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

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Introduction

Fall-planted winter annual cover crops, such as cereal rye and hairy vetch, can be terminated using a roller-crimper rather than incorporated using tillage, as is typical on organic vegetable farms. The roller-crimper lays the cover crop flat on the soil surface, providing a mulch through which vegetables can be seeded or transplanted, thus suppressing weeds and reducing the need for tillage. Some studies have found organic no-till to produce equal yields (Delate et al. 2012), while others found reduced yields (Leavitt et al. 2011), as compared with conventional tillage.

This study looks at the effects of reduced tillage and split nitrogen application on crop yield, soil health, weed suppression, and nitrate leaching in organic broccoli and pepper production systems. The two reduced tillage systems being evaluated are no-tilll and strip-till, where strip-till serves as a hybrid between no-till and conventional-till by concentrating the tillage only in the crop row, leaving the between-row region undisturbed.

The fertility treatments test the effect of split application of nitrogen fertilizer, addressing the potential for decreased nitrogen availability under reduced tillage conditions (Wells et al. 2013). Because the cover crop mulch provides a physical obstruction to sidedressing of granular fertilizer post-planting, fertigation was used to provide the fertilizer after planting.

Questions of Interest

- Can crop yields be maintained under reduced tillage systems?
- Is the tillage system effect on crop yield dependent on the type of crop, such as warm-season vs. cool-season?
- Does strip tillage increase soil temperatures and nitrogen availability, as compared to no tillage?
- Will split fertilizer application using fertigation help the plant overcome potential nitrogen immobilization caused by cover crop residue?
- Does cover crop mulch provide adequate weed suppression?
- Will reduced tillage and presence of cover crop residue decrease nitrate leaching?

Materials and Methods

Treatments

Two crops: Bell pepper and broccoli

Whole plot treatments:
- No tillage (NT)
- Strip tillage (ST)
- Conventional tillage (CT)

Subplot treatments:
- All nitrogen supplied through pre-plant granular fertilizer (Preplant)
- 2/3 of nitrogen from pre-plant fertilizer and 1/3 from post-plant fertigation (Split)
- No fertilizer (Control)

Site Info and Planting Details

Location: Horticulture Research Station, Ames, IA

Soil types: Clarion loam and Nicollet clay loam

Row spacing: 30”

In-row plant spacing
- Broccoli: 12”
- Pepper: 18”

Cover crop seeding rates:
- Rye: 90 lbs/acre
- Vetch: 25 lbs/acre

Cover crop drilled in mid-September

CT

Cover crop flail mowed in mid-May

...and then incorporated with a rototiller

NT

ST

Strip tilled in mid-October using Hiniker 6000

ST

In early June, when rye is at anthesis, cover crop is terminated with roller-crimper

One week later, planting zone is prepped and fertilizer banded using strip tiller

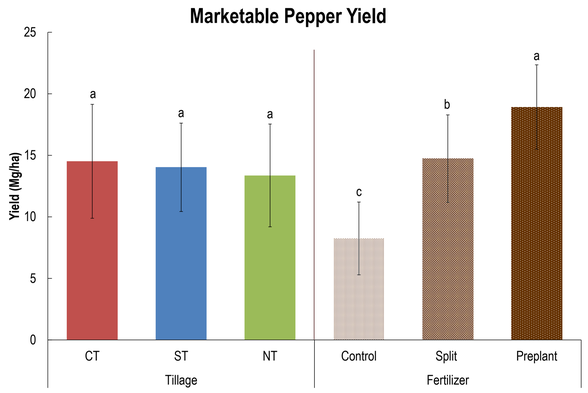
Conventional-till peppers

No-till peppers

Fertilizer injected into drip

Plugs planted with Holland transplanter

Results



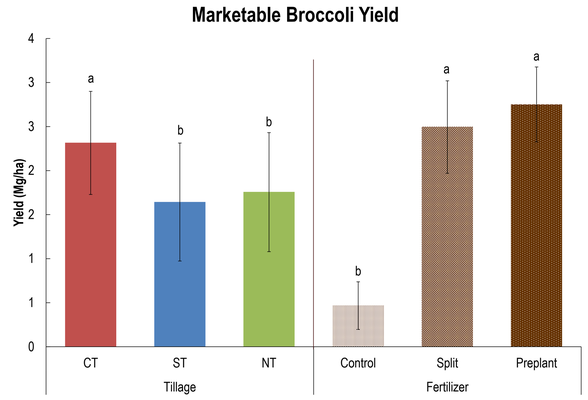


Figure 1. Yield of peppers (top) and broccoli (bottom) under no-till, strip-till, and conventional-till management, and fertilized using only preplant granular fertilizer, a combination of preplant granular and post-plant fertigation, or no fertilizer. Mean separation by least significant difference ($P \leq 0.05$). Error bars refer to standard errors of the mean.

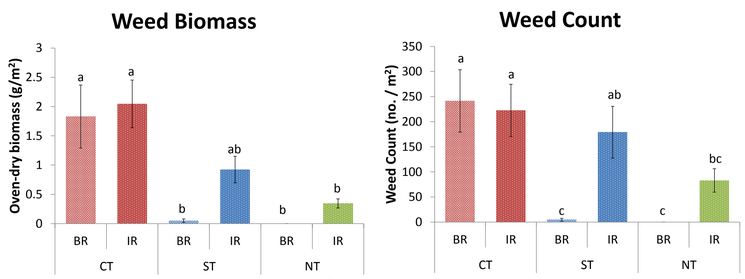


Figure 2. Weed biomass (left) and count (right) per m² from samples taken on 7/2/14, three weeks after transplanting. In-row (IR) refers to the 12 inch-wide region centered on the crop row and between-row (BR) refers to the space between adjacent in-row regions. Mean separation by least significant difference ($P \leq 0.05$). Error bars refer to standard errors of the mean.

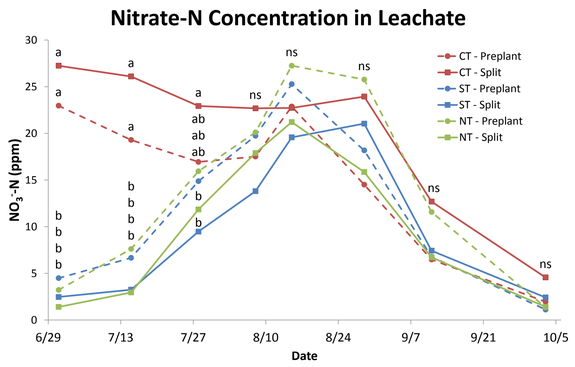
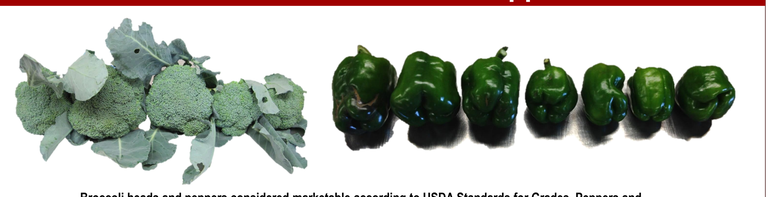


Figure 3. Parts-per-million of nitrate-N measured in leachate samples in 2014 from lysimeters installed to 24” depth. Mean separation on each date by least significant difference ($P \leq 0.05$).

Marketable Broccoli and Peppers



Broccoli heads and peppers considered marketable according to USDA Standards for Grades. Peppers and broccoli deemed marketable were those categorized as Fancy, Grade 1, and Grade 2.

Results (cont’d)

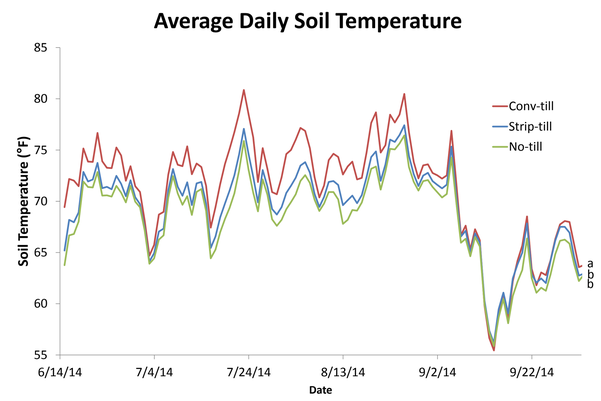


Figure 4. Daily average soil temperature measurements taken at 6” depth within the crop row using Hobo data loggers. Line labels (at far right) containing the same letter are not significantly different from each other ($\alpha = 0.05$), referring to soil temperature averaged across the entire season. Error bars refer to standard errors of the mean.

Summary of Results

Crop yield

Pepper: Yields were equal among conventional-till, strip-till, and no-till treatments. Preplant fertilization produced higher yields than did split fertilizer application.

Broccoli: Conventional-till treatment had the highest yields, while strip-till and no-till yielded equally. There was no difference in yield between preplant and split fertilizer treatments.

Note: The fungal disease Fusarium Yellows was observed throughout the plot beginning after three weeks of waterlogged conditions in June. A slow decline of plants throughout the season likely favored the earlier-maturing conventional-till treatments, thus confounding yield with time.

Weed suppression

Conventional-till had significantly more weeds and weed biomass than did the no-till and strip-till. Weed biomass was highest in regions with exposed soil: conventional-till plots and the in-row region in strip-till plots.

Nitrate leaching

Conventional-till using split fertilizer application resulted in more nitrate leaching than all other treatments when averaged across all sampling dates. Differences between treatments were most stark during June and July, decreasing later in the season. Preplant fertilizer tended to increase leaching of nitrate in no-till and strip-till treatments, but decrease leaching of nitrate in the conventional-till treatment.

Soil temperature

Averaged across the entire season, temperatures under conventional-till were 3 and 2.5 degrees F warmer than no-till and strip-till, respectively. There was no significant difference between temperatures in no-till and strip-till. Differences between treatments were most pronounced June – August, with temperatures becoming equal among treatments in September and October.

Literature Cited

Delate, K., D. Cwach, and C. Chase. 2012. Organic no-tillage system effects on soybean, corn and irrigated tomato production and economic performance in Iowa, USA. Renewable Agriculture and Food Systems 27(Special Issue 01): 49–59.

Leavitt, M.J., C.C. Sheaffer, D.L. Wyse, and D.L. Allan. 2011. Rolled Winter Rye and Hairy Vetch Cover Crops Lower Weed Density but Reduce Vegetable Yields in No-tillage Organic Production. HortScience 46(3): 387–395.

Wells, M.S., S.C. Reberg-Horton, A.N. Smith, and J.M. Grossman. 2013. The Reduction of Plant-Available Nitrogen by Cover Crop Mulches and Subsequent Effects on Soybean Performance and Weed Interference. Agronomy Journal 105(2): 539.

Acknowledgements

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