A Low Input, Sustainable Production System for Fresh Market Tomatoes

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Introduction

Fresh market tomato is an important vegetable crop in Florida. During the 2009 season, the crop was grown on over 33,000 acres and was valued at over 390 million dollars. The production system, almost universally practiced by growers in Florida, is an intensively managed raised-bed system which includes soil fumigation, polyethylene mulch, drip or seepage irrigation, and stakes. This system produces yields that can exceed 30 tons/acre and has been widely used for over 40 years. Fumigation with a mixture of methyl bromide and chloropicrin has been a critical component for managing soil-borne pests including diseases, nematodes and weeds. However, methyl bromide is scheduled for total phase-out in the United States in the near future due to its potential to deplete ozone.

With the impending loss from use of methyl bromide, intensive efforts have been made by growers and scientists to develop methyl bromide alternatives, mainly in the form of soil-applied fumigants. Data from a series of tests conducted statewide have identified mixtures of 1,3-dichloropropene (Telone II) and chloropicrin as the most likely alternatives to methyl bromide for disease management. These fumigant alternatives, however, provide poor weed control and less than optimal nematode management for second crops.

An effective yet little used pest management practice in tomato production systems is rotation with perennial grasses (sod-based production systems). For example, watermelon growers have traditionally sought bahiagrass sod fields which have lower levels of weeds, pathogenic fungi, and plant-parasitic nematodes. In fact, sod-based rotation is still widely used in many southeastern U.S. production areas. Production systems with perennial grasses such as bahiagrass not only reduce soil-borne pest and weed problems but are also known to provide nutrient recycling, improved soil tilth, organic matter, and increased water holding capacities.

Plant resistance is another important practice that can be used in tomato pest management systems. During the development of the raised-bed production...
system, availability of plant disease resistance in
tomato to nematodes and soil-borne fungi was
limited. However in subsequent years, both the range
of resistance and incorporation of resistances into
highly productive tomato varieties have increased
dramatically. For example, a number of fresh market
tomato varieties available in Florida now have
resistance to Verticillium (race 1) and Fusarium wilts
(races 1, 2, 3), and root-knot nematode diseases. Due
to pathogen adaptability, plant resistance is seldom
recommended as a single control practice but rather
used in an integrated management system consisting
of rotation or chemicals.

With the horticultural improvements for disease
resistance in tomatoes and the well-known record of
sod-based rotation systems, combinations of these
two practices could prove adequate without use of
fumigation in most Florida tomato production fields.
This is particularly relevant with improved scouting
and prediction methods. The utilization and testing of
sod-based systems plus disease resistance in tomato,
however, has been precluded by dependence on
methyl bromide and other soil fumigants. Thus, little
work has been conducted to determine either the
merit or limitations of these two practices as
replacements for soil fumigation. In the very least,
these pest management practices could augment
chemical alternatives that are replacing methyl
bromide.

A Strip Tillage System

Ten field trials were conducted over five years
on well established 'Pensacola' bahiagrass at the
North Florida Research and Education Center,
Quincy. Strip tillage was applied in bahiagrass sod
and tomatoes subsequently transplanted into the
strips. The main factors explored were: 1) sod
management with mowing and herbicides, 2) strip
tillage widths, 3) fertilizer rates, and 4) disease
management. A summary of findings and
observations from these trials are listed below.

Cultural Practices and Weed
Management

The bahiagrass pasture chosen should be a solid
stand at least three-years-old and have little weed
growth. This period of time is required to establish a
good stand of bahiagrass that does not contain weeds
which may serve as hosts to plant disease and insect
pests. Row spacing of four to six feet wide can be
used since no bed is formed. In fact, 4 feet wide row
spacings have produced higher yields than the 6 feet
wide normal spacings in our tests. Bahiagrass strips
should be killed with glyphosate herbicide (sold as
Roundup, Touchdown, Glyphomax, etc.) and then
aggressively roto-tilled two months prior to
transplanting. Strips should be a minimum of
24-inches-wide and on 48” to 72” centers. After the
initial strip tillage operations, pre-plant fertilizer can
be applied and mixed into soil. For weed suppression
before transplanting, apply a recommended pre-plant
herbicide into the tilled strip (Table 1). Under these
conditions, weed management should be minimal
with the exception of managing the bahiagrass
growth in and between rows. To do so, mow the
bahiagrass as needed and/or apply the herbicide
sethoxydim (Poast) or clethodim (Select, Arrow) at
low labeled rates. These herbicides are used to stunt
or reduce growth of the bahiagrass since we
generally do not want to totally kill the grass. A
herbicide is best used immediately before
transplanting in the tilled strips, and 2-4 wks after
transplanting in rows and middles to stunt growth of
the bahiagrass and reduce its competition for
fertilizer.

A summary of studies evaluating tomato yield as
influenced by sod growth management practices in
middles are shown in Table 2. These data show that
tomato yields in the 24-inch-wide tilled strips were
superior to those in the 15-inch-wide strips. Tomato
yield in the mowed treatment with 180 lb/A of N and
24-inch-wide tilled strips was almost twice that of the
1/2 rate of Poast treatment with 180 lb/A of N and
15-inch tilled strips. The full rate of Poast and
Gramoxone (paraquat) plus the 24-inch tilled strips
gave highest yield with 180 lb/A of N. However,
there is a danger of damaging tomato plants with
paraquat and using a third application of a grass
herbicide to replace the paraquat may be as
effective.
Fertilization

As noted earlier, it was found that bahiagrass was a strong competitor with the tomatoes for fertilizer and water. However, with use of appropriate herbicides, competition is limited and fertilizer management is similar to that of conventional systems. Fertilizer N, P$_2$O$_5$ and K$_2$O recommendations for tomato from the Florida Agricultural Extension Service are shown in Table 3. A nitrogen rate of 200 lb/A is recommended for tomato in the raised bed, plastic mulch production system. In our tests, near maximum yields were obtained in strip-tilled tomato with 180 lb/A of N where tilled strip width was 24 inches and sod growth in middles was adequately controlled (Table 2). Extension service soil test recommendations for tomato with very low levels of soil P and K are 150 lb/A of P$_2$O$_5$ and 225 lb/A of K$_2$O. Strip-tilled tomato did not respond to P$_2$O$_5$ levels above 160 lb/A. A response of strip-tilled tomato to K$_2$O levels between 130 and 260 lb/A was observed in only one of the field trials. All P$_2$O$_5$, 50% of K$_2$O and all dolomite, if needed, should be incorporated into the strips before transplanting. Additional potassium should be applied through the drip system at 10% per week at 2, 3, 4, 5, and 6 weeks after transplanting. Nitrogen, at the normal 200 lb actual/acre rate, is recommended with application of 40% incorporated into the tilled strip before transplanting, and 10% per week through the drip system at 1, 2, 3, 4, 5, and 6 weeks after transplanting, also to minimize leaching and competitive uptake by the bahiagrass.

Disease Management

The use of tomato cultivars with multiple nematode and fungal resistances is very important in both the conventional and the strip tillage system. In the field trial reported in Table 4, tomato exhibited good yields and no significant differences in yield or percent marketable fruit were found between a conventional fumigant treatment (Telone C-35) and the non-treated control. Significant differences in yield were observed among tomato varieties, but these were related to differing yield potentials of the varieties and resistance to tomato spotted wilt (TSW). Soil-borne fungal diseases were not detected in tomatoes and root galling caused by nematodes was not detected or at very low levels in the Telone C-35 and non-treated control plots. In those cases where root-galling was found, it was only present in tomato varieties without the Mi-gene resistance. These data show the importance of using varieties resistant to nematodes and other plant diseases since previously weedy spots in the bahiagrass could harbor pockets of disease-causing organisms.

Other Practices

Other tomato production practices in the strip tillage system are similar to those used in raised-bed production. Normal foliar pesticide application schedules are maintained, and tomato plants are staked. An insecticide for wireworms, cutworms and mole crickets may be necessary. In our tests, only mole crickets were a problem and in only one spring trial. An additional consideration is use of subsoiling in the planting row. Subsoiling not only increases tomato rooting depth but also allows for easier and deeper stake placement. The amount of irrigation may need to be increased because of greater evaporation in the absence plastic mulch. Tensiometers installed in tilled strips between plants and observed daily will be valuable to help determine when to irrigate. Tensiometers have a readable scale between 0 and 100 cb with 0 being wet and 100 dry, the ideal range is 5 to 20. Plastic mulch application may be used in the strip-till system for soil warming and weed management. However, equipment will need to be modified or built for applying the mulch.

Advantages

The strip-till tomato production system offers many advantages compared to the conventional production system. The conventional raised-bed plastic mulch system creates conditions that favor the outbreak of many plant pests. Windblown soil created by bare row middles leads to plant injury, which increases foliar diseases. Rain splash dispersal of plant pathogens is increased on bare soil, and populations of key insect pests may be increased. Benefits of strip tillage into bahiagrass include reductions in production costs associated with land preparation, no fumigant costs, and reduced erosion.
due to storm water runoff. Sod-based rotation minimizes the increase of soil-borne pests and reduces the effect of soil compaction due to repeated movement of heavy machinery over the same area. Limited but sound economic data show that grower profits can be increased using this strip tillage system due to fewer inputs required compared to the conventional tomato production system (Chellemi et al. 1999)

Conclusion

Over six million acres of bahiagrass are planted in Florida. This represents a largely untapped resource for Florida tomato growers and indeed other vegetable growers. The present strip-till system will allow for good tomato production and a quick return to grazing since the bahiagrass is not destroyed as in the conventional system. More research and farmer experience is needed to improve tomato production in the strip tillage system. However, this system offers the potential for tomato production that is more environmentally sound and could help the industry remain competitive.

References


Table 1. Herbicides labeled for use in bare-ground tomato production.¹

<table>
<thead>
<tr>
<th>Product</th>
<th>Application method</th>
<th>Pretransplant burndown</th>
<th>Preplant incorporated</th>
<th>Pretransplant surface</th>
<th>Post transplant</th>
<th>Post directed</th>
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<tbody>
<tr>
<td>Aim</td>
<td></td>
<td>X</td>
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<td>X</td>
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<td>Clethodem</td>
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<td>(Select, Arrow,</td>
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<td>Dacthal 75 DF</td>
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<td>Devrinol 50 DF</td>
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<td>X</td>
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<tr>
<td>Dual Magnum</td>
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<td>Glyphosate</td>
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<td>Matrix</td>
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<td>Metribuzin</td>
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<tr>
<td>Paraquat</td>
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<td>X</td>
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<tr>
<td>(Gramoxone</td>
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<td>Inteon, Firestorm</td>
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<td>Poast</td>
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</table>

¹See label for detailed instructions on use, restrictions, precautions, pre-harvest intervals and specific weeds controlled.

Table 2. Yield response of strip-till tomato in bahiagrass pasture to nitrogen (N) rate and management of sod growth in middles.

<table>
<thead>
<tr>
<th>N rate in lb/A</th>
<th>Width of tilled strip-inches</th>
<th>Sod growth management in middles</th>
<th>Yield in 25 lb. Boxes/A</th>
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</thead>
<tbody>
<tr>
<td>180</td>
<td>15</td>
<td>1/2 rate of Poast 4 &amp; 6 wks after transplanting</td>
<td>641</td>
</tr>
<tr>
<td>360</td>
<td></td>
<td></td>
<td>1071*</td>
</tr>
<tr>
<td>180</td>
<td>24</td>
<td>Full rate of Poast 4 &amp; 6 wks after transplanting</td>
<td>1133</td>
</tr>
<tr>
<td>360</td>
<td></td>
<td></td>
<td>1265</td>
</tr>
<tr>
<td>180</td>
<td>24</td>
<td>Sod mowed as needed</td>
<td>1104</td>
</tr>
<tr>
<td>360</td>
<td></td>
<td></td>
<td>1562*</td>
</tr>
<tr>
<td>180</td>
<td>24</td>
<td>Full rate of Poast preplant &amp; 4 wks after transplanting plus Gramoxone 9 wks after transplanting</td>
<td>1634</td>
</tr>
<tr>
<td>360</td>
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<td>1556</td>
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</table>

* Asterisk denotes a significant difference between the two N rates in each row at the 5% level.
Table 3. IFAS fertilizer recommendations for mineral soils for tomato on 6-foot centers.\(^1\)

<table>
<thead>
<tr>
<th>Soil-test level</th>
<th>Fertilizer Recommendations in lbs./A</th>
<th>N</th>
<th>P(_2)O(_5)</th>
<th>K(_2)O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very High (VH)</td>
<td>200</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>High (H)</td>
<td>200</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Medium (M)</td>
<td>200</td>
<td>100</td>
<td>100</td>
<td></td>
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<tr>
<td>Low (L)</td>
<td>200</td>
<td>120</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>Very Low (VL)</td>
<td>200</td>
<td>150</td>
<td>225</td>
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</tr>
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</table>

\(^1\)Olson, S.M., Stall et al., 2009 (see reference section).

Table 4. Tomato yield and percent marketable fruit in a field trial utilizing bahiagrass sod, Telone C-35 and disease resistant varieties.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield, 25 lb. Boxes/A</th>
<th>% Marketable</th>
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<tbody>
<tr>
<td>Telone C-35</td>
<td>1279 a</td>
<td>88.0 a</td>
</tr>
<tr>
<td>Control</td>
<td>1303 a</td>
<td>89.4 a</td>
</tr>
<tr>
<td>BHN 577 (VFFNFCrTsw)</td>
<td>1327 b</td>
<td>91.5 a</td>
</tr>
<tr>
<td>BHN 543 (VFFN)</td>
<td>1524 a</td>
<td>85.1 a</td>
</tr>
<tr>
<td>Solar Set (VFF)</td>
<td>1459 ab</td>
<td>88.9 a</td>
</tr>
<tr>
<td>Rutgers (none)</td>
<td>852 c</td>
<td>88.7 a</td>
</tr>
</tbody>
</table>

\(^1\)Column means followed by the same letter are not significantly different at the 5% level (P ≤ 0.05). Statistical comparisons were not made between varieties and Telone C-35.