2013

# Corn Interseeding Trial

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Growing a cover crop can enhance nutrient cycling and soil health while reducing soil erosion. However, getting cover crops established in corn silage systems has historically been problematic for Northeast growers due to the length of the growing season. Commonly, corn silage is harvested mid-September through mid-October. This leaves little time to get a cover crop planted and adequately established before going into the winter. This late planting also limits the number of species of cover crops that can be grown. Interseeding cover crops into the corn crop just prior to canopy would allow for earlier establishment and potentially a broader diversity. This project evaluated interseeding 3 species of cover crops into corn silage at the V6 stage of development (just prior to canopy closure) with a specialized piece of equipment developed by Penn State University.

## MATERIALS AND METHODS

In 2013, UVM Extension's Northwest Crops & Soils Program initiated a trial at Borderview Research Farm in Alburgh, VT to assess the growth and yield of interseeded crops in corn silage, as well as the soil characteristics within the trial. The experimental design was a randomized complete block with interseeded crops (ryegrass, radish, red clover, and control) as treatments (Table 1, Figure 1).

**Table 1. Intercrop planting specifics for crop interseeding trial, Alburgh, VT, 2013.**

| Crop | Variety | Seeding rate (lbs $ac^{-1}$) |
|---|---|---|
| Annual ryegrass | Greenspirit | 25 |
| Radish | Tillage Radish® | 18 |
| Red clover | Freedom | 10 |

**Figure 1. Annual ryegrass, radish, and red clover interseeded between rows of corn, Alburgh, VT, 2013.**

The soil type at the research site was a Benson rocky silt loam with 8-15% slopes (Table 2). There were three replications, and each plot was 10'x50'. Flax had been grown at the site previously. The corn variety was Pioneer's '9690HR,' which has a relative maturity (RM) of 96 days and the following traits: Herculex I®, which provides protection against above-ground pests such as European corn borer, Western bean cutworm and black cutworm; LibertyLink® glufosinate ammonium tolerance; and Roundup® and Touchdown® glyphosate tolerance. Corn was seeded in 30" rows on 8-May with a John Deere 1750 corn planter at 34,000 seeds per acre. At planting, 200 lbs per acre of the starter fertilizer 10-20-20 was applied.

**Table 2. Agronomic information for corn interseeding trial, Alburgh, VT, 2013.**

| Location | Borderview Research Farm – Alburgh, VT |
|---|---|
| **Soil type** | Benson rocky silt loam, 8-15% slope |
| **Previous crop** | Flax |
| **Plot size (ft)** | 10 x 50 |
| **Replications** | 3 |
| **Interseeding treatments** | Annual ryegrass, red clover, radish, control (no intercrop) |
| **Corn variety** | Pioneer '9690HR' (96 RM) |
| **Seeding rates (seeds $ac^{-1}$)** | 34,000 |
| **Planting equipment** | John Deere 1750 corn planter |
| **Planting date** | 8-May |
| **Row width (in.)** | 30 |
| **Starter fertilizer (at planting)** | 200 lbs $ac^{-1}$ 10-20-20 |
| **Chemical weed control** | 2.5 qts $ac^{-1}$ Touchdown®, 6-Jun |
| **Additional fertilizer (topdress)** | 200 lbs $ac^{-1}$ urea (46-0-0), 20-Jun |
| **Interseeding equipment** | Penn State Cover Crop Interseeder and Applicator |
| **Interseeding date** | 24-Jun |
| **Corn harvest date** | 26-Sep |
| **Cover crop harvest dates** | 6-Nov and 14-Nov |

**Figure 2. Penn State Cover Crop Interseeder and Applicator.**

On 6-Jun, 2.5 quarts per acre of Touchdown® was applied per acre for weed control. Corn was topdressed on 20-Jun with 200 lbs per acre of 46-0-0 (providing 92 lbs available N per acre). The interseeded crops were established with an implement from Pennsylvania State University which has the capability to both seed and apply nutrients (Figure 2). Crops were interseeded on 24-Jun, when corn was at V6 stage, at varying rates (Table 1). Corn was harvested for silage on 26-Sep; yields were not recorded by treatment.

Cover crop biomass samples were harvested by hand in annual ryegrass and tillage radish treatments on 6-Nov, after measuring plant height. Soil samples were also collected on this date, and samples were analyzed at the University of

Vermont's Agricultural and Environmental Testing Laboratory for soil pH, nutrients, organic matter, and cation exchange capacity (CEC). No samples from red clover treatments were collected, as there was not enough biomass accumulated during the growing season. Moisture and dry matter yield were calculated. Tillage radish plots were sampled again on 14-Nov to provide a subsample for testing nitrogen content. These subsamples were dried and coarsely ground with a UDY cyclone sample mill, then tested for nitrogen levels within plant tissue with combustion CHN analysis.

Data were analyzed using mixed model analysis using the mixed procedure of SAS (SAS Institute, 1999). Replications within trials were treated as random effects, and treatments were fixed. Mean comparisons were made using the Least Significant Difference (LSD) procedure when the F-test was considered significant ($p<0.10$).

Variations in yield and quality can occur because of variations in genetics, soil, weather, and other growing conditions. Statistical analysis makes it possible to determine whether a difference among treatments is real or whether it might have occurred due to other variations in the field. At the bottom of each table a LSD value is presented for each variable (i.e. yield). Least Significant Differences (LSDs) at the 0.10 level of significance are shown, except where analyzed by pairwise comparison (t-test). Where the difference between two treatments within a column is equal to or greater than the LSD value at the bottom of the column, you can be sure that for 9 out of 10 times, there is a real difference between the two treatments. Treatments that were not significantly lower in performance than the top-performing treatment in a particular column are indicated with an asterisk. In the example below, hybrid C is significantly different from hybrid A but not from hybrid B. The difference between C and B is equal to 1.5, which is less than the LSD value of 2.0. This means that these hybrids did not differ in yield. The difference between C and A is equal to 3.0, which is greater than the LSD value of 2.0. This means that the yields of these hybrids were significantly different from one another. The asterisk indicates that hybrid B was not significantly lower than the top yielding hybrid C, indicated in bold.

| **Treatment** | **Variety** |
|---|---|
| A | 6.0 |
| B | 7.5* |
| C | **9.0*** |
| LSD | 2.0 |

# RESULTS

Weather data was collected with an onsite Davis Instruments Vantage Pro2 weather station equipped with a WeatherLink data logger. Temperature, precipitation, and accumulation of Growing Degree Days (GDDs) are consolidated for the 2013 growing season (Table 3). Historical weather data are from 1981-2010 at cooperative observation stations in Burlington, VT, approximately 45 miles from Alburgh, VT.

The spring of 2013 was much wetter than normal, which delayed corn planting for many farmers. In June, there were 5.54 more inches of precipitation than normal. After June, however, the summer was drier than normal, with an average of 5.20 inches fewer than average in July, August, and September. GDDs are calculated below at a base temperature of 50°F for corn and 32°F for cover crops. Between planting in May and harvest in September, there were a total of 2259 corn GDDs, 47 more than the 30-year average. There were 4739 GDDs accumulated for cover crops between June and October (28 more than the historical average).

**Table 3. Consolidated weather data and GDDs for corn and cover crops, Alburgh, VT, 2013.**

| **Alburgh, VT** | May | June | July | August | September | October |
|---|---|---|---|---|---|---|
| Average temperature (°F) | 59.1 | 64.0 | 71.7 | 67.7 | 59.3 | 51.1 |
| Departure from normal | 2.7 | -1.8 | 1.1 | -1.1 | -1.3 | 2.9 |
| | | | | | | |
| Precipitation (inches) | 4.79 | 9.23* | 1.89 | 2.41 | 2.20 | 2.22* |
| Departure from normal | 1.34 | 5.54 | -2.26 | -1.50 | -1.44 | -1.38 |
| | | | | | | |
| Corn GDDs (base 50°F) | 312 | 427 | 677 | 554 | 289 | 142 |
| Departure from normal | 113 | -47 | 37 | -27 | -29 | 142 |
| | | | | | | |
| Cover Crop GDDs (base 32°F) | 848 | 967 | 1235 | 1112 | 825 | 600 |
| Departure from normal | 91 | -47 | 37 | -27 | -33 | 98 |

Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger. Historical averages are for 30 years of NOAA data (1981-2010) from Burlington, VT.
* Jun and Oct 2013 precipitation data based on National Weather Service data from cooperative stations in South Hero, VT.

On 6-Nov, data was collected on cover crop plant height and plots were harvested to determine moisture and yield (Table 4). Annual ryegrass was significantly taller than radish, averaging 26.1 cm, compared to 22.2 cm. The moisture level was significantly greater in radish (77.8%) than ryegrass. Dry matter yields of radish were also significantly greater (977 lbs per acre) (Figure 3).

**Table 4. Height and aboveground yield of cover crops planted 24-Jun and harvested 6-Nov, Alburgh, VT, 2013.**

| Cover crop treatment | Height | Moisture | Dry matter yield |
|---|---|---|---|
| | cm | % | lbs $ac^{-1}$ |
| Annual ryegrass | **26.1*** | 72.7 | 640 |
| Radish | 22.2 | **77.8*** | **977*** |
| LSD (0.10) | 9.7 | 5.0 | 339 |
| Trial mean | 16.1 | 50.2 | 539 |

Treatments shown in **bold** are top-performing in a particular column.
* Treatments with an asterisk did not perform significantly lower than the top-performing treatment in a particular column.

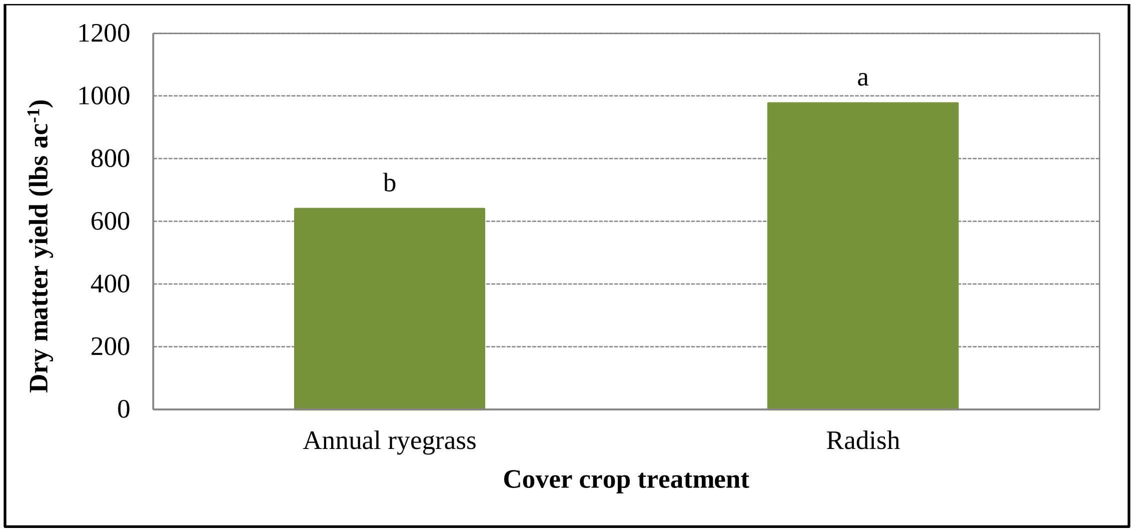


**Figure 3. Dry matter yields of annual ryegrass and radish, Alburgh, VT, 2013. Treatments that share a letter were not significantly different from one another (p=0.10).**

Soil samples were collected to determine whether there was a significant impact of interseeded cover crops on soil composition (Table 5). The only significant change in soil nutrients was in the level of potassium (K), which was significantly reduced by both ryegrass and radish cover crop treatments. The average soil pH was 7.18, statistically unaffected by cover crop. Available P, Mg, Al, Ca, and Zn were not statistically different by treatment. Cation exchange capacity (CEC) was lowest in the radish treatment, but not statistically significant. The soil organic matter was highest (4.30%) in the control treatment, though the trend was not statistically significant.

**Table 5. Soil analysis of cover crop treatments, Alburgh, VT, 2013.**

| Cover crop treatment | Soil pH | Available P | K | Mg | Al | Ca | CEC | Zn | Soil Organic Matter |
|---|---|---|---|---|---|---|---|---|---|
| | | ppm | ppm | ppm | ppm | ppm | meq 100 $g^{-1}$ | ppm | % |
| Annual ryegrass | **7.23** | 44.3 | 284 | 193 | **11.0** | **3231** | **18.5** | 1.33 | 3.93 |
| Radish | 7.10 | 39.8 | 253 | 191 | 9.7 | 3009 | 17.3 | 1.13 | 4.07 |
| Control | 7.20 | **57.4** | **322*** | **219** | 9.3 | 3175 | **18.5** | **1.40** | **4.30** |
| LSD (0.10) | NS | NS | 34 | NS | NS | NS | NS | NS | NS |
| Trial mean | 7.18 | 47.2 | 286 | 201 | 10.0 | 3138 | 18.1 | 1.29 | 4.10 |

Treatments shown in **bold** are top-performing in a particular column.
NS – Treatments were not significantly different from one another (p=0.10).
* Treatments with an asterisk did not perform significantly lower than the top-performing treatment in a particular column.

Micronutrients varied little by cover crop treatment (Table 6). The level of sulfur (S) in the control treatment was greatest (8.67 ppm), though this was not statistically greater than the level of S in the annual ryegrass treatment. Levels of Mn, B, Cu, Fe, and Na were not statistically impacted by the introduction of cover crops. Nitrate ($NO_3$) levels were statistically significant by treatment, with a significantly higher level of $NO_3$ (10.3 mg per kg) in the control treatment than either of the treatments with a cover crop interseeded (Figure 4).

**Table 6. Micronutrient and nitrate analysis by cover crop treatment, Alburgh, VT, 2013.**

| Cover crop treatment | S | Mn | B | Cu | Fe | Na | $NO_3$ |
|---|---|---|---|---|---|---|---|
| | ppm | ppm | ppm | ppm | ppm | ppm | mg $kg^{-1}$ |
| Annual ryegrass | 7.67* | **4.73** | 0.77 | **0.17** | **2.57** | 10.7 | 6.2 |
| Radish | 6.33 | 4.20 | 0.67 | **0.17** | 2.43 | **11.7** | 5.7 |
| Control | **8.67*** | 4.33 | **0.83** | 0.15 | 2.47 | 11.0 | **10.3*** |
| LSD (0.10) | 1.69 | NS | NS | NS | NS | NS | 3.3 |
| Trial mean | 7.56 | 4.42 | 0.76 | 0.16 | 2.49 | 11.1 | 7.4 |

Treatments shown in **bold** are top-performing in a particular column.
NS – Treatments were not significantly different from one another (p=0.10).
* Treatments with an asterisk did not perform significantly lower than the top-performing treatment in a particular column.

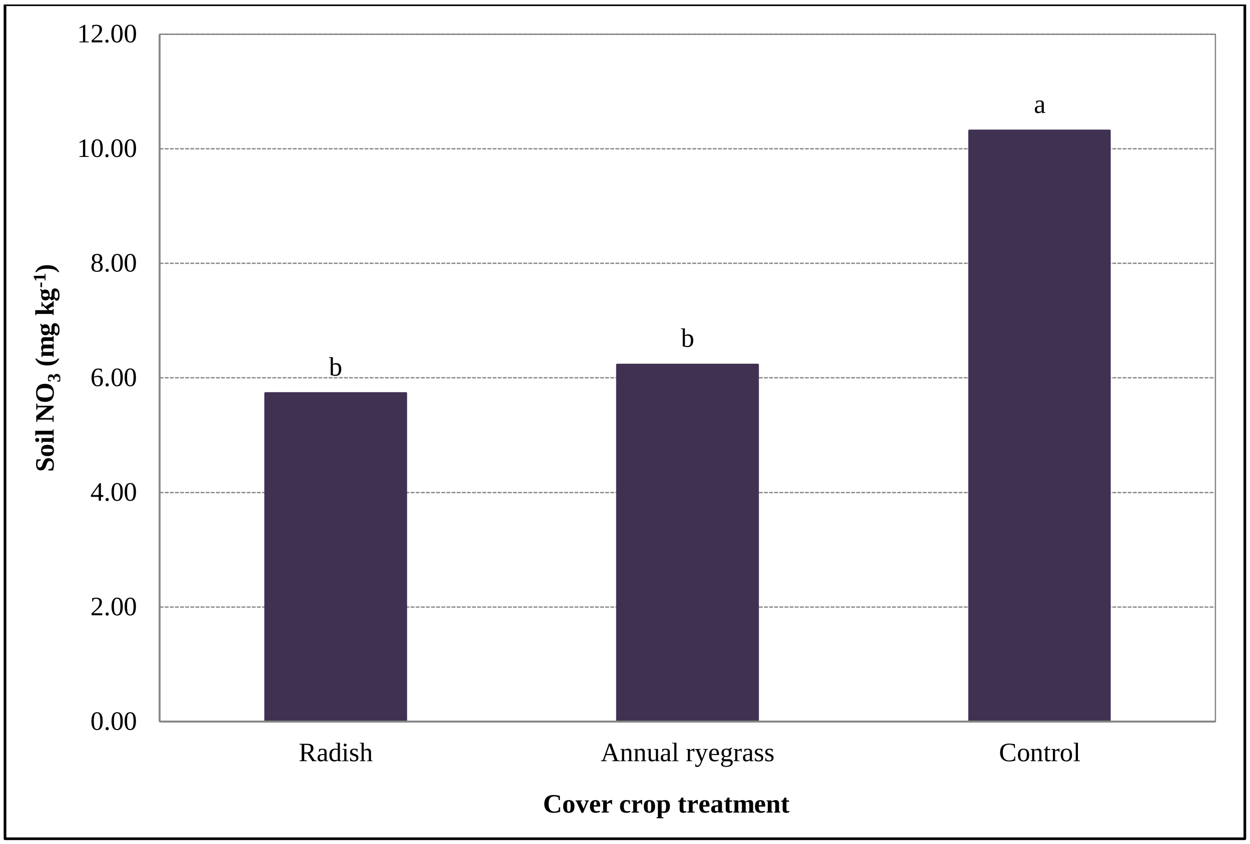


**Figure 4. Effects of cover crop treatments on nitrate levels in soil, Alburgh, VT, 2013. Treatments that share a letter were not statistically different from one another (p=0.10).**

Tillage radish was harvested on 14-Nov, approximately one week after cover crop biomass was measured (Table 7). The average moisture at harvest was 81.2%. Dry matter yield averaged 3460 lbs per acre (1.73 tons) across reps. The average nitrogen content of the tillage radish at this growth stage was 9.65%.

**Table 7. Interseeded tillage radish, above and below ground biomass harvested 14-Nov, Alburgh, VT.**

| | Moisture | DM Yield | Nitrogen |
|---|---|---|---|
| | % | lbs ac$^{-1}$ | % |
| Tillage radish | 81.2 | 3460 | 9.65 |

# DISCUSSION

In this trial, interseeding crops between rows of corn (at V6 stage) was an effective strategy for establishing a timely cover crop. There was ample soil moisture at the time of planting and the seed was lightly incorporated likely leading to cover crop establishment. Corn silage yields were not measured but appeared average, unaffected by interseeded crops. Seeding rates may need adjustment; the red clover seeded at 10 lbs per acre failed to produce a sufficient crop for sampling or providing cover into the winter. Annual ryegrass and radish, seeded at 25 and 18 lbs per acre, respectively, yielded an average of 539 lbs of dry matter per acre, when harvested on 6-Nov. Annual ryegrass was 26.1 cm tall in early Nov, and radish plant height averaged 22.2 cm. Radish plots harvested just over one week later (14-Nov) averaged 3460 lbs of dry matter per acre. This included both above and below ground biomass.

Soil analysis varied slightly by cover crop treatment, with slight differences in potassium and sulfur. Brassica crops are heavy feeders of sulfur and hence would more likely reduce soil sulfur contents compared to other crops. Cover crops also scavenged soil potassium. This could be especially important to farms growing crops on lighter-textured soils where soil potassium leaches readily. In addition, there were higher nitrate levels in the control treatment than in soils taken from both cover crop treatments. This indicates that the production of cover crops also scavenges extra $NO_3$ in soils. Nitrogen uptake in radish plants led to 9.65% N in plant tissue when harvested on 14-Nov. Decomposition of the cover crops and subsequent nutrient release to the following crop will be monitored in 2015.

Tools like the Penn State Cover Crop Interseeder and Applicator may become more common in the Northeast as growers work to implement regionally-appropriate cover cropping strategies. With proper timing and agronomic management, this strategy has the potential to improve soil health and water quality without jeopardizing corn silage yields. It is important to remember that these data represent only one year of research, and in only one location. More data should be generated and considered before making agronomic management decisions.

## ACKNOWLEDGEMENTS

UVM Extension would like to thank Roger Rainville at Borderview Research Farm for his generous help implementing and maintaining this research trial, as well as Greg Roth at Penn State for his assistance with the Interseeder and Applicator. We would also like to acknowledge Katie Blair, Ben Leduc, and Laura Madden of the UVM Extension Northwest Crops & Soils Program for their assistance with data collection and entry.


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