The Belle Glade isolate and the two ICPB isolates of *P. marginalis* caused rotting of lettuce heads, cucumber fruit, and potato tubers. Appreciable decay of these inoculated vegetables was evident within 24 hours (Figure 2) and extensive rotting occurred in 4 days. The Belle Glade isolate was considerably more active than the other two isolates in its decay-causing ability. Reisolation of the bacterium from such artificially inoculated tissues was made with ease.

Discussion.—Marginal leaf blight probably occurs to some extent each year in Florida on lettuce and related crops. The disease reached epiphytotic proportions during the winter season of 1966-1967 in the Everglades farming area. The reason for the extreme severity was difficult to determine. Darby (6) suggested that cold temperatures may predispose lettuce tissues to bacterial rots. Affected tissues on plants in the Belle Glade area all appeared to be of the same general age which gives credence to the suggestion of a common predisposing factor. Cold temperatures followed by warm humid days preceded the disease outbreak in 1966-1967.

Marginal leaf blight has gone unrecognized in Florida as an important disease of lettuce. The fact that *P. marginalis* not only caused a field disease but was also capable of bringing about extensive losses of produce in transit and in market should be of concern to Florida growers and shippers. No specific control measures for the field phase of the disease have been worked out. The maneb (manganese ethylene bisdithio carbamate)—copper sprays failed to give control in the 1966-1967 season. Streptomycin may be effective against the disease (5) but its use does not have the Food and Drug Administration approval. Rotation with a non-susceptible crop may be of value as the bacterium probably lives between seasons in the crop residue. Care in cultivation, harvesting and packing along with rapid precooling should reduce losses. *P. marginalis* was capable of causing decay at temperatures as low as 36°F (7) so in-transit temperatures of 32-33°F should be maintained.

LITERATURE CITED

SUPERIOR NEW STRAWBERRY CLONES RESIST VERTICILLIUM WILT

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*Sub-Tropical Experiment Station*

*Homestead*

Florida's $8,000,000 strawberry industry, concentrated in west central and southeast sections of the state, produced 20,930,000 pounds of fruit from 2,300 acres in 1965-1966 according to Florida Department of Agriculture records (2). Preliminary 1966-1967 statistics revealed a slight decrease to 2,000 acres; however, the long range outlook of the DARE Report* suggested expansion of this industry in the future (1). Since 1960, acreage in Dade County accounted for 30% of the state production; in 1967, 685 acres were harvested in Dade County.

Research has contributed to the solution of some strawberry production problems with new

*Refers to University of Florida analysis of agriculture industry entitled "Developing Agricultural Resources Effectively."*
and improved cultural techniques and methods (11, 13) and effective pest control programs (6, 8). The introduction of the variety Florida 90 by Brooks in 1952 (7) had a significant impact on the growth and present vitality of the industry. In recent years the need for more productive varieties with better shipping qualities and good flavor has become apparent. The possibility of introducing varieties from other areas into Florida to meet these needs was pointed out by Locascio (12).

Dade growers need new highly productive varieties with superior horticultural characteristics that are also resistant to Verticillium wilt (*Verticillium albo-atrum* Reinke & Berth.), a disease which became a limiting factor during the 1963 season (17). This wilt, new to strawberries in Florida, but long a serious problem in other states (15, 14, 19, 24), caused production losses in one-fourth of Dade's acreage in 1963 and was a problem in subsequent seasons as the infestation of agricultural land rapidly increased. The widely grown Florida 90 is very susceptible to this soil-borne fungus.

To meet the need for new varieties for Florida, a breeding program was initiated in 1963 at the Sub-Tropical Experiment Station in Homestead. Its immediate goal was evaluation of sources of Verticillium wilt resistance for subsequent incorporation into adapted, superior varieties. The progress and prospects of this research are described herein.

**Sources of Resistance**

There are several Verticillium wilt resistant strawberries (10, 22). Most have limited geographic adaptation and one or more undesirable horticultural traits. California strawberry breeders have noted a possible negative relationship between Verticillium wilt resistance and desirable performance traits (10).

Although the original source of resistance in modern varieties and clones is obscure, there is evidence it originated in *Fragaria chiloensis* (L.) Dene. used in some early breeding of the Ettersburg clones (9). Verticillium resistance in *F. chiloensis* clones from different areas is well documented (20, 21, 23, 16), and recently Bringhurst et al (5) found resistant plants in several natural populations from California coastal sand dunes. California researchers (2, 4) suggested that factors governing Verticillium resistance are complex and not fully understood.

Several resistant varieties and breeding stocks were evaluated at the Sub-Tropical Experiment Station for: 1) resistance to Florida isolates of the pathogen; 2) commercial potential and adaptation to subtropical growing conditions; and 3) potential use as parental material to breed varieties for winter and spring production in Florida.

Since no resistant clone or variety from other areas showed promise for commercial production (18), five resistant clones supplied by Dr. Bringhurst, University of California, Davis, were selected for matings with Florida 90, which served as one parent in most hybridizations. The female parent of promising new Florida clone, 113 V, was California stock 39.11-74; the male parent was Florida 90.

**Evaluation of Verticillium Wilt Resistance**

Inoculation and disease rating techniques employed were similar to those described by Bringhurst *et al* (4).

Seed of each hybrid was germinated in finely screened peat moss-vermiculite mix. When seedlings were three to four weeks old, their roots were dipped in a viscous water suspension of conidia and microsclerotia of *Verticillium albo-atrum*. They were planted in pots and observed two to three months and symptomless survivors were inoculated again. At this point plants were transplanted into plant production beds for runner plant development. Since the necessity for repeated inoculations to reveal true clonal reaction to Verticillium was well documented (4, 5), plants removed from beds for field trials were inoculated a third time. Three field trials were purposely located on infested land which provided season-long opportunity for clonal phenotypic expression of Verticillium wilt resistance or susceptibility.

**1966 and 1967 Replicated Tests**

Yield trials, principally comparing promising new Verticillium wilt resistant clones with Florida 90, were conducted during the winters of 1966 and 1967. Randomized 20 plant plots consisted of two rows 15 inches apart with 15 inch spacing between plants. A randomized block design was used, with each of four beds constituting one replication. The fertilizer was 5000 pounds per acre of 4-8-6-2-1 with 20% of the nitrogen as nitrate. It was incorporated by a
rotovator before the beds were covered with 1½ mil black plastic. Plants, selected for uniformity, were planted through the mulch.

The 1966 trial was on virgin Rockdale soil and the 1967 test was on “old” Rockdale soil thoroughly infested with the Verticillium fungus, encouraged since 1964 with cover crops of okra and four uniform spray applications of Verticillium conidia and microsclerotia. In 1967 wilt susceptible Florida 90 and resistant 113-D5 V were compared both on plots fumigated by injection of Vorlex (50 gpa) and on non-fumigated plots.

Routine irrigation and pest control programs were used.

RESULTS AND DISCUSSION

Of the four clonal families compared with Florida 90 in 1966, the 113 clonal family had superior yields, plant vigor, Verticillium wilt resistance, fruit size and shape. Yield and fruit size data for 10 breeding clones and Florida 90 are presented in Table 1. These data supported further evaluation of 113 clones, but revealed little promise for other breeding stocks.

In 1967 four of the most promising 113 clones were compared with Florida 90, Dabreak and 112-D4 on Verticillium-infested land. Yield, fruit size and percent crop culled for the seven stocks are presented in Table 2. The 113 clones were again superior, but in this test the wilt pathogen severely affected growth and yields of Florida 90 and Dabreak plants shortly after harvests were initiated. For the second consecutive year 113-D1 proved superior. The 112-D4 clone, included because of high sugar content, flavor and dark-red color, proved worthless.

The 1967 comparison of fumigated and untreated infested plots is shown in Table 3. The conspicuous differences in the Florida 90 fumigated and untreated plots were attributed to Verticillium wilt; however, this was not the case with the comparison of plants in fumigated and unfumigated plots of 113-D5 V, which appeared similar. The cause of the yield difference in 113-D5 plots was not determined. It is noteworthy that 113-D1 plot responses without fumigation were statistically similar to 113-D5 fumigated plots and superior to Florida 90 fumigated plots.

DESCRIPTION OF 113 V CLONES

Plants are slightly larger than Florida 90 plants due mainly to larger leaves with broader leaflets. Individual leaflets have wider, more prominent serrations and are flatter than Florida 90 leaves. The foliage provides excellent protection for fruit, which generally do not protrude from the edge of the foliage canopy.

Inflorescences are predominantly basal branching and do not proliferate into numerous branches bearing small fruit; a rather substantial proportion of fruit is produced on primary and secondary flowers. This tendency was in part responsible for the production of larger fruit (see Tables 1, 2 and 3).

Fruit of all 113 clones were medium-long conic in shape with very few catfaced or multiple-tipped fruit. Their shape was intermediate between parental shapes (i.e. the long-necked, conic of Florida 90 and globose-conic of the California numbered breeding clones). They ripened from fruit tip to stem end which is opposite to the way Florida 90 ripens.

Preliminary grower evaluations indicated the fruit shape was desirable in packing and ship-

Table 1. Yields and fruit size of 10 Verticillium wilt resistant strawberry clones and Florida 90 on virgin Rockdale soil. *

<table>
<thead>
<tr>
<th>Clone</th>
<th>Total Yield ** (oz.)</th>
<th>Fruit Size (oz.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>113-D1 V</td>
<td>60 a</td>
<td>.23 ab</td>
</tr>
<tr>
<td>113-D6 V</td>
<td>58 a</td>
<td>.22 ab</td>
</tr>
<tr>
<td>113-D5 V</td>
<td>54 ab</td>
<td>.24 a</td>
</tr>
<tr>
<td>113-D2 V</td>
<td>51 ab</td>
<td>.23 ab</td>
</tr>
<tr>
<td>113-D3 V</td>
<td>48 abc</td>
<td>.21 b</td>
</tr>
<tr>
<td>91-D12-D1 V</td>
<td>40 bcd</td>
<td>.18 e</td>
</tr>
<tr>
<td>Fla. 90</td>
<td>37 cd</td>
<td>.16 cd</td>
</tr>
<tr>
<td>112-D6 V</td>
<td>36 cd</td>
<td>.17 cd</td>
</tr>
<tr>
<td>112-D4 V</td>
<td>27 de</td>
<td>.17 cd</td>
</tr>
<tr>
<td>112-D7 V</td>
<td>22 e</td>
<td>.15 d</td>
</tr>
<tr>
<td>Fla. 90 (inoc.)</td>
<td>9 f</td>
<td>.15 d</td>
</tr>
</tbody>
</table>

* Values = plot averages; differences between numbers followed by same letter are not statistically significant at the 5% level according to Duncan's Multiple Range test.

** From 20 plant plots harvested 10 times from 2/14/66 to 5/5/66.
Table 2. Fruit production and fruit size of Verticillium wilt resistant clones, Florida 90 and Dabreak on Rockdale soil infested with *Verticillium albo-atrum* Reinke & Berth. *

<table>
<thead>
<tr>
<th>Clone</th>
<th>Marketable Yield (lbs/plot)**</th>
<th>Total Yield (lbs/plot)</th>
<th>Fruit size (oz./fruit)</th>
<th>% Crop Culled (frt./acre)***</th>
<th>Lbs Marketable</th>
</tr>
</thead>
<tbody>
<tr>
<td>113-D1 V</td>
<td>15.4 ab</td>
<td>16.1 ab</td>
<td>.28 a</td>
<td>3.9 a</td>
<td>8,965</td>
</tr>
<tr>
<td>113-D3 V</td>
<td>14.3 bc</td>
<td>15.1 bc</td>
<td>.28 a</td>
<td>5.4 ab</td>
<td>8,328</td>
</tr>
<tr>
<td>113-D5 V</td>
<td>13.8 bc</td>
<td>14.2 bc</td>
<td>.28 a</td>
<td>3.2 a</td>
<td>8,012</td>
</tr>
<tr>
<td>113-D6 V</td>
<td>11.8 c</td>
<td>12.4 c</td>
<td>.26 b</td>
<td>5.0 ab</td>
<td>6,867</td>
</tr>
<tr>
<td>Dabreak</td>
<td>7.1 d</td>
<td>8.0 d</td>
<td>.22 c</td>
<td>11.7 c</td>
<td>4,106</td>
</tr>
<tr>
<td>Fla. 90</td>
<td>5.6 d</td>
<td>6.0 d</td>
<td>.20 d</td>
<td>8.4 bc</td>
<td>3,229</td>
</tr>
<tr>
<td>112-D4 V</td>
<td>4.8 d</td>
<td>6.4 d</td>
<td>.17 e</td>
<td>25.5 d</td>
<td>2,779</td>
</tr>
</tbody>
</table>

* Values = plot averages; differences between numbers followed by same letter are not statistically significant at the 5% level according to Duncan's Multiple Range test.

** From 20 plant plots harvested 26 times from 1/5/67 to 5/16/67.

*** Based on 11,616 plants per acre.

The fruit were brighter red than Florida 90 and were firmer, particularly during the warm periods of the mid-spring season, and had longer shelf-life than Florida 90 fruit. Fruit were flavorful and sweeter than Florida 90 throughout the production season.

In 1967, 113 clones produced ripe fruit nine days before Florida 90, and production peaks occurred on the same dates as Florida 90 until final May harvests when only 113 clones produced fruit. Quality factors such as firmness, flavor, high soluble solids accompanied high yields and fruit size of these late spring harvests.

Runner production, although still under study, appears satisfactory under Florida's summer conditions.

Conclusions

Several promising new strawberry clones developed at the Sub-Tropical Experiment Station have excellent resistance to Verticillium wilt, are highly productive and bear large fruit. The 113 clonal family excelled the commercial variety, Florida 90, in these respects for two seasons in Dade County. 113-D1 V emerged as the top candidate for varietal consideration and, as such, it will be evaluated in the major strawberry production areas in 1968.

The value of Verticillium wilt resistance in reducing losses sustained by susceptible varieties was particularly evident in 1967. Verticillium wilt resistant clones were vastly superior in Florida 90 in yield and fruit size with and with-
Table 3. Fruit production and fruit size of Verticillium wilt resistant clones and susceptible Florida 90 on Vorlex fumigated soil (50 gpa) and Verticillium infested soil. *

<table>
<thead>
<tr>
<th>Clone</th>
<th>Marketable Yield (lbs/plot)**</th>
<th>Total Yield (lbs/plot)</th>
<th>Fruit size (oz./fruit)</th>
<th>% Crop Culled</th>
<th>Marketable Lbs (frt./acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fla. 90</td>
<td>12.2 c</td>
<td>12.9 c</td>
<td>.23 c</td>
<td>5.4 ab</td>
<td>7.093</td>
</tr>
<tr>
<td>no fum.</td>
<td>5.6 d</td>
<td>6.0 d</td>
<td>.20 d</td>
<td>8.4 bc</td>
<td>3.229</td>
</tr>
<tr>
<td>113-D5</td>
<td>17.3 a</td>
<td>18.2 a</td>
<td>.29 a</td>
<td>4.9 ab</td>
<td>10.074</td>
</tr>
<tr>
<td>fum.</td>
<td>13.8 bc</td>
<td>14.2 bc</td>
<td>.28 a</td>
<td>3.2 a</td>
<td>8.012</td>
</tr>
<tr>
<td>no fum.</td>
<td>15.4 ab</td>
<td>16.1 ab</td>
<td>.28 a</td>
<td>3.9 a</td>
<td>8.965</td>
</tr>
</tbody>
</table>

* Values = plot averages; differences between numbers followed by same letter are not statistically significant at the 5% level according to Duncan's Multiple Range test.

** From 20 plant plots harvested 26 times from 1/5/67 to 5/16/67.

out exposure to Verticillium wilt. The uniformity of the disease in the test area and its progressive development in susceptible varieties strengthened these observations and data.

Continued testing and analysis of new hybrid clones, some representing backcross populations involving 113 clones, may aid in understanding the mechanism governing Verticillium wilt resistance, as well as provide additional breeding material for satisfying future varietal needs of the strawberry industry in Florida.

LITERATURE CITED

Influence of Lime on the Development of Fusarium Wilt of Watermelons

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Abstract

Experiments were conducted to evaluate the effect of lime on the severity of Fusarium wilt of watermelons. Lime rates used in a field test, on virgin soil artificially infested with Races 1 and 2 of Fusarium oxysporum niveum Snyder & Hansen, were: no lime, 3,000, 6,000 and 9,000 pounds per acre, derived from a 2.5 - 2.5 - 1.0 ratio of dolomite-calcic limestone-hydrated lime. At the end of the test, the plant stand was 6.2%, 53.0%, 62.0% and 85.5% and the soil pH 4.6, 5.5, 6.0 and 6.5 for the no lime, 3,000, 6,000 and 9,000 pounds of lime per acre, respectively. Marketable melon yields increased linearly from zero for the no lime treatment to 13.8 tons per acre for the highest lime rate. Ninety per cent of the fungal isolates obtained from diseased plants were Fusarium sp. and were pathogenic on the varieties 'Florida Giant', 'Charleston Gray', and to a lesser degree on 'Summit'.

In a greenhouse experiment calcium carbonate and calcium sulfate were compared for their effect on Fusarium wilt of watermelons. Both materials supply calcium to the plant but only calcium carbonate raises the soil pH. Calcium carbonate was much more effective in reducing the severity of wilt than was calcium sulfate. The latter was no more effective than the unlimed control.

This preliminary result indicates that an increase in soil pH may be more important than a readily available calcium supply in reducing Fusarium wilt of watermelons.

Introduction

Watermelon growers have, for many years, experienced considerable economic loss to Fusarium oxysporum niveum Snyder & Hansen. Attempts toward reducing this loss have been by the use of resistant varieties; crop rotation, with five to eight year intervals between watermelon crops; and by planting on land not previously cropped to watermelons. All have given some control, but none has been completely adequate. To date, control by soil fumigation has not proven practical due to the expense of treatment and to recontamination by the pathogen.

The effect of nutrition on plant diseases has been studied extensively and there have been many cases where partial control has been obtained by altering certain nutritional practices. Several researchers (1, 2, 3, 5, 7, 9) have reported a decrease in the severity of Fusarium wilt of tomato, F. oxysporum f. lycopersici (Sacc.) Snyder & Hansen, by either increasing the pH or by improving the calcium status of the substrate. Reports (10, 11, 12) showing a relationship between plant nutrition and the severity of Fusarium wilt of other crops, have also been made.

Stoddard (10) found that liming the soil to pH 6.0 significantly reduced the incidence of Fusarium wilt of muskmelons as compared to that in soils of pH 4.8 or 4.1. He also found that high nitrogen increased the wilt suscepi-