# Effects of Reduced Tillage and Split Fertilizer Application in Organic Broccoli and Pepper Production Systems

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## Introduction

Organic farmers rely extensively on tillage to incorporate plant residues, prepare seedbed, and control weeds. However, tillage has many adverse effects on soil health. Conventional no-till production methods, which rely on herbicide for weed control, are not compatible with organic farming. Field research was carried out over two years (2014 and 2015) to compare two cover crop-based reduced tillage systems, no tillage (NT) and strip tillage (ST), with conventional tillage (CT) in production of organic bell pepper and broccoli. Two fertility treatments (preplant or split fertilizer application) also were included within tillage treatments.

## Materials and Methods

A cereal rye-hairy vetch cover crop mixture was drilled in all plots on September 12, 2013 and September 8, 2014, at a rate of 100 lb/acre for cereal rye and 25 lb/acre for hairy vetch. Strips were tilled in strip-till plots on November 14, 2014 and October 12, 2015 using a Hiniker 6000 strip tiller. In CT plots, the cover crop was mown and tilled in mid-May and then rotovated again just before transplanting. The cover crop in NT and ST plots was roller-crimped on June 3, 2014 and June 1, 2015 when rye was at anthesis using a roller crimper (I&J Manufacturing, Gap, PA). Strips were re-tilled in ST plots and a narrow band of soil was loosened in no-till plots just before transplanting on June 11, 2014 and June 4, 2015. Dehydrated poultry manure fertilizer was banded in preplant fertility subplots at this time at a rate of 150 lb total N/acre for broccoli and 80 lb total N/acre for pepper. Split fertility subplots received only a 2/3 rate of the preplant fertilizer, with the remaining 1/3 of total N applied post-planting using fertigation. Fertilizer control subplots, presented only in results of the broccoli study, received no fertilizer. Pepper and broccoli plugs were transplanted on June 13, 2014 and June 9, 2015 in rows 30 in. apart, with in-row spacing of 12 and 18 in. for broccoli and pepper, respectively.

Broccoli and green bell peppers were harvested and graded for marketability. Soil temperature was monitored at a 6-in. depth using Hobo data loggers. Weed biomass was measured in-row (IR) and between-row (BR) regions of CT, NT, and ST plots just before the first hand weeding event, about four weeks after transplanting. Weed biomass data are reported for broccoli only.

## Results and Discussion

*Broccoli yield*. Marketable broccoli yield was reduced under NT and ST management in 2014, but was unaffected by tillage treatment in 2015 (Table 1). Fertilizer had a strong effect on yield, with unfertilized treatments producing an average of 85 percent less than the two fertilized treatments. There was no significant difference between NT and ST treatments.

*Bell pepper yield*. Marketable yield was similar among tillage treatments in 2014, averaging 16.8 $Mg \cdot ha^{-1}$, but 67 percent more in CT than NT and ST treatments in 2015 (Table 1). Preplant fertility increased yield in 2014 compared with split fertility, but the two treatments were not different in 2015.

*Soil temperature.* During early and mid-season of each year, all three means were different, with CT plots having the highest temperature and NT plots the lowest (Figure 1). Differences were reduced or not observed in the late season.

*Weed biomass and density.* For the broccoli, conventional tillage led to greater dry weight and density of weeds in both years, as compared with ST or NT (Table 2). There was no significant difference between NT and ST in either year. In 2014, the in-row (IR) region contained greater dry weight and density of weeds than the between-row (BR) region, but there was no difference between IR and BR in 2015. Perennial weeds in 2015 were unsuppressed by the cover crop mulch, explaining the similar weed biomass in IR and BR regions.

In this study, we showed that reduced tillage treatments can produce yields of broccoli and bell pepper similar to those of CT. However, yield reductions under NT and ST in one out of two years prevent us from making definitive conclusions. Although ST did increase soil temperature compared with NT, it did not lead to higher yields. Early season annual weed suppression by the cover crop mulch was good, but perennial weeds pose a challenge in this system. Our findings indicate good potential for reducing tillage on organic farms, but further refinement of the system is necessary to ensure consistent results.

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**Table 1. Marketable broccoli and bell pepper yield (Mg·ha$^{-1}$) as affected by tillage and fertility treatments, Ames, IA, 2014 and 2015.**

| | Broccoli | | Bell pepper | |
|---|---|---|---|---|
| **Treatment**[z] | **2014** | **2015** | **2014 Yield** | **2015 Yield** |
| Tillage (T) | | | | |
| CT | 5.9 a[y] | 20.6 | 17.9 | 37.7 a |
| ST | 3.2 b | 19.0 | 16.0 | 21.8 b |
| NT | 4.1 b | 20.4 | 16.6 | 23.4 b |
| *Significance* | *** | NS | NS | ** |
| Fertility (F) | | | | |
| Preplant | 6.4 a | 22.6 a | 18.9 a | 26.1 |
| Split | 5.8 a | 22.5 a | 14.7 b | 29.2 |
| No fert | 0.9 b | 14.9 b | --- | --- |
| *Significance* | *** | *** | ** | NS |
| T × F | NS | NS | NS | NS |

[z]CT = conventional tillage; ST = strip tillage; NT = no tillage; Preplant = only preplant fertilizer; Split = 2/3 of N from preplant fertilizer and 1/3 from fertigation; No fert = unfertilized control.
[y]Means in a column within the same column and treatment followed by the same letter are not significantly different according to Fisher's protected LSD ($P \leq 0.05$).
NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively, based on F test.

**Table 2. Weed biomass (g·m$^2$) and density (weeds·m$^2$) as affected by tillage treatments and sampling region in broccoli production, Ames, IA, 2014 and 2015.**

| | 2014 | | 2015 | |
|---|---|---|---|---|
| **Treatment**[y] | **Biomass** | **Density** | **Biomass** | **Density** |
| Tillage (T) | | | | |
| CT | 1.4 a[x] | 150 a | 10.3 a | 83 a |
| ST | 0.5 b | 38 b | 0.9 b | 14 b |
| NT | 0.3 b | 14 b | 2.2 b | 33 b |
| *Significance* | * | * | ** | * |
| Region (R) | | | | |
| IR | 1.0 a | 111 a | 2.3 | 41 |
| BR | 0.4 b | 18 b | 3.1 | 37 |
| *Significance* | ** | ** | NS | NS |
| T × R | NS | NS | NS | NS |

[z]Weeds were sampled on July 2, 2014 and July 8, 2015.
[y]CT = conventional tillage; ST = strip tillage; NT = no tillage; IR = in-row; BR = between-row.
[x]Medians within a column and treatment followed by the same letter are not significantly different according to Fisher's protected LSD ($P \leq 0.05$).
NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively, based on F test.

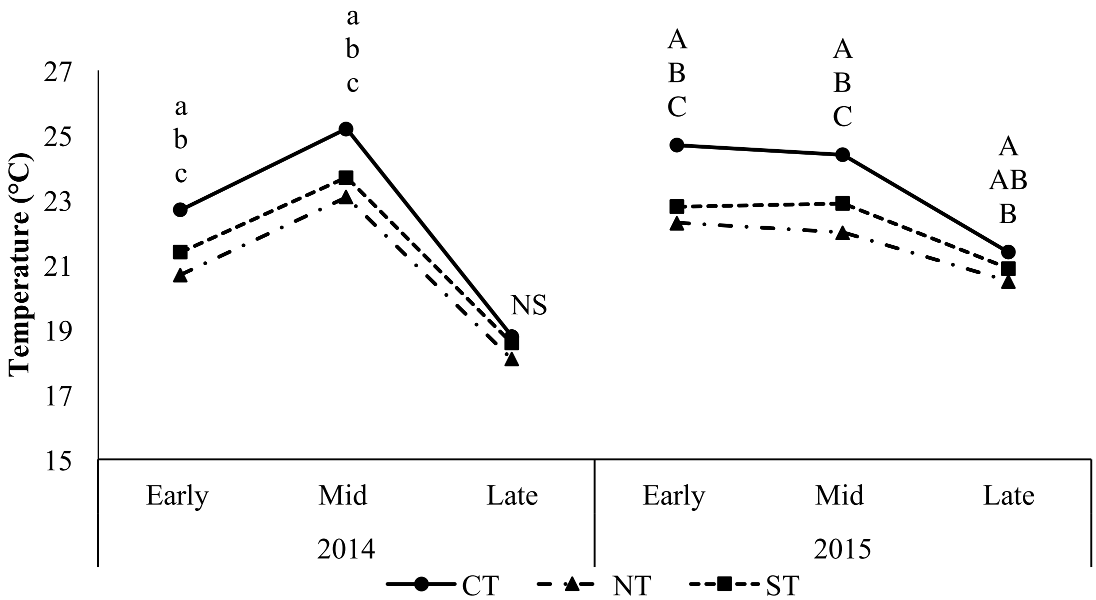


**Figure 1. Soil temperature (°C) at 6-in. depth in early, mid, and late seasons of pepper production in 2014 and 2015 as affected by CT, NT, and ST treatments. Early season: June 14 – July 21, 2014; June 14 – July 17, 2015. Midseason: July 22 – Aug. 28, 2014; July 18 – Aug. 19, 2015; Late season: Aug. 29 – Oct. 2, 2014; Aug. 20 – Sept. 22, 2015. Mean separation within season and year by Fisher's protected LSD ($P \leq 0.05$).**