COVER CROP MANAGEMENT IN PROCESSING SNAP BEAN

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Vegetable crop production is the third leading agricultural industry in Wisconsin behind dairy and grain production. The primary region for intensively managed vegetable cropping is located in central Wisconsin, with large production regions located near Spring Green, Janesville, Fond du Lac, Markesan, Manitowoc, and Cumberland also playing a vital role in the industry. The current vegetable cropping system inherently demands high fertilizer inputs, specifically nitrogen. Due to current global instability in oil producing regions, chemical nitrogen prices have risen 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 cropping systems without limiting yield or quality of harvested crops is a rapidly developing area of needed research.

Cover crops in vegetable production have been utilized by producers for years as a means of preventing wind erosion following harvest operations (Hurley et al., 1996). Cereal rye is the most common species used in production fields today. Cereal rye is advantageous for erosion control due to its rapid establishment and ability to grow at cooler temperatures in fall following harvest. The growth duration for fall planted cover crops can range from two months to a week. Cereal rye has been identified as a potential cover crop for its ability to scavenge for residual nitrogen remaining in the soil following cash crop harvest. Bundy and Andraski (1997) showed that despite the presence of a fall planted rye cover crop, 64% of the fertilizer applied to potato and 49% of fertilizer applied to sweet corn was lost from the system. Furthermore, none of the applied fertilizer N in potato was recovered by the rye cover crop and less than 1% of the fertilizer applied to sweet corn was recovered by the rye. Current University of Wisconsin nitrogen fertilizer recommendations are based mainly on soil type and the rates range from 180-230 lb/A for potato, 150 lb/A for sweet corn, and 60 lb/A for snap bean. The potential to reduce or even eliminate some of the fertilizer nitrogen inputs and greatly enhance grower profitability through utilization of cover crops exists. Many of the logistical issues associated with implementing such a system have not been studied or solved by previous research. The lack of information on cover crop management strategies and nitrogen crediting has led to reluctance by producers to adopt these practices.

Addressing key management issues is critical to developing a functional alternative cover cropping practices that can easily be implemented by producers without major modifications to their current cropping strategies. Research was initiated in 2007 to increase sustainability, reduced environmental impacts, and enhanced profitability through the use of alternative cover crops. The primary goal is to improve and capture nitrogen released from a spring planted cover crop. Several key objectives were

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identified to solve problems and issues surrounding cover crop systems. Cover crop species were identified that will provide adequate levels of plant available nitrogen for a subsequent vegetable crop by scavenging and accumulating any residual nitrogen in the soil or by producing nitrogen through atmospheric nitrogen fixation. This involves use of different cover crop species identified in previous research as having benefits such as fertility or disease management. A second objective involves timing the soil incorporation of cover crops based on stage of development, so that the maximum amount of nitrogen is available to a subsequent vegetable. This research will take into account total nitrogen, biomass production and the C:N ratio of the developing cover crops to determine the optimal growth stage for soil incorporation and the timing of nitrogen release from those residues. In addition, this research will identify proper methods for incorporating cover crop residue to maximize nitrogen benefits, while minimizing residue interference with harvest yield and quality. Meeting this objective requires managing cover crop residues through herbicide and tillage operations that would vary the timing and type of plant material incorporated into the soil prior to a vegetable cash crop.

Two trials were initiated at the Hancock Agricultural Research Station to address questions related to alternative cover cropping strategies for vegetable systems. The first examines spring planted cover crops, and the timing of their incorporation based on the stage of plant development and the subsequent yield and quality effects on snap bean production. The second contrasts different cover crop species and various methods of plant residue management and their effects on yield and harvest quality of a subsequent snap bean crop. The initial results in this paper were collected from a preliminary study that focused on different cover crop species and their effects on snap bean yield and quality. Hopefully this research will spur interest in cover crop strategies and provide a viable alternative for vegetable producers looking to reduce fertilizer inputs and strive for a more sustainable and profitable system.

Annual Cover Crop Species Evaluation

Countless studies have focused on the use of multiple cover crops for potential benefits to subsequent crops or benefits to the cropping system. Research has outlined potential cover crop species for their function as green manure, bio-fumigant properties, companion crops, elimination of soil compaction, and contributions to soil quality. A preliminary study was conducted to determine which species would be feasible to implement into a Wisconsin vegetable rotation. The study was conducted at two sites (Hancock and Arlington) and compared cover crop species effects on snap bean yield and grade, as well as the total nitrogen contributed to the soil system by the cover crop. Eight cover crop species were spring seeded and allowed to reach pre-reproductive stages before being incorporated as a green manure. Results indicated that field pea, hairy vetch, oats, and mustard provided not only the highest biomass amounts, but contributed substantial amounts of nitrogen to the soil upon incorporation (Table 1). It is anticipated that much of this nitrogen was unavailable to the subsequent snap bean crop because of leaching, lack of mineralization, or immobilization because no response in yield or quality was noted.

Nitrogen from plant residues may become available to plants at different times based on the species, the amount of soil to residue incorporated, and the environmental factors experienced during decomposition of the plant material. It was determined that field pea, oats, and mustard had high potential as spring planted cover crops due to the high amount of nitrogen measured in above ground plant material. In addition, mustard and oats provide the additional benefits of providing bio-fumigant properties. Hairy vetch was determined to be too much of a risk to the current cropping system due to invasiveness and weed control issues if escapes from the system occurred.

Table 1. Total aboveground biomass and total nitrogen content of aboveground biomass prior to soil incorporation at two locations in 2004.

	Arlington 5/23 - 6/22		Hancock 4/12 - 6/14	
	Biomass	**N**	**Biomass**	**N**
Crop	ton/A	lb/A	ton/A	lb/A
No cover crop	1.00	89.73	0.93	66.12
Field pea	1.17	122.22	2.97	213.66
Hairy vetch	1.23	129.00	1.73	167.72
Oats	1.21	112.90	1.81	83.90
Oilseed rape	1.12	105.16	1.42	66.17
Oriental mustard	1.51	144.16	1.63	82.43
Sorghum x Sudangrass	1.33	105.30	1.11	74.84
Marigold	1.07	90.27	1.21	58.73
LSD (0.05)	0.14	1.03	0.33	2.00

Snap Bean Yield and Quality Responses Following the Incorporation of Different Cover Crop Species at Various Growth Stages

In current vegetable cropping systems, cover crops are utilized for wind erosion control. As such, they are incorporated at vegetative growth stages of 8" in height or less. The highest total nitrogen by weight in a plant occurs at physiological maturity, but the highest nitrogen content by weight occurs during early vegetative stages (Brady and Weil, 1996). The challenge in this project is to determine the optimal developmental stage for soil incorporation of each cover crop species so plant available nitrogen is maximized during growth of a subsequent snap bean crop. This experiment compared oats, field pea, and a 50:50 oat:field pea mixture that were soil incorporated at three different stages of development. Snap bean yield response to 0 and 40 lb/A nitrogen fertilizer application were compared to determine the relative effect of each cover crop on snap bean nutrient uptake for crop productivity.

The 50:50 oat:field pea yielded the highest biomass during the final two sampling dates corresponding to the pre-reproductive and reproductively mature stages of plant development (Table 2). Pea was lowest during the final sample date because garden pea was planted instead of field pea and pods were harvested to mimic double crop system. Snap beans were planted ten days after the date of cover crop incorporation, and snap bean harvest occurred approximately 60 days after planting. Preliminary analysis shows obvious yield differences between 0 N and 40 lb N/A treatments (Table 2). Within the data however, no difference was seen between 0 N treatments with a field pea and 50:50 mixed species cover crop when compared to the 40 lb N/A with no cover crop in two of three harvest dates. The third harvest date experienced much lower yields than the previous two dates. This was due to the combination of high temperatures coupled with a missed irrigation, and an unusually high virus infestation in early August.

Table 2. Dried weight of cover crop biomass and yield of snap bean in 0N and 40 lbs N/A as influenced by cover crop stage of development and planting date.

Date	June 6			June 15			July 5		
	Biomass (Tons/A)	Snap Bean Yield (Tons/A)		Biomass (Tons/A)	Snap Bean Yield (Tons/A)		Biomass (Tons/A)	Snap Bean Yield (Tons/A)	
Cover Crop		0 N	40 N		0 N	40 N		0 N	40 N
Mix	0.37	2.71	3.57	0.97 a	2.81	3.56	2.94 a	1.27	1.44
Oat	0.34	2.59	2.99	0.70 b	2.64	3.62	2.28 b	1.26	1.50
Pea	0.37	2.68	3.02	0.88 a	3.21	4.03	1.03 c*	1.30	1.42
No Cover	N/A	2.20	2.84	N/A	2.56	3.87	N/A	1.28	1.62
		b	a		b	a		b	a

Statistical difference in treatment means denoted by different letters
* Garden pea planted in place of field pea

Residue Management of Different Cover Crop Species Based on Stage of Development and Incorporation Method

Residue management can be a challenge for vegetable producers and processors. Repeated cultural practices to manage cover crop growth in the spring and early summer prior to the main vegetable cash crop can be costly and labor intensive for producers. Heavy residue can limit vegetable producers' ability to use cultural control practices to manage weeds within established vegetable crops later in the cropping season. For vegetable processors, heavy residue in the field can be picked up during mechanical harvest activities and introduce foreign material into the harvest crop that causes difficulties at the processing facilities. The cost to processors can be passed on to producers in the form of harvest dockage, that decreases profit. This experiment was established to determine the effects of different management strategies on oat, field pea, and mustard cover crops. Three soil incorporation methods (green manure, Roundup burndown with conservation tillage, and no-till) at vegetative and mature reproductive stages for the three cover crop species was evaluated prior to snap bean planting. This project will focus on yield and quality of snap bean in response to cover crop, and residue persistence on the soil surface under the developing crop. The project will also assess residue contamination of cover crop residues in the harvested bean crop.

Biomass yield was highest in mustard during the vegetative stage and at reproductive stage samples (Table 3). Reproductive stages provided high amounts of crop residue regardless of cover crop. This residue caused problems with disking operations due to matting and clumping of plant material. Snap bean yields were highest in treatments where cover crops were soil incorporated with conventional tillage following a glyphosate application (Table 4). Yields were lowest in no-till treatments, part of which may be attributed poor seed-soil contact due to the inability of the planter to cut through the residue. Preliminary analysis of harvest data show there was no apparent effect of these high levels of residue found in the harvested beans (data not shown).

Developing an alternative cover crop system will provide many new management challenges for researchers and vegetable crop producers. Diminishing profit margins and pressures to create a more sustainable cropping system may dictate management changes and cover crops could serve as a viable alternative to the current system.

Table 3. Total dried weight of aboveground biomass in cover crop treatments at vegetative and reproductive development stages at Hancock, 2007.

	Cover Crop Development Stage	
	Vegetative	**Reproductive**
Cover Crop	Yield (Tons/A)	
Oat	0.28 b	1.81 b
Mustard	0.47 a	2.24 a
Pea	0.22 c	1.90 b

Statistical difference in treatment means denoted by different letters.

Table 4. Snap bean yield as influenced by stage of cover crop development and method of cover crop residue incorporation at Hancock, 2007.

Yield (Tons/A)	Cover Crop Development Stage					
	Vegetative			**Reproductive**		
Cover Crop	No-Till	Conventional Green	Conventional + Glyphosate	No-Till	Conventional Green	Conventional + Glyphosate
Oat	2.58	2.91	3.45	2.54	3.35	3.33
Mustard	2.65	2.98	3.91	2.14	3.21	3.58
Field Pea	2.06	2.92	3.45	2.40	3.38	3.35
	c	b	a	c	b	a

Statistical difference between treatment means denoted by different letters, significance at p<0.05 level.

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