Evaluating overwintering cover crops options in strip-till corn: Part 1 (Haldimand County)

Purpose:

To evaluate a variety of potential overwintering cover crop options ahead of corn, measure their growth and determine their impact on corn development, yield, and the most economic rate of nitrogen.

Highlights:

- Three different overwintering cover crop treatments were compared to a fall-terminated cover crop mixture ahead of strip-tilled corn on a silty clay soil.
- Corn yield was greatest where cover crops were fall-terminated. It was lowest when planted green into a crimson clover cover crop.
- Soil moisture depletion negatively impacted corn germination, emergence and final plant stand where cover crops were spring terminated.
- Fall termination of cover crops prior to corn in strip-till systems is recommended, particularly on heavy textured soils. Further research is needed to determine best practices to lower risk for overwintering cover crops ahead of corn.

Methods:

The trial was established on a silty clay soil just outside Hagersville, in Haldimand County. Following winter wheat harvest, the field had solid manure applied and a cover crop mixture (treatments 1 and 2) seeded on August 1st, 2020 (Table 1). On August 9th, six strips were sprayed out and seeded to different cover crop mixtures for evaluation (treatments 3 and 4). All cover crops were seeded by broadcast plus shallow incorporation following winter wheat.

Cover crop management and sampling

Strips of the cover crop mixture from treatment 1 were terminated with herbicide (1L Roundup + 1L Marksman per acre) in the fall of 2020 to create a “fall-terminated” control treatment. Treatments 2, 3 and 4 were terminated with 1.5 L Roundup + 2 L Acuron / acre with 20 gallons of 28% urea ammonium nitrate on May 19th. There were three replicates of each treatment, except for treatment 1, which only had two replicates.

Table 1. Treatment details, including cover crop species, seeding rate and date and termination.

Treatment	Species	Seeding rate (lbs/ac)	Seeding Date	Termination Date
1	Cereal rye Oats Purple-top turnip Rape Radish	22 14 1 1 2	August 1, 2020	Fall 2020
2	Same as above	Same as above	Same as above	May 19, 2021
3	Oats Austrian Winter Pea	30 20	August 9, 2020	May 19, 2021
4	Oats Crimson Clover	30 20	August 9, 2020	May 19, 2021

Strip-tillage was performed in the fall of 2020 with a Dawn Pluribus (coulter-based) strip-tiller to create a seedbed for corn planting in the spring of 2021.

Cover crop biomass was collected on November 10, 2020, just prior to a hard frost using a 55-cm diameter hula hoop from nine locations per treatment. Biomass samples were also collected on May 14, 2021, four days prior to corn planting (May 18) and five days before cover crop termination (May 19).

Estimation of maximum economic rate of nitrogen (MERN)

A high nitrogen (N) rate was applied as well as a low N rate to evaluate the most economic rate of nitrogen via the delta-yield method for each cover crop treatment. The low N rate was 5 lbs-N/acre, delivered from 5 gallons/acre of 7-24-7 liquid starter. The high N rate was 191 lbs-N/acre, delivered as 5 gallons/acre 7-24-7, 40 gallons/ac of 28% UAN (instead of 20 gallons/ac, the rate applied to remainder of plot area), as well as 22 gallons/acre applied as 28% UAN at tasseling via Y-drops. The two nitrogen rates ran perpendicular across treatments and were each 75 feet of plot length.

In-season measurements

Corn was planted on May 18th at a rate of 34,000-40,000 seeds/acre (variable rate across field). Corn population was evaluated by counting plants per 1/1,000th of an acre in 6-9 locations per treatment on June 17, 2021. Soil moisture was measured using a FieldScout TDR-150 at a 3-inch depth in 6-9 locations in each treatment (except treatment 1) on May 14, 2021. Corn yield was measured by hand harvesting cobs from four 25 feet of row per plot and converting to a bushel per acre value at 15.5% moisture. Statistics were performed using a one-way ANOVA calculator and Tukey HSD with significant differences considered when $P<0.10$. Statistics could not be performed on treatment 1, as it only had two replicates.

Results:

Cover crop biomass: Fall 2020

Cover crop biomass collected just prior to freeze-up in the fall of 2020 showed that treatments 1 and 2 had higher biomass than treatments 3 and 4 (Figures 1 and 2; Table 2). This was to be expected, as those treatments were seeded earlier and included more species expected to put on summer and fall growth, especially following manure (e.g. oats, forage peas, radish). The oats did not establish well in treatments 3 and 4 due to lack of rainfall following seeding. Crimson clover established very well. It created a dense stand and accumulated over 1,300 lbs/ac of dry matter, compared to only 150 lbs/ac from Austrian winter peas (Table 2), which did not perform well. The winter peas appeared diseased. Lack of rainfall after seeding may also have negatively impacted their density.

Figure 1. The boundary between treatment 2 (right; overwinter cover crop mixture) and treatment 3 (left; oats and Austrian winter pea) on November 10, 2020.

Figure 2. Treatment 4 (oats and crimson clover) on November 10, 2020.

Table 2. Dry biomass in pounds/acre for cover crops from each treatment.

Treatment	Dry biomass (lbs/acre)				
	Brassicas	***Legume***	***Oats***	***Volunteer wheat + rye***	***Total***
1 (mixture, fall-terminated)	-	-	-	-	2,804
2 (mixture, spring-terminated)					
3 (oats + Austrian winter pea)	n/a	150	901	588	1,640
4 (oats + crimson clover)	n/a	1,314	914	232	2,460
Average	**n/a**	**732**	**908**	**410**	**2,301**

- Data not collected; species not separated

Cover crop biomass: Spring 2021

Spring growth consisted largely of volunteer wheat (all treatments), rape, purple-top turnip, and cereal rye (treatment 1), as well as crimson clover (treatment 2). In treatment 3, volunteer wheat was much more dominant than overwintering Austrian winter pea, which was sparse (Table 3). Rape, along with some purple-top turnip, was in flower by mid-May (Figure 3) after having unexpectedly survived the winter. Crimson clover overwintered well and was very thick (Table 3).

Table 3. Dry biomass in pounds/acre for cover crops from each treatment.

Treatment	Dry biomass (lbs/acre)				
	Brassicas	***Legume***	***Cereal rye***	***Volunteer wheat***	***Total***
1 (mixture, fall-terminated)	n/a	n/a	n/a	n/a	n/a
2 (mixture, spring-terminated)	1,753	n/a	1,224	962	3,939
3 (oats + Austrian winter pea)	n/a	576	n/a	1,728	2,304
4 (oats + crimson clover)	n/a	2,154	n/a	1,678	3,831
Average	**n/a**	**1,365**	**n/a**	**1,456**	**3,358**

- Data not collected; species not separated

Figure 3. Flowering brassica cover crops from treatment 2. May 14, 2021.

Corn stand and development

Under treatments 2, 3 and 4, cover crops depleted soil moisture in the days following seeding (Figure 4), despite corn being planted into moisture on May 18th. A ~1-inch rain on May 28th enabled germination of corn in those treatments; however, its development was delayed and the stand was reduced relative to the cover crop-free treatment 1 (Table 4).

Figure 4. Dry, ungerminated corn seed in the trench of a cover crop treatment on May 27th, 2021.

Crimson clover depleted soil moisture more substantially than the cover crops in Treatments 2 and 3 (Table 5). Its dense root system also created challenges making a good seedbed with fall strip-tillage. It dried out soil strongly in mid-May and was slow to die with the herbicide mixture applied after planting. These challenges are reflected in the lowest corn stand, shortest plants, and most delayed corn in treatment 4 (Table 4).

Table 4. Corn stand, growth stage and average height by treatment. Measured on June 17th, 2021.

Treatment	Corn stand (plants per acre)	Vegetative Growth Stage	Height (in)
1 (mixture, fall-terminated)	34,500	V6	13
2 (mixture, spring-terminated)	30,556	V3.5	8.5
3 (oats + Austrian winter pea)	30,444	V3.5	8.2
4 (oats + crimson clover)	28,556	V2.5	6.6
Average	**31,014**	**V3.9**	**9.1**

Table 5. Soil moisture at 3-inch depth on May 14, 2021, 4 days prior to planting.

Treatment	Average volumetric water content – 2-inch depth (m^3/m^3)
1 (mixture, fall-terminated)	-
2 (mixture, spring-terminated)	28.8
3 (oats + Austrian winter pea)	27.9
4 (oats + crimson clover)	25.7
Average	**27.5**

- Data not collected

Due to earlier germination, corn planted into fall-terminated cover crop had a significant developmental advantage over corn planted green into cover crops in other treatments (Figure 5). Corn planted into crimson clover (Figure 6) was the slowest to progress.

Figure 5. Corn stand in a replicate of treatment 2 (left) compared to treatment 1 (right) on June 17th.

Figure 6. Corn growing in treatment 4 (spring-terminated crimson clover) on June 17th.

Corn yield

Yields were not statistically different amongst treatments 2, 3 and 4. Although it was not included in the statistical analysis, yield under treatment 1 (fall-terminated cover crop mixture) was numerically higher than any other treatment (Table 6). It yielded 225.5 bu/ac, based on hand harvests, which was 15 bu/ac greater than treatment 3 and 17.8 bu/ac greater than treatment 2.

2021 was an excellent growing season for corn, with ample precipitation throughout the later vegetative and reproductive growth stages. Without these favourable environmental conditions, it's likely that the yield gap would have been much greater between treatment 1 and the three spring-terminated cover crop treatments.

Corn yield was numerically lowest when planted into crimson clover in treatment 4 (180.6 bu/ac). This 44.9 bu/ac lower yield than the fall-terminated cover crop mixture was due to a combination of factors, namely a reduction in the number of cob-bearing plants (Table 6), delayed germination and emergence, and possibly shading by the slow-to-die clover. The yield reduction highlights the risks associated with spring termination of densely rooted clovers, particularly on heavy textured soils (so called "three-day clays"). While the dense root system can help to reduce soil moisture, if conditions turn dry it can lead to excessive soil drying.

Table 6. Corn yield in sections of each treatment from section with high rate of nitrogen. Results with same letter are not statistically different.

Treatment	Mean yield at 15.5% moisture (bu/ac) (standard deviation)	Mean moisture (%) (standard deviation)	Mean plants per acre with a cob at harvest (standard deviation)
1 (mixture, fall-terminated)	225.5 (37.2)	33.2 (2.5)	32,269 (2,666)
2 (mixture, spring-terminated)	207.7 (20.0) A	33.9 (2.3)	27,572 (2,868)
3 (oats + Austrian winter pea)	210.5 (41.0) A	34.3 (1.5)	25,695 (6,291)
4 (oats + crimson clover)	180.6 (37.0) A	34.6 (2.5)	22,651 (2,916)
Average	**206.1**	**34.0**	**27,047**

Most economic rate of nitrogen

Low and high nitrogen rates were compared across all treatments (Figure 7). Based on the delta-yield method of estimating the most economic rate of nitrogen, treatment 4 had the lowest MERN value (104 lbs-N/ac). This was expected, as crimson clover was the only legume cover crop with substantial growth. These results, however, should be interpreted with caution. The yield potential of corn was greatly reduced due to several non-nitrogen related factors under treatment 4.

Figure 7. A low nitrogen section (foreground) and high nitrogen section (background) ran perpendicular across each cover crop treatment.

The MERN value for treatment 1 was similar, at 105 lbs-N/acre (Table 7), which was 27-34 lbs-N/acre less than for treatment 2 and 3. This largely reflects the higher yields achieved at the low N rate under treatment 1, which may have been due to improved early season corn development. High carbon: nitrogen ratio residue from spring-terminated cover crops (cereal rye and volunteer wheat) also may have contributed to lower yields at the low N rate – and therefore higher MERN values – under treatments 2 and 3.

Table 7. Yield at high (non-limiting) and low (5 lbs-N/acre) rates of nitrogen for each treatment, along with an estimated most economic rate of nitrogen (based on $5/bu corn and $0.50/lb-N and sidedress application).

Treatment	Mean yield at 15.5% moisture (bu/ac) (standard deviation) High N rate	Mean yield at 15.5% moisture (bu/ac) (standard deviation) Low N rate	Delta Yield (bushels/acre)	Estimated most economic rate of nitrogen (MERN)
1 (mixture, fall-terminated)	225.5 (37.2)	180.1 (22.7)	45.4	105 lbs-N/ac
2 (mixture, spring-terminated)	207.7 (20.0)	133.5 (22.4)	74.2	132 lbs-N/ac
3 (oats + Austrian winter pea)	210.5 (41.0)	128.7 (15.4)	81.8	139 lbs-N/ac
4 (oats + crimson clover)	180.6 (37.0)	136.4 (24.2)	44.2	104 lbs-N/ac
Average	**206.1**	**144.7**	**61.4**	**120 lbs-N/ac**

Overall, MERN estimates from this trial were confounded by cover crop impacts on soil moisture and delayed emergence. Future trials are needed to establish nitrogen credits (or penalties) from overwintering cover crops in Ontario.

Summary:

This trial highlighted the risks associated with overwintering cover crops and planting corn “green” into them in reduced tillage systems. Based on differences in crop emergence and development, as well as yield trends, fall termination of cover crops was the best practice in this trial. Although cover crops can assist with drying soil out in the spring, they can dry soils excessively under some circumstances; this is especially true on heavy textured soils that can quickly go from being too wet to too dry.

Further trials are needed to evaluate best practices for managing overwintering cover crops on heavy textured soils. For the time being, fall termination prior to corn planting is recommended.

Next Steps:

A similar trial evaluating overwintering cover crops before corn in a strip-till system was conducted in 2021-22 and results are reported in a separate Crop Advance report titled “Evaluating overwintering cover crops options in strip-till corn: Part 2 (Brant and Norfolk Counties).”

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Location of Project Final Report:

This is the final project report.