Conclusions

Drip irrigation resulted in better control of soil moisture, uniformity of growth and higher yields of mulched and unmulched tomatoes, pole beans and sweet corn than standard irrigation practices. This was accomplished with lower water and energy use. If regulations are imposed to restrict water use for agricultural production growers can then switch to drip irrigation or they may wish to switch sooner to realize higher yields and better quality.

Chlorine should be used in drip irrigation lines after each fertilizer injection to keep the lines free from bacteria and other microorganisms that clog the system. A minimum of 0.5 to 2.0 ppm residual chlorine should be maintained through all lines for at least 30 minutes. Fertilizer injection through drip irrigation can provide precise efficient nutrition for crops. The effectiveness of drip irrigation on row crops is shown by its rapidly expanding use. Acreage in Dade County increased from 10 acres to 1200 acres last year and about 4000 acres are estimated this season.

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CHEMICAL CONTROL OF FUSARIUM WILT OF WATERMELON

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Abstract. During 1972-1974, soil fungicides and fumigants were evaluated for the control of fusarium wilt (Fusarium oxysporum Schlecht. f. sp. niveum [E. F. Sm.] Snyd. & Hans.) of watermelon cultivars with different levels of tolerance to the disease. Only the fumigant-type materials—DD-MENCS and sodium azide—provided good, consistent control. Benomyl and thiabendazole reduced wilt in some treatments, but control was very inconsistent. With the highly susceptible 'New Hampshire Midget' and 'Garrisonian', none of the materials controlled fusarium wilt throughout the season. Yields of these 2 cultivars were negligible regardless of treatment. With the moderately resistant 'Charleston Gray', the better treatments generally provided sufficient wilt control to prevent a large loss of plants. Melon size was sometimes small, however, indicating a need for better late-season control.

Fusarium wilt is the main reason that watermelons are best grown on new land in Florida. When watermelon growers use "old" land—land previously planted in watermelons—they may suffer losses from reduced stands due to seedling wilt and from wilting of plants throughout the season. Plants that do not die may be stunted, and yields reduced. When it is impractical to use new land, or new land is not available, a rotation of at least 6 years between watermelon crops is recommended. This long rotation is advisable even when growing resistant watermelon cultivars.

Resistance coupled with the long rotation is the only control available for fusarium wilt of watermelon. With the decreasing availability of land, the lengthy rotation is becoming more burdensome each year. In an earlier study in Florida on fungus populations in soil planted annually in watermelons, broad-spectrum fumigants reduced Fusarium populations considerably more than did fungicides (4). The broad-spectrum fumigant was also effective in reducing seedling wilt (2). The systemic fungicide benomyl has provided some control of fusarium wilt in greenhouse studies (1, 5, 6) and in at least one field study (6). The purpose of this report is to present the results of a 3-year evaluation of several fungicides and fumigants for the control of watermelon fusarium wilt on "old" land.

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Materials and Methods

Test plots were arranged in randomized complete blocks with 4 replications. In 1972 and 1973 each row in a plot contained 5 hills with 5 ft between hills. In 1974 each row contained 10 hills with 2.5 ft between hills. Rows were 10 ft apart. In 1972 each treatment plot consisted of one row of 'New Hampshire Midget', susceptible to fusarium wilt, and one row of 'Charleston Gray', moderately resistant to wilt (3). In 1973 each treatment plot consisted of one row of 'New Hampshire Midget', one row of 'Charleston Gray', and one row of 'Smokylee'—highly resistant to wilt. In 1974 a plot consisted of one row of 'Charleston Gray' and one row of 'Garrisonian', susceptible to wilt. Watermelon seed, 6 per hill, were planted on March 2, 1972, March 1, 1973, and March 1, 1974. The 1972 and 1974 tests were conducted in the same field. Watermelons had been grown there 3 times during the 2 years preceding the initiation of this test. The 1973 test area had been planted in watermelons in 1972 and wilt had been severe.

Chemicals tested were: methyl l-(butylcarbamoyl)-2-benzimidazolcarbamate (benomyl) (Benlate); a 1:1 mixture of 1,2-dichloropropane and 1,3-dichloropropene and related chlorinated C₃ hydrocarbons (80%) and methyl isothiocyanate (20%) (DD-MENCS) (Vorlex); 2-(4-thiazolyl)-benzimidazole (thiabendazole) (Merbert 360); pentachloro-nitrobenzene (10%) and 5-ethoxy-3-(trichloromethyl)-1,2,4-thiadiazole (2.5%) (PCNB-ETMT) (Terraclor Super-X); and sodium azide (Smite).

Benomyl and thiabendazole treatments that were incorporated into the soil were dissolved in water, sprayed over a 30-inch bed, and rotovated into the soil 1 day prior to planting. In 1974, benomyl was applied as a soil drench on the 30-inch bed both at planting and 6 weeks after planting. Weekly spray treatments of benomyl and thiabendazole were applied to a 1-ft band centered on the bed, beginning 4 days after planting. In 1972 and 1973 this band was widened, as the plants grew, in order to always cover the foliage, but in 1974 the weekly benomyl spray was applied only during the first 3 weeks after planting. PCNB-ETMT granules were broadcast over the 30-inch bed and rotovated into the soil the day before planting.

DD-MENCS was applied 3 weeks before planting by injection 8 inches deep and with an 8-inch spacing over a 30-inch bed. Sodium azide granules were incorporated into a 6-ft band with a rotovar and the beds were formed immediately in the center of this band. One treatment of sodium azide was applied 3 months prior to planting and the other treatment was applied 3 weeks prior to planting. The surface of the plot was sealed with about 0.7-inch of water immediately after the application of DD-MENCS and sodium azide.

Dead plants were counted 3 times weekly during the first 5 weeks, and weekly thereafter. *Fusarium* was identified by correlating symptoms with microscopic identification either directly from dead seedlings which had been in a moist chamber or from cultures isolated from the seedlings.

Results

1972 test. In 'New Hampshire Midget', some control of seedling wilt was provided by the benomyl spray, incorporated benomyl, and PCNB-ETMT treatments (Table 1). Through thinning, at 6 weeks after planting, only DD-MENCS and incorporated benomyl were still providing good control. The lack of effectiveness of the DD-MENCS against seedling wilt was surprising, but may have resulted from survival of *Fusarium* on the soil surface since a plastic cover was not used.

From thinning to harvest none of the treatments controlled fusarium wilt in 'New Hampshire Midget' (Table 1). DD-MENCS provided excellent control until 2 weeks after thinning when the plants began to wilt, and within 4 weeks 90% of them were dead. No yields in 'New Hampshire Midget' were over 2 tons/acre.

In 'Charleston Gray', DD-MENCS and benomyl spray were very effective through thinning (Table 1). Incorporated benomyl, thiabendazole, and PCNB-ETMT also reduced fusarium wilt slightly during the first 6 weeks. Only DD-MENCS provided good control through harvest. Highest yields were from the DD-MENCS and benomyl spray treatments.

1973 test. Only DD-MENCS provided any control of fusarium wilt of 'New Hampshire Midget', and it was only effective for 5-6 weeks after planting (Table 2). The DD-MENCS and benomyl combination treatments controlled seedling wilt in 'Charleston Gray'. From 3 weeks after planting through harvest, the loss of 'Charleston Gray' plants to wilt was insignificant. 'Smokylee' had 3% or less loss from fusarium wilt over the entire season regardless of treatment.
Table 1. Effect of soil fungicides and a fumigant on Fusarium wilt of watermelon in 1972.

<table>
<thead>
<tr>
<th>Treatment and rate</th>
<th>New Hampshire Midget</th>
<th>Charleston Gray</th>
<th>Yield (tons/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-3 hrs.</td>
<td>3-6 hrs.</td>
<td>6 wks- harvest</td>
</tr>
<tr>
<td>DD-MENCS, 30 gal</td>
<td>16</td>
<td>1</td>
<td>98</td>
</tr>
<tr>
<td>Benomyl, 10 lb.</td>
<td>4</td>
<td>16</td>
<td>76</td>
</tr>
<tr>
<td>Benomyl spray, 1 lb.</td>
<td>6</td>
<td>47</td>
<td>100</td>
</tr>
<tr>
<td>Thiabendazole, 13 lb.</td>
<td>14</td>
<td>43</td>
<td>85</td>
</tr>
<tr>
<td>PCNB-ETMT, 12.5 lb.</td>
<td>7</td>
<td>29</td>
<td>74</td>
</tr>
<tr>
<td>Untreated</td>
<td>13</td>
<td>39</td>
<td>83</td>
</tr>
</tbody>
</table>

z Rates are given on a broadcast basis. Benomyl weekly sprays were applied to a 1-ft band and all other chemicals to a 30-inch bed. Rows were 10 ft apart.

* Data is given as percentage plants dying during the first 3 weeks after planting, 3 to 6 weeks, and 6 weeks (thinning time) to harvest.

There was no marketable yield of 'New Hampshire Midget'. Although differences in yield among treatments of 'Smokylee' and 'Charleston Gray' were small, the untreated plots had the lowest yields. The highly resistant 'Smokylee' yielded better than 'Charleston Gray'.

1974 test. In 'Garrisonian', DD-MENCS and both treatments of sodium azide provided good wilt control to thinning at 5 weeks (Table 3). After 8 weeks only the February sodium azide treatment was still effective. Plants in the DD-MENCS and December sodium azide treatments started wilting and dying after 5-6 weeks. Wilt became severe in the February sodium azide treatment 9-10 weeks after planting. There was no yield of 'Garrisonian'.

DD-MENCS and both treatments of sodium azide provided some protection from wilt in

Table 2. Effect of soil fungicides and a fumigant on Fusarium wilt of watermelon, 1973.

<table>
<thead>
<tr>
<th>Treatment and rate</th>
<th>New Hampshire Midget</th>
<th>Charleston Gray</th>
<th>Yield (tons/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-3 hrs.</td>
<td>3-6 hrs.</td>
<td>6 wks- harvest</td>
</tr>
<tr>
<td>DD-MENCS, 30 gal</td>
<td>1</td>
<td>8</td>
<td>85</td>
</tr>
<tr>
<td>Benomyl comb., 10 lbs. + 1.0 lb.</td>
<td>17</td>
<td>11</td>
<td>85</td>
</tr>
<tr>
<td>Benomyl incorp., 10 lbs.</td>
<td>20</td>
<td>13</td>
<td>85</td>
</tr>
<tr>
<td>Benomyl, 1.0 lb.</td>
<td>14</td>
<td>13</td>
<td>87</td>
</tr>
<tr>
<td>Thiabendazole spray, 1.2 lb.</td>
<td>18</td>
<td>17</td>
<td>82</td>
</tr>
<tr>
<td>Untreated</td>
<td>14</td>
<td>12</td>
<td>65</td>
</tr>
</tbody>
</table>

z Weekly sprays were applied to a 1-ft band and all other treatments to a 30-inch bed. Benomyl combination treatment received both incorporated and weekly spray applications. Rates are given on a broadcast basis.

* Data is given as percentage plants dying during the first 3 weeks after planting, 3 to 6 weeks, and 6 weeks (thinning time) to harvest.
'Charleston Gray' through thinning at 5 weeks after planting (Table 3). In 'Charleston Gray' there was less than 15% wilt from thinning to harvest with no obvious differences among treatments.

Early yield from the February sodium azide treatments, harvests through June 6, was fairly good for "old" land (Table 3). This early yield, which would be the most valuable one in the market, was 3 times that of the untreated plot. Total yield was also highest in the February sodium azide treatment. Melon size was not very good, indicating that late-season wilt control was not sufficient.

**Discussion**

Under the severe fusarium wilt pressure on the "old" land used in these tests only the fumigant-type materials, DD-MENCS and sodium azide, were consistently effective. Benomyl and thiabendazole, incorporated or as a spray, reduced wilt in some treatments, but were very inconsistent.

With the highly susceptible cultivars, 'New Hampshire Midget' and 'Garrisonian', this test demonstrated that a high level of control of the wilt fungus must be maintained throughout the season. This fact was clearly shown by the fumigant-type materials where control of wilt was almost complete for 6-8 weeks and then the plants suddenly began to die. This could indicate either reinfestation of the fumigated area or growth of the roots into unfumigated soil. The longer-lasting effectiveness of the 6-ft sodium azide band over the 3-ft DD-MENCS in 1974 indicated that growth of the roots out of the fumigated area may be a problem.

With the moderately resistant 'Charleston Gray', a high level of *Fusarium* control during the first 6 weeks seemed sufficient to prevent a large scale loss of plants. Although there was no large scale loss of plants, reinfestation or root growth out of the fumigated band resulted in some re-

<table>
<thead>
<tr>
<th>Treatment and rate</th>
<th>0-5 wks</th>
<th>5-8 wks</th>
<th>5 wks harvest</th>
<th>0-5 wks</th>
<th>Early yield</th>
<th>Total yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium azide (Feb.), 30 lbs.</td>
<td>12</td>
<td>20</td>
<td>60</td>
<td>10</td>
<td>10.3 a</td>
<td>13.7</td>
</tr>
<tr>
<td>DD-MENCS, 30 gal</td>
<td>5</td>
<td>63</td>
<td>84</td>
<td>4</td>
<td>5.7 ab</td>
<td>10.3</td>
</tr>
<tr>
<td>Sodium azide (Dec.), 30 lbs.</td>
<td>17</td>
<td>53</td>
<td>69</td>
<td>15</td>
<td>6.4 ab</td>
<td>11.6</td>
</tr>
<tr>
<td>Benomyl drench, 10 lbs.</td>
<td>30</td>
<td>60</td>
<td>70</td>
<td>24</td>
<td>2.6</td>
<td>9.7</td>
</tr>
<tr>
<td>Benomyl spray, 2.5 lbs.</td>
<td>40</td>
<td>60</td>
<td>78</td>
<td>28</td>
<td>3.2 b</td>
<td>10.2</td>
</tr>
<tr>
<td>Untreated</td>
<td>41</td>
<td>45</td>
<td>73</td>
<td>25</td>
<td>3.3 b</td>
<td>10.9</td>
</tr>
</tbody>
</table>

Benomyl weekly spray was applied to a 1-ft band, sodium azide to a 6-ft band prior to bedding, and the other two treatments to a 30-inch bed. Sodium azide was applied either in December or prior to planting in February. Rates are given on a broadcast basis.

Wilt data is given as percentage plants dying during the time from planting to thinning (5 weeks), from 5 to 8 weeks, and from 5 weeks to harvest. Yields are given in tons per acre.

Early yield included harvests through June 6. Mean separation in columns by Duncan's new multiple range test, 5% level. Benomyl drench treatment was not included in statistical analysis because of 2 missing plots.
duced yields and melon size in 'Charleston Gray'. Perhaps if highly resistant cultivars, such as 'Smokeylee' and 'Calhoun Gray', were protected from Fusarium for 3-6 weeks, they would then be resistant enough to produce normal yields on "old" land.

Chemical control of fusarium wilt on highly susceptible cultivars appears impractical and they were included in these tests merely as a measure of the disease pressure. It may be possible in the future to combine some kind of chemical treatment with the moderate resistance of 'Charleston Gray', or some other cultivar, and obtain acceptable commercial yields on Fusarium-infested soil. The best approach for conquering the "old" land problem in watermelon would seem to lie in integrating chemical treatments such as DD-MENCS or sodium azide with the high type resistance of cultivars such as 'Calhoun Gray' or 'Smokeylee' and modified cultural practices such as delayed thinning.

**Literature Cited**


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**EFFECT OF LIMING AND NITROGEN SOURCE ON FUSARIUM WILT OF CUCUMBER AND WATERMELON**

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*IFAS, Agricultural Research Center*

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Abstract. Two field experiments (Spring, 1974 and 1975) were conducted on Myakka fine sand to determine the effect of lime and nitrogen source on the development of Fusarium wilt of cucumber and watermelon. The same site, with the same experimental design, was used for each experiment. In both experiments, gross yields were increased and wilt development decreased by raising the soil pH with hydrated lime. In the first experiment with watermelon and in the second experiment with both crops the beneficial effect of liming was reversed by the use of ammonia-nitrogen compared to nitrate-nitrogen. For maximum control of wilt, liming had to be augmented by the use of nitrate-nitrogen.

Everett and Blazquez (2) demonstrated that increasing amounts of lime from zero to 9,000 lbs/A decreased Fusarium wilt, incited by *Fusarium oxysporum* f. *niveum*, development and linearly increased marketable yields of watermelon from zero to 13.8 T/A. They further demonstrated that wilt control resulted from an increased soil pH, not from an increased calcium supply.

Several workers (1, 2, 3, 4, 5, 6, 8) have reported control or decreased incidence of Fusarium wilt of tomato, incited by *F. oxysporum* f. *lycopersici*, by applying lime to the soil. Jones and Woltz (3, 4) demonstrated that this control resulted from an elevated soil pH that created a micronutrient imbalance which decreased the growth, sporulation, and virulence of the soil-borne pathogen.

Although control of watermelon and cantaloupe wilt (7) by lime amendments has been reported, similar control has not been demonstrated for cucumber wilt. Because of this and because Crall and Hopkins (personal communication) were unable to duplicate the work of Everett and Blazquez, two field experiments (Spring, 1974 and 1975) were carried out to determine the effect of lime and nitrogen source on development of Fusarium wilt of cucumber and watermelon in-