the case. One possible explanation is that other species, which become more prevalent as the season progresses, have higher concentrations of cobalt. For example, other investigators have reported higher concentrations of cobalt in the legumes growing in mixed grass-legume pastures. Samples of other species growing at the plot site should be collected and analyzed in subsequent studies.

Question remains

The question of why the disorder occurs with such severity at this site and not in other areas where Hardinggrass is used for grazing sheep has not been answered. Not enough samples have yet been analyzed to provide good comparisons. If lack of sufficient cobalt is the causative agent, it must also be explained why the deficiency is manifested as "staggers" when animals are grazing Hardinggrass. These are not the same symptoms as have been reported in cases of simple cobalt deficiency.

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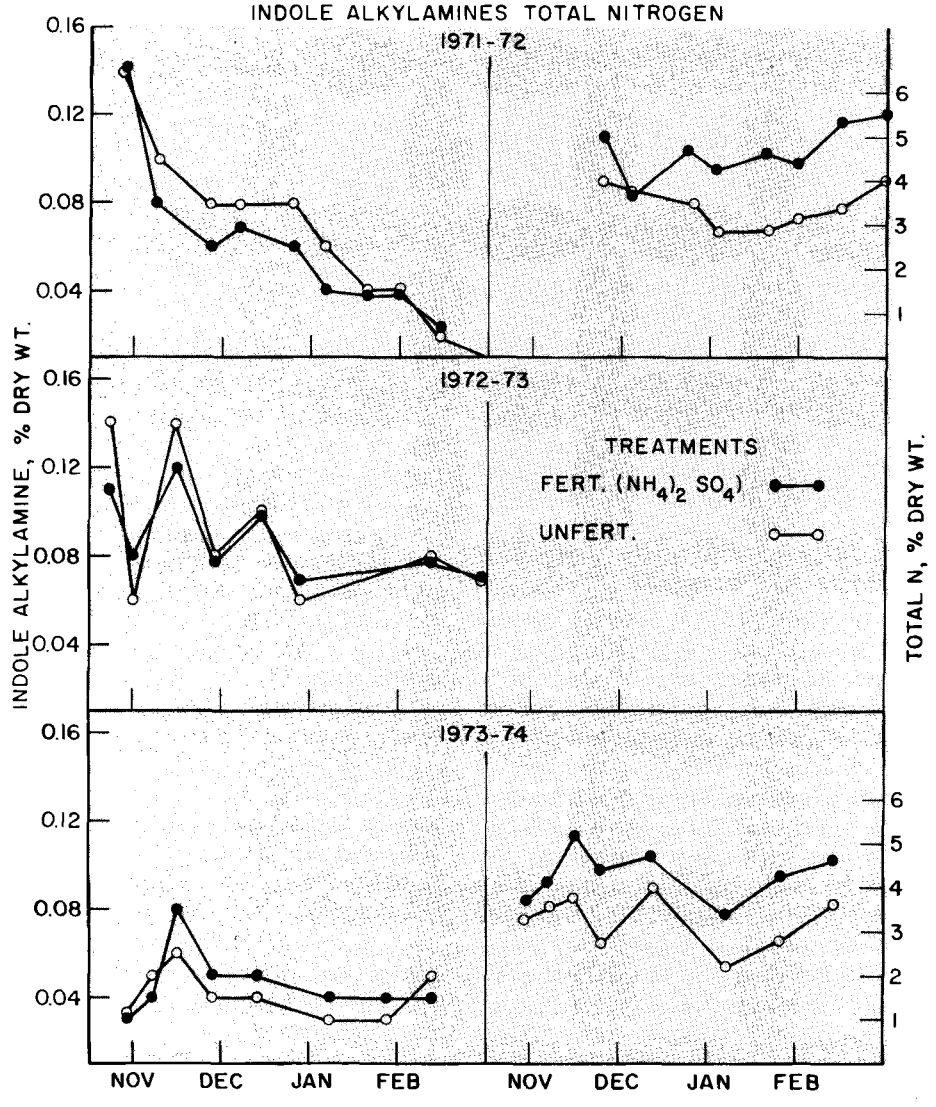

Fig. 2. Concentrations of indolealkylamines and total nitrogen in Hardingrass samples collected during three seasons. Total nitrogen was not determined in 1972 to 1973.

"In some fields 90 to 100 percent of the plants have been affected, and growers have been forced to move to new locations."

A Crown

California's coast, from Salinas to San Diego—one of the few areas in the United States that produces celery throughout the year—is now threatened with a soil-borne disease. To date, it has been observed in Orange, Ventura, and San Luis Obispo counties.

When the disease first appears in a circular location within a field, plants at the core of the affected area are severely yellowed and stunted; those at the margins are only slightly affected. In later years the affected area enlarges in size and increases in number. Disease incidence is high in summer but low in winter. Growers' observations suggest that extensive spread within a field may occur within three years, probably because fields are normally land-planed after each crop. In some fields 90 to 100 percent of the plants have been affected, and growers have been forced to move to new locations. (An estimated 440 acres in celery in Orange County alone have been abandoned.) Most of California's acreage is planted to Tall Utah 5270 R, a variety highly susceptible to the disease.

The initial symptom is a lag in growth, usually followed by yellowing of foliage. The water-conducting tissues of the roots, crown, and petiole are orange to brown in color (see fig. 1). A brown to black dry rot of the internal crown tissues is often present as well (see fig. 2).

Investigations of the cause of the disease (by L. P. Hart and R. M. Endo) to date indicate that the disease is the *Fusarium* yellows disease caused by *F. oxysporum* f. sp. *apii*. Steam sterilization of naturally infested field soil collected from San Luis Obispo, Orange, and Ventura counties eliminated the pathogen

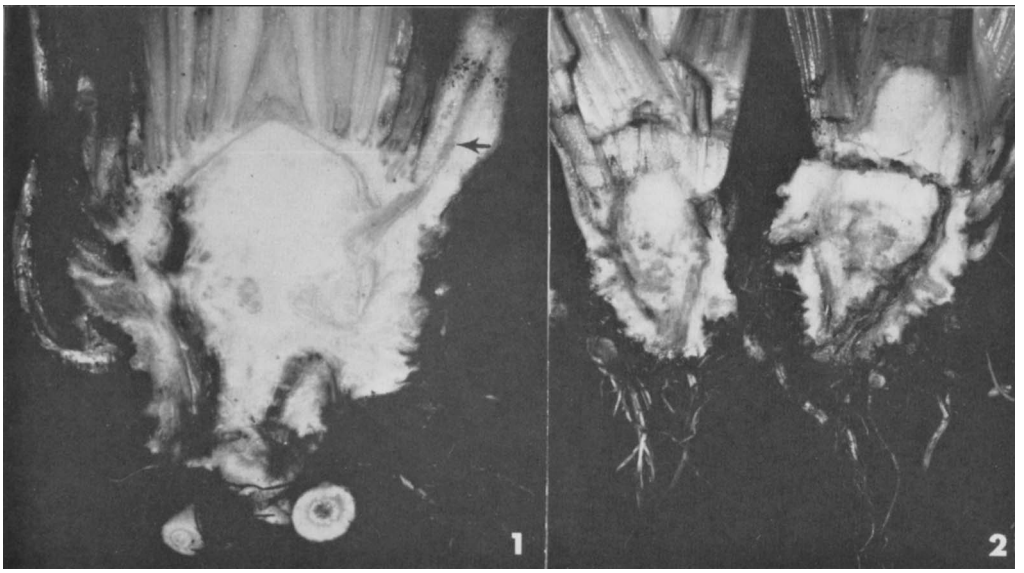

Fig. 1. Celery crown and roots, cut open, show vascular discoloration. Note that the vascular discoloration is beginning to extend into the petiole (arrow).

Fig. 2. Here, the interior of the crown is beginning to show signs of a dry rot.

Rot of Celery

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from the soils, but plants grown in the same soils without treatment developed typical symptoms, and pathogenic isolates of *F. oxysporum* were isolated readily from the affected plants. In greenhouse studies, isolates of *F. oxysporum* from all three counties have produced the stunting and yellowing of plants and the vascular discoloration of the roots, crown, and petioles. The brown to black dry rot of the interior of the crown is usually produced when infections occur early and high numbers of *Fusarium* spores are used in the inoculations.

Research is in progress to learn whether other micro-organisms may be involved, since the crown's interior dry rot may also be caused by secondary rot-producing organisms. Investigations are also in progress to determine whether the *Fusarium* fungus is a new race of the *Fusarium* yellows fungus; circumstantial evidence indicates that it is since the susceptible variety, Tall Utah 5270 R, is resistant to the old race. The old race caused damage to celery varieties in California prior to World War II, but the disease disappeared when growers switched from the susceptible yellow varieties to the resistant green varieties, such as Tall Utah 5270 R.

Several approaches to control have been made. Before transplanting to the field, transplants were dipped in various fungicidal dips. In pounds of fungicide per 100 gallons of water these fungicides were: Benlate 50W, 2 pounds; Topsin 50 W, 2 pounds; Bravo 75 W, 3 pounds; and Truban 30W, 0.75 pound. No treatment was effective, since disease development was as severe as in the untreated checks. Similar results were obtained with a slurry root dip made by adding Celite to the previously mentioned fungicidal dips.

A second approach to control was soil fumigation using mixtures of methyl bromide and chloropicrin (3:1, 400 pounds/acre), chloropicrin and DD (3:2, 500 pounds/acre) or DD alone (40 pounds/acre). The fumigation was carried out on a silty clay loam soil, with the assistance of Tri Cal Incorporated, on the Fukuhara Brothers farms in Arroyo Grande. Fumigation was on April 29, 1974. Although incidence of infection and severity of the disease were reduced by the soil treatments, economic control of the disease was not obtained.

A varietal field trial was conducted in 1973 in Costa Mesa (Orange County) in cooperation with Western Marketing to determine the susceptibility and resistance to the disease of 22 celery varieties. The land selected had previously shown a high incidence of the disease. Healthy seedlings were grown in the greenhouse in sterile soil and transplanted to plots 30 feet long and replicated four times. Excellent uniform symptoms developed. Mature plants were dug and the roots, crown, and petioles cut open and rated for extent of vascular discoloration and crown rot. Plants were rated May 3 on a scale of 1 to 5, with 5 indicating severe vascular discoloration and severe crown rot and 1 indicating mild vascular discoloration and no crown rot. The variety Golden Detroit (1.0) and the experimental line XP152 (1.5) showed significantly less disease than all other varieties. Other varieties showing somewhat tolerant responses were Tall Utah 5270 H 6-1-3 (1.7), Tendercrisp (2.2), Tall Utah 52-75 (2.2), Pascal 259-19 (2.2), Slow Bolting Green No. 96 (2.6), Green Light Original Strain (2.6), and Tall Utah 52-70 H (2.7). The remaining 13 varieties (Beacon, Calmar, Earlibelle, Florida 683, Florida 683 60-7-6, Florida 2-13, Florimart, June Belle, Processor 34, Tall Green Light, Tall Utah 5270, Tall Utah 5270 R, and XP 74) were rated 5 or extremely susceptible.

A similar varietal screening trial was conducted in 1974 in cooperation with Fukuhara Brothers on land manifesting high incidence of the disease. Plants were rated on October 10 on a scale of 1 to 4, instead of 1 to 5, with 4 indicating severe vascular discoloration and no crown rot. The varieties Tendercrisp (0.5), XP 152 (1.5) and Tall Utah 5270 H 60-1-3 (1.5) showed less disease than the six other varieties in the test: Tall Utah 5270 H (2.0), Surepak (2.5), Tall Utah 5270 R (3.0), Tall Utah 5270 (3.5), 3037 (3.5), and Golden Detroit (4.0). Of the seven varieties common to the Arroyo Grande and Costa Mesa trials, six showed similar responses in both tests. The variety Golden Detroit, however, performed best in the Costa Mesa trial and worst in the Arroyo Grande trial. The reason for this complete reversal in plant response is not known. Research is in progress to develop a varietal screening technique that may be conducted in the greenhouse employing a pure line of the fungus.

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