Integrating Vegetable and Poultry Production for Sustainable Organic Cropping Systems

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Introduction

Integrating vegetable production with livestock or poultry production can increase soil nutrition and soil organic matter. It also can offer additional business opportunities for vegetable producers by adding a premium product to their enterprise.

A system that integrates crops, livestock, and cover crops potentially reduces input costs (compost application, chicken feed, etc.). Additionally, integrated systems can increase farm resiliency by allowing success of one product to compensate for the failure of another.

A total of three treatments were designed (Figure 1) to compare two vegetable-poultry-cover crop rotations with a typical vegetable-cover crop rotation system. The hypothesis is the implementation of integrated systems will increase soil health while also increasing farm profitability and resiliency.

Materials and Methods

This project is on certified organic land at the Iowa State University Horticulture Research Station, Ames, Iowa. The 2018 growing season represents the second year of the project. Multi-season rotation treatments (Figure 1) include vegetable-chickens-cover crop (R1), vegetable-cover crop-chickens (R2), and vegetable-cover crop (R3). Each rotation was replicated four times. In 2017, the rotations started with organic broccoli as the vegetable and chickens were integrated in the summer after broccoli harvest and in the fall to forage on a summer cover crop. In R3, fall lettuce was planted following a summer cover crop. The plots assigned to each rotation continued in 2018. On March 8 and 16, five cultivars of organic romaine lettuce (Jericho, Coastal Star, Paris Island, Green Towers, and Freckles) and pepper (Sweet Chocolate, Milena, King of the North, California Wonder, and Golden California Wonder) were seeded in 72- and 288-celled flats in an organic medium (Beautiful Land Products, West Branch, IA) in the Department of Horticulture greenhouses (pepper seedlings later were repotted into 50 cell flats). On March 30, 2018, an initial composite soil sample was collected consisting of five cores from each plot.

On April 24, 2018, in treatments R1 and R2, nitrogen was applied using 4-6-4 (Sustane Natural Fertilizer, Inc., Cannon Falls, MN), plots were tilled, and lettuce was transplanted. Each plot (370 sq ft) consisted of five double rows of lettuce spaced 3 ft apart (center-to-center) on bare ground. The crop was irrigated using drip irrigation and hand weeded as needed. Lettuce harvest began May 29, 2018, and continued once a week until June 14, 2018. On June 18, 2018, soil samples were collected from all treatments (R1, R2, and R3). Peppers were transplanted May 16, 2018, in single rows 3 ft apart. Spacing between plants within row was 18 in. Three days after transplanting, a crimson clover (120 lb/acre) was seeded between rows of peppers and mowed regularly to suppress weeds. Peppers were irrigated through drip irrigation and weeded (within row) and scouted regularly following recommended organic production practices.

Peppers were harvested weekly beginning July 17, 2018, and continued until September 26, 2018.

After completion of lettuce harvest, an electric fence was erected around the perimeter of the field in an effort to protect chickens from predators. On June 7, 2018, 3-week old chickens were introduced into R1 plots. They were housed in a 5 ft x 4 ft floorless movable coop (Figure 2) to allow them to forage on lettuce residue. One pen/plot was used (one coop for each rep 1-4). R1 coops 1-4 had 10, 8, 9, and 9 birds, respectively, and R2 coops had 10, 11, 10, and 10 birds, respectively.

In R2, after lettuce harvest, plots were tilled and seeded to a cover crop mixture of oats and crimson clover. In R1 and R2, chickens foraged on the plots for six weeks. During this time, they received a full balanced ration of organic chicken feed (Natures Grown Organics, Westby, WI). Chicken coops were moved every day to allow access to fresh residue/cover crop. Throughout the six weeks chickens were on the plots, feed and weight data were collected by weighing feed left over and feed added. Chicken weight data was collected three times during the season at two-week intervals. From R1, chickens were removed August 8, 2018, a third soil sample was collected, and a fall cover crop of cereal rye was broadcasted. In R2, chickens were introduced into the standing cover crop mixture of oats and crimson clover September 7, 2018. Feed and weight data were collected in similar manner as in R1. Chickens were removed after six weeks on October 20, 2018. A final set of end-of-the season soil samples were collected from all treatments (R1, R2, and R3) October 24, 2018. All soil samples were analyzed for chemical and physical properties for determination of soil health. Additionally, soil samples were collected November 2, 2018 from all treatments and analyzed for presence or absence of *E. coli* and *Salmonella*.

Results and Discussion

Nitrogen application rates were decided based on soil tests in the spring. Fertilizer application rate for R2 was reduced by up to half as those plots had chickens integrated the previous fall. This shows a positive impact of having an integrated system where off-farm fertilizer inputs could be reduced by having uniformly distributed chicken manure through the use of movable chicken coops the fall of the previous year. Soil organic matter increased in all plots from the start of the project in 2017 to the beginning of the 2018 growing season (Table 1). There were no significant differences between treatments. Soil samples collected throughout the growing season are being extracted for soil microbial biomass analysis. Samples collected at the end of the 2018 growing season did not show presence of *E. coli* or *Salmonella* after having chickens on them for two seasons.

Marketable yield for lettuce cultivars in Treatment R2 were statistically similar except for Freckles, which had a significantly lower marketable yield (Table 2) compared with all other cultivars. A similar trend was observed in lettuce yield in R1. Among pepper cultivars in R3, Sweet Chocolate, Milena, California Wonder, and King of the North had statistically similar yields. However, Sweet Chocolate produced higher marketable yield than Golden California Wonder (Table 3). Chicken Feed Conversion Ratio (FCR) ranged from 2.36 to 2.88 (Table 4). FCR tended to be higher for chickens introduced to established cover crop plots in the fall (R2) as compared with those introduced to crop residue in the summer (R1). FCR for commercial broiler production averages 1.85 indicating better efficiency at turning feed into meat. Birds on pasture tend to have higher FCR (lower efficiency) due to exposure to fluctuations in

temperature and relative humidity, increased physical activity, and the added forage consumption.

This study was approved by the Institutional Animal Care and Use Committee.

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Table 1. Soil organic matter at the start of the project (April 2017) and at planting time in 2018 (April) at the ISU Horticulture Research Station, Ames, IA.

	Percentage soil organic matter	
Treatment/rotations	**2017**	**2018**
R1[†]	3.20a*	3.68b
R2	2.95a	3.83b
R3	3.25a	3.68b

[†]R1 = vegetable – chicken – cover crop; R2 = vegetable – cover crop – chicken; R3 = vegetable – vegetable – cover crop.

*Mean separation between years within a particular treatment. Treatments with the same letters are not significantly different at $P < 0.05$.

Table 2. Lettuce marketable yields at the Horticulture Research Station, Ames, IA, in 2018 from Treatment R2. Yield reported from 25-ft long double rows of lettuce.

Cultivar	Marketable yield (lb)*
Green Towers	42.0a
Paris Island	36.5a
Jericho	36.5a
Coastal Star	36.3a
Freckles	20.8b

*Treatments with the same letters are not significantly different at $P < 0.05$

Table 3. Pepper marketable yield at the Horticulture Research Station, Ames, IA, in 2018 from Treatment R3. Yield reported from 25-ft long single row of pepper.

Cultivar	Marketable yield (lb)*
Sweet chocolate	14.8a
Milena	12.4ab
California Wonder	11.4ab
King of the North	9.1ab
Golden California Wonder	7.5b

*Treatments with the same letters are not significantly different at $P < 0.05$.

Table 4. Average Feed Conversion Ratio (FCR) for chickens in Treatment R1 and R2 (R1 = vegetable – chicken – cover crop; R2 = vegetable – cover crop – chicken).

	FCR	
Chicken coop	**Treatment R1**	**Treatment R2**
1	2.36	2.88
2	2.57	2.79
3	2.44	2.59
4	2.37	2.67

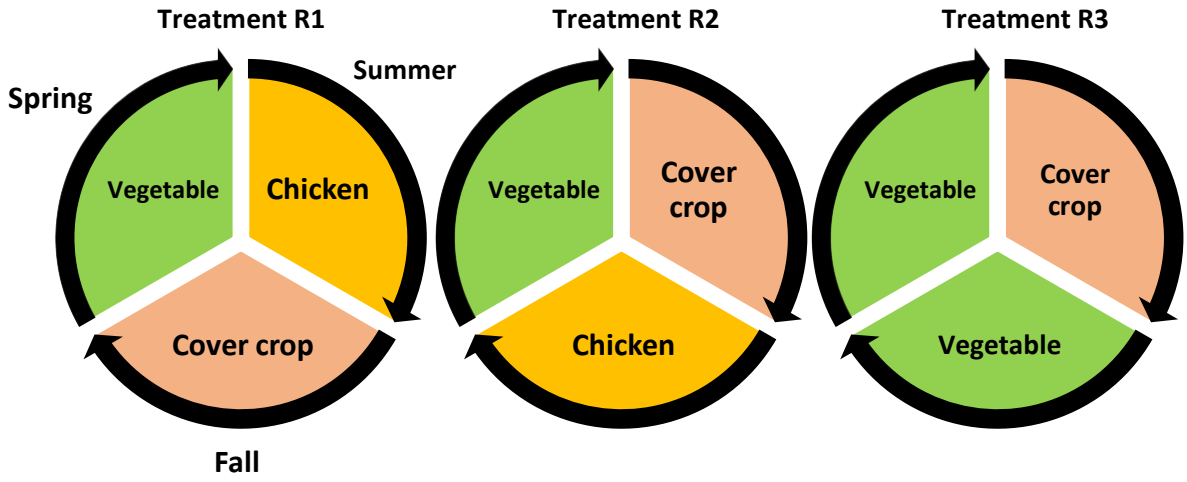

Figure 1. Treatments (rotations) at the Horticulture Research Station, Ames, IA, for the 2018 growing season.

Figure 2. 5 x 4 ft floorless, movable, chicken coops used to integrate chickens into R1 and R2 treatments at the ISU Horticulture Research Station, Ames, IA.