# Vertical

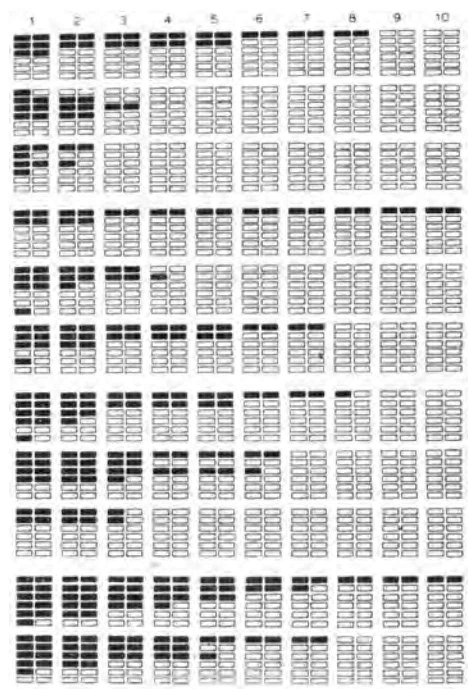
Rigolen plowing. A blade in front of the plow turns the surface soil into the bottom of the furrow to be covered by soil from below.

CONTROL OF SOIL-BORNE PLANT DISEASES by the "rigolen" method of plowing means the careful inversion of the surface soil (usually about the first foot) with soil from below. Knowing that crops generally produced less and less when grown repeatedly without rotation in the same soil, but not knowing why, an unknown farmer developed the rigolen or soil-inversion technique over a century ago to counter diminishing yields. Thus, rigolen plowing (spades were used in the early days) was developed before the causes of soil-borne plant diseases were known. Actually, rigolen plowing is a method for controlling soil-borne diseases by rotation—but the soil, not the crop, is rotated. This three-year study was conducted to determine whether the rigolen method would control soil-borne diseases today—and especially Verticillium wilt of cotton.

Knowledge of the vertical distribution in soil of the Verticillium wilt fungus is basic to control efforts by any of the means available—involving soil manipulation, crop rotation, or fumigation. It is also important to know whether cotton roots can be attacked by Verticillium throughout the entire soil volume occupied by the fungus, and what relationship exists between depth of rooting of the cotton and vertical distribution of the Verticillium fungus.

## Vertical distribution

To study the vertical distribution of Verticillium in soils and learn to what depths cotton roots are attacked, soil and root samples were taken from three different cotton fields at 4-inch increments to a depth of 24 inches. Samples were taken prior to seeding of the cotton, twice during the growing season within the standing cotton plants, and after harvest. Soils were both heavy and medium loams, and represented a fair cross section of the kinds in which Verticillium wilt is most troublesome in Tulare County. Collections of soil samples were made with utmost care to avoid contamination. First, a trench was dug about 4 ft deep, and large enough for a man to work in. Next, the face of the trench was scraped clean and samples of soil were taken in two 6-inch pots at each 4-inch increment. Between soil collections, tools were sterilized by heat from a portable butane burner.




Black squares in chart above indicate vertical distribution of Verticillium (in 4-inch increments) in 10 paired soil samples taken from 10 different areas in a Tulare County cotton field. The top three groups of samples from the 10 areas were taken prior to planting and show no Verticillium below 16 inches. Only three samples taken during the growing season showed Verticillium below 16 inches, as indicated in the second and third groups of three samples. Bottom two groups of samples were taken following harvest and reflect Verticillium inoculum released from diseased cotton plants during harvest, plus favorable conditions for the fungus created by heavy early fall rains (1964).

TABLE 1. PERCENTAGE OF SOIL SAMPLES YIELDING VERTICILLIUM

| Localities | Soil depths in inches | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0–4 | | | 4–8 | | | 8–12 | | | 12–16 | | | 16–20 | | | 20–24 | | |
| | A | B | C | A | B | C | A | B | C | A | B | C | A | B | C | A | B | C |
| Preplant | 80 | 5 | 20 | 50 | 20 | 5 | 10 | 30 | 15 | 0 | 20 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Flowering | 100 | 30 | 70 | 20 | 35 | 30 | 0 | 15 | 15 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 5 | 0 |
| Maturing | 75 | 60 | 25 | 50 | 30 | 25 | 20 | 55 | 0 | 15 | 25 | 0 | 0 | 0 | 0 | 5 | 0 | 0 |
| Postharvest | 100 | 70 | .. | 65 | 40 | .. | 50 | 45 | .. | 35 | 20 | .. | 20 | 5 | .. | 5 | 0 | .. |

A—Chino clay loam, mottled at 16 to 20 inches, sandy below.
B—Cajon fine sandy loam, compacted at 16 to 20 inches.
C—Chino clay loam, clay at 18 inches.

# *distribution of fungus suggests . . .*

# RIGOLEN PLOWING

## *for control of Verticillium wilt in cotton*

STEPHEN WILHELM · J. E. SAGEN · HELGA TIETZ · ALAN GEORGE

While the cotton was growing, depth measurements were taken from the top of the ridge formed when the irrigation furrow was made. This ridge was approximately 6 to 8 inches higher than the soil surface before planting, and consisted of surface soil (which must be taken into account in interpreting the results).

In each test soil, an Acala cotton plant was grown. Care was taken to insure vigorous vegetative growth and to prevent pot-to-pot contamination by soil and water. Check plants planted in previously sterilized soil were interspersed among the test plants, and none of these became infected with Verticillium. As test plants showed symptoms of Verticillium, they were cultured for the fungus and discarded. Finally, the plants surviving to maturity were also cultured for Verticillium. A total of 1320 soil samples were studied in all.

### Results

The technique for detection in this study cannot be used to indicate the actual amounts of the fungus in a given soil sample; however, it can detect the *presence* of Verticillium more reliably than can any other method known. The technique also detects the strains of Verticillium specific to cotton. Data show that the Verticillium fungus is most prevalent in the upper soil (table 1). Of the 360 soil samples taken at each 4-inch depth increment the following percentage contained Verticillium: 0–4 inches, 57.7; 4–8 inches, 33.6; 8–12 inches, 23.2; 12–16 inches, 10.9; 16–20 inches, 2.7; 20–24 inches, 1.4%. In view of the fact that for most samples taken, measurements of depth were made from the top of the irrigation ridge, the 24-inch depth corresponds to about a 16-inch depth prior to planting. Preplant soil sampling failed to detect Verticillium below 16 inches, but subsequently Verticillium was detected sporadically in the soil below that depth. The high incidence of Verticillium in the postharvest sampling reflects inoculum release from diseased cotton plants and the favorable conditions for the fungus created by the heavy early fall rains of 1964.

TABLE 2. NUMBER OF VERTICILLIUM DETECTIONS IN COTTON ROOTLETS AT DIFFERENT SOIL DEPTHS

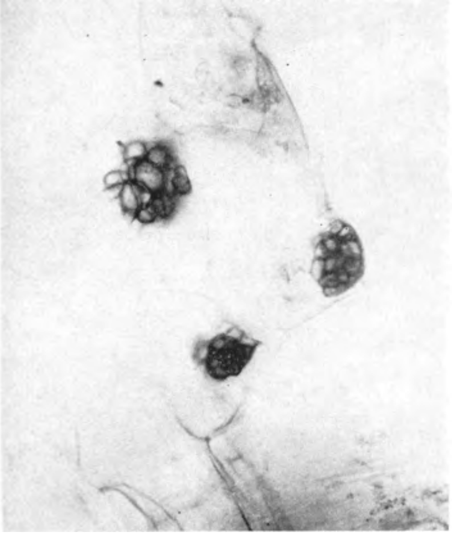
| Depth of root (inches) | A | B | C* |
|---|---|---|---|
| 0–4 | + | +++ | ++++ |
| 4–8 | ++ | ++++ | ++ |
| → | | | |
| 8–12 | ++++ | ++ | +++ |
| 12–16 | ++ | – | – |
| 16–20 | – | + | – |
| 20–24 | – | – | – |

* See legend below Table 1 for explanation.
+ Verticillium detection.
– Verticillium was not detected.
→ Corresponds approximately to the soil surface before irrigation.

### Depth at which roots are infected

Root samples collected during diggings made in late May, June, and July 1964, were each surface-disinfected, and cultured in the field on a medium selective for Verticillium. Frequently, it was pos-

The amount of straw visible after plowing is a measure of the completeness of the soil inversion.



Unusually small microsclerotia of Verticillium formed in laboratory culture within cortical root cells of cotton indicating that infection had occurred.

sible only to identify Verticillium from its characteristic microsclerotia formed in culture within cortical root cells. The microsclerotia provided evidence that infection had occurred prior to culturing of the root (see photo). The results indicate that roots which primarily occupy the surface soil are infected (table 2). When roots were collected, depth measurements were made from the top of the irrigation ridge, and thus the first 8 to 12 inches of soil were actually surface soil.

Data are not quantitative, because no estimation of the amount of rootlet material collected from each depth is given. It is significant that roots occupying the upper 8 to 12 inches of soil, including the irrigation ridge, are readily infected by Verticillium. This zone of soil also contains most of the Verticillium. The deepest infected root was found at about 16 inches.

Attempts were made, using the equipment shown (see photos), to invert the surface foot of soil with soil from below. To help accomplish the inversion, a rye winter cover crop was grown which holds the surface soil together. The effectiveness of the inversion was indicated by the amount of rye showing after invert plowing.

*Stephen Wilhelm is Professor of Plant Pathology and Plant Pathologist in the Experiment Station; James E. Sagen is Laboratory Technician; and Helga Tietz is Junior Specialist, Department of Plant Pathology, University of California, Berkeley. Alan George is Farm Advisor, Tulare County.* *Research from which this progress report was prepared was supported in part by the California Planting Cotton Seed Distributors.*

# *Heat treatment, and cutting, for* INCREASED SWEET SLIP PRODUCTION

N. C. WELCH · T. M. LITTLE

MANY OF THE ROOTS used for sweet potato slip production produce only a few shoots. This is because the end of the root is strongly dominant and can inhibit slip growth. Various chemical and physical methods have been tried to find a practical method to overcome this inhibition. None of the chemicals that showed promise has found extensive commercial use. Sectioning the sweet potatoes by cross-cutting overcomes part of the dominance expressed by the apical end of the root. However, each cut end has a distinct proximal dominance.

Research conducted in eastern states indicates early and more prolific sprouting could be obtained from sweet potato roots if they were held at 85° F at high humidity for 23 days. In some seed lots in California, 10 to 14 days will greatly increase slip production at this temperature and humidity.

When sweet potato roots are held at 109° to 111° F for 26 hours, root nematodes are inactivated and light infections of black rot have been reported to be controlled.

The study reported here was conducted to determine how the combination of the above-mentioned heat treating with cutting would influence slip production.

## Test 1964

Velvet sweet potato roots were obtained from Anderson Bros. of Bloomington, San Bernardino County, and stored as field-packed roots in an unheated shed until planting time. In the 1964 experiment, the sweet potato roots were cured at 85° F and 85% humidity before storage. At bedding time, the roots were carefully grouped so that each treatment was applied to the same number and weight. The heat-treated roots were placed in an oven for 26 hours at temperatures between 109° and 111° F.

The cut roots were sliced transversely at the middle. All roots were immersed for 30 seconds in a solution of Semesan Bel (1 lb/8 gallons water), drained of excessive solution, laid in planting beds, and covered with 3 inches of sand. The beds were then sprinkled and covered with plastic. Heat was provided by placing bean straw under the sand before bedding.

Each treatment was repeated six times and contained nine whole roots or 18 sections weighing 3¼ lbs. The statistical

**CALIFORNIA AGRICULTURE**

Progress Reports of Agricultural Research, published monthly by the University of California Division of Agricultural Sciences.

William W. Paul .............. *Manager* Agricultural Publications
Jerry Lester .................... *Editor*
Chispa Olsen ........... *Assistant Editor* California Agriculture



*California Agriculture* will be sent free upon request addressed to: Editor, *California Agriculture*, 207 University Hall, University of California, Berkeley, California 94720.