

# The Effect of In-Season Herbicide Use on Subsequent Cover Crop Establishment

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## BACKGROUND

In the face of a changing climate, growers are driven to protect their soil from intense rain events and open winters. Producers also want to improve the water-holding capacity of their soils as a response to longer periods between rain events and drought conditions. Growers are interested in increasing their soil organic matter to sequester carbon but also to optimize nutrient applications and nutrient cycling in their fields, which can lower input costs. The literature has well-documented that cover crops can aid in all these things and are important tools in sequestering carbon, improving soil health, and building agricultural resiliency.

The bulk of cover crop research has been targeted at field crop commodities (corn, soybean, small grains). In horticulture operations, numerous chemistries are used to control weeds while the cash crop is growing. Growers who are looking to establish a cover crop after their cash crop has been harvested can run into problems with germination and establishment because of residual herbicide effects.

To effectively and efficiently integrate cover crops into a horticulture system is a complex problem that has yet to be fully addressed. The effect of residual herbicides used in the previous cash crop can impede cover crop germination and establishment. For growers to feel confident in planting a cover crop after the cash crop has been harvested, more information is needed on this critical piece of the puzzle.

In conjunction with Horticulture Nova Scotia and with funding from the Nova Scotia Department of Agriculture, Perennia designed a demonstration to help growers identify which species of cover crops could be planted in their cropping systems after residual herbicides were used in their horticultural cash crop.

The objectives of the project were:

1. Evaluate the effect of residual herbicides on the establishment of cover crops under tillage and no-till cover crop seeding systems.
2. Promote cover crops as key tools for sequestering carbon, reducing greenhouse gas emissions, enhancing soil health, improving agricultural resiliency and ensuring food security.

The site had a uniform, slightly north-facing slope, with a loamy sand soil, a pH of 6.4 and organic matter of 1.6%. In 2020, over-grazed perennial pasture was terminated, and fall rye was planted. In 2021, the field grew strawberry nursery plants, followed by a winter rye cover crop. As a result, this field has not had a history of intense management or herbicide use.

The winter rye cover crop was incorporated with a Lemken Heliodor before the herbicides were applied on June 22 to bare ground in East-West strips. The list of herbicide products and rate chosen for the trial can be found in Table 1. These products were chosen because they have lengthy residual activity and are widely used in horticultural crops in Nova Scotia. To terminate any emerged weeds, Credit Xtreme® (glyphosate) was applied at 0.7 L/ac before planting the cover crops on July 11. Half of the herbicide area was given a light tillage with a Lemkin Heliodor prior to planting. The cover crops were planted on July 14 using a double disc opener grain drill in both the tilled and no-tilled areas and were planted in North-South strips. The cover crops and seeding rates in the trial are listed in Table 2.

The seeding date was chosen in order to simulate planting after an early cash crop was harvested or strawberries were terminated after renovation. The date between herbicide application and cover crop establishment is tighter than would typically be expected in a commercial field to make herbicide effects more visible.

Table 1. Herbicide products and rate applied on June 22<sup>nd</sup>

Trade Name	Active ingredient	Rate
Control		
Valtera	Flumioxazin	56 g/ac
Devrinol	Napropamide	5 kg/ac
Pardner	Bromoxynil	0.2 l/ac
Sandea	Halosulfuron	21 g/ac
Prism	Rimsulfuron	24 g/ac
Lontrel	Clopyralid	0.2 l/ac
Converge	Isoxaflutole	0.78 ml/ac
Authority	selfentrazone	0.118 l/ac
Callisto	Mesotrione	120 ml/ac
Sinbar	Terbacil	1.4 kg/ac
Prowl H2O	Pendimethalin	1.34 l/ac
Goal 2XL	Oxyfluorfen	0.2 l/ac
Lorox	Linuron	1.30 l/ac
Chateau	Flumioxazin	56 g/ac
Dual II Magnum	S-Metolachor	0.6 l/ac
Sencor	Metribuzin	0.62 l/ac

 Table 2. Cover crops and rates planted on July 14<sup>th</sup>.

Species	Seeding (lbs/ac)	rate (Kg/ha)
<b>Broadleaf</b>		
1. Brown mustard	8	7
2. Buckwheat	40	36
3. Tillage radish	8	7
4. Oats/pea	60	53
<b>Grasses</b>		
5. Sorghum sudangrass	40	36
6. Pearl millet	20	18
7. Perennial ryegrass	12	11
8. Italian ryegrass	12	11
9. Annual ryegrass	12	11
10. Fall rye	60	53
11. Oats	60	53
12. Barley	60	53
<b>Legume</b>		
13. Red Clover	5	4
14. Hairy Vetch	25	22
15. Peas	120	107



Figure 1. Annual ryegrass establishment on July 27<sup>th</sup>, 2022.

Two methods of evaluating cover crop establishment were used. On July 27 and 28 (2 weeks after planting), photos were taken of each plot and uploaded to Canopeo, a tool that measures fractional green canopy cover. Ratings were scaled within each cover crop species, and a heat map was created (Figure 2). On the right side of Figure 2 is an index for cover crop establishment. Closer to zero (blue) meant no cover crop was present. Closer to one (red) meant more vegetative cover was present. As different cover crops will naturally establish at different rates, the data was scaled for within each crop. This means that when looking at Figure 2, cover crops should be compared across herbicide treatments within the same cover crop. Annual and perennial ryegrass results are not depicted as ryegrasses are slowly establishing, and data was poorly captured by the Canopeo app (Figure 1).

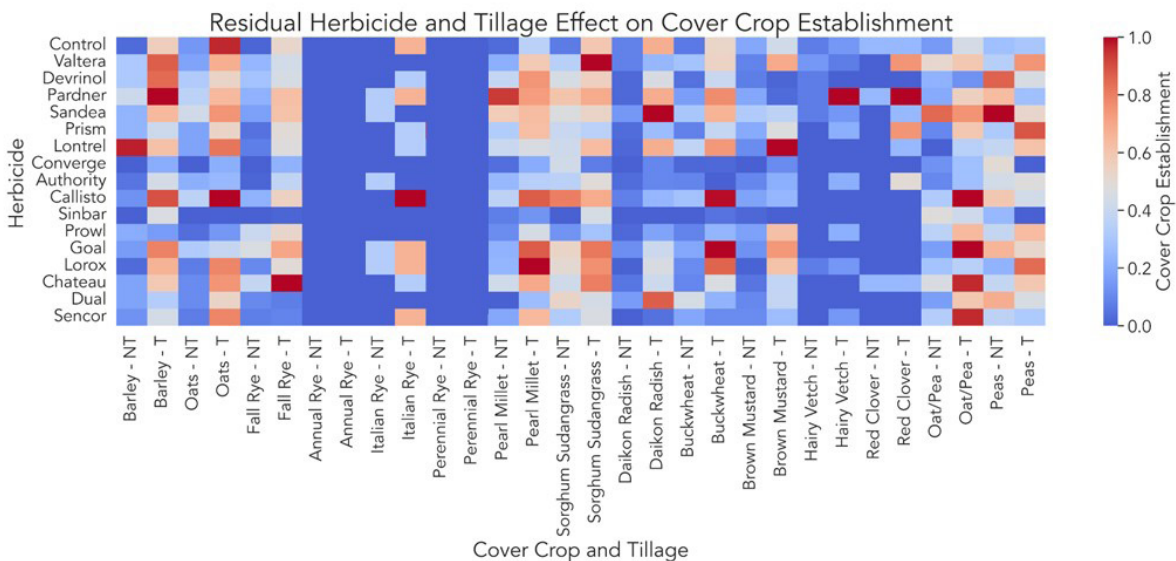


Figure 2. The measure of cover crop establishment two weeks after planting using the Canopeo app. Comparisons should be made within cover crop type, not across cover crop type. Residual effects of herbicides were measured on ground that was tilled (T) before cover crop seeding and on ground where the cover crops were seeded without tillage (NT). Annual and perennial ryegrass had not established enough for Canopeo images. Image courtesy of J.D. Gillis.

The second evaluation was done with a visual rating, taken on July 29 and again on August 18. Each plot was assessed by comparing each herbicide and cover crop combination to the untreated check for each cover crop species. The ratings are summarized in Figure 3. For the oat/pea cover crop, where a herbicide may have damaged pea establishment (i.e. Lontrel, Dual II Magnum), the oats established sufficiently to provide good ground cover.

NO-TILLED															
	barley	oats	fall rye	annual rye	italian rye	perennial rye	pearl millet	sorghum sundangrass	daikon radish	buckwheat	brown mustard	hairy vetch	red clover	oat/pea	peas
Control	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Valtera	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Devrinol	Green	Yellow	Green	Yellow	Yellow	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green
Pardner	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Sandea	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Prism	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Lontrel	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Yellow	Red	Green	Yellow
Converge	Red	Red	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Red	Green	Green
Authority	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Callisto	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Sinbar	Red	Red	Red	Red	Red	Red	Yellow	Red	Red	Red	Red	Red	Red	Red	Red
Prowl	Green	Green	Green	Yellow	Yellow	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green
Goal	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Lorox	Yellow	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Yellow	Red
Chateau	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Dual II Magnum	Green	Green	Green	Red	Red	Green	Green	Green	Green	Green	Green	Green	Yellow	Green	Green
Sencor	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Red	Green	Green

	TILLED														
	barley	oats	fall rye	annual rye	italian rye	perennial rye	pearl millet	sorghum sundangrass	daikon radish	buckwheat	brown mustard	hairy vetch	red clover	oat/pea	peas
Control	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Valtera	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Yellow	Green	Green
Devrinol	Green	Yellow	Green	Yellow	Yellow	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green
Pardner	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Sandea	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Prism	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Lontrel	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Yellow	Red	Green	Yellow
Converge	Red	Red	Green	Green	Green	Green	Green	Green	Red	Red	Red	Green	Red	Green	Green
Authority	Green	Green	Green	Green	Green	Green	Green	Green	Green	Red	Green	Green	Green	Green	Green
Callisto	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Sinbar	Red	Red	Red	Red	Red	Red	Yellow	Red	Red	Red	Red	Red	Red	Red	Red
Prowl	Green	Green	Green	Yellow	Yellow	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green
Goal	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Lorox	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Chateau	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Dual II Magnum	Green	Green	Green	Red	Red	Green	Green	Green	Green	Green	Green	Green	Red	Yellow	Red
Sencor	Yellow	Yellow	Green	Green	Green	Green	Green	Green	Yellow	Green	Green	Green	Yellow	Green	Green

Figure 3. The effect of residual herbicides on cover crop establishment 2-5 weeks after planting. Residual effects of herbicides were measured on ground that was tilled before cover crop seeding, and on ground where the cover crops were seeded without tillage. Green means the growth of the cover crop was no different from the control within that same species, yellow indicates some reduction in growth compared to the control, and red indicates unacceptable damage.





Figure 4. Aerial view of demo area during August 23<sup>rd</sup> “The Dirt on Cover Crops” Field Tour. Bare strip down the center of the photo is the Sinbar treatment.

## RESULTS AND DISCUSSION:

There are several factors that influence residual herbicide breakdown. Factors such as soil pH, moisture and temperature, soil texture and soil biology are just a few. Figure 2 and Figure 3 show that there are several cover crop options that can be used within a herbicide program. The use of Sinbar really limits cover crops as a meaningful part of soil management. Some herbicides, such as Prowl and Sencor, need to be managed carefully if a producer wishes to also use cover crops in rotation. When these herbicides, in particular, are used, careful selection of cover crop species and establishment method are required. Growers should consult Figure 2 and Figure 3 when they are developing their cover cropping systems.

### Tillage

Horticultural crops tend to use a lot of tillage to incorporate cash crop residues. Tillage drives microbial activity as oxygen is incorporated into the soil, often resulting in faster herbicide breakdown. However, some herbicides are more resistant to microbial degradation, leading to varying results on subsequent cover crop establishment. Tillage can also be used to dilute the concentration of a surface-applied herbicide by mixing it with a larger volume of soil – but this may also move the herbicide into the root zone of the desired crop, impairing germination. In the control, tillage prior to cover crop seeding resulted in better establishment two weeks after planting (Figure 2), but by five weeks after planting (Figure 3), differences could not be detected. In the case of products such as Valtera, Devrinol (with the exception of red clover), Pardner, Sandea, Prism, Lontrel, Authority, Callisto, Goal, Lorox, Chateau, soil disturbance will usually dramatically decrease the residual effect of the herbicide and enhance the success of a cover crop.

### Tillage before pea cover crop establishment

As mentioned, the effect of tillage for most herbicide x cover crops was beneficial. The exception is planting peas after Devrinol, Pardner, Sandea, Prism, Converge, Callisto, Goal, and Dual II Magnum, where tillage reduced establishment as measured at two weeks after planting.

### No-till cover crop establishment

Tillage after using products such as Converge and Dual II Magnum incorporates the herbicide into the root zone of the cover crop. This can result in more damage to the establishing cover crop compared to no-tillage.

### Red clover

Red clover is particularly sensitive to residual herbicides. Five weeks after planting (and eight weeks after herbicide application), red clover establishment after Lontrel, Converge, Sinbar, Dual II Magnum and Sencor was hampered regardless of tillage.

**Specific herbicides of note: Caution warranted****Sinbar**

Sinbar is used in tree fruit, strawberry, blueberry (both high and low-bush), asparagus and raspberry production. Negative effects at two weeks after cover crop planting (five weeks after herbicide application) were measured (Figure 2). The negative effect on cover crop growth is seen even five weeks after planting (Figure 3). The only acceptable cover crop to be grown after Sinbar application was pearl millet, and even then, reduced vigour was easily detected.

**Prowl**

Prowl can be used in Allium, Brassica, fruit trees, celery, carrots and field tomato production. Cover crops planted three weeks after Prowl was applied, while hindered in early establishment, largely grew out of it by five weeks, with the exception of annual, Italian and perennial ryegrass, which showed reduced establishment in our demonstration.

**Sencor**

Sencor is labelled for use in soybeans, potatoes, field corn, field tomatoes, asparagus, carrots, fruit trees and highbush blueberries. Sencor, while hindering early establishment across the board, regardless of tillage, by five weeks, in a no-till system, all cover crops were thriving, with the exception of red clover. Where Sencor was applied, and then the ground was tilled three weeks later, Sencor inhibited the growth of barley, oats, daikon radish, and red clover. Depending on the selected cover crop, it may be best not to till fields with Sencor applied if the producer hopes for good cover crop establishment.

**Converge**

Converge is used in field corn systems. Two weeks after establishment, tilling negatively impacted cover crop establishment after Converge, most notably in sorghum-sudan grass and peas. In tilled systems, by five weeks after planting, negative effects were still noted on barley, oats, daikon radish, buckwheat, mustard and red clover. In no-till systems, the effects of Converge were slightly less at five weeks on the broadleaf crops (with the exception of red clover) but still negatively affected barley and oat establishment. If Converge is used in the rotation, it may be best to A.) plant the cover crop using no-till and B.) opt for fall rye or one of the ryegrasses.

**Dual II Magnum**

Dual II Magnum is labelled for use in corn, soybeans, snap beans, potatoes, tree fruit, rutabaga, asparagus, carrots, celery, cucurbits, highbush blueberries, parsnips, strawberries, sweet potatoes, Brassicas, and caneberry production. Two weeks after establishment, tilling negatively impacted cover crop establishment for sorghum-sudan grass, buckwheat, and peas. By five weeks after planting, Dual II Magnum also showed negative effects on red clover and peas. If Dual II Magnum is part of the herbicide regime on a field, it is recommended to A.) plant the subsequent cover crop no-till, and B.) opt for a cereal (oats, barley, fall rye) or warm season grass (pearl millet, sorghum-Sudangrass).

**Lontrel**

Lontrel is labelled for use in rutabaga, highbush blueberries, tree fruit, Brassicas, strawberries, spinach, beets and onions. Lontrel had a negative effect on legume (red clover, hairy vetch, peas) establishment. It is recommended to till prior to cover crop establishment and to plant a cereal (barley, oats, fall rye), grass (any of the ryegrasses, sorghum-Sudangrass, or pearl millet), or forb (daikon radish, buckwheat, or brown mustard) after a Lontrel application.

**Devrinol**

Devrinol is labelled for use on strawberries, grapes, caneberries, high and low-bush blueberries, Brassicas, rutabaga, asparagus, tomatoes, garlic and some cucurbits. The use of Devrinol has a negative effect on oat, annual ryegrass, Italian ryegrass and perennial ryegrass establishment, so other cover crops should be selected if Devrinol is part of the cropping system. Tillage prior to cover crop establishment is likely to enhance cover crop establishment.

**Lorox**

Lorox is labelled for use in carrots, potatoes, parsnips, and asparagus. Lorox has a negative effect in no-till systems on the establishment of barley, oats and peas. When Lorox residue is incorporated into the soil, the negative effects on small grains are reduced/eliminated, but peas are a poor choice of cover crop if the window between herbicide use and cover crop planting is three weeks or less.

**Conclusion:**

Of the residual herbicide products tested, the results show that there are many good options for cover crop species that can be grown in a horticulture rotation after the cash crop is harvested. Sinbar is the most restrictive herbicide, and pearl millet was the only cover crop that was identified as an acceptable option. For the best success, growers must remember the residual effects of herbicides used in their systems to avoid cover crop establishment failures by referring to Figure 2 and Figure 3 prior to implementing their cover crop program. It is likely that if this trial were repeated with a longer period between herbicide application and cover crop establishment, some of the residual effects of the herbicides on cover crop growth would be reduced.

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*Recommendations in this report come from one non-replicated, observational study. Growers should always check the herbicide label for any replanting restrictions. Please note that recommendations in this report are given for general information only and do not give the user the right to use a product in a manner not in accordance with the pesticide label or Pest Control Products Act. Always read and follow the label.*

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