ORGANIC FARMING RESEARCH FOUNDATION

Project report submitted to the Organic Farming Research Foundation:

Project Title:

Weed Suppression Using Brassicaceae Cover Crops in Organically Grown Peppers

FINAL PROJECT REPORT

Principal investigator:
Jason Norsworthy
Clemson University
277 Poole Agricultural Center
Clemson, SC 29634
864-656-2607
jnorswo@clemson.edu

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Project Summary

Weed management strategies on most organic farms are comprised of multiple ecological approaches that strive to minimize weed emergence and interference. One component of most successful systems is the use of cereal and/or legume cover crops. Recently, research in Australia demonstrated that Brassicaceae (the cabbage plant family) cover crops offer a broader array of pest suppression. Additionally, potato producers in the Pacific Northwest have used Brassicaceae cover crops for pest suppression with success, including weeds. Brassicaceae cover crops are known to produce a range of “natural” pest suppressants, capable of diminishing weed, disease, insect, and nematode occurrence in subsequent crops. Objectives of this research were to a) compare in-field growth characteristics and biomass production of fall-planted Brassicaceae cover crops, b) determine fruit yield of bell pepper planted into mechanically terminated Brassicaceae cover crops, and c) characterize the suppression of an endemic weed population in the field in Brassica amended soil. All evaluated Brassicaceae cover crops were well adapted to Fall seeding in the southeastern U.S. Total biomass produced by the cover crops ranged from a low of 2078 lb/acre for meadowfoam to a high of 4085 lb/acre for brown mustard. Palmer amaranth and large crabgrass, two weeds infesting the test site, were suppressed by the cover crops through 4 weeks after transplanting bell pepper. By 6 weeks after transplanting, there was little or no weed suppression from the cover crops due to their decay in soil. Bell pepper failed to produce marketable fruit in all plots in which weeds were allowed to emerge and interference with the crop. In hand-weeded plots, bell pepper fruit yields were numerically higher than in the absence of a cover crop, indicating the cover crops may have provided some benefit to the bell pepper crop. While use of Brassicaceae cover crops is not a stand alone system for weed management in organically grown vegetables, the early-season weed suppression provided by the cover crop will reduce mechanical or hand-weeding and have no negative affect on crops such as bell pepper.

2) Introduction to Topic

Many farmers consider the difficulty in controlling weeds in organic systems to be a major constraint to broad-scale adoption of organic farming (Bond and Grundy 2001), and hand labor continues to be a necessary and costly component of vegetable production (Mayberry et al. 1995). Thus, many producers are reluctant to make the transition to organic production because of the perception of limited weed management options and difficulties they will face in terms of weed management. These producers still rely heavily on herbicides, even though there are known environmental risks associated with their use. Using ecological approaches to weed management, it is conceivable to develop highly effective non-chemical weed control systems (reviewed in Bond and Grundy 2001), and cover crops are a vital component. While cereal and legume cover crops are the most commonly used cover crops, Brassicaceae cover crops offer a broader array of "natural" pest suppression. Brassicaceae cover crops are highly effective in suppressing weed germination and growth (Norsworthy 2003) along with other pests such as insects (Borek et al. 1998), soil-borne plant pathogens (Mayton et al. 1996), and nematodes (Kirby 1995). Recent research with wild radish, an endemic Brassicaceae, has shown that a ground plant mulch is effective in suppressing many weeds under greenhouse conditions (Norsworthy 2003). Additionally, it has been determined that sweet corn, tomato, and pepper have sufficient tolerance while the cucurbits are sensitive to these residues (Norsworthy, unpublished data). Thus, field-scale evaluation of Brassicaceae cover crops as a weed management aid in tolerant vegetable crops is needed.

3) Objectives Statement

A) Compare in-field growth characteristics and biomass production of fall-planted Brassicaceae cover crops.

B) Determine fruit yield of bell pepper transplanted into mechanically terminated Brassicaceae cover crops.

C) Characterize the suppression of an endemic weed population in the field in soil amended with Brassicaceae residues.

4) Materials and Methods

Field experiments were conducted on the campus of Clemson University to evaluate adaptation of the following cover crops to the Southeast: Indian mustard (Fumus F-E75 and Fumus F-L71), canola, meadowfoam, gardencress, brown mustard, and turnip. The cover crops were drill-seeded in 7-inch width rows on October 24, 2003. Some of the Brassicaceae cover crops were chosen because of previous successes in the Pacific Northwest and Australia, whereas others were chosen based on availability. All plots were fertilized with blood meal and gypsum to ensure adequate growth of the cover crops and bell pepper crop. All plots were flail mowed and immediately roto-tilled on April 24, 2004. Prior to termination, aboveground and belowground cover crop biomass were determined in a randomly selected 10.9-ft^2 quadrat in each plot. Following soil-incorporation of the cover crops, 4-leaf 'Stilleto' bell pepper were transplanted into each plot. The experiment was a randomized complete block consisting of the cover crops and a non-cover crop treatment. One-half of each plot was hand-weeded throughout the experiment while weeds were allowed to infest the remaining half. The weed-free portion of each plot allowed assessment of whether the cover crops had a negative influence on bell pepper while the weedy portion allowed assessment of weed suppression from the cover crops. Cover crop plots were 6 by 35 ft and replicated four times, with the bell pepper plots consisting of 6 plants with a 1-ft spacing between plants for both the hand-weeded and weedy plots.

Weed suppression by species was visually evaluated at 2, 4, and 6 weeks after bell pepper transplanting. Bell pepper injury was also visually determined on the same day along with height of bell pepper in the hand-weeded plots. Bell pepper fruit yields were determined throughout the growing season. Data were subjected to analysis of variance, and means were separated by Fisher's protected LSD test at the 5% level of significance.

5) Project Results

Shoot biomass of all cover crops was 5 to 11 times greater than root biomass at mechanical termination of the cover crops (Table 1). All Brassicaceae cover crops appeared well adapted to Fall seeding in the southeastern U.S. (Table 1). The quantity of biomass produced by the Brassicaceae cover crops was as high as 4085 lb/acre for brown mustard, which was comparable to that produced by rye in other research (Bauer et al. 1999); a common cereal cover crop in the Southeast. Weed suppression 2 to 4 weeks after terminating the cover crop was more effective in cover crop plots compared to the absence of a cover crop (Table 2). Indian mustard (Fumus F-E75) was numerically the most effective cover crop at suppressing large crabgrass at 2 and 4 weeks after transplanting bell pepper. Cover crops were generally less effective at suppressing Palmer amaranth. Unlike for large crabgrass, Fumus F-E75 was not superior to other cover crops in suppressing Palmer amaranth, indicating the effectiveness of each cover crop was weed species specific. Following 4 weeks after transplanting, weed suppression rapidly diminished, with little or no weed suppression observed from any treatment by 6 weeks after transplanting. Less than 5% visual injury was observed at 2, 4, and 6 weeks after transplanting, an indication of bell pepper tolerance to the Brassicaceae cover crops. Furthermore, height of bell pepper plants at 6 weeks after transplanting was comparable to the no cover crop treatment (Table 3). Bell pepper plants in all hand-weeded plots began producing mature fruit 8 weeks after transplanting, with no delay in maturity as a result of any cover crops. No bell pepper fruit was produced in any plot in the absence of hand weeding due to substantial weed interference. In the portion of cover crop plots that were hand-weeded, fruit yields were statistically comparable among cover crops and similar to the hand-weeded, no cover crop treatment, another indication that the cover crops did not negatively affect bell pepper. Average yield of the no cover crop treatment was numerically the lowest among all cover crop treatments, an indication that Brassicaceae cover crops may improve yield of organically grown bell pepper.

6) Conclusions and Discussion

Each of the evaluated Brassicaceae cover crops was well adapted to Fall seeding in the Southeast. The cover crops provided sufficient soil cover throughout the winter months and suppressed Spring emerging weeds, although weed densities in the cover crops prior to mechanical termination were not quantified. Hours of hand weeding were not recorded in this trial; however, the reduction in the need for mechanical weeding or hand weeding are evidenced by the weed suppression that occurred from 2 to 4 weeks after bell pepper transplanting. With a 6-ft spacing between bell pepper rows, it would have also been feasible to mow the row middles, which would have further aided weed management and reduced the time required for hand-weeding.

Bell pepper fruit yields in Brassicaceae cover crops were numerically higher than in the absence of a cover crop. This increase in yield, although not significant, may be partially linked to improvements in soil tilth from the cover crops along with an increase in available soil nutrients following mineralization of the cover crops. Additionally, as observed in other research, Brassicaceae cover crops are known to suppress numerous soil borne pathogens, insects, and nematodes, which could have also contributed to the higher yields in the cover crop compared to the non-cover crop plots.

Table 1. Root, shoot, and total dry biomass produced by various fall-seeded Brassicaceae cover crops on April 24, 2004 at Clemson University.

Brassicaceae cover crop	Root	Shoot	Total
	---------------- lb/acre --------------------		
Indian mustard (Fumus F-E75)	401	3586	3987
Indian mustard (Fumus F-L71)	384	3068	2452
Canola (Humus)	437	2212	2261
Brown mustard (Southern giant)	544	3541	4085
Turnip (Seventop)	169	1936	2105
Herbcress	330	2507	2837
Meadowfoam	——[a]	2078	2078
LSD (0.05)	250	1142	1204

[a] A fibrous root system prevented quantifying root biomass of meadowfoam.

Table 2. Weed suppression by Brassicaceae cover crops relative to a non-weeded control treatment at 2 and 4 weeks after transplanting bell pepper.

	Large crabgrasss		Palmer amaranth	
Brassicaceae cover corp	2 WATP	4 WATP	2 WATP	4 WATP
	---------------- % suppression --------------------			
Indian mustard (Fumus F-E75)	73	79	25	33
Indian mustard (Fumus F-L71)	48	45	38	40
Canola (Humus)	48	49	36	44
Brown mustard (Southern giant)	64	48	35	23
Turnip (Seventop)	54	66	30	48
Herbcress	68	63	31	41
Meadowfoam	55	38	55	24
LSD (0.05)	18	26	23	21

[a] Abbreviation: WATP, weeks after transplanting bell pepper

Table 3. Bell pepper height at 6 weeks after transplanting and bell pepper total yield of marketable fruit in weed-free plots in 2004.

Brassicaceae cover corp	Height	Fruit yield
	--- inch ---	------ lb/plant ----
Indian mustard (Fumus F-E75)	24.4	0.57
Indian mustard (Fumus F-L71)	23.6	0.44
Canola (Humus)	26.4	0.63
Brown mustard (Southern giant)	20.5	0.62
Turnip (Seventop)	14.2	0.65
Herbcress	28.3	0.59
Meadowfoam	24.0	0.44
None	22.8	0.43
LSD (0.05)	9.4	NS

7) Dissemination

Findings from this research have been presented to students in the Introductory Weed Science class at Clemson University. Additionally, a poster entitled, "Tolerance of bell pepper to glucosinolates naturally produced by Brassicaceae cover crops" was presented at the Governor's School for Science and Mathematics held July 16, 2004 at Clemson, South Carolina. In the future, results will be conveyed to participants in the organic farming laboratory held on the campus of Clemson University.

8) References

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