**	**25.0**

King's Concept mix #2 "Nutrient Mix"
Broadcast at 25 to 30 lbs./acre, Interseed at 20 to 25 lbs./acre
Planted at Jim Biddle's farm, Williamsburg, PA - King's strip #5

# of crops	Crop or mix	Percentage of Mix by Weight	At 25 lbs./acre Seeding Rate (lbs. of each crop in the mix)
1	Annual Ryegrass	69.50	17.375
2	Crimson Clover-'Dixie'	12.50	3.125
3	King's Three-way clover mix	7.50	1.875
4	Berseem Clover c.v. 'Balady'	2.50	0.625
5	Balansa Clover c.v. 'Fixation'	4.50	1.125
6	Dwarf Essex Rape	2.50	0.625
7	Daikon Radish	1.00	0.25
	Totals→	**100.00**	**25.0**

King's Concept mix #3 "Strong Legume Overwintering Mix"
Broadcast at 25 to 30 lbs./acre, Interseed at 20 to 25 lbs./acre

# of crops	Crop or mix	Percentage of Mix by Weight	At 25 lbs./acre Seeding Rate (lbs. of each crop in the mix)
1	Annual Ryegrass	60.00	15.0
2	Crimson Clover-'Dixie'	12.50	3.125
3	Hairy Vetch	12.50	3.125
4	King's Three-way clover mix	7.50	1.875
5	Berseem Clover c.v. 'Balady'	2.50	0.625
6	Balansa Clover c.v. 'Fixation'	2.50	0.625
7	Dwarf Essex Rape	2.50	0.625
	Totals→	**100.00**	**25.0**

King's Concept mix #4
"Ryegrass/ Rape overwinter, Berseem & Daikon are Summer/Fall Legume Nitrogen fixer &, Nutrient recycler and then they winter kill"
Broadcast at 25 to 30 lbs./acre, Interseed at 20 to 25 lbs./acre

# of crops or mixes	Crop or mix	Percentage of Mix by Weight	At 30 lbs./acre Seeding Rate (lbs. of each crop in the mix)
1	Green Spirit Italian Ryegrass or Annual Ryegrass	70.00	21.0
2	Daikon Radish	9.00	2.70
3	Berseem Clover c.v. 'Balady'	14.60	4.38
4	Winter Rape (Barsica or Dwarf Essex)	6.40	1.92
	Totals→	**100.00**	**30.0**

King's Concept mix #5
Simple 4 way overwintering mix
Broadcast at 25 to 30 lbs./acre, Interseed at 20 to 25 lbs./acre

# of crops or mixes	Crop or mix	Percentage of Mix by Weight	At 25 lbs./acre Seeding Rate (lbs. of each crop in the mix)
1	Green Spirit Italian Ryegrass or Annual Ryegrass	40.00	10.0
2	Crimson Clover-'Dixie'	36.00	9.0
3	Medium Red Clover "VNS"	16.00	4.0
4	Dwarf Essex Winter Rape	8.00	2.0
	Totals→	**100.00**	**25.0**

Mixes without Ryegrass Component

King's Concept mix #6 Multi-clover mix Broadcast at 12 to 15 lbs./acre, Interseed at 8 to 12 lbs./acre			
# of crops or mixes	**Crop or mix**	**Percentage of Mix by Weight**	**At 12 lbs./acre Seeding Rate (lbs. of each crop in the mix)**
1	Crimson Clover-'Dixie'	45.00	5.40
2	Berseem Clover c.v. 'Balady'	25.00	3.00
3	King's Three-way clover mix	20.00	2.4
4	Balansa Clover c.v. 'Fixation'	10.00	1.2
	Totals→	**100.00**	**12.0**

King's Concept mix #7 Clover-Rape mix Broadcast at 12 to 15 lbs./acre, Interseed at 8 to 12 lbs./acre			
# of crops or mixes	**Crop or mix**	**Percentage of Mix by Weight**	**At 12 lbs./acre Seeding Rate (lbs. of each crop in the mix)**
1	Crimson Clover-'Dixie'	36.00	7.2
2	Berseem Clover c.v. 'Balady'	30.00	6.0
3	King's Three-way clover mix	24.00	4.8
4	Dwarf Essex Winter Rape	10.00	2.0
	Totals→	**100.00**	**20.0**

King's Concept mix #8 2 crop Clover-Rape mix Broadcast at 15 to 20 lbs./acre, Interseed at 12 to 15 lbs./acre			
# of crops	**Crop or mix**	**Percentage of Mix by Weight**	**At 15 lbs./acre Seeding Rate (lbs. of each crop in the mix)**
1	Crimson Clover-'Dixie'	60.00	9.0
2	Dwarf Essex Winter Rape	40.00	6.0
	Totals→	**100.00**	**15.0**

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

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

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, pyroxasulfuone, 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

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

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

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.

	Rate* (lb/acre)	Annual ryegrass	Winter rye	Winter wheat	Crimson clover	Red clover	White clover	Hairy vetch
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.

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Penn State **Extension**

Impacts of Interseeding on Corn Yield

Relay cropping or interseeding of cover crops in corn has resurfaced as a potential way of establishing cover crops in areas where cover crop establishment is impractical due to the late harvest of the primary crop. Relay cropping is not a new practice in corn.

Broadcasting ryegrass at the last cultivation was considered a standard recommendation in the 1940's in Pennsylvania (Dickey, 1947) to help curb erosion of tilled fields. Our recent work at Penn State has demonstrated that the practice can be effective as well in establishing cover crops to protect and improve soils and provide many of the benefits that cover crops can provide.

There is some concern about the impact of the cover crop on the corn. In most cases, though, we have observed that the corn is very competitive with the cover crop. The concept is to seed the cover crop so that establishment occurs following the "weed free" period (6-7 weeks after planting) so that any impact on the corn is minimal, provide weed control treatments at interseeding and use cool season cover crops that are not as competitive as warm season weed species. We are currently conducting a multistate trial with interseeded cover crops in NY, PA, VT and MD to further assess yield impacts of interseeded crops in our region.

Our initial results are supporting the concept that yield impacts are minimal. In our 2013 trial at Rock Springs where we got good establishment early of several species, the impacts on corn yield were negligible (Figure 1). We are conducting these studies across a range of environments to better understand the relationship between interseeding and grain yield. Our hope is that any yield impacts in the year of interseeding would be offset by higher yields, better soil quality and less fertilizer use in subsequent years.

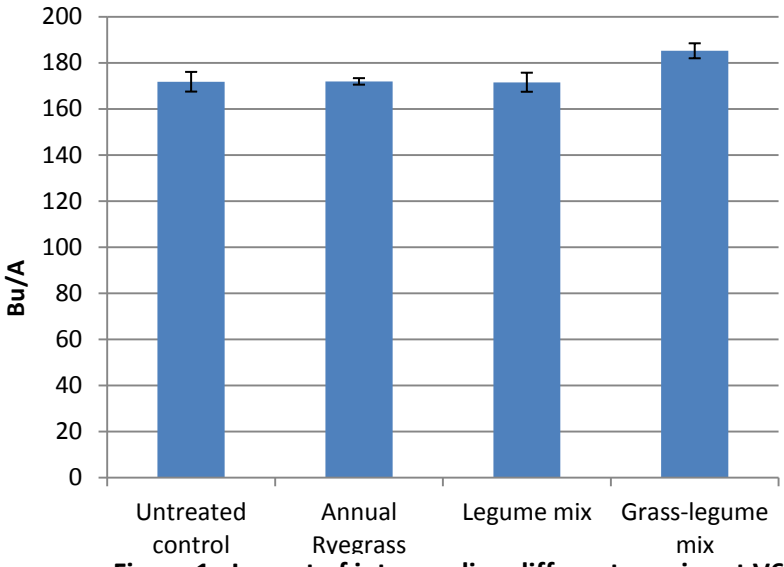

Figure 1. Impact of interseeding different species at V6 on corn grain yields at Rock Springs in 2013.

A number of published studies have evaluated interseeding in the literature and have generally found no impact on corn yield with plantings at the V4 to V7 stages of growth, or 4 to 7 fully exposed leaves. A Cornell study concluded that intercrops of red clover, ryegrass and other species had no impact on corn yields when the interseeding was done at the 6 to 12 inch tall corn stage (Scott et al, 1987). A Michigan State study (Baributsa et al., 2008) found that interseeding red clover or chickling vetch in corn over four years had no impacts on corn yields and that the clover could provide N to a succeeding crop.

Canadian studies have found similar conclusions. In Ontario, a two year study concluded that intercropping corn with red clover could provide soil protection without impacting silage corn yields (Wall et al., 1991). In Quebec, Carruthers et al. (2000) also showed that intercropping with forages seeded 3 weeks after corn planting did not impact corn yields and concluded "The ability toproduce silage equal in yield to monocrop corn at a reduced cost and risk of environmental damage makes this an attractive intercropping system for eastern Canada". In British Columbia, relay cropping with ryegrass planted at the 3 to 6 leaf stage is an accepted practice described in an advanced production manual for corn silage (Bittman and Schmidt, 2004). They note that planting ryegrass before the 3 leaf stage may suppress corn growth. Relay cropping in that region has been shown to dramatically reduce runoff from manured silage corn fields (van Vliet, 2002).

South American studies are also evaluating intercropping and have found similar results. One recent example of the studies there is that Borghi et al. (2013) concluded that Intercropping systems with corn and guineagrass did not reduce the corn grain yield compared with sole corn crops.

This is not an exhaustive list of the literature on the topic of yield impacts of interseeded crops, but provides a sampling of the evidence that cover crops can be intereseeded in corn with minimal impacts on yield in the year of intereseeding.

However, as with the introduction of any new technology, there will likely be some new concepts learned about this system and continuing improvements in management. In the introduction of no-till corn for example, weed control, soil compaction and planting issues often reduced yields in initial work, but eventually these were overcome with improved management to reap the benefits of no-till crop production. Our goal is that we can achieve the same with the concept of interseeding cover crops.

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Opportunities with Interseeding

Figure 2. Interseeded clover during midsummer under the corn canopy.

To address this issue, we developed a machine in conjunction with Penn State Agronomy Research Farm to facilitate interseeding in no-till and reduced tillage corn crops. The machine uses coulter tillage in the row to prepare a shallow seedbed followed by packing wheels and a drag chain to incorporate the seed. Since interseeding often coincides with sidedressing and postemergent herbicide applications, we added the capability of applying N fertilizer next to the corn row and applying herbicide to the machine. Our goal with the design of the interseeder was to develop an affordable machine that could do the interseeding effectively as well as improve the application of the fertilizer and herbicide.

In 2010, we initiated several studies evaluating the potential of interseeding cover crops in corn using the newly developed machine. Our initial studies with interseeding cover crops have been positive. We established two studies to evaluate the potential of seeding several cover crop species at sidedressing (V7 growth stage of corn). We were able to successfully establish ryegrass, red clover, white clover and a red clover/ryegrass mixture in no-till corn following both corn and soybeans. There was no significant impact on yield. Since the establishment of the crop is after the "critical weed free period" in corn, the expected impacts on yield are likely to be small. Future studies will attempt to duplicate these results and will assess the impact of the cover crops on subsequent crop yields.

Figure 3. Interseeded ryegrass/clover cover crop growth in April that could be grazed.

Characteristics of the ideal interseeding species may be different that those for more traditional cover crops. Species or varieties that can emerge with minimal moisture, can tolerate the heat and shade in these environments, and can provide good fall growth and winter cover are ideal. Also refining the ideal seeding rates for this system in our environment is also critical. Lower seeding rates could reduce the cost associated with the cover cropping system and also allow for inclusion of more species in the cover crop mix if desired. Earlier seeding dates could have more potential in shorter season environments or in fields where fall grazing and forage production has some potential.

Another timely potential benefit is the potential for improved nutrient recycling. There should be potential for improving the nutrient retention of mobile nutrients such as N, S and even P and K, as noted in some previous research. Grasses are vigorous competitors for soil K and could help to extract soil K for use by subsequent crops. Interseeded legumes could fix nitrogen, which could be used by subsequent crops.

The potential of fall grazing corn stalks is another application that could be attractive to some producers. A ryegrass or ryegrass/clover cover crop could provide a nice complement to grazing corn stalks for beef or sheep animals. Grazing could be done in the fall or early spring. It may be necessary to fertilize the cover crop late in the summer to maximize the potential dry matter production in this system.

Figure 4. Planting corn in an interseeded corn stubble field.

An interseeded cover crop could be especially useful where corn stalks are removed for bedding or other uses. In these fields, removal of carbon in the stalks can be an issue and could eventually lead to lower soil organic matter levels. Soil erosion can also be an issue on these fields unless a cover crop is established, which is difficult in northern counties. An interseeded cover crop could help to alleviate both of these issues.

Finally, an interseeding may also be able to minimize the potential yield impact of growing corn following corn, which is common in Pennsylvania. In interseeded fields, second year corn could be planted into a legume grass mix, for example, which is a much different environment than corn stubble. If the interseeding is done only in row middles, then the second year of corn can be planted next to the original corn rows and avoid the problem of planting into a dense cover crop.

Another interesting issue is the potential impact of the cover crops on the development of weed species in corn fields. It is likely that a vigorous interseeded cover crop could minimize the development of some late emerging winter annual weed species that are becoming a problem in row crops. A Canadian group, Abdin et al. (2000), indicated that interseeded cover crops complemented cultivation in providing weed control in corn.

Challenges

Several challenges exist to maximize the potential of interseeding cover crops. One issue related to interseeding is the impact of the preemergent herbicide application on the establishment of the cover crop approximately 6 weeks later. We have initiated a study to assess the impacts of various common herbicides on the establishment of the ryegrass, red clover, and white clover seeded at sidedressing. Our initial results were encouraging with successful establishment under most of the herbicide regimes. More evaluation of this issue is necessary before we can make recommendations. It may be that a reduced rate preemergence program followed by a non selective glyphosate or glufosinate application at sidedress may be the optimum solution.

Another weed management issue is the termination of the cover crop. One of the most successful cover crops, ryegrass, can be difficult, but not impossible to kill in the spring. Careful attention to glyphosate rates is necessary to effectively terminate the crop.

Interseeding would also be an additional cost to the producer, but if the seeding could be combined with another trip across the field, then this cost could minimized. And if the potential benefits can be documented from nutrient savings, increased yield of corn on corn, additional revenue from stover or forage, and decreased runoff and leaching, then cost of establishment will be less of an issue.

CORNELL SUSTAINABLE CROPPING SYSTEMS LAB

Cover Crop Interseeding

Effectively establishing cover crops earlier

Background

Cover crops can provide important benefits such as reducing erosion, increasing soil organic matter, recycling nutrients, fixing nitrogen (legumes), and suppressing pests. However, to achieve these benefits, cover crops must be managed properly. Late seeding after corn and soybean harvest often results in poor performance. Interseeding cover crops prior to harvesting is one way to overcome this obstacle and increase your return on investment with cover crops.

Above: Interseeded annual ryegrass at silage harvest on September 23, 2014 (Virgil, NY). Once the corn was harvested, this cover crop grew vigorously. See results from this on-farm trial below.

Interseeder Options

a) The InterSeeder (Penn State) drills cover crops in three 7.5" rows, b) the Dawn DuoSeed interseeder (Hershey Farm) drills cover crops in two 10" rows, and c) the RoGator interseeder (Donn Branton) broadcasts seed between 30" crop rows.

Data from New York

Results from on-farm and research station trials in 2013-2014 with the InterSeeder.

Treatment Information			Corn Silage †					Corn Grain ‡				
Treatment	Seeding Rate (by species) (lb/a)	Cover Crop	Fall 2013 Cover Crop[1] (lb/a)	Fall 2013 Weeds (lb/a)	Adjusted Yield (tons/a)	Spring 2014 Cover Crop[2] (lb/a)	Spring 2014 Weeds (lb/a)	Fall 2013 Cover Crop[3] (lb/a)	Fall 2013 Weeds (lb/a)	Adjusted Yield (bu/a)	Spring 2014 Cover Crop[4] (lb/a)	Spring 2014 Weeds (lb/a)
1	NA	No cover crop control	NA	678 (363)	18 (1)	NA	563 (153)	NA	24 (14)	157 (25)	NA	34 (10)
2	20	Annual Ryegrass	**2054 (475)	103 (17)	18 (1)	776 (207)	98 (24)	187 (42)	30 (9)	146 (18)	195 (44)	30 (9)
3	5	Daikon Radish	NA	NA	NA	NA	NA	181 (40)	10 (4)	153 (26)	0	33 (8)
4	10 20 15	Hairy Vetch Crimson Clover Red Clover	1273 (160)	61 (25)	19 (1)	715 (160)	176 (15)	359 (132)	29 (10)	147 (26)	847 (366)	31 (9)
5	7.5 10 5 10	Hairy Vetch Crimson Clover Red Clover Annual Ryegrass	1853 (84)	137 (60)	18 (1)	739 (248)	295 (52)	450 (44)	20 (8)	144 (24)	905 (386)	33 (11)

[1]Sampling date 10/30/13, [2]Sampling date 5/1/14 [3]Sampling dates 11/20/13 (Musgrave) and 11/15/14 (Adams Center) [4]Sampling dates 5/22/14 (Musgrave) and 5/13/14 (Adams Center)

**Standard error is found in parentheses next to each treatment mean

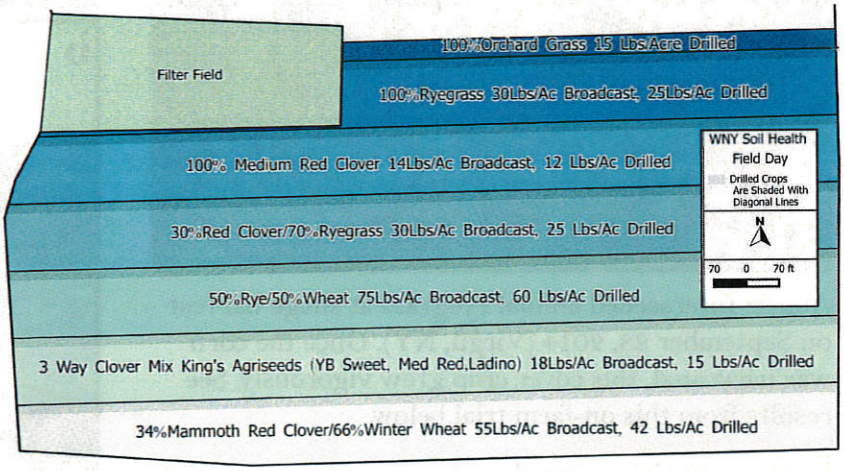
† Corn Silage treatment values are from Virgil, NY

‡Corn Grain treatment values are from Adams Center, NY and Musgrave Research Farm, Aurora, NY

Two interseeders were used to establish seven cover crop treatments for this demonstration strip trial (map below). Left: RoGator (Branton) interseeder. Right: InterSeeder (Penn State).

Demonstration Plot Details: Western New York Soil Health Field Day

Planting date: May 27, 2015
Variety: Mycogen TMF2Q413 (96-day RM)
Population: 34,000 seeds/acre
Herbicides: Glyphosate at 2 qts, Banvel at 0.5 pts, and 2-4D at 1 pt applied fall 2014 to control alfalfa sod. Touchdown at 24 oz. applied June 19, 2015 with corn at V4 stage.
Broadcast interseeding: AgChem 1274c RoGator (Branton) on June 24, 2015, 28 days after planting, at corn stage V5-6. 60-ft seeding width. Sidedress N at 46 lbs N/a.
Drill interseeding: InterSeeder on July 6 2015, 40 days after planting, at corn stage V7-V8. 10-ft seeding width. No sidedress N.



Above: Dueppengiesser Farm Field Map. Seven cover crop treatments seeded with two different interseeder machines (above).

Summary

Cover crop interseeding research in New York over the past three years shows that establishing cover crops prior to harvesting can have benefits. Interseeding enables the establishment and fall growth of legume and brassica cover crops that have traditionally been excluded by late seeding after corn and soybean harvest. Interseeding also increases the scavenging ability of grass cover crops and nitrogen recycling. Based on data from Willsboro, it appears that grass-legume mixtures can self-regulate and do well under both low and high nitrogen conditions. We also observed challenges with interseeding cover crops including reduced herbicide options, damage to headlands, and variability in cover crop performance. Although legume cover crops grow rapidly in the spring and can provide extra nitrogen if allowed to grow longer, early termination and corn planting maximizes yield potential. More research is needed to better understand the economics of interseeding and how termination timing in the spring affects the nitrogen credit from the cover crop.

Interseeding Demonstration: Donn Branton, Chad Branton, Brian Caldwell, Mike Dueppengiesser, Dave DeGoyler, Chris Pelzer, Rod Porter, Matt Ryan, Sandra Wayman. For more information about cover crop interseeding e-mail Matt Ryan at mrr232@cornell.edu. or visit our website at https://scslabcu.wordpress.com/

Common corn herbicides, estimated half-lives, cash crop restrictions and their potential to injure fall cover crops

(Prepared by Bill Curran and Dwight Lingenfelter, Extension Weed Science, Penn State University)

Corn

Herbicide	Active Ingredient	Normal Rate/Acre	Half Life (days)	Cash Crop Restrictions	Fall Cover Crops OK to plant	Concern for	Other
2,4-D 4S	2,4-D	1-2 pt	7	Plant anything 30 days after application	All grasses	Wait 30 days before planting sensitive broadleaves	Amine formulations more water soluble and can leach into speed zone
Accent 75DF/ Steadfast 75DF	Nicosulfuron/ nicosulfuron+ rimsulfuron	0.66 oz/ .075 oz	21	Sensitive crops have 10-18 month restriction	Fall cereal grains, ryegrass	Small seeded legumes, mustards, sorghum	More persistent in high pH soils (>7)
Atrazine 4L	Atrazine	1-2 qt	60	Can plant corn, sorghum and soybean the following year (some products allow others)	Sorghum species	Cereals, ryegrass, legumes, and mustards	More persistent in high pH soils (>7) Rates >1 lb/acre can allow more flexibility
Balance Pro 4L	Isoxaflutole	2 fl. Oz	50-120	Small seeded legumes and vegetables have a 10-18 month restriction	Fall Cereals grains	Cereals, ryegrass, legumes, and mustards	15 inches of cumulative precipitation required from application to planting rotations crops except soybean, barely, wheat, sorghum, and sunflower
Callisto (includes Lumax, Lexar, Halex GT)	Mesotrione	3-6 fl. Oz	5-32	10 to 18 months for legumes and vegetables	All grasses	Small seeded legumes, mustards	Sequential applications (PRE fb POST) increase the potential for injury
Clarity/ Banvel 4S (Distinct and Status)	Dicamba	16 to 24 fl. Oz	5-14	15 days per 8 fl. oz/acre for small grains	All crops	Only at high rates or less than 120 days after application	Anything can be planted after 120 days with 24 fl. oz/acre or less
Dual II Mag 7.62E/Cinch	Metolachlor	1.67 pt	15-50	Labeled for use on many crops	Almost anything	Annual ryegrass or other small seeded grasses	Higher rates and later applications more of a potential problem
Capreno 3.45SC	Tembotrione + thiencarbazone	3 fl. Oz	50-120	Four mo. For wheat, 10 mo. For barley, sorghum, oats and alfalfa	Wheat, triticale, rye	Small seeded legumes, mustards, sorghum	15 inches of cumulative precipitations required from application to planting rotations crops except wheat
Corvus 2.63SC	Isoxaflutole + thiencarbazone	5.6 fl. Oz	50-120	Four mo. For wheat, 9 mo. For barley and 17 mo. For alfalfa, oats, sorghum,& canola	Wheat, triticale, rye	Small seeded legumes, mustards, sorghum	15 to 30 inches of cumulative precipitations from application to planting for sensitive crops

Harness 7E (Degree,Warrant)	Acetochlor	2 pt	10-20	Four mo. For wheat and 9 mo. For alfalfa and clovers	Most crops should be fine	Food or feed residues rather than crop injury may be a concern	Nonfood/feed winter cover crops are allowed after corn harvest
Impact 2.8SC	Topromesone	0.75 fl. Oz	14	Alfalfa, canola, soybean, and sunflower have a 9 mo. Restriction	Wheat, barley, oats and rye are allowed after 3 mo. Ryegrass should also be ok	Although many broadleaves are restricted, impact does not have much soil activity	We have not seen thin herbicide carryover in PA
Laudis 3.5sc	Tembotrione	3 fl. Oz	14	Four mo. For cereal grains 10 mo. For sorghum, canola, and alfalfa	Cereal grains after 4 months	Unknown-Small seeded legumes, mustards could be a problem	Other crops may be seeded after a successful field bioassay
Peak 57WG (Spirit)	Prosulfuron	1 oz	9-152	Cash crop restrictions ranged from 10 mo. For soybean and tobacco to 22 mo. For alfalfa and canola	Cereal grains and sorghum are labeled, other grasses	Small seeded legumes, mustards	More persistent in high pH soils (>7)
Permit/Sandea 75DF	Halosulfuron	2/3 oz	9-27	9 mo. For alfalfa, clovers, soybean and 15 mo. For canola	Cereal grains and sorghum after 2 mo. And other grasses	Small seeded legumes, mustards	Halosulfuron also an ingredient in Yukon
Resolve 25DF (Resolve Q)	Rimsulfuron	2 oz	2-4	Winter cereals have 3 mo. Restriction and many crops are restricted for 10 mo.	Based on the short half-life, most fall cover crops should be ok in PA	None	More persistent in drought conditions
Simazine 4L (Princep)	Simazine	1-2 qt	60	Can plant corn, sorghum, and soybean the following year (some products allow others)	Sorghum species	Cereals, ryegrass, legumes, and mustards	Soil p H >7
Stinger 3S (Hornet and Surestart)	Clopyralid	5 oz	40	Recrop intervals 10.5 to 18 mo. For legumes	All grasses	Small seeded legumes	

Corn and Soybean

Herbicide	Active Ingredient	Normal Rate/Acre	Half life (days)	Cash crop restrictions	Fall cover crops		Other
					Ok to plant	Concern for	
Glyphosate 4L	Glyphosate	.075 to 1.25 lb.	47	No restrictions pre-emergence	All	None	Glyphosate does not have soil activity at normal use rates
Gramoxone 2S	Paraquat	2 pt.	1000	No restrictions pre-emergence	All	None	Paraquat does not have soil activity at normal use rates
Harmony 50WDG	Thifensulfuron	1/8 oz.	12	Any crop can be planted 45 days after application	No restrictions for wheat, barley and oats	None with 45 day waiting interval	Harmony extra also contains tribenuron
Liberty 2.34L	Glufosinate	22-36 fl. Oz.	7	No restrictions for canola, corn and soybean. Small grains have a 70 day restriction	All	Food or feed residues rather than crop injury may be a concern	Glufosinate does not have soil activity at normal use rates
Outlook 6E	Dimethenamid	16 fl. Oz	20	Four mo. For cereal grains and anything the following spring	Most crops should be fine	Food or feed residues rather than crop injury may be a concern	Nonfood/feed winter cover crops should be ok after corn harvest
Prowl H2O 3.8CS	Pendamethalin	3 pt.	44	Wheat and barley after 4 mo. Other rotational crops the following year	Cereal grains	Small seeded legumes and annual ryegrass	We have not seen this herbicide carryover in PA nonfood/feed winter cover crops should be ok
Python 80WDG (Hornet & Surestart)	Flumetsulam	1 oz.	14-120	Cash crop restrictions from 4 mo. For alfalfa and cereals to 26 mo. For canola	Cereal grains	Small seeded legumes, mustards and annual ryegrass	Cover crops and forage grasses are restricted for 9 mo.
Metribuzin 75DF (sencor)	Metribuzin	0.33 lb.	14-60	Recrop restrictions range from 4 to 12 mo.	Cereal grains and ryegrass	Slight risk for small seeded legumes and mustards	Nonfood/feed winter cover crops allowed
Sharpen 2.85SC (Verdict & Optill)	Saflufenacil	3 fl. Oz.	7-35	Any crop can be planted 4 mo. After application	All	None	This product has been reported more persistent in western Canada

Soybean

Herbicide	Active Ingredient	Normal Rate/Acre	Half Life (days)	Cash Crop Restrictions	Fall Cover Crops Ok to Plant	Concern for	Other
Assure II/Targa 0.88E	Quizalofop	8 oz.	60	Most broadleaves ok	Most broadleaves	All grasses if less than 120 days or at high rates	Plant anything after 120 days
Authority 75DF (Spartan 4F)	Sulfentrazone	4 oz.	32-302	12 to 24 Months for legumes and some vegetables	Cereals and ryegrass	Small seeded legumes, mustards, sorghum	Labeled on tobacco, sunflowers, transplanted tomato
Classic 25DF (Canopy, Envive, etc.)	Chlorimuron	0.5-2 oz.	40	12 to 30 months for small seeded legumes	Cereals and ryegrass	Small seeded legumes, mustards, sorghum	More persistent in high p H soils (>7) and with higher soil applied rates
First Rate 84WDG	Cloransulam	0.3 to 0.6 oz.	8-33	Four months to wheat, 9 mo. To alfalfa, corn sorghum and oats, 12 mo. For barley, and 18 mo. For tobacco	Wheat, triticale, rye	Small seeded legumes, mustards, sorghum	The restrictions for transplanted tobacco is 10 mo. For 0.3 oz./acre. Sugarbeet and sunflower have a 30 month restriction
Pursuit 2S	Imazethapyr	4 fl. Oz.	60-90	Recrop restrictions range from 4 to 18 months	Wheat, triticale, rye, alfalfa, clover	Oats, sorghum, mustards	Any crop can be planted 40 months after pursuit applications
Raptor 1E	Imazamox	5 fl. Oz	20-30	Recrop intervals range from 3 to 18 mo.	Wheat, triticale, rye, alfalfa, clovers	Slight risk for mustards	Most cash crops allowed 9 mo. Following application
Reflex 2E/ Flexstar 1.88E	Fomesafen	1.5 pt.	100	Recrop intervals range 4 to 18 mo.	Cereal grains	Small seeded legumes, mustards, sorghum	Since fomesafen is often applied postemergence, soil activity can surprise users
Scepter 1.5AS	Imazaquin	0.66 pt.	60-90	Recrop intervals range from 11 to 18 mo.	Cereal grains	Small seeded legumes, mustards	Carryover much more of a risk with drought
Select 2E	Clethodim	10 oz.	3 d	Most broadleaves ok	All broadleaves	None assuming at least 30 days	Plant anything after 30 days
Valor 51WDG	Flumioxazin	2.5 oz.	12-20	Recrop restrictions up to 10 mo. For no-till alfalfa, clover and 12 mo. For no-till canola	All grasses	Small seeded legumes and mustards	Based on the half-life all nonfood/feed winter cover crops should be ok

Cover Crop Interseeding Effects on Establishment, Weed Control, and Crop Yield: Overcoming Winter Cover Crop Establishment Issues for Improving Soil Health

Chris J. Pelzer[1], Matthew R. Ryan[1], Steven B. Mirsky[2], William S. Curran[3], and Gregory W. Roth[3]
(1) Cornell University, Ithaca, NY (2) USDA-ARS, Beltsville, MD (3) The Pennsylvania State University, University Park, PA

Introduction

Post harvest cover crop establishment is often cited by grain farmers as the greatest obstacle to incorporating winter cover crops (WCC) into their existing cropping systems. Sufficient WCC biomass is essential to achieving soil health benefits such as nitrogen cycling, reduced soil erosion, offsetting carbon losses via grain harvest or biomass removal, and pest control.

Potential solutions to overcome timely establishment have included aerial seeding WCC, but results can be variable as there is often poor seed-to-soil contact. We evaluated the effectiveness of a new implement, the InterSeeder, at establishing WCC in the Northeast in both research and production farm experiments.

Materials & Methods

The InterSeeder **(**Fig. 1**)** plants three WCC rows between existing 76-cm rows in corn at recommended growth stage V5-V7 (Fig 1. A & D). Each drill unit row has a wavy coulter (Fig 1. B) and double-disc opener to create the seed furrow followed by press wheels to provide adequate seed-to-soil contact (Fig 1. C).

Figure 1. InterSeeder operating components

Experimental design consisted of a RCBD at each site with at least three replications. Sites were at both research and production farms in New York, Maryland, and Pennsylvania. Crop management practices specific to each farm were maintained over the duration of the experiment. Seeding rates for each treatment were calibrated prior to seeding.

Cover Crop Treatment	Species Number	Seeding Rate (by treatment)	Seeding Rate (by species)	Common Name	Species Name
		----------kg/ha----------			
Control	NA	NA	NA	NA	NA
Annual Ryegrass	1	22.4	22.4	Annual Ryegrass	*Lolium multiflorum*
Daikon Radish	1	5.6	5.6	Daikon Radish	*Raphanus sativus*
Legumes	3	50.4	11.2	Hairy Vetch	*Vicia villosa*
			22.4	Crimson Clover	*Trifolium incarnatum*
			16.8	Red Clover	*Trifolium pratense*
Grass + Legumes	4	36.4	8.4	Hairy Vetch	*Vicia villosa*
			11.2	Crimson Clover	*Trifolium incarnatum*
			5.6	Red Clover	*Trifolium pratense*
			11.2	Annual Ryegrass	*Lolium multiflorum*

Table 1. Cover crop treatments and rates

Sampling methods included collecting cover crop and weed biomass samples between crop rows in 0.5 m^2 quadrats after which they were oven-dried at 60°C. Corn yields were adjusted and standardized to 15.5% grain moisture. Silage dry matter yields are adjusted to 35% dry matter.

Results & Discussion

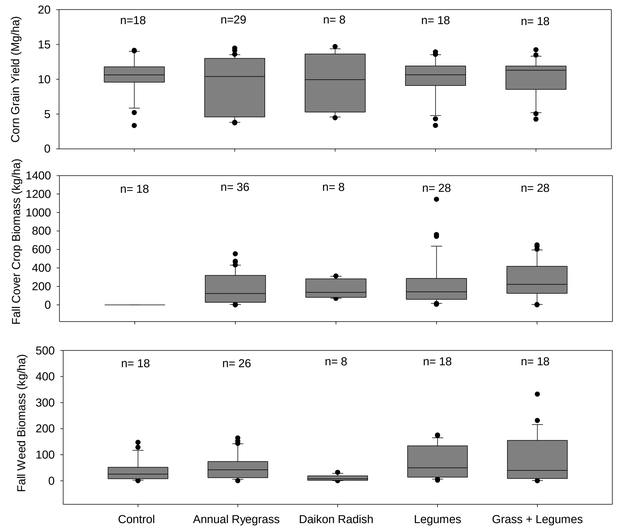


Figure 2. Crop yield, fall cover crop and weed biomass across 8 sites in 2013.

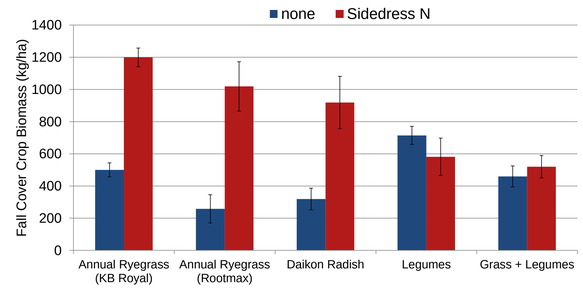


Figure 3. Effect of sidedress nitrogen (UAN, 60 kg N/ha) on fall cover crop biomass at the research farm in Willsboro, NY in 2013.

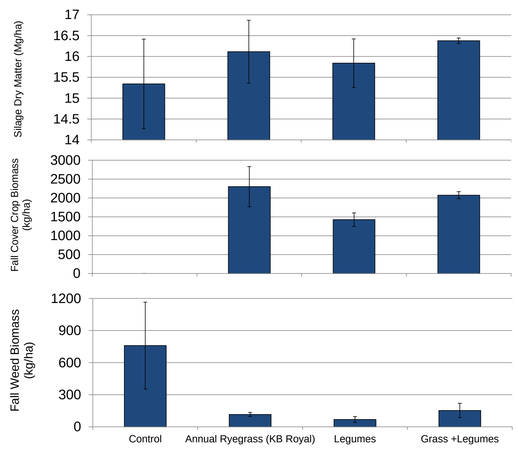


Figure 4. Silage yield, fall cover crop and weed biomass at Pine Hollow Farm, Virgil, NY in 2013.

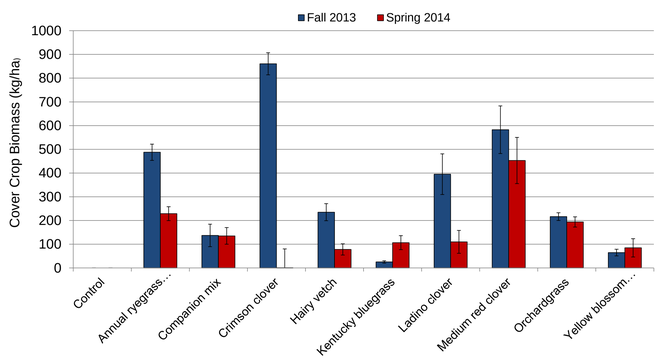


Figure 5. Effect of overwintering on cover crop biomass at Rock Springs, PA .

Figure 6. Grass + Legumes mixture under corn canopy (top). Grass + Legumes treatment stand prior to corn grain harvest (middle). Ryegrass treatment immediately after corn silage harvest (bottom).

Conclusions

- Interseeded cover crops had a negligible impact on crop yields; however, crop populations and yields were reduced in some cases when cover crops were interseeded when the host crop was too tall.
- Cover crop biomass was greatest in cases when shading from the host crop was reduced.
- Cover crop treatments differed in their response to sidedress nitrogen with grasses increasing in biomass but not legumes.
- Cover crops differed in their winter hardiness, and this should be considered when selecting cover crop species.
- More research is needed to better understand the effects of interseeded cover crops on host crop performance and how competition for light and nutrients can influence results.

Acknowledgements

Research funding was provided by a NRCS Conservation Innovation Grant. We thank on-farm cooperators and research farm managers for assisting in management operations and data collection.

InterSeeder Technologies Operators Manual

2015

Before you start

- ✓ Please read and understand this manual before using your InterSeeder
- ✓ Make sure your aware of all the safety warnings on the InterSeeder
- ✓ Always use the jack stands when unhooking the unit and when servicing
- ✓ Always use the cylinder locks when servicing in the raised position
- ✓ Never crawl under the unit in the raised position
- ✓ Stay clear of moving parts
- ✓ Never ride on the unit
- ✓ Do not turn tightly with the unit when planting in the down planting position
- ✓ Grease the unit each day of use and oil chains weekly
- ✓ Check oil level in the seed box transmission daily

Transporting

- ✓ Always transport the unit in the raised position, use the transport locks on each cylinder
- ✓ Remove the wheel lock on the rear wheels to allow the wheels to caster 360 degrees
- ✓ Always plant with the wheels in the unlocked position
- ✓ Travel at a safe speed < 20 MPH

Lift handle up to unlatch wheels

Hitching to the tractor

- ✓ Use an appropriate sized tractor with ample front end weight
- ✓ 4 row machine 70 – 90 hp, 6 row machine 110 -130 hp
- ✓ This unit is a semi-mount hitch
- ✓ **ONLY USE THE DRAFT ARMS OF THE TRACTOR , DO NOT USE THE CENTER LINK**
- ✓ Only use the center link on the 2 row model
- ✓ Remove as much lateral movement as possible on your 3 point hitch
- ✓ Couple the hydraulic lines to the tractor remote as a **set** not as individuals
- ✓ Stand clear of the hitch and unit when hitching

Leveling the InterSeeder

- ✓ The unit performs best when it sets level from hitch to transport wheels
- ✓ On the 4 and 6 row units set the tractor hitch to the float positon and lower the transport wheels on the rear
- ✓ On the 2 row, use the center link to achieve a level setting, set tractor hitch to float
- ✓ With the opening coulters on the ground use the transport wheels to level the unit
- ✓ The opening coulters should run either at the same level as seed depth or slightly deeper
- ✓ Once the unit is level, use cylinder stops on the 4 and 6 row to maintain planting position
- ✓ If the units tips towards the tractor in operation, raise tractor hitch slightly

6 Row Gauge Wheels

- ✓ Gauge wheels are removed for transport and need to be remounted
- ✓ Center between corn rows 1 and 2, 5 and 6. Count in 4 units from each end set up as an ***interseeder*** and mount wheels directly in front of the fourth row unit.
- ✓ Adjust slightly to avoid tank mounts
- ✓ Wheels can be optional as well depending on soil conditions, use your judgment

Leveling the InterSeeder

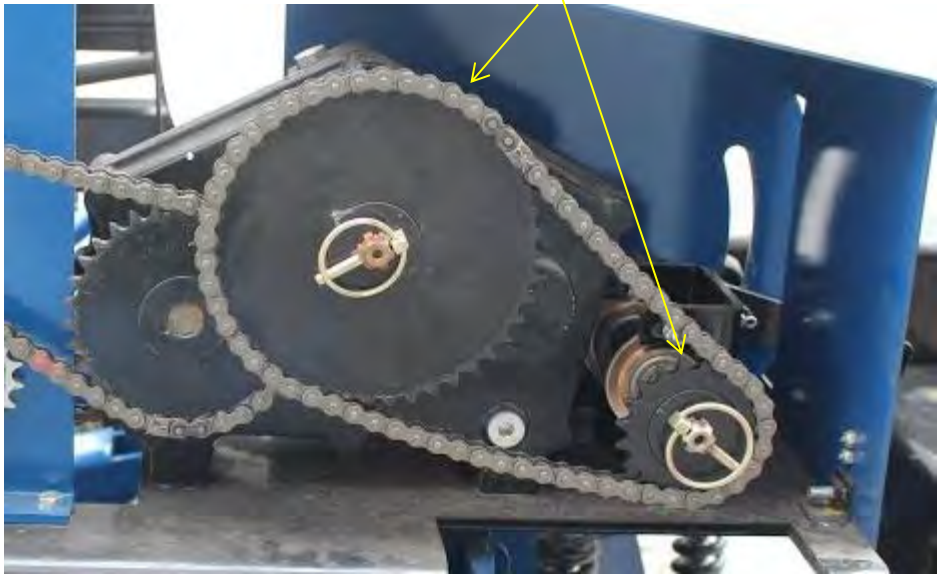
Insert cylinder stops here to assist with leveling if needed

Seed Settings

- ✓ **CALIBRATE YOUR INTERSEEDER FOR THE BEST RESULTS**
- ✓ The seed chart is only a **starting point**, seed size will vary and effect rates
- ✓ There is a high and low range drive on the seed box , see seeding chart for drive type
- ✓ Use the lever on the seed box transmission to set seeding rate

Seed chart is located under the seed box lid

High and low range gears are interchangeable, look for the door sticker to indicate which range



Calibration as a grain drill

- ✓ Accurately measure 200 ft, drive the unit and count the revolutions of the drive wheel
- ✓ Multiply the width of the machine by the length traveled
- ✓ EXP - 15 ft X 200 = 3000 sqft / (43560 sq ft in an acre) = .068 of an acre
- ✓ Place a tarp under the drill and prepare to catch the seed from the entire unit
- ✓ Make sure the metering units are charged with seed / turn the drive wheel several time prior to catching seed on tarp
- ✓ Now turn drive wheel the amount of turns in 200 feet and catch all of the seed and weigh
- ✓ Remember there is 453grams in 1lbs for conversion if needed

✓ Take the weight of the collected seed for example 2.3 lbs divide by percentage of an acre from above 2.3/.068 = 34lbs of seed per acre

Calibration as an InterSeeder

Here is a quick way to accurately calibrate the InterSeeder for your cover crop seeds. Keep in mind that seed sizes do vary among cover crop species. To get an accurate calibration we recommend you calibrate for each species you use. When using a mix we typically will set the calibration based on the species that dominates the mix. **For example, annual rye grass and red clover with a 60/40 mix at 20lbs/acre, we would calibrate for annual rye at 20lbs/acre.**
To calibrate is simple and takes about 15 minutes. First, measure off 100 feet setting a flag at the start and stop locations. Next, drive your tractor pulling the unit from the start location to the stop location and count the revolutions of the drive wheel using the white handle as a reference. Write down your drive wheel rpm for future reference , you will manually turn the drive wheel for calibrating in the next step. Now, remove 3 seed tubes next to one another. Add seed to the seed box and rotate the drive wheel until seed come out of each seed tube. Place a clean container under the seed tubes and turn the drive wheel the number of revolutions per 100ft and weigh the seed. For 30 inch corn rows the calibration formula is;

30 inch or 2.5ft X 100 ft = 250 square feet (This represents the area with in a thirty inch wide corn row 100 ft long.)
453 grams in 1 lb you will need to covert.

10 lbs seed /acre X 453 grams = 4350 grams
4350/43560 = .104 grams seeds per square foot in 1 acre
.104 g X 250 = 26 grams per 250 square feet which is the area you measured off

So for every 1 lb of cover crop seed desired per acre, you will need 2.6 grams of seed collected from 3 seed tubes.

Seed Chart for grain drill operation, drive wheel turns 710 times per acre

17 ROWS ... 710 turns Per acre

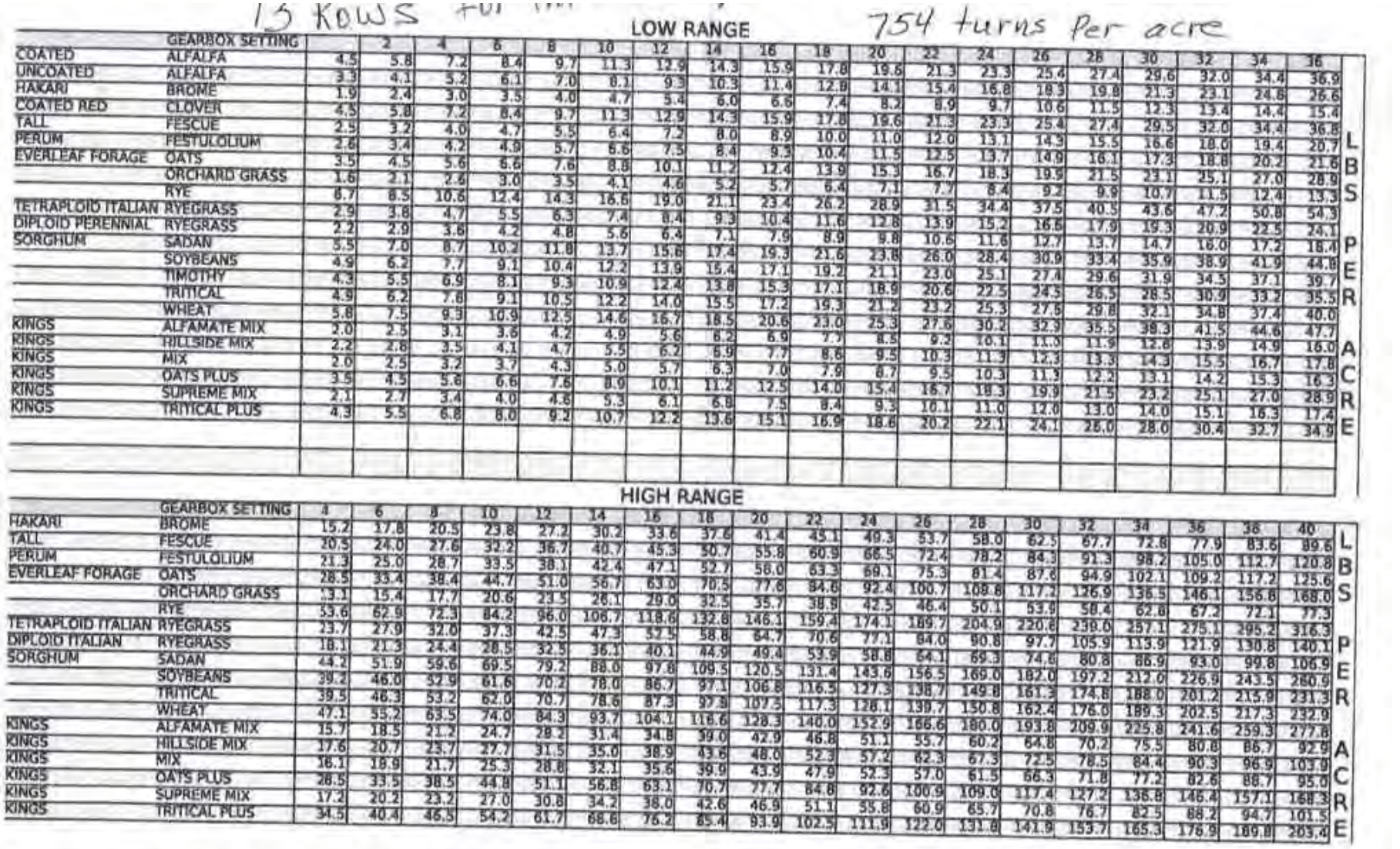
LOW RANGE

	GEARBOX SETTING		2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	LBS PER ACRE
COATED	ALFALFA	5.6	7.1	8.8	10.4	11.9	13.9	15.6	17.6	19.5	21.9	24.1	26.3	28.7	31.3	33.8	36.4	39.4	42.4	45.4	
UNCOATED	ALFALFA	4.0	5.1	6.4	7.5	8.6	10.0	11.4	12.7	14.1	15.8	17.4	18.9	20.7	22.5	24.3	26.2	28.4	30.5	32.7	
HAKARI	BROME	2.3	3.0	3.7	4.3	5.0	5.8	6.6	7.3	8.2	9.1	10.1	11.0	12.0	13.1	14.1	15.2	16.4	17.7	18.9	
COATED RED	CLOVER	5.5	7.1	8.8	10.4	11.9	13.9	15.8	17.6	19.5	21.9	24.1	26.3	28.7	31.3	33.8	36.3	39.4	42.3	45.3	
TALL	FESCUE	3.1	4.0	5.0	5.8	6.7	7.8	8.9	9.9	11.0	12.3	13.6	14.8	16.2	17.6	19.0	20.5	22.2	23.9	25.5	
PERUM	FESTULOLIUM	3.3	4.1	5.2	6.1	7.0	8.1	9.3	10.3	11.4	12.8	14.1	15.4	16.8	18.3	19.8	21.3	23.1	24.8	26.6	
EVERLEAF FORAGE	OATS	4.3	5.5	6.9	8.1	9.3	10.9	12.4	13.8	15.3	17.1	18.9	20.6	22.5	24.5	26.5	28.5	30.9	33.2	35.5	
	ORCHARD GRASS	2.0	2.6	3.2	3.7	4.3	5.0	5.7	6.3	7.0	7.9	8.7	9.5	10.3	11.3	12.2	13.1	14.2	15.3	16.3	
	RYE	8.2	10.4	13.0	15.3	17.6	20.5	23.3	25.9	28.6	32.3	35.5	38.7	42.3	46.1	49.8	53.6	58.1	62.5	66.9	
TETRAPLOID ITALIAN	RYEGRASS	3.6	4.6	5.8	6.8	7.8	9.1	10.3	11.5	12.8	14.3	15.7	17.2	18.7	20.4	22.1	23.8	25.7	27.7	29.6	
DIPLOID PERENNIAL	RYEGRASS	2.8	3.5	4.4	5.2	5.9	6.9	7.9	8.8	9.7	10.9	12.0	13.1	14.3	15.6	16.8	18.1	19.6	21.1	22.6	
SORGHUM	SADAN	6.8	8.6	10.7	12.6	14.5	16.9	19.2	21.4	23.8	26.8	29.3	32.0	34.9	38.0	41.1	44.2	47.9	51.5	55.2	
	SOYBEANS	6.0	7.6	9.5	11.2	12.8	15.0	17.1	19.0	21.1	23.6	26.0	28.3	30.9	33.7	36.4	39.2	42.5	45.7	48.9	
	TIMOTHY	5.4	6.8	8.5	10.0	11.5	13.4	15.3	17.0	18.8	21.1	23.2	25.3	27.7	30.1	32.6	35.1	38.0	40.9	43.7	
	TRITICAL	6.0	7.7	9.6	11.3	12.9	15.1	17.2	19.1	21.2	23.8	26.1	28.5	31.2	34.0	36.7	39.5	42.8	46.0	49.2	
	WHEAT	7.2	9.2	11.4	13.4	15.4	18.0	20.5	22.8	25.3	28.4	31.2	34.0	37.2	40.5	43.7	47.1	51.0	54.9	58.7	
KINGS	ALFAMATE MIX	2.4	3.1	3.8	4.5	5.2	6.0	6.9	7.6	8.5	9.5	10.4	11.4	12.4	13.5	14.6	15.8	17.1	18.4	19.6	
KINGS	HILLSIDE MIX	2.7	3.4	4.3	5.0	5.8	6.7	7.7	8.5	9.5	10.6	11.7	12.7	13.9	15.1	16.4	17.6	19.1	20.5	22.0	
KINGS	MIX	2.5	3.1	3.9	4.6	5.3	6.2	7.0	7.8	8.7	9.7	10.7	11.6	12.7	13.9	15.0	16.1	17.5	18.8	20.1	
KINGS	OATS PLUS	4.4	5.6	6.9	8.1	9.3	10.9	12.4	13.8	15.3	17.2	18.9	20.6	22.5	24.5	26.5	28.5	30.9	33.2	35.6	
KINGS	SUPREME MIX	2.6	3.4	4.2	4.9	5.6	6.6	7.5	8.3	9.2	10.4	11.4	12.4	13.6	14.8	16.0	17.2	18.6	20.0	21.4	
KINGS	TRITICAL PLUS	5.3	6.7	8.4	9.8	11.3	13.2	15.0	16.7	18.5	20.8	22.8	24.9	27.2	29.7	32.0	34.5	37.4	40.2	43.0	

HIGH RANGE

	GEARBOX SETTING	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	LBS PER ACRE
HAKARI	BROME	18.7	21.9	25.2	29.3	33.4	37.2	41.3	46.3	50.9	55.5	60.6	66.1	71.4	76.9	83.3	89.6	95.8	102.8	110.2	
TALL	FESCUE	25.2	29.6	34.0	39.6	45.1	50.1	55.7	62.4	68.6	74.9	81.8	89.2	96.3	103.7	112.3	120.8	129.3	138.7	148.7	
PERUM	FESTULOLIUM	26.2	30.7	35.3	41.2	46.9	52.2	58.0	64.9	71.4	77.9	85.1	92.7	100.1	107.8	116.8	125.6	134.4	144.3	154.6	
EVERLEAF FORAGE	OATS	35.0	41.1	47.2	55.0	62.7	69.7	77.5	86.8	95.5	104.1	113.8	124.0	133.9	144.2	156.2	168.0	179.8	192.9	206.7	
	ORCHARD GRASS	16.1	18.9	21.7	25.3	28.8	32.1	35.7	39.9	43.9	47.9	52.4	57.1	61.6	66.4	71.9	77.3	82.7	88.8	95.1	
	RYE	66.0	77.4	89.0	103.7	118.1	131.3	145.9	163.4	179.8	196.1	214.2	233.5	252.1	271.5	294.2	316.3	338.5	363.3	389.3	
TETRAPLOID ITALIAN	RYEGRASS	29.2	34.3	39.4	45.9	52.3	58.2	64.6	72.4	79.6	86.9	94.9	103.4	111.7	120.3	130.3	140.1	150.0	160.9	172.5	
DIPLOID ITALIAN	RYEGRASS	22.3	26.2	30.1	35.0	39.9	44.4	49.3	55.3	60.8	66.3	72.4	78.9	85.2	91.8	99.5	107.0	114.5	122.8	131.6	
SORGHUM	SADAN	54.4	63.8	73.4	85.5	97.4	108.3	120.4	134.8	148.3	161.8	176.7	192.6	208.0	224.0	242.6	260.9	279.2	299.6	321.1	
	SOYBEANS	48.2	56.6	65.0	75.8	86.4	96.0	106.7	119.5	131.5	143.4	156.6	170.7	184.4	198.6	215.1	231.3	247.6	265.7	284.7	
	TRITICAL	48.6	57.0	65.5	76.3	87.0	96.7	107.4	120.3	132.4	144.4	157.7	171.9	185.6	199.9	216.6	232.9	249.2	267.5	286.6	
	WHEAT	57.9	68.0	78.1	91.0	103.8	115.3	128.2	143.5	157.9	172.2	188.1	205.1	221.5	238.5	258.4	277.9	297.3	319.1	341.9	
KINGS	ALFAMATE MIX	19.4	22.7	26.1	30.5	34.7	38.6	42.9	48.0	52.8	57.6	62.9	68.6	74.1	79.8	86.4	92.9	99.5	106.7	114.4	
KINGS	HILLSIDE MIX	21.7	25.4	29.2	34.0	38.8	43.1	47.9	53.7	59.0	64.4	70.3	76.7	82.8	89.2	96.6	103.9	111.2	119.3	127.9	
KINGS	MIX	19.8	23.2	26.7	31.1	35.5	39.5	43.8	49.1	54.0	58.9	64.3	70.1	75.7	81.6	88.4	95.0	101.7	109.1	117.0	
KINGS	OATS PLUS	35.1	41.2	47.3	55.2	62.9	69.9	77.6	87.0	95.7	104.3	114.0	124.2	134.2	144.5	156.5	168.3	180.1	193.3	207.1	
KINGS	SUPREME MIX	21.2	24.8	28.5	33.3	37.9	42.1	46.8	52.4	57.7	62.9	68.7	74.9	80.9	87.1	94.4	101.5	108.6	116.5	124.9	
KINGS	TRITICAL PLUS	42.4	49.8	57.2	66.7	76.0	84.5	93.8	105.1	115.6	126.1	137.8	150.1	162.1	174.6	189.2	203.4	217.7	233.8	250.4	

Seed chart for interseeding, drive wheel will turn 754 times in 1 acre



15 ROWS for ... 754 turns per acre

LOW RANGE

	GEARBOX SETTING	1	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36
COATED	ALFALFA	4.5	5.8	7.2	8.4	9.7	11.3	12.9	14.3	15.9	17.8	19.6	21.3	23.3	25.4	27.4	29.6	32.0	34.4	36.9
UNCOATED	ALFALFA	3.3	4.1	5.2	6.1	7.0	8.1	9.3	10.3	11.4	12.8	14.1	15.4	16.8	18.3	19.8	21.3	23.1	24.8	26.6
HAKARI	BROME	1.9	2.4	3.0	3.5	4.0	4.7	5.4	6.0	6.6	7.4	8.2	8.9	9.7	10.6	11.5	12.3	13.4	14.4	15.4
COATED RED	CLOVER	4.5	5.8	7.2	8.4	9.7	11.3	12.9	14.3	15.9	17.8	19.6	21.3	23.3	25.4	27.4	29.5	32.0	34.4	36.8
TALL	FESCUE	2.5	3.2	4.0	4.7	5.5	6.4	7.2	8.0	8.9	10.0	11.0	12.0	13.1	14.3	15.5	16.6	18.0	19.4	20.7
PERUM	FESTULOLIUM	2.6	3.4	4.2	4.9	5.7	6.6	7.5	8.4	9.3	10.4	11.5	12.5	13.7	14.9	16.1	17.3	18.8	20.2	21.6
EVERLEAF FORAGE	OATS	3.5	4.5	5.6	6.6	7.6	8.8	10.1	11.2	12.4	13.9	15.3	16.7	18.3	19.9	21.5	23.1	25.1	27.0	28.9
	ORCHARD GRASS	1.6	2.1	2.6	3.0	3.5	4.1	4.6	5.2	5.7	6.4	7.1	7.7	8.4	9.2	9.9	10.7	11.5	12.4	13.3
	RYE	6.7	8.5	10.6	12.4	14.3	16.6	19.0	21.1	23.4	26.2	28.9	31.5	34.4	37.5	40.5	43.6	47.2	50.8	54.3
TETRAPLOID ITALIAN	RYEGRASS	2.9	3.8	4.7	5.5	6.3	7.4	8.4	9.3	10.4	11.6	12.8	13.9	15.2	16.6	17.9	19.3	20.9	22.5	24.1
DIPLOID PERENNIAL	RYEGRASS	2.2	2.9	3.8	4.2	4.8	5.6	6.4	7.1	7.9	8.9	9.8	10.6	11.6	12.7	13.7	14.7	16.0	17.2	18.4
SORGHUM	SADAN	5.5	7.0	8.7	10.2	11.8	13.7	15.6	17.4	19.3	21.6	23.8	26.0	28.4	30.9	33.4	35.9	38.9	41.9	44.8
	SOYBEANS	4.9	6.2	7.7	9.1	10.4	12.2	13.9	15.4	17.1	19.2	21.1	23.0	25.1	27.4	29.6	31.9	34.5	37.1	39.7
	TIMOTHY	4.3	5.5	6.9	8.1	9.3	10.9	12.4	13.8	15.3	17.1	18.9	20.6	22.5	24.5	26.5	28.5	30.9	33.2	35.5
	TRITICAL	4.9	6.2	7.8	9.1	10.5	12.2	14.0	15.5	17.2	19.3	21.2	23.2	25.3	27.5	29.8	32.1	34.8	37.4	40.0
	WHEAT	5.8	7.5	9.3	10.9	12.5	14.6	16.7	18.5	20.6	23.0	25.3	27.6	30.2	32.9	35.5	38.3	41.5	44.6	47.7
KINGS	ALFAMATE MIX	2.0	2.5	3.1	3.6	4.2	4.9	5.6	6.2	6.9	7.7	8.5	9.2	10.1	11.0	11.9	12.8	13.9	14.9	16.0
KINGS	HILLSIDE MIX	2.2	2.8	3.5	4.1	4.7	5.5	6.2	6.9	7.7	8.6	9.5	10.3	11.3	12.3	13.3	14.3	15.5	16.7	17.8
KINGS	MIX	2.0	2.5	3.2	3.7	4.3	5.0	5.7	6.3	7.0	7.9	8.7	9.5	10.3	11.3	12.2	13.1	14.2	15.3	16.3
KINGS	OATS PLUS	3.5	4.5	5.6	6.6	7.6	8.9	10.1	11.2	12.5	14.0	15.4	16.7	18.3	19.9	21.5	23.2	25.1	27.0	28.9
KINGS	SUPREME MIX	2.1	2.7	3.4	4.0	4.8	5.3	6.1	6.8	7.5	8.4	9.3	10.1	11.0	12.0	13.0	14.0	15.1	16.3	17.4
KINGS	TRITICAL PLUS	4.3	5.5	6.8	8.0	9.2	10.7	12.2	13.6	15.1	16.9	18.6	20.2	22.1	24.1	25.0	28.0	30.4	32.7	34.9

HIGH RANGE

	GEARBOX SETTING	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
HAKARI	BROME	15.2	17.8	20.5	23.8	27.2	30.2	33.6	37.6	41.4	45.1	49.3	53.7	58.0	62.5	67.7	72.8	77.9	83.6	89.6
TALL	FESCUE	20.5	24.0	27.6	32.2	36.7	40.7	45.3	50.7	55.8	60.9	66.5	72.4	78.2	84.3	91.3	98.2	105.0	112.7	120.8
PERUM	FESTULOLIUM	21.3	25.0	28.7	33.5	38.1	42.4	47.1	52.7	58.0	63.3	69.1	75.3	81.4	87.6	94.9	102.1	109.2	117.2	125.6
EVERLEAF FORAGE	OATS	28.5	33.4	38.4	44.7	51.0	56.7	63.0	70.5	77.6	84.6	92.4	100.7	108.8	117.2	126.9	136.5	146.1	156.8	168.0
	ORCHARD GRASS	13.1	15.4	17.7	20.6	23.5	26.1	29.0	32.5	35.7	38.9	42.5	46.4	50.1	53.9	58.4	62.8	67.2	72.1	77.3
	RYE	53.6	62.9	72.3	84.2	96.0	106.7	118.6	132.8	146.1	159.4	174.1	189.7	204.9	220.8	238.0	257.1	275.1	295.2	316.3
TETRAPLOID ITALIAN	RYEGRASS	23.7	27.9	32.0	37.3	42.5	47.3	52.5	58.8	64.7	70.6	77.1	84.0	90.8	97.7	105.9	113.9	121.9	130.8	140.1
DIPLOID ITALIAN	RYEGRASS	18.1	21.3	24.4	28.5	32.5	36.1	40.1	44.9	49.4	53.9	58.8	64.1	69.3	74.6	80.8	86.9	93.0	99.8	106.9
SORGHUM	SADAN	44.2	51.9	59.6	69.5	79.2	88.0	97.8	109.5	120.5	131.4	143.6	156.5	169.0	182.0	197.2	212.0	226.9	243.5	260.9
	SOYBEANS	39.2	46.0	52.9	61.6	70.2	78.0	86.7	97.1	106.8	116.5	127.3	138.7	149.8	161.3	174.8	188.0	201.2	215.9	231.3
	TRITICAL	39.5	46.3	53.2	62.0	70.7	78.6	87.3	97.8	107.5	117.3	128.1	139.7	150.8	162.4	176.0	189.3	202.5	217.3	232.9
	WHEAT	47.1	55.2	63.5	74.0	84.3	93.7	104.1	116.6	128.3	140.0	152.9	166.6	180.0	193.8	209.9	225.8	241.6	259.3	277.8
KINGS	ALFAMATE MIX	15.7	18.5	21.2	24.7	28.2	31.4	34.8	39.0	42.9	46.8	51.1	55.7	60.2	64.8	70.2	75.5	80.8	86.7	92.9
KINGS	HILLSIDE MIX	17.6	20.7	23.7	27.7	31.5	35.0	38.9	43.6	48.0	52.3	57.2	62.3	67.3	72.5	78.5	84.4	90.3	96.9	103.9
KINGS	MIX	16.1	18.9	21.7	25.3	28.8	32.1	35.6	39.9	43.9	47.9	52.3	57.0	61.5	66.3	71.8	77.2	82.6	88.7	95.0
KINGS	OATS PLUS	28.5	33.5	38.5	44.8	51.1	56.8	63.1	70.7	77.7	84.8	92.6	100.9	109.0	117.4	127.2	136.8	146.4	157.1	168.3
KINGS	SUPREME MIX	17.2	20.2	23.2	27.0	30.8	34.2	38.0	42.6	46.9	51.1	55.8	60.9	65.7	70.8	76.7	82.5	88.2	94.7	101.5
KINGS	TRITICAL PLUS	34.5	40.4	46.5	54.2	61.7	68.6	76.2	85.4	93.9	102.5	111.9	122.0	131.8	141.9	153.7	165.3	176.9	189.8	203.4

LBS PER ACRE

Seeding Rate

- ✓ Calibrate drill and refer to seed chart for setting
- ✓ Slide seed rate handle to # setting for seed rate
- ✓ Check RANGE = HIGH or LOW
- ✓ Move handle beyond setting and then bring it back to the correct position

Align arrow on handle
With # on sticker, tighten handle

Setting Seed Depth

- ✓ Remember to have the InterSeeder leveled for planting
- ✓ Run the opening coulter at desired seed depth or deeper
- ✓ Double disk opener depth is set by the “T” handle near the packing wheel
- ✓ Move “T” handle forward towards the tractor to shallow the seed depth
- ✓ Move “T” handle rearward away from the tractor to deepen the seed depth
- ✓ **CHECK SEED DEPTH OFTEN AS SOIL CONDITIONS CONSTANTLY CHANGE**

Shallow

↕

Deeper

“T” Handle

- Forwards = Shallow
- Rearwards = Deeper

The Seed Box

- ✓ **KEEP THE SEEDBOX CLEAN WHEN NOT IN USE**
- ✓ The seed box uses a sponge meter to regulate seed
- ✓ Keep seed clean of debris and foreign material that could damage sponges
- ✓ Sponges can be replaced if damaged by scraping off old sponge and gluing on new
- ✓ Contact InterSeeder for replacement parts and adhesive
- ✓ Sweep out seed box service panel when not in use to prevent rodent damage
- ✓ Oil chains weekly that drive the seed box

Seed meter

Service Panel

Helpful Tips

- ✓ Operate the unit between 3 and 5 mph depending on field conditions
- ✓ If you need additional weight, add water to the tanks
- ✓ Do not turn tightly with the drill in the planting position
- ✓ Use clean seed
- ✓ Calibrate to be accurate on seed rate
- ✓ Remember to add seed meter cover plates to the units removed for interseeding they will lay in the seed box and cover the sponge meter
- ✓ **WHEN USING LIQUID N, RINSE THE UNIT OFF EACH DAY OF USE TO PREVENT CORROSION FROM LIQUID SPLASH ONTO THE DRILLING UNITS**