Horticulture
Research

Summer Squash Following Winter Rye With Strip and No-Till

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Cooperators:
- **Mustard Seed Community Farm – Ames**

Funding By:
CERES

Web Link:
http://bit.ly/pfi_horticulture

In a Nutshell

- Fruit and Vegetable farmers want to use cover crops to control weeds, which reduces labor costs and competition with cash crops.
- In tilled plots, two-foot wide strips of rye were incorporated prior to seeding. In no-till plots, summer squash was seeded into an overwintered stand of cereal rye that was scythed at maturity.

Key Findings

- Squash yield (lb) and number of squash produced were greater in tilled plots than in no-till plots.
- Weeding the tilled plots took significantly more time during the first weeding of the season (July 8).
- Survival rate of seedlings was not different between treatments on July 1, but plant survival by Sept. 25 was 72% in the till plots compared to 50% in the no-till plots.
- Average pounds of squash produced per plant were not significantly different between treatments.

Project Timeline:
2014-2015

Squash growing in till and no-till plots at Mustard Seed Farm on Sept. 17, 2015.

Background

For the past several years, roller-crimping a cereal rye cover crop before a summer vegetable cash crop has been attracting interests as a research topic at the Practical Farmers of Iowa Cooperators' Meeting. A roller-crimper is a specialized tool designed by the Rodale Institute that, once the cover crop nearly reaches physiological maturity, simultaneously terminates a living cover crop and converts it to a mulch layer. Often a planting implement follows it.

Mustard Seed Community Farm does not own a roller-crimper, but wanted to test a different way to terminate a cereal rye cover crop. This experiment compared the effect on summer squash yield of two different ways of terminating a winter rye cover crop. Treatments were:

1. Till a two-foot strip down the center of the bed, then scythe remaining rye at maturity (Till).

2. Scythe all rye at maturity and plant directly into straw mulch (No-till).

The members of Mustard Seed Community Farm wanted to test these methods before implementing them into the farm's production. These two cereal rye termination methods were chosen because they mimic their normal operations of seed preparation for various vegetable crops. For some crops, seedbeds are tilled prior to planting while others are no-till planted. Including the mulched cover crop to their production system with the no-till treatment would mimic the straw they would normally use to control weeds.

Mustard Seed Community Farm near Ames is a diversified vegetable farm with a mission of healthy food accessible to everyone. Members of the farm grow vegetables and herbs to supply their CSA and food donations. They incorporate farming practices such as cover crops, permaculture, perennial crops, beneficial insects and animal habitats as they try to create a farming system that closely mimics nature.

Methods

2015

In the fall of 2014, Mustard Seed Farm broadcast seeded cereal rye onto eight plots six ft wide by 36 ft long. Cereal rye overwintered, and in the spring (May 9, 2015) a two-foot wide strip was tilled down the center of the four "till" treatment plots. The rye was quite thick, and needed three passes with the tiller for termination. On June 2 when rye was mature, all plots was scythed and the straw was raked to lie evenly over the plots except in the two-foot tilled strips of the till plots.

Prior to planting on June 17, all weeds in the plots were removed by hand weeding or hoeing. Dunja zucchini from Johnny's Seeds, a variety with high yields and resistant to powdery mildew, were planted two seeds per hole, with a single row of 24 plant spaces per plot (if both seeds germinated, they were thinned to 1.5 ft spacing in the row, designed to achieve 24 plants per row). At planting, straw in the no-till plots was pushed back two inches from the hole. Soil temperature was not measured, but Alice McGary, founder and lead farmer at Mustard Seed Farm, reported the plots in the till treatment were drier on the surface, damp below the surface, and seemed slightly warmer. Soil in the no-till plots seemed a little cooler and damp. The number of surviving plants from the seeding was counted weekly beginning July 1 and ending Sept. 25.

Plots were weeded on July 8, July 29, and Sept. 10. Weeding labor time was recorded by plot on each date. Harvest occurred three times per week, beginning on July 20 and ending October 15. All squash over 5 in. long were harvested, along with all culls. Toward the end, culls included squash with mosaic virus that were deformed and not marketable, but still edible as seconds.

Seeding squash into cereal rye residue in a no-till plot on June 17, 2015.

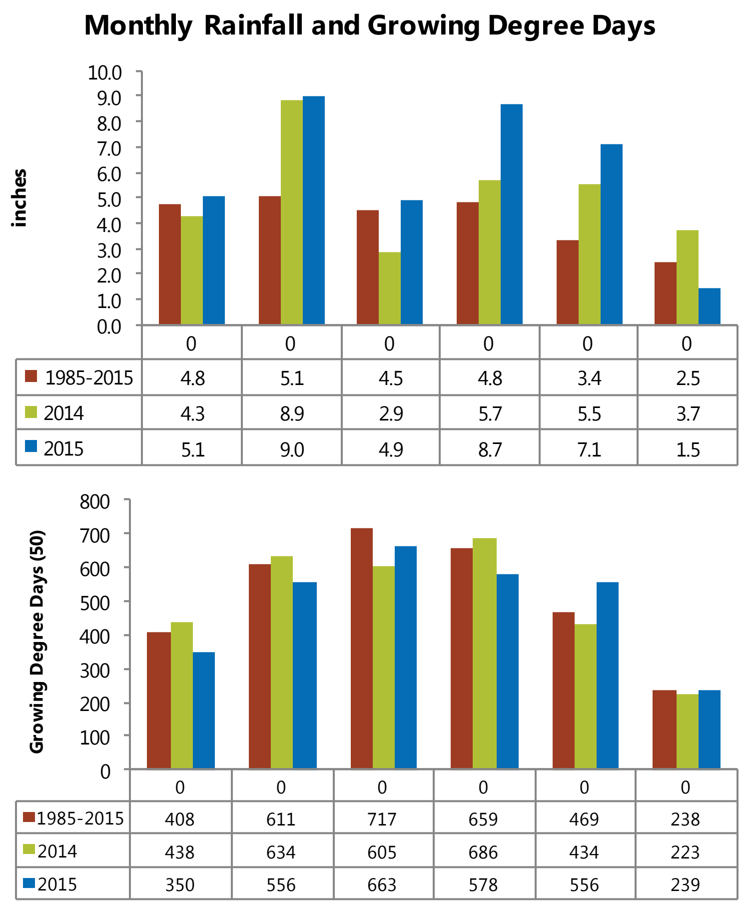
2014

In 2014, Mustard Seed Community Farm purchased 'Variety Not Stated' cereal rye from Sexauer Discount Farm Services and broadcast seeded at a rate of 70 lb/ac on September 24, 2013 onto eight plots five feet wide and 25 ft long. Cereal rye overwintered, and in the spring four plots were mowed and tilled on May 10 while four were only mowed on June 4, 2014, when cereal rye had reached boot stage. In each treatment, biomass samples were collected prior to termination. Summer squash seeds were planted on June 6, 2014 across both treatments. Yield was recorded during 14 harvests between July 21, 2014 and August 23, 2014 for pounds of marketable fruit, number of marketable fruit, pounds of cull fruit and number of cull fruit.

In both years, data were analyzed using JMP Pro 11 (SAS Institute Inc., Cary, NC) and comparisons among measured variables employ least squares means for accuracy. A repeated measures approach was used to examine the effects of harvest date, treatment, and their interaction on cumulative squash yield per plot. For yield per plant, a weighted average was calculated based on dates when squash plants per plot were counted, because the number of plants and pounds harvested changed weekly.

Means separations are reported using Tukey's least significant difference (LSD). Statistical significance is reported at the $P \leq 0.10$ and $P \leq 0.05$ levels. Due to the significant interaction between tillage treatment and date, differences in weeding time between the treatments at each date are reported using contrast statements.

Figure 1



	0	0	0	0	0	0
1985-2015	4.8	5.1	4.5	4.8	3.4	2.5
2014	4.3	8.9	2.9	5.7	5.5	3.7
2015	5.1	9.0	4.9	8.7	7.1	1.5

	0	0	0	0	0	0
1985-2015	408	611	717	659	469	238
2014	438	634	605	686	434	223
2015	350	556	663	578	556	239

Figure 1. Monthly rainfall (in.) and growing degree days (base 50˚F) from the Ames weather station (Iowa Environmental Mesonet, 2015).

Figure 2

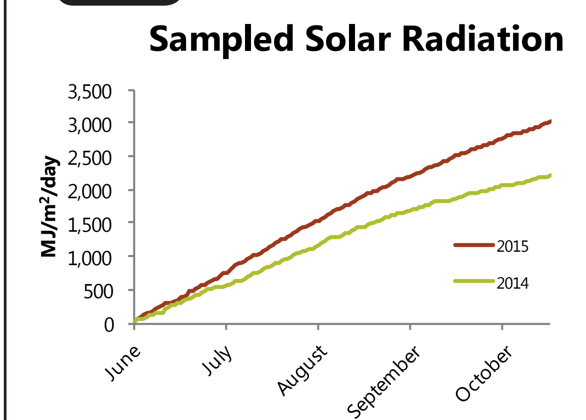


Figure 2. Cumulative sampled solar radiation (SSRAD) for June – October 2014 and 2015 for Ames. SSRAD is an output of the High Resolution Rapid Refresh model (HRRR). Iowa Environmental Mesonet (2015).

Results and Discussion

The 2015 growing season saw rainfall above the 30 year-average, especially during June, August and September, as shown in **Figure 1**. Growing degree days (base 50˚F) were generally lower than the 30-year average, except during September. **Figure 2** compares cumulative insolation (sampled solar radiation MJ/m^2/day) for 2014 and 2015 (historical data are not available). From the graph, 2015 received more solar energy than 2014.

Examples of culled squash affected by mosaic virus.

Mosaic Virus 2015

On Aug. 29, mosaic virus appeared on one plant in plot 6 (no-till), which otherwise appeared healthy. The virus was not identified right away, and spread to more plants and plots on harvest knives, down the row to plot 7 (no-till) and plot 8 (till), but other plants and plots were affected, too. The fruit from infected plants were increasingly odd looking as the virus progressed, and were harvested as seconds and counted as culls.

Figure 3

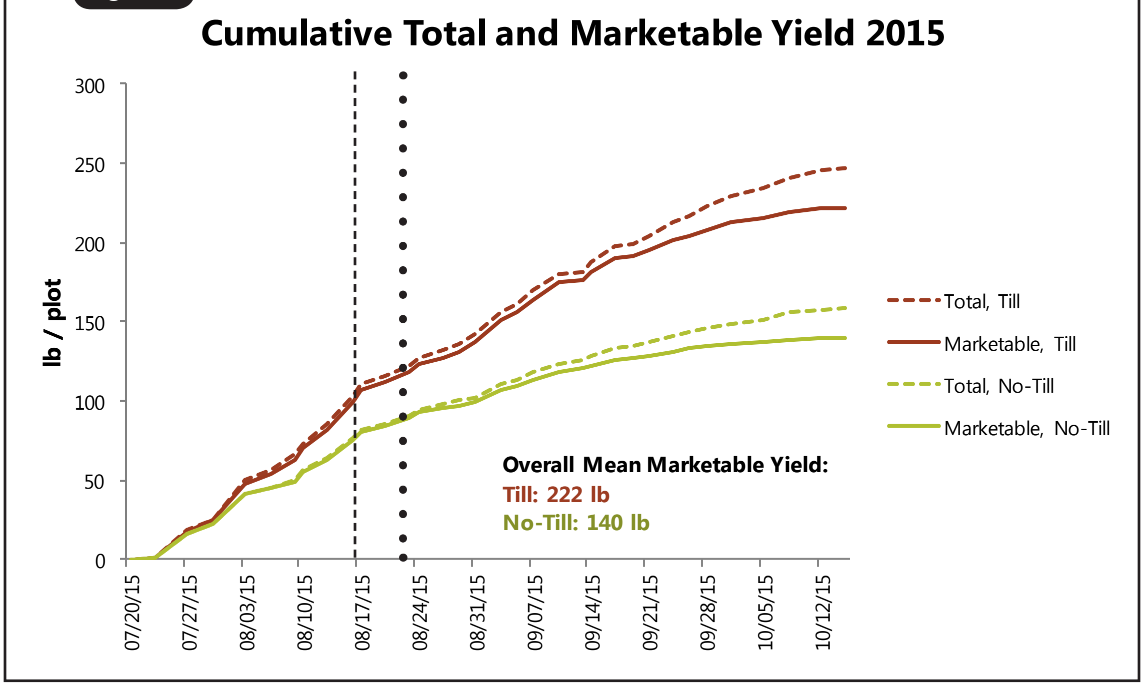


Figure 3. Mean cumulative total (marketable+cull) and marketable fruit yield for each treatment in 2015. At the dashed vertical line, the difference between mean cumulative total yield of till and no-till plots becomes (and remains) significant at $P \leq 0.10$. At the dotted vertical line, mean cumulative marketable pounds of fruit by treatment become and remain significantly different at $P \leq 0.10$. Plot size was 36 ft x 5 ft (180 ft^2). Cumulative end-of-season marketable yields per plot for each treatment are displayed at the final date (Oct. 15).

Pounds of Marketable Fruit

In 2015, squash was harvested from plots beginning on July 20. Cumulative total and marketable yield, in pounds per plot, through the season for both treatments are shown in **Figure 3**. Beginning on Aug. 17, the till treatment produced more total pounds of fruit than the no-till treatment at the $P \leq 0.10$ level (as indicated by the vertical dashed line in **Figure 3**). On Aug. 23, the difference in marketable pounds of fruit harvested per plot between till and no-till treatments became (and remained) significant at the $P \leq 0.10$ level (as indicated by the vertical dotted line). Mean cumulative marketable yield at the end of the season was 222 vs. 140 lb/plot for the till and no-till treatments, respectively. On the other hand, there was no significant difference in mean cumulative pounds of cull (unmarketable) fruits harvested per plot between till and no-till treatments at $P \leq 0.10$. Thus, the proportion of total harvested fruit that was marketable did not differ between treatments at $P \leq 0.10$; proportion of total yield that was marketable in tilled plots was 90% and for no-till plots was 87% (LSD = 7%).

Additionally, average weight per marketable fruit did not differ by treatment. Tilled plots averaged 0.58 lb/fruit; no-till plots averaged 0.60 lb/fruit (LSD = 0.09 lb/fruit; $P \leq 0.05$).

Marketable squash harvested from test plots.

In 2014, yields were much lower, perhaps due to poor germination and thus, fewer plants per plot. In 2014, squash were seeded only one seed per hole on June 6 (two seeds per hole were used in 2015 planting). Neither plant survival rate, germination rate, nor final plant count, however, were collected for 2014. In addition, lower insolation throughout the growing season may also have reduced flower production and pollinator activity compared to 2015 (**Figure 2**).

Looking at 2014 data, mean marketable yield by treatment separated on July 31, 2014, with the till treatment producing more pounds of marketable fruit than the no-till treatment at the $P \leq 0.10$ level (as indicated by the vertical dashed line in **Figure 4**). Mean cumulative marketable yields at the end of the season were 11.1 and 4.0 lb/plot for the till and no-till treatments, respectively.

Figure 4

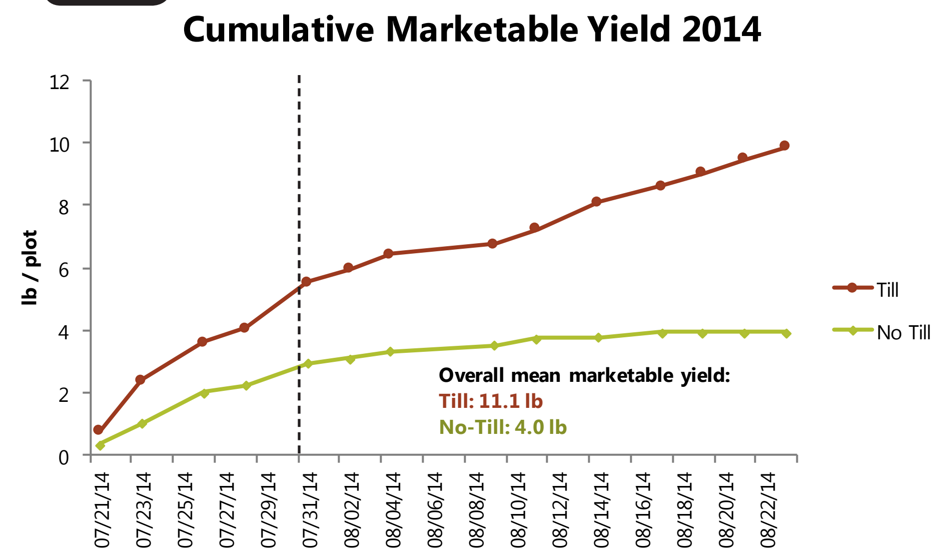


Figure 4. Mean cumulative marketable fruit yield for each treatment in 2014. At the dashed vertical line on July 31, the difference between mean cumulative yield of till and no-till plots becomes (and remains) significant at $P \leq 0.10$. Plot size was 25 ft x 5 ft (125 ft^2). Cumulative end-of-season marketable yields per plot are displayed for both treatments at the final date (Aug. 23, 2014).

Number of Marketable Fruit

The number of total and marketable fruit for each treatment was also collected through the season. In 2015, beginning on Aug. 17, the till treatment produced more total number fruit per plot than the no-till treatment at the $P \leq 0.10$ level (as indicated by the vertical dashed line in **Figure 5**). On Aug. 20, the difference in marketable fruit harvested per plot between till and no-till treatments became (and remained) significant at the $P \leq 0.10$ level (as indicated by the vertical dotted line).The tilled plots, on average, produced more marketable fruit (384 squash) than the no-till plots (233 squash) by the end of the season. Mean cumulative number of cull fruit harvested in till and no-till plots were not significantly different at any date during harvest in 2015 (no cull data were collected in 2014). As with pounds of marketable fruit, the proportion of number of fruits harvested per plot that were marketable were not significantly different between the treatments at $P \leq 0.10$. The proportion of number of marketable fruit harvested in tilled plots was 87%, and in no-till plots was 82% (LSD = 7%).

Squash seedlings emerge through cereal rye residue in a no-till plot in early July 2015.

Figure 5

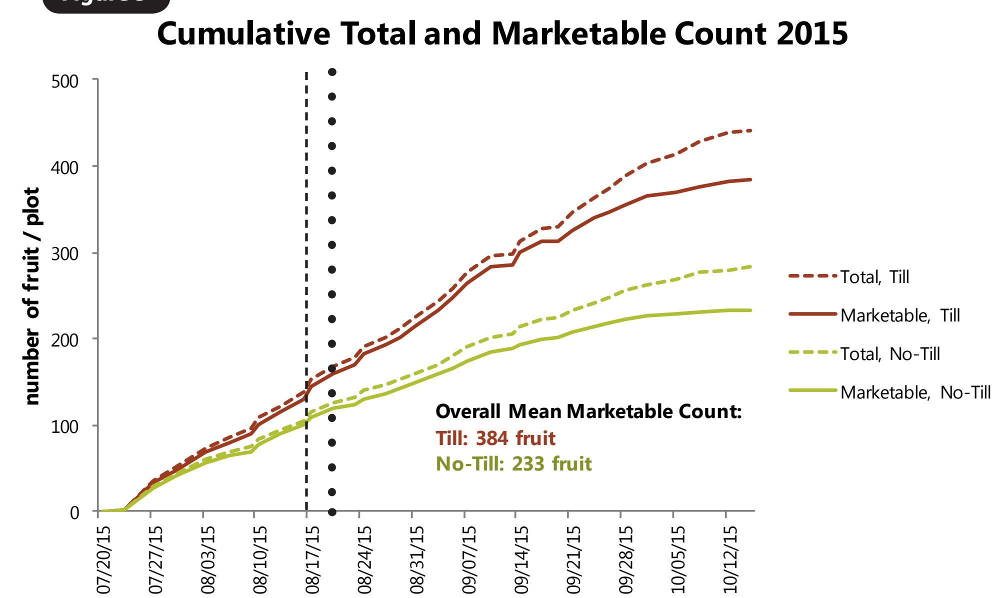


Figure 5. Mean cumulative total (marketable+cull) and marketable number of fruit for each treatment in 2015. At the dashed vertical line, the difference between mean cumulative total fruit count of till and no-till plots becomes (and remains) significant at $P \leq 0.10$. At the dotted vertical line, mean cumulative marketable number of fruits by treatment become and remain significantly different at at $P \leq 0.10$. Plot size was 36 ft x 5 ft (180 ft^2). Cumulative end-of-season numbers of marketable fruit for both treatments are displayed at the final date (Oct. 15).

In 2014, cumulative number of marketable fruits harvested per plot between the treatments began to differ on July 31. The till treatment produced a greater number of marketable fruits than the no-till treatment at the $P \leq 0.10$ level (as indicated by the vertical dashed line in **Figure 6**). Mean cumulative number of marketable fruits harvested per plot at the end of the season were 51.0 and 20.3 for the till and no-till treatments, respectively.

Figure 6

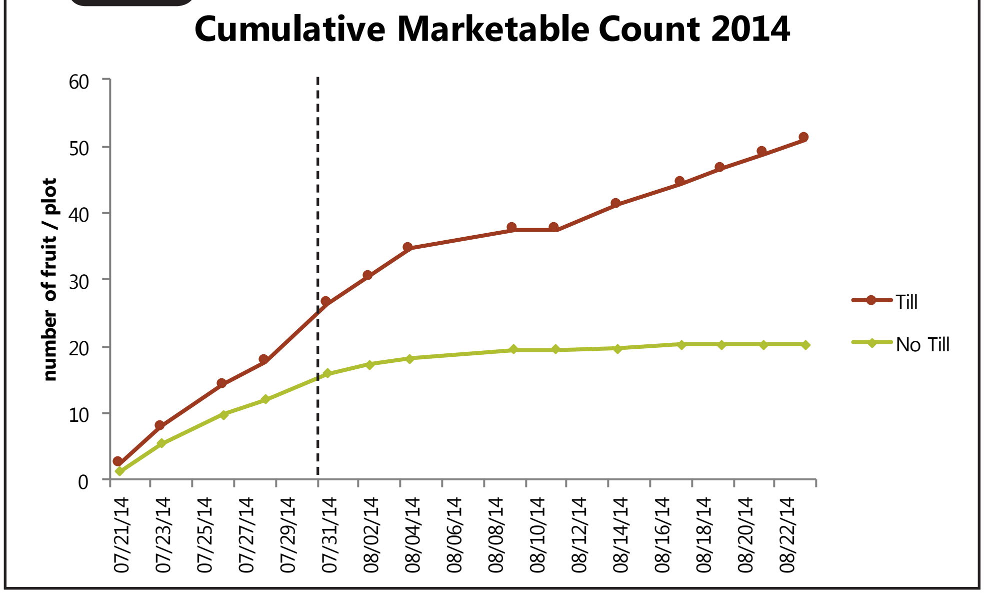


Figure 6. Mean cumulative marketable number of fruits for each treatment in 2015. At the dashed vertical line, the difference between mean cumulative number of fruit in till and no-till plots becomes (and remains) significant at $P \leq 0.10$. Plot size was 25 ft x 5 ft (125 ft^2). Cumulative end-of-season numbers of marketable fruit per plot for both treatments are displayed at the final date (Aug. 23, 2014).

Plant survival rate and pounds of fruit per plant in 2015

Though each plot was seeded with the same number of seeds and thinned, when necessary, to one plant every 1.5 ft, plant survival varied between treatments (**Figure 7**). On July 1 when the first count of plant survival was taken, mean survival rates were not significantly different by treatment. At the last date when plants were counted, Sept. 25, tilled plots had better plant survival (72%) than no-till plots (50%).

The pounds of marketable fruit produced per plant were estimated using a weighted average. These did not differ by treatment. The weighted mean of tilled plots was 13.0 lb/plant, while the weighted mean of no-till plots was 12.1 lb/plant (LSD = 2.1; $P \leq 0.05$).

Thus, the higher rate of survival in the till treatment was the primary reason for greater total and marketable yield in those plots in 2015 (**Figure 3**).

Squash seedlings emerging in till (left) and no-till plots in early July 2015.

Figure 7

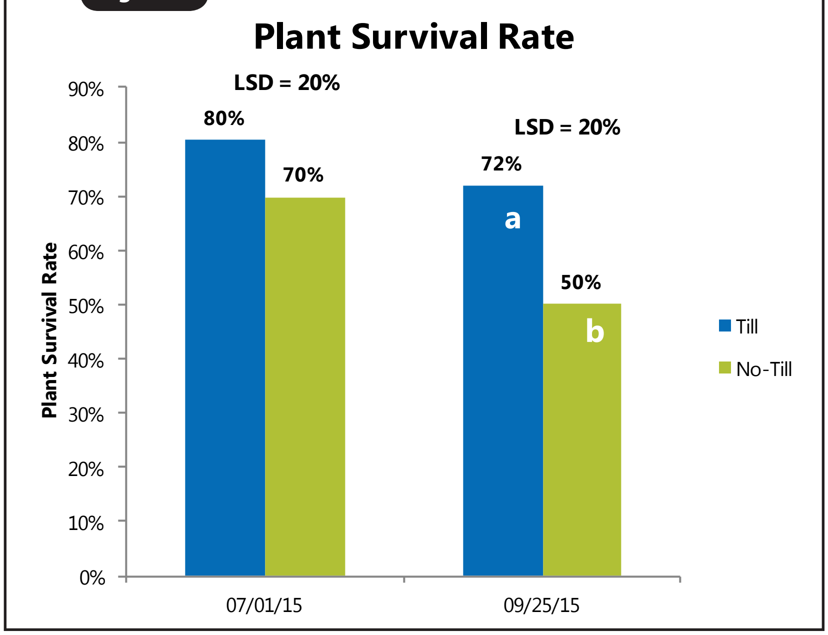


Figure 7. Survival rates of squash plants in till and no-till plots on two dates at Mustard Seed Farm in 2015. For each date, columns with different letters are significantly different. Columns without letters are not different. Means are reported at the top of each column, with the least significant difference (LSD) by pair across the center. If the difference of the means is not greater than the LSD, means are not significantly different. Plot size for which means are reported is 36 ft x 5 ft (180 ft^2). Initial population per plot was 24 plants with a 1.5-ft spacing.

Weeding Time 2015

The amount of time spent weeding plots was measured on three dates in 2015. Though the tilled plots had higher yields due to higher plant survival, there was also a higher labor investment, specifically for weeding. **Figure 8** shows the mean amount of time spent weeding by date. The tilled plots required the most amount of time during the first weeding on July 8. After that initial weeding, there was no difference in the amount of time spent weeding between the treatments at successive dates. Using the average amount of time spent weeding for each date and a labor rate of $10/hour, weeding cost $8.46 per plot in the till treatment and cost $2.56 per plot in the no-till treatment over the course of the growing season.

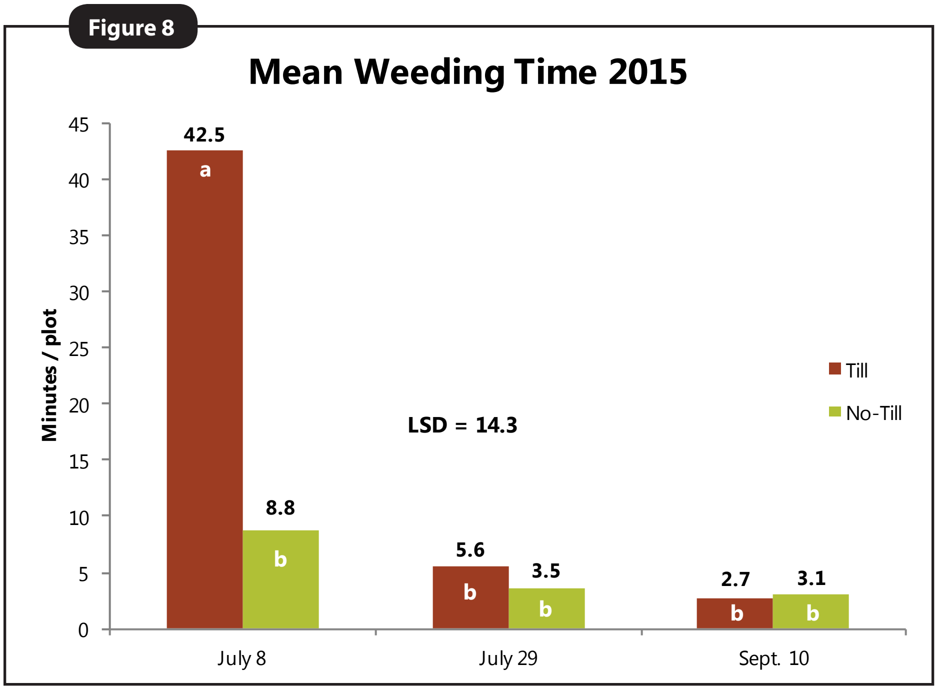


Figure 8. Mean amount of time spent weeding by date for each plot in 2015. Columns with different letters are significantly different. Means are reported at the top of each bar, with the least significant difference (LSD) for the entire season across the center. If the difference of the means is not greater than the LSD, means are not significantly different. Plot size for which means are reported is 36 ft x 5 ft (180 ft^2).

Conclusions and Next Steps

This trial compared till and no-till methods for terminating a cereal rye cover crop ahead of growing summer squash. Like in the 2014 trial, mean plot yields and number of fruit produced were higher in tilled plots than no-till plots in 2015. This trend was driven by better plant survival in the till plots, which had significantly more plants at the beginning and end of the harvest season than the no-till plots. McGary suspected this was due to a mosaic virus outbreak, which could not be determined from the data.

The average pounds of fruit produced per surviving plant were not different between the treatments, nor was the marketable proportion of total yield. Time spent weeding (and thus, cost of weeding) was higher in the tilled plots. Analysis of revenue would be needed to determine if the extra labor is worth the expense.

Said Alice McGary of Mustard Seed Farm, "We were hoping that the no-till method would be as good, or better, than the till method; but it doesn't seem to be the case. I suspect this is because the young plants have less access to nitrogen and are growing in cooler soil and therefore are less able to withstand pests and disease." Alice suspected, and the results confirmed, that surviving plants under each treatment would produce similar yields.

McGary continued, "We would like to use as many no-till practices as possible to decrease the destruction of soil structure and biology, to reduce the use of fossil fuels, erosion, and our time spent weeding. The 'till' method in this project is only a strip tilling, with the majority of the soil remaining mulched and untilled. This 'till' method seems very productive, and maybe it's a good compromise."

Squash seedlings and weeds in a till plot on in early July 2015. Weed pressure was noticeably greater in till plots compared to no-till plots.

References

Iowa Environmental Mesonet. 2015. Climodat Reports. Iowa State University, Ames, IA. http://mesonet.agron.iastate.edu/climodat/ (accessed Nov. 2, 2015).

PFI Cooperators' Program

PFI's Cooperators' Program gives farmers practical answers to questions they have about on-farm challenges through research, record-keeping, and demonstration projects. The Cooperators' Program began in 1987 with farmers looking to save money through more judicious use of inputs. If you are interested in conducting an on-farm trial contact Stefan Gailans @ 515-232-5661 or stefan@practicalfarmers.org.