Root Distribution as a Factor Influencing Symptom Expression of Verticillium Wilt of Cotton

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ABSTRACT

Acala SJ-1 cotton, *Gossypium hirsutum* L., which is susceptible to Verticillium wilt, developed fewer major lateral roots deep in the soil than did the more resistant Waukena White cotton, *G. barbadense* L. The resistance of the Waukena cotton may, in part, be due to the ability of the plant to develop a root system below the high inoculum densities of the microsclerotial type of *Verticillium albo-atrum* found near the surface of the soil. Phytopathology 61:1312-1313.

Additional key words: root morphology.

Symptom expression of Verticillium wilt of cotton depends on the virulence of the pathogen, the inherent resistance of the cotton plant, and the environmental conditions influencing plant growth (1, 3, 8, 14). Symptoms range from leaf chlorosis to collapse and death of the plant. Host resistance mechanisms, such as phytoalexin production and vessel element maturation, may influence symptom expression (2, 3, 4, 6).

The Acala SJ-1 cotton, *Gossypium hirsutum* L., was more susceptible to *Verticillium* wilt than a University of California, Berkeley, breeding line subsequently named Waukena White, *G. barbadense* L., when both were grown in a test plot in Tulare County, Calif. (11, 13). The difference between the two selections was less apparent when evaluated in a greenhouse test in which conidial suspensions were sprayed on exposed roots.

The gross morphology of the cotton root systems was determined by washing the soil from the intact roots. Mature root systems were taken from the field supported by a 2- × 2- × 3-ft box pin board (9).

A preliminary examination suggested a difference in the gross morphology of the two cottons. Consequently, 15 root systems from Acala SJ-1 and Waukena White growing in the Tulare field were examined. The mature tap root of each cotton plant penetrated the soil vertically to a depth of about 4 ft, and bore from it many ranks of lateral roots. The smallest of the lateral roots formed a rather coarse network of feeder roots, whereas the largest formed a plagiotropic root system coursing out horizontally 2 or 3 ft from their origin on the tap root before penetrating downward.

The Acala cotton had many major lateral roots in the upper 18 inches of the soil, and few below this depth. Waukena White had few major laterals in this upper zone, but many occurred below 18 inches (Fig. 1-A). In both types of cotton, the maximum depth of the tap root coincided with the level of the hardpan. The tap roots of five Acala plants growing in a nearby field of sandy soil penetrated deeper into the softer soil, but the type of lateral root branching conformed basically to the growth pattern found in the heavier soil.

Following these field observations, the two varieties of cotton were grown together in 4-ft-deep root-observation boxes filled with fumigated soil consisting of four parts sand, one part peat, and one part garden soil. The boxes were watered as needed to keep the soil moist throughout. After 2 months' growth in the greenhouse, the roots had reached the bottoms of the boxes and the soil was washed from them. Root prints were made by silhouetting the root systems on poster boards with spray paint and drawing in the shadow outline. Representative drawings were reduced photographically (Fig. 1-B). A low level of infection occurred in these root systems. More lateral roots developed near the surface of the soil than in field-grown plants, but we observed the same basic pattern of root

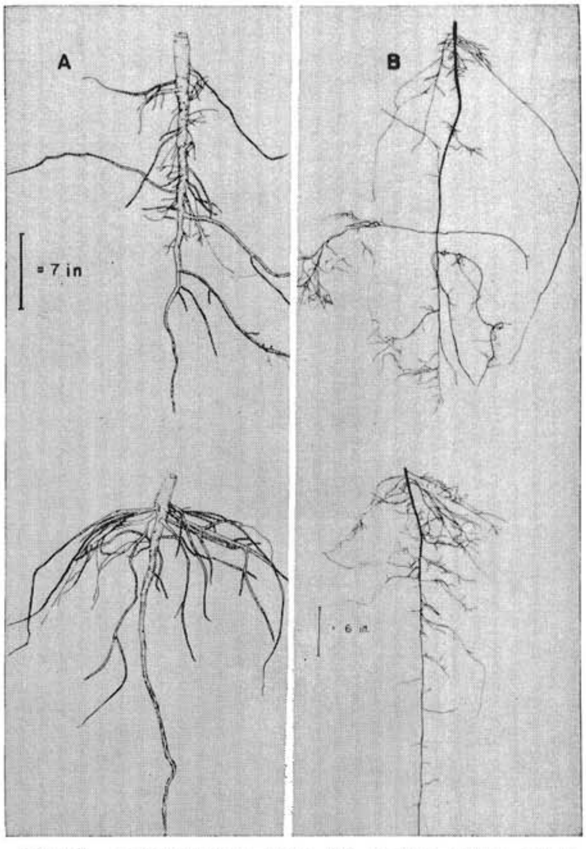

Fig. 1. Root systems from **A)** mature cotton plants grown in a field in Tulare County, Calif.; **B)** cotton plants grown for 2 months in fumigated soil in a greenhouse. The top two plants are Waukena White cotton, *Gossypium barbadense* L. The bottom two are Acala SJ-1 cotton, *G. hirsutum* L.

branching observed previously on the two cotton varieties in the field.

The gross morphology of the root system may influence infection by *Verticillium* and symptoms of the disease. An increase in the inoculum density of *Verticillium* produces a corresponding increase in disease severity (7). Inoculum potential, sensu Garrett, is defined as the energy of growth of a parasite available for infection of a host at the surface of the host organ to be infected (5). Because the microsclerotial type of *Verticillium albo-atrum* Rke. & Berth. occurs primarily in the first 18 inches of the soil (10, 12), a plant that establishes a root system below this concentration of inoculum would not only encounter a lower inoculum potential, but may find more moisture and nutrient reserves than a plant whose roots are confined to a surface layer of the soil. Thus, resistance to Verticillium wilt expressed by Waukena White cotton in the field may, in part, be due to the ability of the plant to develop a root system below the high inoculum densities found near the surface of the soil.

LITERATURE CITED

1. Barrow, J. R. 1970. Critical requirements for genetic expression of Verticillium wilt tolerance in Acala cotton. Phytopathology 60:559-560.
2. Bell, A. A. 1969. Phytoalexin production and Verticillium wilt resistance in cotton. Phytopathology 59: 1119-1127.
3. Bell, A. A., & J. T. Presley. 1969. Temperature effects upon resistance and phytoalexin synthesis in cotton inoculated with Verticillium albo-atrum. Phytopathology 59:1141-1146.
4. Bell, A. A., & J. T. Presley. 1969. Heat-inhibited or heat-killed conidia of Verticillium albo-atrum induce disease resistance and phytoalexin synthesis in cotton. Phytopathology 59:1147-1151.
5. Garrett, S. D. 1970. Pathogenic root-infecting fungi. Cambridge Univ. Press. London. 294 p.
6. Presley, J. T., & E. E. Taylor. 1969. Ontogeny of vessels influence the development of Verticillium in young cotton plants. Phytopathology 59:253-254.
7. Schnathorst, W. C., & D. E. Mathre. 1966. Host range and differentiation of a severe form of Verticillium albo-atrum in cotton. Phytopathology 56: 1155-1161.
8. Schnathorst, W. C., & D. E. Mathre. 1966. Cross-protection in cotton with strains of Verticillium albo-atrum. Phytopathology 56:1204-1209.
9. Schuurman, J. J., & M. A. J. Goedewaagen. 1965. Methods for the examination of root systems and roots. Center Agr. Publ. Doc. Wageningen, The Netherlands. 86 p.
10. Wilhelm, S. 1950. Vertical distribution of Verticillium albo-atrum in soils. Phytopathology 40:368-376.
11. Wilhelm, S., J. E. Sagen, & Helga Tietz. 1970. Sea brook (Gossypium barbadense) × Rex (Gossypium hirsutum) crosses give Verticillium wilt resistant, upland-type, all fertile offspring. Beltwide Cotton Production Res. Conf. 1970. p. 70-76.
12. Wilhelm, S., J. E. Sagen, Helga Tietz, & A. G. George. 1967. Vertical distribution of fungus suggests rigolen plowing for control of Verticillium wilt in cotton. Calif. Agr. 21:2-4.
13. Wilhelm, S., J. E. Sagen, Helga Tietz, & A. G. George. 1970. Waukena White . . . a new cotton breeding line resistant to Verticillium wilt. Calif. Agr. 24:8-12.
14. Young, V. H., N. D. Fulton, & B. A. Waddle. 1959. Factors affecting the incidence and severity of Verticillium wilt disease of cotton. Ark. Agr. Exp. Sta. Bull. No. 612. 26 p.