Assessing Nitrogen Credits from Clover Cover Crops and Effects of Seed Inoculation

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Introduction

A wide array of information is available on cover crop selection, planting date, and potential advantages, but very little data is available on cover crop performance under Iowa growing conditions. In order to expand cover crop options for Iowa growers, more precise and region-specific information is needed.

Legume cover crops such as clovers are planted as winter annuals (6-8 weeks before a killing frost) or as summer annuals (in the spring). In colder climates such as Iowa, summer-annual use of legume cover crops is common as it is a useful tool in crop rotation planning. Sustainable and organic growers strictly follow crop rotation principles, as it is one of the most effective tools to manage soil-borne diseases and pests and maintain soil fertility. Legume cover crops form symbiotic relationships with soil bacterium (*Rhizobium sp.*) and fix atmospheric nitrogen adding significant amounts of nitrogen to the soil. However, legumes vary widely in the amount of nitrogen supplied. For example, the amount of nitrogen added to the soil by berseem clover, crimson clover, red clover, and yellow sweetclover can range from 50 to 180 lb nitrogen/acre. Moreover, the amount of nitrogen a cover crop can add depends on biomass generated, which in turn depends on temperature, rainfall, and soil fertility status. Also, legume cover crops need specific strains of *Rhizobium* to effectively fix atmospheric nitrogen. In order to generate Iowa specific N-credit data, this study investigated three legume cover crops (crimson clover, red clover, and yellow sweetclover) and evaluated them for the amount of nitrogen they can contribute under inoculated and non-inoculated conditions at the Horticulture Research Station, Ames, Iowa.

Materials and Methods

Cover crops were seeded (broadcasted) on June 25, 2014, and raked in to ensure good seed-to-soil contact. Each treatment plot was 30 ft by 20 ft. Soil type was Clarion loam, moderately eroded, with 5 to 9 percent slope. Experimental design was a split plot randomized complete block design with four replications. The whole plot factor was cover crop and sub plot factor was inoculation (cover crop seeds either inoculated or not inoculated with clover specific *Rhizobium* inoculant). Cover crop biomass was collected on September 30, 2014, using a 50 cm by 50 cm quadrat for each subplot. Biomass was dried in an oven at 60°C for seven days. Later, the dried biomass was ground in a Wiley Mill® and sent for tissue analysis to determine percentage C and N concentrations.

Results and Discussion

Seeding of cover crops was delayed due to a wet spring. Saturated soil conditions hindered plot preparation activity. Cover crop establishment was slow but steady. Because we did not use a pre-emergent herbicide, weed pressure was high. Weeds such as redroot pigweed and common lambsquarters were opportunistic and capitalized on the slow establishment of cover crops. Plots were hand weeded in early August. Visual evaluation of the plots revealed fewer weeds in the crimson clover plot than other two cover crops. At the end of the season, there were significant differences in cover crop biomass (dry weight basis). There were significant differences between inoculation treatments as well. There was no interaction between clover specie and inoculation treatment. The highest amount of biomass was produced by red clover and crimson clover, however they were not statistically different among themselves (Table 1). Yellow sweetclover produced the lowest amount of biomass of 2,797 lb/acre. Inoculation of seeds with the *Rhizobium* significantly increased biomass. Inoculated seeds produced almost 1½ times more biomass than the non-inoculated seeds. Figure 1 shows the effect of inoculation on yellow sweetclover biomass. Inoculated seeds also produced plants with larger root masses than the non-inoculated seeds (visual evaluation).

Percentage nitrogen on a whole plant basis was significant for clover species and inoculation treatments. Red clover had higher percentage nitrogen than crimson clover or yellow sweetclover (Table 1). Nitrogen percentage in plants was not significantly different between inoculation treatments. Similarly, C:N ratio of plants was not affected by the inoculation process, however, C:N ratio varied between clover species. Highest C:N ratio was recorded for crimson clover followed by yellow sweetclover and red clover. This metric is important as it affects nitrogen dynamics in soil. Higher C:N ratio cover crops such as grasses could lead to N tie-up in the soil, making it difficult for the successive crop to utilize that N. The C:N ratio in our study ranged from 15:1 to 22:1, which is typical for clover cover crops.

Multiplying biomass generated by N content in the plant provides an estimate of how much N will be added/recycled back into the soil. Nitrogen contribution of red clover was the highest followed by crimson clover and yellow clover (Table 1). Crimson clover has the potential to contribute close to 100 lb/acre of N. Seed inoculation increased the amount of N contributed by cover crops. Amount of N contributed to the soil by the cover crop is dependent on cover crop biomass, amount of N fixed from the atmosphere, and N taken up by the plant from the soil. Because the percentage of N within plants did not differ based on inoculation, but yet there was increase in the amount of N contributed, it suggests beneficial effects of inoculation on ability of plants to assimilate nutrients and enhance plant growth.

Research-based information is pivotal in facilitating enhanced understanding and utilization of cover crops by vegetable growers. Results from the study show differences in cover crop biomass between clover species tested under Iowa growing conditions. Differences in plant biomass were observed if the seeds were inoculated. Seed inoculation of legume cover crops is not practiced often given the high organic matter soils in most parts of Iowa. However, results from this study indicate significant improvement in biomass and N contribution by clover cover crops if seeds are inoculated with appropriate *Rhizobium* strains.

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Table 1. Cover crop biomass, percentage N, C:N ratio and N contribution of clover cover crops as affected by cover crop species and seed inoculation.

Treatment	Cover crop biomass* (lb/A)	N %	C:N ratio	N contribution (lb/A)
Cover crop				
Crimson clover	4,096 A	1.74 B	22 A	72 B
Red clover	4,985 A	2.18 A	15 C	104 A
Yellow sweetclover	2,797 A	2.00 B	18 B	57 B
Inoculation				
Inoculated	4,751 a	2.02 NS	18.5 NS	93 a
Non-inoculated	3,167 b	1.93	18.1	62 b

*Mean separation within columns for cover crop (uppercase) and inoculation (lowercase); means followed by same letter(s) are not significantly different ($P \leq 0.05$).
NSNon-significant at $P \leq 0.05$.

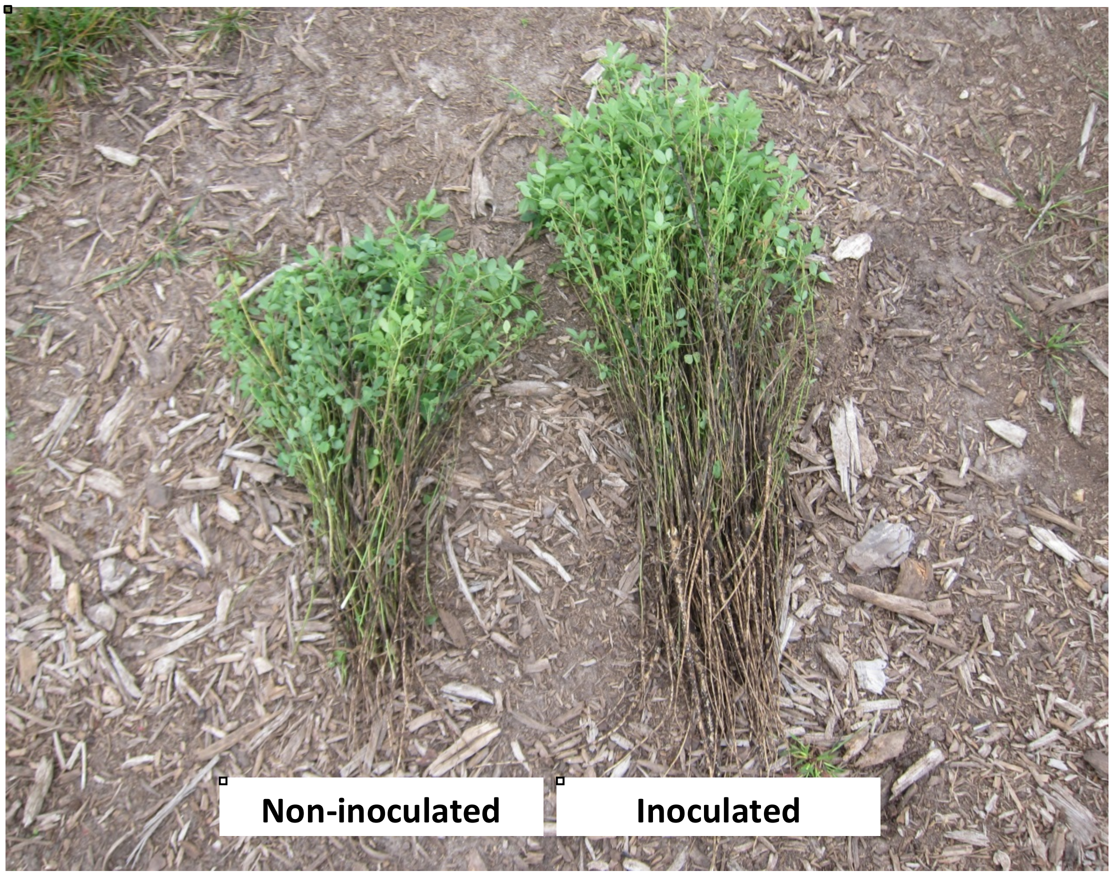

Figure 1. Effect of seed inoculation on sweetclover biomass. Seeds were inoculated with *Rhizobium* an hour before seeding.