Cover Crops and Compost in Organic Vegetable Systems: Benefits and Challenges

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In order to meet certified organic requirements, a soil-building cover crop is required in organic vegetable production systems. The majority of organic producers incorporate cover crops prior to planting, but others have been successful using conservation, strip-, or zone-tillage, or simply leaving the mowed cover crop on the surface to help mitigate weeds and soil erosion. A long-term experiment was established at the Iowa State University Muscatine Island Research and Demonstration Farm (MIRDF) in Fruitland, Iowa, to compare pepper growth, yield, insect populations, harvest cullage and postharvest weight loss under conventional and organic management. Treatments consisted of combinations of two synthetic fertilizer and three compost-based certified organic soil amendments. In addition to the compost treatments, effects of a cover crop of hairy vetch (*Vicia villosa* Roth) and rye (*Secale cereale* L.) were evaluated in the organic system. The Iowa State University Muscatine Island Research and Demonstration Farm is located on Mississippi River bottomland soil in southeast Iowa. Soils on the farm site are predominantly Fruitland coarse sands, well-drained with a slope of <5%, and an average organic matter content of <2.5%. Treatments established at the MIRDF included the following: Treatment 1 = Organic control (no fertilization/no pesticides); Treatment 2 = Organic fertilizer (100 lb N/A), preplant incorporated; Treatment 3 = Organic fertilizer (50 lb N/A) + gypsum (500 lb /A), preplant incorporated; Treatment 4 = Organic fertilizer (100 lb N/A) + gypsum (500 lb /A), preplant incorporated; Treatment 5 = Hairy vetch cover crop tilled completely into field before planting; Treatment 6 = Hairy vetch cover crop strip-tilled in field with an organic fertilizer side-dress application (50 lb N/A); Treatment 7 = Conventional Control (no fertilizer or lime/recommended pesticides); Treatment 8 = Conventional fertilizer (conventional rates); and Treatment 9 = Conventional fertilizer (conventional rates), lime (hydrated lime (357 lb/A) and elemental sulfur (993 lb/A). Bell pepper plants were seeded in trays in April and mechanically transplanted into rows (at 18 x 42-inch spacing) in 15 x 20 ft. plots in early June. Four replications of nine treatments were planted within the field plots in a randomized complete block design. Pepper cultivars during the course of the experiment included Lantern and Red Knight from Johnny's Seeds, Albion, Maine. Forty-eight pepper plants were planted in each replicated plot for a total of 1,728 plants in the experiment.

A cover crop of hairy vetch was seeded with rye at 60 and 90 lb/acre, respectively, in plots with cover crop treatments (Treatments 5 and 6) at the MIRDF in September of each year of the study (1999-2002). The cover crop germinated and remained dormant throughout the winter. Soil samples (a composite of 5 6-in. cores) were taken in Treatments 1, 5 and 6 plots at pre-season and at transplanting. Treatment 5 vetch plots were mowed and roto-tilled to completely incorporate the residue two weeks prior to

transplanting. The vetch in the zone-tilled vetch plots was killed with a cultipak, followed by a disc coulter and chisel sweep acting as an undercutter, sweeping 8-10 in. under the vetch to cut roots and loosen the soil under the mulch without disturbing the soil surface. Passage of the disc coulter and chisel sweep left a 1-3 in. strip down the center of the row into which the peppers were planted.

The goal of the fertilization program was to obtain similar rates of nutrients in the organic and conventional system (≈100 lb N/A and equivalent calcium and sulfur rates). The conventional fertilizer rates consisted of 14-14-14 (N-P-K) at 400 lb/A and 0-0-60 at 200 lb/A, which provided 56 lb. N/A, 56 lb. P/A, and 176 lb. of K per acre prior to planting. A side-dress of 34-0-0 at 143 lb/A provided an additional 44 lb N/A at first flower. The nitrogen source in the organic fertilizer, Cinagrow™ (Midwestern Bio-Ag®, Blue Mounds, Wisconsin) was a blend of blood meal, feather meal, and composted poultry litter and consisted of 4-3-5 N-P-K. Organic fertilizer was applied at a rate of 50 lb. N/A (Treatment 3) or 100 lb. N/A (Treatments 1 and 3) prior to planting, or as a side-dress application (50 lb. N/A) after plants were established within tilled vetch strips at first flower. The gypsum contained 21% calcium and 17% sulfur. Treflan® was applied at 1 pt/A in the conventional plots. No insecticides were applied in any treatments based on monitoring reports. Weeds were machine or hand cultivated throughout the season in organic plots, except in vetch strip-tilled plots, where the cover crop was left as a mulch between plant rows. As a result of inadequate growth of the vetch cover, rye straw was applied as a mulch to maintain a 3-in. depth. Irrigation was applied as needed through overhead risers. A core set of measurements was taken on 10 plants per plot (total of 40 plants per treatment) for crop plant productivity (biomass) and plant health three times per season. Height of plants, number of leaves, and number of pepper fruit were monitored, along with numbers of harmful and beneficial insects.

Peppers were harvested according to schedule during August and September until no harvestable peppers remained. Fresh weights were taken immediately after harvest and blemishes (insect or disease lesions rendering peppers unsalable) were enumerated. At initial weighing, 24 unblemished peppers per treatment per harvest were transferred to 50° F chambers in the Iowa State University Horticulture Department for postharvest storage-life studies. Fresh weights and visual quality of stored peppers were recorded two, four and six weeks after storage. Evaluations were terminated when peppers were unmarketable. All measurements were subjected to analysis of variance and Fisher's PLSD test ($P \leq 0.05$).

In the first 3 years of the transition to organic (1998 to 2000), pepper growth, harvest weight and marketable fruit numbers were similar in conventional and organic production systems when 100 lb. N/A was applied through synthetic fertilizer or compost/organic fertilizer. Pepper growth, harvest weight and marketable fruit numbers were also similar in conventional and organic production systems in 2001 and 2002 when 100 lb. N/A was applied. Zone-tillage organic pepper production resulted in significantly reduced growth and pepper weight in two out of the first three years at the MIDRF. The modification of this treatment in 2002 to include a side-dress application of organic fertilizer (50 lb N/A) after plant establishment resulted in a significant increase in plant production in 2002 and 2003. Mean leaf height was significantly greater in the treatments containing organic fertilizer (50 and 100 lb N/A) alone and with gypsum, and in both vetch treatments. Leaf number was also greater in the organic treatments. Fruit number was similar in all

treatments, except in the vetch treatments, where fruit numbers were the lowest. Plant growth was not increased by adding lime or gypsum to the fertilizer treatments.

Plant height and leaf number in the strip-tilled vetch treatment plus 50 lb. N/A side-dress application were equivalent to the completely incorporated (tilled) vetch treatment. This result contrasts with previous years where the strip-tilled treatment without the additional 50 lb N/A were significantly smaller than the other organic treatments. Insect populations were low overall, and insect pests and beneficial insects were not significantly different among treatments over the course of the experiment.

Higher pepper yields were obtained in the tilled vetch treatments in 2003 compared to 1999-2001 results, similar to 2002 results. In 2002 and 2003, vetch treatments were equivalent to conventional fertilizer treatments, compared to 2001, where strip-tilled vetch plots contained the lowest yielding peppers, and incorporated vetch yields were statistically equivalent to the organic fertilizer treatments, but significantly lower than the conventional treatments. The addition of the 50 lb N/A side-dress application enhanced plant growth in the strip-tilled plots but fruit production was more limited than in 2002. Although vetch biomass production and nitrogen content (2%) was similar between treatments, the cooling effect of the vetch strips may have lowered temperatures in the rooting zone of strip-tilled pepper plants, slowing fruit set and pepper fruit growth in this treatment. There were no differences in average pepper weight and percentage of blemished peppers among treatments. Postharvest weight loss was not consistent across treatments, with the conventional and organic control fruit having the greatest weight loss after 2–6 weeks in storage. In 2004, the organic plots were all rotated to the cover crop mixture of hairy vetch and rye to determine the suitability of "fallowing" an organic vegetable field to a summer cover crop. Unfortunately, the cover crop did not survive the summer heat and low rainfall (irrigation was not applied).

In conclusion, compost will provide the surest source of nitrogen to vegetable crops during the transition to certified organic production. A systematic plan for the incorporation of cover crops is required, however, and if grown in the summer months, plans must be in place for supplemental irrigation. The benefits of cover crops include greater soil quality over the long term and higher nutrient status when used in conjunction with compost or organic fertilizer. The new "No-Till Plus" project from The Rodale Institute has demonstrated "rolling" cover crops and no-tilling into the compressed mat of senesced cover crop as a viable alternative to strip tilling. Research on this aspect of cover cropping will begin in Iowa in 2006.

Publications Resulting From This Work

Delate, K. H. Friedrich and V. Lawson. 2003. Organic pepper production systems using compost and cover crops. Biological Agriculture and Horticulture 21 (1): 131–150.

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