PERENNIAL COVER CROP MANAGEMENT IN PROCESSING SNAP BEAN

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Cover crops play a vital role in the management of processing vegetables in the Central Sands region of Wisconsin. The use of cover crops to reduce soil losses due to wind erosion has become a common practice following the harvest of a given cash crop by producers in the region. The management of these cover crops focuses on erosion control and limits development of the crop beyond vegetative stages through tillage or herbicide control. Currently cereal rye is the most common species used in vegetable production fields as a cover crop. Cereal rye is advantageous for erosion control due to its rapid establishment and the ability to grow at cooler temperatures in fall following harvest.

The current vegetable cropping system inherently demands high fertilizer inputs, especially nitrogen. Due to economic instability in the U.S. and worldwide, the cost of chemical nitrogen products has fluctuated drastically and the potential remains for future price volatility. Exploring alternative cropping systems as a means for providing nitrogen as well as improving the sustainability of the vegetable system without limiting yield or quality of harvested crops is an area where rapid development of research is needed.

Perennial legume forage crops grown in crop rotations are common in non-vegetable systems where these crops are commonly grown in monoculture. There are several characteristics of perennial legumes, however, that limits their implementation into current vegetable crop systems as a cover crop.

1) Perennial legume crops are slow to establish.
2) Establishment of perennial legume crops is costly.
3) Perennial legume cover crops will compete with the vegetable crop for water and nutrients.
4) To utilize the full benefits of a perennial legume cover crop the land must remain in monoculture for an entire cropping season.
5) Certain species of perennial legume crops may serve as alternate hosts for vegetable crop pathogens.

These negative aspects can be minimized or even eliminated through proper management of the 'perennial cover crop' within the vegetable crop systems. By solving these issues the benefits of incorporating a perennial legume cover crop into a vegetable crop system may outweigh the drawbacks.

Two different trials were initiated at the Hancock Agricultural Research Station to address management questions related to the inclusion of perennial species in a vegetable system. The first examines different species of perennial cover crops that were established in the first season under snap bean and maintained through a following season of sweet corn production. The second experiment takes a representative legume (red clover) and determines the proper stage of snap bean growth to inter-seed the cover crop. The effects of commonly used pre-plant herbicides on the establishment of the legume cover crop were also evaluated. Hopefully this research will spur interest in the implementation of perennial cover crops into the existing vegetable crop rotation due to the potential reduction in nitrogen fertilizer inputs, and progression toward a more sustainable and profitable cropping system.

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I. Evaluation of perennial cover crop species in a vegetable crop rotation

Many previous studies have focused on either annual species of cover crop or perennial cover crops as a distinct monoculture within a crop rotation. Cover crop research has primarily focused on the potential benefits of various species in their uses as green manures, bio-fumigants, companion crops, soil compaction reducers, weed suppressors and as contributors to general soil quality. Albrecht, Zemenchek, and Affeldt have evaluated the use of kura clover in annual corn roations. Limited information is available on the implementation of perennial cover crops into an intensively managed vegetable rotation, let alone the use of perennial species grown simultaneously with vegetables. A study was conducted from 2005-2007 that compared several perennial cover crop species, and their persistence and influence on a two year system of snap bean followed by sweet corn. Five different perennial cover crop species and a no cover crop check were seeded at the time of snap bean planting and established as the snap beans matured. Harvest of the snap beans was conducted and the cover crops were maintained following the harvest and through the succeeding winter. The following spring, cover crops were sprayed with a 0.5 lb ae/A glyphosate to limit biomass production and lightly tilled to prepare the field for planting. Sweet corn was planted and the cover crops were allowed to persist under the developing corn. Harvest of the sweet corn was conducted and the cover crops were maintained into the following spring when they were plowed down as a green manure crop.

Results indicated that all five species of cover crop contained similar amounts of nitrogen in their plant material, while hairy vetch and red clover produced the highest amounts of total biomass in the fall of 2005 (Table 1). Hairy vetch also provided the lowest carbon:nitrogen (C:N) ratio. The C:N ratio is a critical component when considering cover crops as a green manure. A higher C:N ratio (greater than 24:1) in plant residues could delay mineralization of the nitrogen from the plant material after incorporation into the soil. High C:N ratios are typical in grasses and cereal crops and can range between 25:1 and 50:1 depending on the species and maturity of the crop. Low C:N ratios are common in legume crops, which are characteristically lush in growth and allocate much of their nitrogen into protein rich leaves and stems ranging from 10:1 to 25:1 depending on species and maturity. The nitrogen contribution by the cover crop species to the snap bean was assumed to be very minimal given the relatively short period of snap bean growth coupled with a longer establishment time for the cover crops.

A problem developed with the simultaneous development of the snap bean and the under-seeded cover crops, as witnessed in the yield numbers from 2005 and 2006 (Table 2). The rate of cover crop development exceeded that of the snap bean resulting in competition between the two crops for nutrients, water, and light. This was believed to be caused by the inability of the snap beans to create a closed canopy between the rows, coupled with the fast development of the perennial cover crop grown under ideal water and nutrient conditions. Yield losses by the snap beans, as well as contamination of cover crop residue in the harvested pods were substantial in all cases. Following the snap bean harvest the cover crops were allowed to persist without the additional irrigation or fertilization. A rye cover crop was planted into the no cover crop check treatments following the snap bean harvest to mimic current management practices. This step is critical for the production of biomass by the cover crop in preparation for winter, as well as a means to reduce inputs by eliminating any post-harvest tillage costs, or irrigation to supplement the cover crop.

Table 1. Total biomass, biomass % nitrogen and carbon nitrogen ratio for perennial cover crop species harvested in the fall of 2005 and spring of 2006 prior to sweet corn planting at Hancock, WI.

2005 Fall Biomass

Cover Crop	Biomass (Tons/A)		% N		C:N Ratio	
Hairy vetch	1.59	a	4.01	a	10.76	c
Alfalfa	0.92	c	3.67	b	11.55	b
Red Clover	1.26	b	3.68	b	11.81	ab
Sweet/Yellow Clover	0.94	c	3.63	b	11.77	ab
Alsike Clover	0.84	c	3.54	b	12.19	a

2006 Fall Biomass

Cover Crop	Biomass (Tons/A)	% N		C:N Ratio	
Hairy vetch	0.65	4.72	a	9.26	b
Alfalfa	0.27	4.13	bc	10.54	ab
Red Clover	0.55	3.95	c	11.06	a
Sweet/Yellow Clover	0.31	4.31	b	9.89	ab
Alsike Clover	0.45	4.19	bc	10.41	ab

Statistical difference in values denoted by different letters

Biomass production by the perennial cover crop was again measured the following spring, with alfalfa, sweet clover, and red clover providing the highest amounts of biomass (data not shown). The total nitrogen in the biomass and C:N ratios were similar to the previous measurements. Glyphosate was applied at 0.5 ae/A to the cover crops, followed by disking 7 to 10 d later to prepare the field for planting. Following sweet corn planting a pre-emergence application of Bicep Lite (atrazine + metolachlor) was applied. This addressed early season weed control and provided a second means of reducing cover crop growth during the early stages of sweet corn development.

Harvest data from the 2006 sweet corn indicated that perennial cover crops provided substantial amounts of nitrogen to the developing sweet corn crop (Table 2). The number of ears per acre in the unfertilized treatments did not differ from the ear numbers seen in the full rate treatments where cover crops were grown in 2006. This indicates that nitrogen was not a limiting factor to the sweet corn where cover crops were present during the period of ear initiation. In 2007, the unfertilized treatments did not yield a similar number of ears as fertilized treatments, but still produced more than the 0 N/A check with no cover crop. Yield of sweet corn in 2006 showed that in the presence of sweet clover, red clover, and alsike clover, sweet corn could yield 7-8 tons/A without the addition of nitrogen fertilizer. Alfalfa and hairy vetch were also able to yield well, with each producing over 6 tons/A. In 2007 yields in unfertilized cover crop treatments were less than those seen in the full fertilization treatment, but were still significantly superior to the unfertilized check. Yield numbers were suppressed in 2007 due to an early frost in September that cut short the anticipated growing season by nearly 10 days.

Table 2. Influence of perennial cover crop species, and nitrogen rate on ear number and yield of sweet corn at Hancock, WI.

2006 Sweet Corn

	Ears				Yield			
N Rate	0 N		150 N		0 N		150 N	
Cover Crop	(1000's / A)				(Tons / A)			
No Cover	15.2	b	27.0	a	1.82	f	8.36	ab
Hairy Vetch	26.1	ab	27.3	a	6.88	de	8.89	a
Alfalfa	27.4	a	28.5	a	6.46	e	8.09	abc
Red Clover	23.9	ab	28.1	a	7.32	bcde	8.82	ab
Sweet Clover	28.6	a	28.2	a	8.09	abc	8.58	ab
Alsike Clover	27.0	a	25.3	b	7.15	cde	7.86	b

2007 Sweet Corn

	Ears				Yield			
N Rate	0 N		150 N		0 N		150 N	
Cover Crop	(1000's / A)				(Tons / A)			
No Cover	11.0	c	24.8	a	1.12	e	5.79	ab
Hairy Vetch	15.7	b	25.8	a	1.62	de	5.26	b
Alfalfa	17.9	b	24.5	a	2.13	c	6.10	a
Red Clover	19.4	b	25.0	a	2.72	c	6.49	a
Sweet Clover	15.6	b	27.4	a	1.86	cd	6.01	a
Alsike Clover	18.2	b	23.6	a	3.00	c	5.84	ab

Statistical difference in values denoted by different letters

Further measurements taken during the course of this study are currently being analyzed, specifically how much nitrogen was available for plant uptake in the soil and how the nitrogen pool changed through the growing season.

The yield results of this study indicate that perennial legume cover crops can provide a substantial amount of the 150 lb of nitrogen currently recommended by the Univ. of Wisconsin to attain >7 tons/acre sweet corn yield. Several management issues that bear further research include: determining the proper timing and methods for establishment of perennial cover crops to limit their interference with snap bean yield and quality, establishing a herbicide program that will control weeds during the snap bean and sweet corn phases and limit destruction of the perennial cover crop, and finally the economic gains or losses by switching to this type of cropping system.

II. Establishment of a perennial cover crop (red clover) under snap bean

The previous study demonstrated that perennial legumes were a viable alternative to the current cover crop system by providing ample nitrogen credits to a second year crop of sweet corn when established under snap beans in the preceding season. A cost of this process was reduced yield and quality of the snap bean crop due to competition from the developing cover crops when planted in tandem with the snap beans. A research project was initiated in 2007 to evaluate if modifying the time of cover crop planting would limit its interference with the snap bean crop. By establishing the cover crop at a time later than snap bean planting, the competition with snap bean may be limited so yield and quality remain unaffected by the cover crop presence.

Red clover was chosen as a model legume species based on its success in the previous perennial cover crop study. This project will also compare the common pre-plant herbicide formulations used in snap bean production and determine their influence on the cover crop establishment and growth.

The study delineated five different stages of snap bean development including: at planting, unifoliate leaf stage, third trifoliate leaf stage, bud stage, and post-harvest, that would function as clover planting periods. Each clover planting date presented a new challenge for seeding due to the accessibility of tillage implements or planters. The first clover planting followed the pre-plant herbicide soil incorporation, but before the snap bean planting, and was conducted using a Brillion model seeder. The second and third plantings of clover, conducted at unifoliate and third trifoliate stages were air seeded over the top of the developing snap beans and followed with a row cultivator. The fourth clover planting was conducted at snap bean bud stage. Due to an inability to till the snap beans due to concerns of pod drop or crop damage and yield loss, the clover was air seeded over the top of the snap beans and immediately followed with an irrigation application. The final clover planting followed harvest and was again conducted with a Brillion model seeder. The three herbicide regimes were pre-plant soil incorporated and included Dual (1.0 pt/A) + Sandea (0.5 oz/A), Eptam 7E (3 lb/A) + Treflan (1 pt/A), and Eptam 7E (3 lb/A).

Snap bean yield was lowest when clover was planted at snap bean planting in 2007, but no response was evident in 2008 (Table 3). The highest snap bean yields were seen at the unifoliate and third trifoliate establishment dates for clover. Determining the influence of the herbicides on clover establishment and its subsequent limitations on snap bean yield will need to take into effect residue levels in the harvested beans, yield differences, and the impact of each herbicide on snap bean stand density. No distinct differences were observed in the sieve size grades across the clover planting dates. The Eptam + Treflan and the single Eptam treatments had the lowest percentage of beans grading out at a sieve size of 3 or less, while Dual + Sandea had the highest percentage. The mechanism for this response is not known at this time, but may be due to a slight delay in snap bean maturity.

The total aboveground biomass of clover was collected at the end of the growing season in 2007 and again prior to sweet corn planting in the spring of 2008 and is reported as dry weight in tons/acre (Table 4). The highest levels of clover biomass were accumulated in the first two clover plantings, at planting and unifoliate leaf stage, except in first clover planting under Dual+Sandea treatments which were lower due to herbicide damage on the cover crop. Clover planted at bud stage provided the least biomass, primarily due to the relatively short time span between clover planting and snap bean harvest. Clover germination was relatively poor in these treatments due to reduced seed-soil contact. This probably resulted from the lack of soil incorporation provided to the clover seeds at this planting date. Clover populations were also recorded prior to snap bean harvest and these numbers are synchronous with the biomass results (data not shown). The most interesting trend in the clover population numbers is that the breakdown of the Dual+Sandea mixture is reflected in the increased population of clover as the time from herbicide application and clover planting lengthened. Biomass was measured again the following spring, prior to planting of sweet corn. Clover planted at the bud stage of snap bean development showed significant improvement relative to other plantings. While total biomass in the spring of 2008 did not vary greatly, populations within the plantings differed with the post harvest plantings having the highest population densities (data not shown).

Table 3. Time of red clover planting based on snap bean stage of development and herbicide regime influence on snap bean sieve size and yield at Hancock, WI, 2007 and 2008.

2007 Beans

Herbicide	Graded Beans Sieve Size						Yield					
	Dual + Sandea		Eptam + Treflan		Eptam		Dual + Sandea		Eptam + Treflan		Eptam	
Planting Date	% ≤ 3						(Tons/A)					
At Planting	29.2	ab	25.9	c	27.8	bc	2.65	e	2.72	de	2.85	d
Unifoliate	27.3	bc	27.3	bc	24.2	cd	3.34	ab	3.26	b	3.29	ab
3rd Trifoliate	27.8	bc	24.8	cd	23.6	d	3.34	ab	3.31	ab	3.47	a
Bud	30.9	a	26.0	c	24.5	cd	3.18	bc	3.47	a	3.29	b
Post-Harvest	29.2	ab	24.9	cd	24.2	cd	3.05	c	3.00	cd	3.43	ab

2008 Beans

Herbicide	Graded Beans Sieve Size						Yield					
	Dual + Sandea		Eptam + Treflan		Eptam		Dual + Sandea		Eptam + Treflan		Eptam	
Planting Date	% ≤ 3						(Tons/A)					
At Planting	32.0	a	27.6	c	31.1	ab	3.71	b	4.11	ab	4.44	a
Unifoliate	30.4	ab	34.1	a	28.2	bc	4.34	a	4.10	ab	4.44	a
3rd Trifoliate	27.6	bc	30.7	ab	33.6	a	4.28	a	4.25	a	4.10	ab
Bud	31.0	ab	30.0	ab	29.8	abc	3.67	b	4.62	a	4.44	a
Post-Harvest	31.3	ab	35.5	a	26.0	c	4.26	a	3.81	b	4.28	a

Statistical difference in values denoted by different letters.

Table 4. Red clover total biomass production at end of season and prior to sweet corn planting as influenced by herbicide regime and planting date based on snap bean stage of development at Hancock, WI, 2007.

Herbicide	Fall Clover Biomass						Spring Clover Biomass					
	Dual + Sandea		Eptam + Treflan		Eptam		Dual + Sandea		Eptam + Treflan		Eptam	
Planting Date	(Tons/A)						(Tons/A)					
At planting	0.22	g	2.43	b	2.69	a	0.89	b	1.40	ab	1.69	ab
Unifoliate	1.03	c	2.71	a	2.70	a	1.27	ab	1.83	a	1.69	a
3rd Trifoliate	0.62	e	0.71	d	0.94	cd	1.52	ab	1.29	ab	1.34	ab
Bud	0.59	f	0.51	f	0.51	f	0.98	ab	1.21	ab	1.03	ab
Post-harvest	0.85	cde	0.84	cde	0.75	def	1.32	ab	1.24	ab	1.32	ab

Statistical difference in values denoted by different letters

The preliminary data in this study indicate that planting clover into snap beans at the unifoliate or third trifoliate stages of development may produce an adequate crop of clover, while limiting the effects of competition and residue contamination that reduce yield and quality in snap beans. Further measurements in this project will account for winter survivability of the clover as well as the effect of different levels of clover population on sweet corn yield.

Further research on perennial cover crops in a vegetable rotation is planned for the future. The research will focus on developing further management recommendations for the implementation of cover crops into a continuous vegetable rotation. We also hope to test and apply these strategies in current vegetable crop systems by developing on-farm research with cooperating growers.