



Science  
Societies

# Interseeding cover crops in corn

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*Oilseed radish interseeded into corn. Photo courtesy of Edwin Remsberg and USDA-SARE.*

Seasonal constraints following corn grain harvest in the upper Midwest often limit cover crop seeding and restrict the species that can establish and produce biomass prior to the winter months. Interseeding cover crops in corn fields in the early vegetative stages of corn is an additional option to establish a cover crop. This article, based on research originally reported in *Agronomy Journal* (see <https://doi.org/10.1002/agj2.20046>), reports on the results of field experiments in Michigan that evaluated interseeding a number of cover crop species at various corn growth stages.

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Seasonal constraints following corn grain harvest in the upper Midwest often limit cover crop seeding and restrict the species that can establish and produce biomass prior to the winter months. Interseeding cover crops in corn fields in the early vegetative stages of corn is an additional option to establish a cover crop. There is limited information available on which cover crop species are successful when interseeded and at what corn growth stages cover crops can be interseeded without reducing corn yield. Establishment of drill-interseeded cover crops has been successful in



*Fall cover crop biomass from 2015 when rainfall was sufficient for establishment of oilseed radish (left) and annual ryegrass (right).*

Pennsylvania and other states in the northeastern U.S.; however, broadcast interseeding is more efficient and of interest to farmers to expedite field operations.

Field experiments were conducted at the Michigan State University Agronomy Farm (MSUAF) in East Lansing, MI in 2015–2016, 2016–2017, and 2017–2018 and at the Saginaw Valley Research and Extension Center (SVREC) in Richville, MI in 2017–2018. Soils at MSUAF were sandy loams and loams with 2.8–2.9% organic matter, and the soil at SVREC was a loam with 3% organic matter. Fields were chisel-plowed and soil finished prior to corn planting. Nitrogen (160 lb/ac) was applied prior to and at planting at each location, and P and K were applied as needed according to soil tests. Corn was planted in late April or early May each year in 30-inch rows at a population of 32,000 seeds/ac.

Cover crop species evaluated included annual ryegrass, oilseed radish (tillage radish), and crimson clover coated with NitroCoat seed coating seeded at 15, 8, and 15 lb/ac, respectively. A cover crop mixture was also evaluated that included annual ryegrass, oilseed radish, and crimson clover at 10, 2, and 2 lb/ac respectively (commercially available as “PeakBlend Indy,” Center Seeds, Sidney, OH). Broadcast interseeding timings evaluated included the V1, V2, V3, V4, V5, V6, and V7 growth stages (Table 1). There were no glyphosate-resistant weed species at any field site, and glyphosate was applied prior to each interseeding timing to control emerged weeds prior to cover crop seeding.

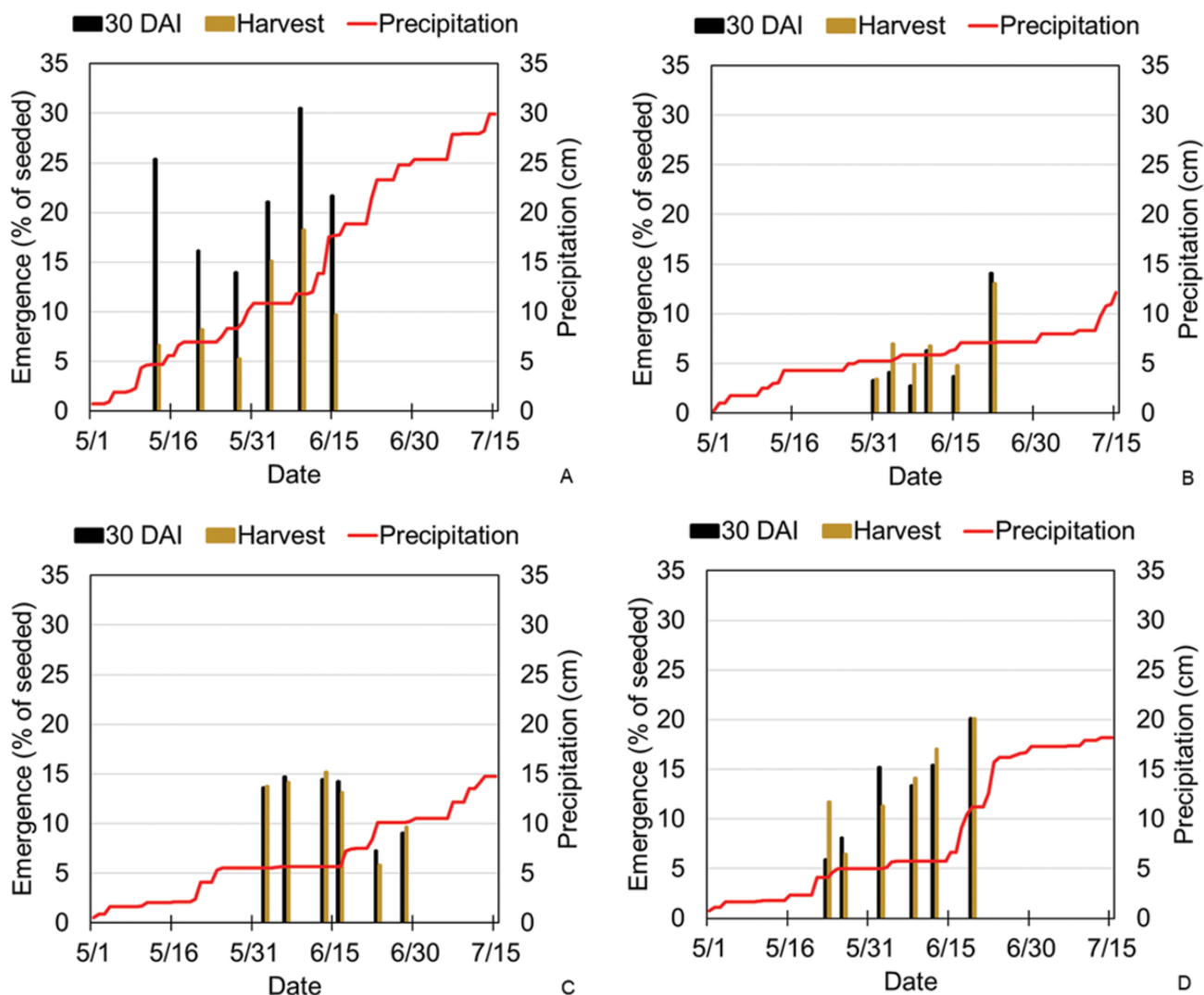
**Table 1.** Cover crop interseeding dates and corn harvest dates for MSUAF 2015, 2016, and 2017, and SVREC 2017<sup>a</sup>

<sup>a</sup> MSUAF, Michigan State University Agronomy Farm, East Lansing, MI; SVREC, Saginaw Valley Research and Extension Center, Richville, MI.

| Interseeding timing | Seeding date |            |            |            |
|---------------------|--------------|------------|------------|------------|
|                     | MSUAF 2015   | MSUAF 2016 | MSUAF 2017 | SVREC 2017 |
| V1                  | May 13       | –          | –          | –          |
| V2                  | May 21       | May 31     | June 2     | May 23     |
| V3                  | May 28       | June 3     | June 6     | May 26     |
| V4                  | June 3       | June 7     | June 13    | June 2     |
| V5                  | June 8       | June 10    | June 16    | June 8     |
| V6                  | June 15      | June 15    | June 23    | June 12    |
| V7                  | –            | June 22    | June 28    | June 19    |
| <b>Corn harvest</b> | Oct. 18      | Oct. 24    | Oct. 13    | Oct. 12    |

Cover crop and weed emergence was evaluated 30 days after each broadcast interseeding (Figure 1). At least four times throughout the growing season, light penetrating the corn canopy was measured to determine the amount of light reaching the cover crops. Precipitation data for each field site was obtained from the Michigan Enviroweather Network from weather stations located at MSUAF and SVREC. Final density of cover crops and weeds was measured in early October just prior to corn harvest. The aboveground biomass of cover crops and weeds was harvested, dried, and weighed (Table 2). Corn grain was harvested using a plot combine and weighed; yields reported are adjusted to 15% moisture counted. In April of the following spring, over-wintering cover crop and winter annual weed density were evaluated.





**Figure 1,** Cover crop emergence as a percent of the seeding rate measured 30 days after interseeding (DAI) (black bars) and just prior to corn harvest in the fall (gold bars). Each pair of bars indicates the date of interseeding from V1–V6 for the Michigan State University Agronomy Farm (MSUAF) 2015 (A) and from V2–V7 for MSUAF 2016 (B), MSUAF 2017 (C), and the Saginaw Valley Research and Extension Center (SVREC) 2017 (D). Cumulative precipitation from May 1 to July 15 during the interseeding period is indicated by the red line.

**Table 2.** Cover crop and weed biomass measured in the fall of interseeding and the spring following interseeding for the main effects of cover crop species and interseeding timing

| Cover crop treatment | Fall       |      | Spring     |      |
|----------------------|------------|------|------------|------|
|                      | Cover crop | Weed | Cover crop | Weed |

|                   | biomass, lb/ac     |        |        |          |
|-------------------|--------------------|--------|--------|----------|
| Annual ryegrass   | 166 a <sup>a</sup> | 222 a  | 342 a  | 123 c    |
| Crimson clover    | 100 b              | 203 a  | 7 c    | 340 a    |
| Oilseed radish    | 131 ab             | 219 a  | 0 c    | 267 ab   |
| Mixture           | 138 ab             | 187 a  | 161 b  | 192 bc   |
| ±SEM <sup>b</sup> | (± 21)             | (± 57) | (± 36) | (± 1127) |
| P-value           | .0337              | .8633  | <.0001 | <.0001   |

\* Values with an asterisk are significantly different at  $\alpha = .05$  according to Fisher's LSD.<sup>a</sup>

Within columns, means with the same letter are not significantly different at  $\alpha = .05$

according to Fisher's LSD.<sup>b</sup> Standard error of mean for LSD comparisons.<sup>c</sup> Analyzed

separately and compared with each cover crop by interseeding timing combination.

| Interseeding timing    | biomass, lb/ac     |        |        |         |
|------------------------|--------------------|--------|--------|---------|
| V2                     | 198 a <sup>‡</sup> | 443 a  | 127 a  | 200 a   |
| V3                     | 163 ab             | 255 b  | 214 a  | 200 a   |
| V4                     | 123 bc             | 194 bc | 151 a  | 270 a   |
| V5                     | 155 ab             | 136 c  | 170 a  | 253 a   |
| V6                     | 78 c               | 98 c   | 168 a  | 273 a   |
| V7                     | 87 c               | 120 c  | 193 a  | 184 a   |
| ±SEM <sup>§</sup>      | (± 24)             | (± 62) | (± 38) | (± 128) |
| P-value                | <.0001             | <.0001 | .2362  | .3038   |
| Weedy <sup>c</sup>     | –                  | 1346*  | –      | 165     |
| Weed-free <sup>c</sup> | –                  | 111    | –      | 251     |

## Cover Crop Density and Biomass

Rainfall before and after cover crop interseeding differed at each field site. Cumulative rainfall from May 1 to July 15 totaled 12, 5, 6, and 7 inches for MSUAF in 2015, 2016, and 2017 and SVREC in 2017, respectively. Differences in rainfall impacted cover crop emergence and biomass production. There were no major differences in the amount of light penetrating the corn canopy at each field site.

Due to the greater number of seeds per pound, annual ryegrass density was always higher compared with oilseed radish and crimson clover. In October, final stands of annual ryegrass averaged 11 plants/ft<sup>2</sup> while crimson clover and oilseed radish averaged 3 and 1 plants/ft<sup>2</sup>, respectively. Annual ryegrass and oilseed radish densities were 12% of the number of seeds interseeded, whereas crimson clover density was 7% of the seeds interseeded, averaged across field sites. Cover crop density was highest at the V5, V6, and V7 interseeding timings when measured 30 days after interseeding. At harvest, V7 had the highest cover crop density averaged over species and field sites. The cover crop mixture was dominated by annual ryegrass with almost no emergence of crimson clover and oilseed radish.

Rainfall following interseeding often improved cover crop establishment. Both rainfall following interseeding and cover crop density were highest for 2015 and lowest for 2016, indicating that frequent rainfall following broadcast interseeding is important for cover crop establishment and survival. Additionally, previous research has shown that annual ryegrass may be more tolerant of dry conditions following interseeding compared with other species, and crimson clover is particularly vulnerable to dry conditions.

Annual ryegrass produced 166 lb/ac of fall biomass, which was statistically greater than crimson clover, which produced only 100 lb/ac when measured in early October prior to corn grain harvest. Oilseed radish and the mixture produced 131 and 138 lb/ac

of biomass, respectively. By the following spring, annual ryegrass biomass more than doubled to 342 lb/ac, and the mixture increased slightly to 161 lb/ac due to the annual ryegrass content. Crimson clover rarely overwintered, and oilseed radish does not overwinter in Michigan and other upper Midwest climates. Crimson clover that emerged was generally unhealthy in appearance and often flowered in late summer and early fall; both of these factors may have contributed to its poor winter survival.

Fall biomass production averaged over species was generally greater for early interseeding timings. This was likely caused by the increased amount of time for growth prior to corn canopy closure compared with later interseedings. This suggests that increased biomass production per plant outweighs reduced emergence or survivability early in the season. In the spring, there were no differences in biomass production (mostly annual ryegrass) among interseeding timings. This means that annual ryegrass was able to compensate for differences in fall density and biomass at corn harvest and build biomass in the later fall and early spring.

### **Weed Density and Biomass**

Fall weed biomass was highest when cover crops were interseeded early compared with later interseeding timings. In fact, the V1 interseeding timing was only tested in 2015 because weed biomass was so high in that treatment. There was no difference in weed biomass when cover crops were seeded at the V4 growth stage or later. This is simply because many weeds emerged after a glyphosate application and cover crop seeding at V1, and to a lesser extent, at V2. By the V4 seeding, few weeds emerged at any of the field sites after this time. Overall, there was no indication that interseeded cover crops suppressed summer annual weeds, regardless of the cover crop species.

### **Corn Grain Yield**



Previous research in the northeastern United States and the upper Midwest have shown that cover crops seeded at or after the V4 growth stage in corn do not reduce corn grain yield; however, there was limited information about seeding prior to these stages. Our research showed that yield loss could occur if interseeding at V1 because high densities of weeds emerge after V1 that cannot be controlled with a postemergence herbicide because of cover crop interseeding. We included weedy control plots in this research, and corn grain yield was also reduced in these plots. Corn grain yield was not reduced at any field site when cover crops were interseeded at V2 or later, indicating that cover crops at the densities in our research did not compete with corn in the same way that summer annual weeds do.

## **Conclusions**

Annual ryegrass and crimson clover established when broadcast-interseeded from the V2–V7 corn stages; however, crimson clover emergence was much lower comparatively. Interseeded cover crops are at risk of attrition due to lack of light and rain reaching the soil surface, and this is especially problematic in broadcast-interseeding situations. Farmers can increase interseeded cover crop biomass production by seeding at V2–V4 compared with V6–V7 interseeding, but weed management options need to be considered for this practice to prevent corn yield loss and stop weed seed production. Applying a preemergence herbicide that does not inhibit emergence of a cover crop seeded at V4–V7 may be an important management option to control weeds and prevent the development of glyphosate-resistant weeds (Brooker et al., 2019). Cover crop biomass was measured in early October just prior to corn grain harvest. Cover crop biomass continued to accumulate until late November each year when a killing frost stopped radish and clover growth. By spring, there was no advantage to early seeding with annual ryegrass, so for

overwintering species, the timing of interseeding may not be as important to maximize the ecosystem services that cover crops provide.

These experiments help to fill some of the research gaps for interseeding cover crops in corn; however, there is much more information to be learned. For example, other species within each functional group of cover crops (grass, legume, and brassicas) may perform very differently in interseeded situations compared with the species we used. Our seeding rates were based on discussions with farmers and consultants and recommendations from the Midwest Cover Crop Council and SARE websites. Furthermore, much more information is needed on the performance of cover crop mixtures when broadcast and drill-interseeded in corn.

For more information on residual herbicide use, see Brooker, A.P., Sprague, C.L., & Renner, K.A. (2019). Interseeded annual ryegrass, oilseed radish, and crimson clover tolerance to residual herbicides commonly used in corn. *Weed Technology*, 34, 35–41.

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