Integrating cover crops and mulch in reduced-tillage spring squash (*Cucurbita pepo*) ‘Delicata’

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Many growers appreciate the importance of soil quality on crop quality and yield. Reducing tillage is frequently associated with an increase in organic matter and biological activity, and a reduction in soil loss due to water or wind. Reduced-tillage vegetable production systems are being tested throughout the U.S (Abdul-Baki et al., 2005; Cher et al., 2006, Treadwell et al., 2007; Zhou and Everts, 2007). Unfortunately, these systems are also associated with an increase in weeds, especially small-seeded annual grasses, as well as a delay in crop establishment associated with cool soil temperatures. This project was designed to test several cover crop and mulch systems to evaluate the effect of ground cover on soil temperatures, weed density, and crop yield of spring squash (*Cucurbita pepo*) ‘Delicata’ (Figure 1).

Materials and Methods

*Experimental Design.* In this experiment, four production systems were tested using a randomized complete block design with four replications at the North Florida Research and Education Unit in Live Oak, Florida from October, 2008 to June 2009. All systems were managed according the USDA National Organic Standards on land that was not certified organic, but that had no history of prohibited materials for the previous five years. The systems were as follows: 1) Standard Grower Practice with a Weedy Fallow (SGP-WF): Overwinter weedy fallow, spring tillage, black plastic; 2) Standard Grower Practice with Cover Crops (SGP-CC): Winter cover crops terminated in spring with a mower, incorporated with a off-set rolling disk and followed by black plastic; 3) Reduced Tillage with Cover Crop Surface Residue (RT-ROLL): Winter cover crops terminated with a roller-crimper in spring; and 4) Reduced Tillage with Cover Crop Surface Residue covered by Landscape Fabric (RT-ROLL+FABRIC) (Figure 2).
Production. On October 28, 2008, winter rye (Secale cereale ‘FL 401’) was seeded to 90 kg ha\(^{-1}\) in a biculture mixture with an unnamed, commercially available cultivar of hairy vetch (Vicia villosa) seeded to 22.4 kg ha\(^{-1}\) in three systems (SPG-CC, RT-ROLL and RT-ROLL+FABRIC), while SGP-WF was allowed to establish with native vegetation. Each plot was 1.8m wide by 6m long. On March 26, 2009, cover crops were in the mid-to late bloom stage and were terminated with a flail mower and incorporated with an off-set rolling disk in SGP-CC and were terminated with a roller-crimper in RT-ROLL and RT-ROLL+FABRIC. Native vegetation in SGP-WF was mowed with the same flail mower, followed by disking with the rolling disk harrow.

On March 31, granular fertilizer (Nature Safe 8-5-5, Griffin Industries) was applied to all plots according to the University of Florida’s recommendations. Seventy-five percent of nitrogen (N) was applied before planting resulting in the following application: N at 160 kg ha\(^{-1}\), phosphorus (P) at 100 kg ha\(^{-1}\) and potassium (K) at 100 kg ha\(^{-1}\). In each system, fertilizer was added in the following manner: a subsurface shank created a furrow approximately 15 cm off-center on both sides of the anticipated crop line and 15 cm deep. Fertilizer was added to each furrow and furrows were closed by hand. Drip tape (John Deere, Roberts Ro-Drip, 8ml, 30 cm spacing at 91 L per hour per 30 meters) was applied to all plots. Plastic mulch was applied to SGP-WF and SGP-CC plots and landscape fabric (60 cm) was secured with ground staples over the rolled cover crop residue in RT-ROLL+FABRIC treatment. Squash seed was planted to 3.8 cm depth at 60 cm in-row spacing in each plot for a planting density of 8,970 plants ha\(^{-1}\). Additional fertility was supplied by an injectable, flowable powder composed of finely ground soybean meal (Soyaplex-SP 8-1-2, NaEx Corporation). This material was applied through the drip system at a nitrogen rate of 2.9 kg ha\(^{-1}\) weekly beginning at week two (April 8, 2009) and continuing for nine weeks through week 11 (June 3, 2009). In addition, fish emulsion (3-1-1) was applied twice with a foliar application rate of 2.34 L ha\(^{-1}\) at week 4 (April 22) and week 6 (May 6) until run-off.

Data collection. Cover crop above-ground plant material was cut at the soil surface in a 0.5 m\(^2\) frame, dried in a forced-air oven at 60 °C and weighed. Soil temperature was collected with four automated sensors that were placed 4 cm in depth in one plot in each system in the same replicate. Data was collected hourly. Weed density was evaluated on May 28 using a 0.6 m\(^2\) frame. Weeds were identified by species, counted and grouped into either broadleaves or grasses/sedges for analysis. Squash was harvested on June 17, and mature fruit was counted, weighed and graded. Marketable fruit were considered to include fruit that was at least 15 cm in length, skin free from blemishes, uniform in color and typical for the cultivar. All data were analyzed using SAS (V. 9.2) general linear models, and when treatments were significantly different (\(\alpha = 0.05\)) means were separated using Least Significant Differences.

Results and Discussion

Cover crop biomass. The winter cover crops were slow to establish due to cold weather in October and early November. In the spring, neither hairy vetch nor rye produced as much biomass as we have observed in previous years at this location. The combined weight of rye and hairy vetch was 2,200 kg ha\(^{-1}\) on a dry weight basis, and was less than the 6,000 kg ha\(^{-1}\) recommended dry weight at cover crop termination if the cover crop surface residue is to be used.
a weed-suppressive mulch (Morse, 2001). No differences were observed for dry weight biomass among treatments planted to cover crops (data not shown).

Soil temperatures. Soil temperature was different among treatments and the effect of treatment varied depending on the time of day (P < 0.0001). For simplicity, seasonal means are presented in Figure 3. While evening temperatures were similar among treatments, daytime soil temperatures were greatest in SGP-CC and SPG-WF and lowest in rolled cover crop treatments (RT-ROLL and RT-ROLL+FABRIC). Temperature differences between the standard grower practice treatments and the rolled cover crop treatments were greatest during April when air temperatures were reaching highs in the low 30-degree Celsius range. We observed soil temperatures differed by up to 15 °C between treatments during the heat of the day. The optimum monthly temperature range for the best growth and yield of squash is 18-24 °C, with a maximum temperature around 35 °C (Maynard and Hochmuth, 2007). The rolled cover crop treatments consistently remained in the optimum range, while soil incorporated cover crops and weed treatments were considerably warmer during the daytime (Figure 3).

Weed density and biomass. Predominant weed species included yellow nutsedge (Cyperus esculentus), purple nutsedge (Cyperus rotundus), Florida pusley (Richardia scabra), crabgrass (Digitaria sanguinalis), catchweed (Galium aparine), pigweed (Amaranthus spp.), cutleaf evening primrose (Oenothera laciniata) and Virginia pepperweed (Lepidium virginicum). Rolled cover crop with no landscape fabric (CC-ROLL) predictably had the most weeds compared to remaining treatments, but it was surprisingly similar in weed density to treatments with black plastic (SGP-WF and SGP-CC) (Table 1).

Squash Establishment and Yield. Plant establishment was 80% on three plots all in replicate three, and 100% on remaining plots. Missing plants were immediately reseeded for a 100% stand. The total number of fruit harvested from treatments ranged from 24,456 to 35,541 per ha; very low numbers compared to commercial yields (Table 2). Many of the fruit were not marketable due to small size, and the greatest percentage of marketable fruit occurred in the SGP-WF and SGP-CC treatments. Similarly, total fruit weight was greatest in SGP treatments compared to ROLL treatments. Although soil temperatures approached the maximum recommended temperature for squash in SPG systems, those systems produced the greatest yield.

Three weeks prior to harvest, we observed chlorosis of mature leaves and attributed this to low potassium measured in plant tissues with a Cardy meter. However, following harvest, further investigation revealed extensive nematode damage to roots in nearly every plot, evidenced by the presence of galls typically caused by Meloidogyne spp. The last income-producing crop in that field was field corn in 2004, and subsequent crops were pearl millet (Pennisetum glaucum) and cereal rye (Secale cereal) with no fumigants or insecticides applied. The degree of infestation we observed would likely reduce yields of any crop.

Summary

Our objective in this experiment was to evaluate the effect of ground cover on soil temperatures, weed density, and crop yield of spring squash. Despite extensive nematode damage, yield differences were observed among cover crop systems and were influenced by weed and most
likely soil temperature data. Soil incorporated cover crops and weeds, and a production system of black plastic and drip irrigation performed better than rolled cover crops under the conditions of this experiment.

*For more information on reduced tillage vegetable production, visit UF-IFAS EDIS at [http://edis.ifas.ufl.edu/](http://edis.ifas.ufl.edu/) and for a series of educational videos based on results from land grant university research, visit the national Extension website at: [http://www.extension.org/article/18368](http://www.extension.org/article/18368).*

**Literature Cited**


**Figure 1.** Early fruit set on squash (*Cucurbita pepo*) ‘Delicata’.

**Figure 2.** Four spring squash production systems tested in Live Ok, FL: Standard Grower Practice with a Weedy Fallow (SGP-WF): 1) Overwinter weedy fallow, spring tillage, black plastic; 2) Standard Grower Practice with Cover Crops (SGP-CC): Winter cover crops terminated in spring with a mower, incorporated with an off-set rolling disk and followed by black plastic; 3) Reduced Tillage with Cover Crop Surface Residue (RT-ROLL): Winter cover crops terminated with a roller-crimper in spring; and 4) Reduced Tillage with Cover Crop Surface Residue covered by Landscape Fabric (RT-ROLL+FABRIC).
**Figure 3.** Mean soil temperatures in treatments during squash production in Live Oak, FL in spring 2009 over a 24-hour period. Treatments are as follows: SGP-WF = standard grower practice, winter weedy fallow; SGP-CC = standard grower practice, winter cover crop; CC-ROLL = winter cover crop terminated by rolling; and CC-ROLL+LSF = winter cover crop terminated by rolling and covered with landscape fabric.

**Table 1.** Weed density of grass plus sedge weeds and broadleaf weeds per 0.6 m² in squash (*Cucurbita pepo*) ‘Delicata’ produced in four cover management treatments in Live Oak, FL in May 2009.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Grasses/Sedges</th>
<th>Broadleaves</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>SGP-WF</td>
<td>12.00b</td>
<td>0.50</td>
<td>12.50b</td>
</tr>
<tr>
<td>SGP-CC</td>
<td>17.00b</td>
<td>4.75</td>
<td>21.75b</td>
</tr>
<tr>
<td>CC-ROLL</td>
<td>60.25a</td>
<td>20.00</td>
<td>80.25a</td>
</tr>
<tr>
<td>CC-ROLL+LSF</td>
<td>9.75b</td>
<td>3.50</td>
<td>13.25b</td>
</tr>
</tbody>
</table>

| Significance | 0.0216  | NS | 0.0004 |

²Treatments are as follows: SGP-WF = standard grower practice, winter weedy fallow; SGP-CC = standard grower practice, winter cover crop; CC-ROLL = winter cover crop terminated by rolling; and CC-ROLL+LSF = winter cover crop terminated by rolling and covered with landscape fabric.

³Mean separation within column by Fisher’s protected LSD at 0.05. NS = not significant.
Table 2. Number, quality and weight of harvested squash (*Cucurbita pepo*) ‘Delicata’ produced in four cover management treatments in Live Oak, FL in May 2009.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No/Fruit Plant</th>
<th>Average kg/fruit</th>
<th>Marketable No. per ha</th>
<th>Total No. per ha</th>
<th>Total Wt kg/ ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>SGP-WF</td>
<td>1.60a</td>
<td>0.196a</td>
<td>19,846a</td>
<td>35,541a</td>
<td>4360a</td>
</tr>
<tr>
<td>SGP-CC</td>
<td>1.45ab</td>
<td>0.216a</td>
<td>15,003a</td>
<td>32,080ab</td>
<td>4792a</td>
</tr>
<tr>
<td>CC-ROLL</td>
<td>1.10b</td>
<td>0.156b</td>
<td>7,662b</td>
<td>24,458b</td>
<td>3446b</td>
</tr>
<tr>
<td>CC-ROLL+LSF</td>
<td>1.20ab</td>
<td>0.168b</td>
<td>7,699b</td>
<td>26,481ab</td>
<td>3731b</td>
</tr>
</tbody>
</table>

Significance: 0.1030 0.0018 0.0025 0.1030 0.0018

Treatments are as follows: SGP-WF = standard grower practice, winter weedy fallow; SGP-CC = standard grower practice, winter cover crop; CC-ROLL = winter cover crop terminated by rolling; and CC-ROLL+LSF = winter cover crop terminated by rolling and covered with landscape fabric.

Mean separation within column by Fisher’s protected LSD at 0.05. NS = not significant.