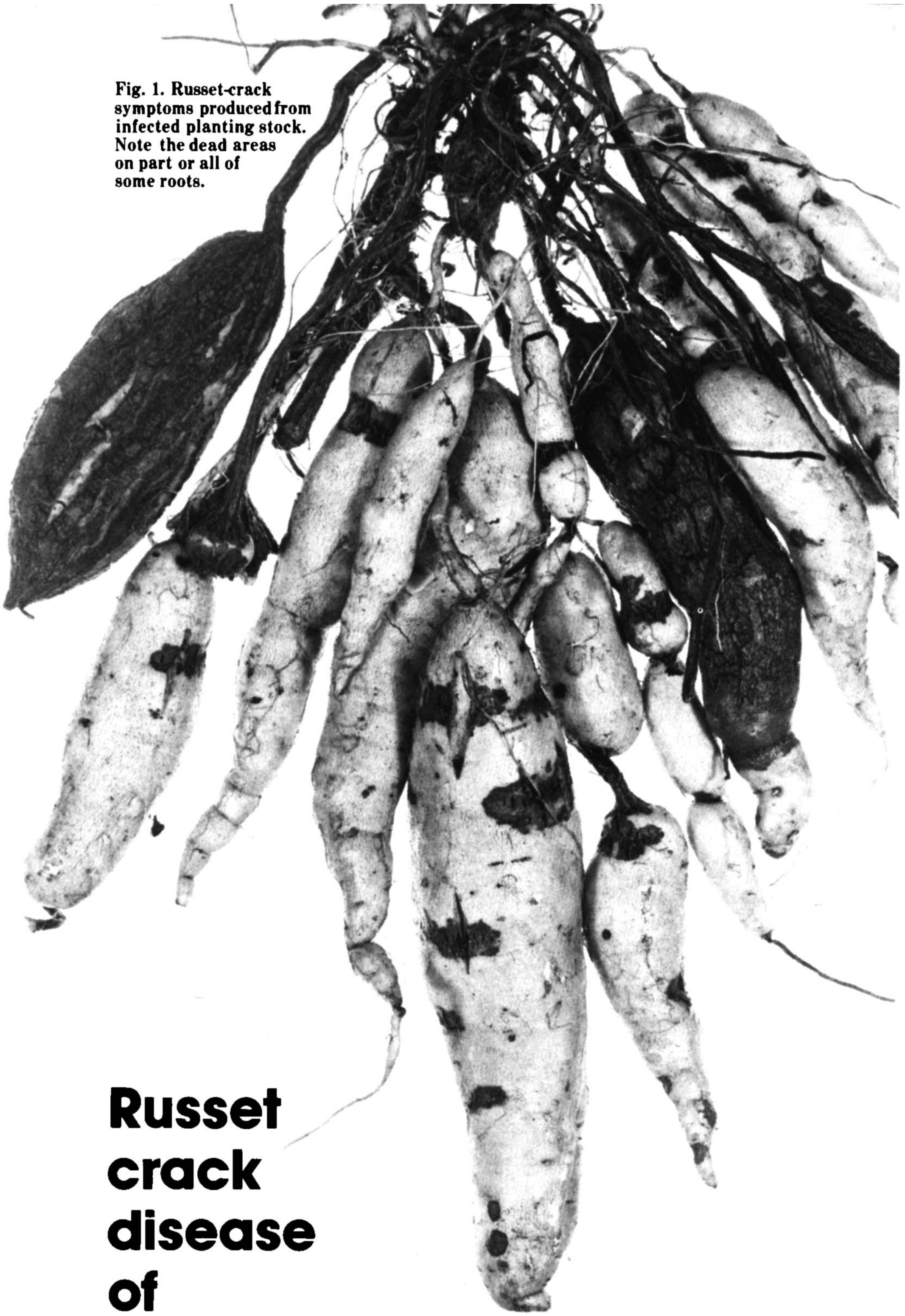

Fig. 1. Russet-crack symptoms produced from infected planting stock. Note the dead areas on part or all of some roots.

Russet crack disease of sweet potatoes

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Russet crack disease of sweet potatoes (*Ipomoea batatas*) was first reported in New Jersey in 1961 and it was suggested a virus might be the cause. Soon after, the disease was in California; probably it had been imported with propagative roots from the east coast. The present paper reports studies done at the University of California at Davis and in Merced County, California, to clarify the cause of russet crack and its method of transmission.

Russet crack can only be identified with certainty by the symptoms produced on the roots of susceptible sweet potatoes. Of those currently grown in California, the cultivar 'Jersey' shows the most severe symptoms and, unless otherwise stated, was used in the trials reported here. Early-season infections, whether through propagative stocks or by means of vector transmission in the plant bed or field, lead to the formation of typical symptoms on roots of all sizes (fig. 1). Similar darkened, rough areas may develop on the lower stem (fig. 2) and, if formed, they are useful for detection of the disease.

Later-season infections in the field may lead to less extensive necrotic symptoms on enlarged roots (fig. 3), to "leopard-tail" symptoms consisting of small necrotic bands on small roots (fig. 4), or there may be no obvious symptoms at all. The leaves of infected plants may show chlorotic spots or small rings, but this symptom is not consistent and is of no value for detecting the disease.

Although technical problems have prevented absolute proof, we regard the

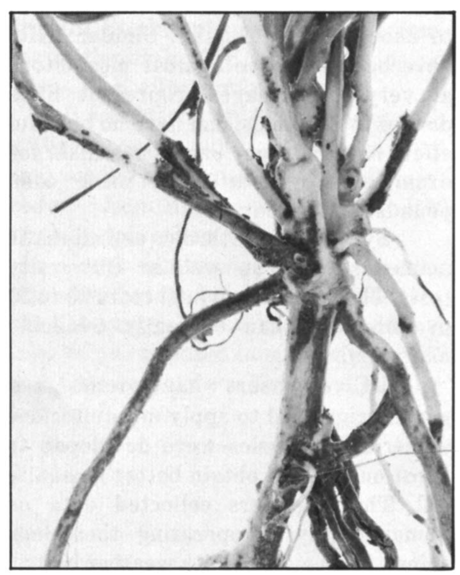

Fig. 2. Necrotic lesions formed during the growing season on stem and lower parts of branches of Jersey sweet potato.

Detection of the Russet-crack Agent by Interplanting with Virus-free Trap Plants in Fields Planted with Various Sweet Potato Cultivars

Cultivar	Type of seed	Frequency of detection*
Garnet	New†	1/3
	Old‡	7/9
Jewel	New	1/4
	Old	2/7
779	Old	1/2

*Number of fields in which trap plants were infected with russet crack/ number of fields tested.
†Field planted from propagative stock brought into Merced County during the current year.
‡Field planted from propagative stock grown in commercial fields in Merced County for one or more years.

probable causal agent of russet crack as a strain of the sweet-potato feathery-mottle virus. The major difference is that the russet-crack agent causes symptoms on roots of the cultivar 'Jersey' and occasionally on other cultivars, whereas feathery-mottle virus does not. In other characteristics, the russet-crack agent and feathery-mottle virus both: are stylet-borne by aphids, are associated with flexuous rod-shaped particles, cause similar symptoms on all hosts except Jersey, and can be sap-transmitted in the glasshouse with difficulty. In addition, Jersey plants infected with feathery-mottle virus are "protected" from subsequent infection by the russet-crack agent. This phenomenon is called "cross-protection" and it is generally interpreted to mean that viruses are closely related -- but such tests are not foolproof.

If propagative stocks show symptoms of russet crack, a high proportion of the following crop will have russet crack, as was shown in field trials in Merced County. Propagative roots showing mild symptoms of late season infection were saved from the first crop produced from field-grown, virus-free, foundation stock. About 180 plants derived from these roots were grown in a replicated field trial and compared with a similar number of plants from new virus-free foundation stock. From the stock with symptoms 87 percent of the plants had russet crack; from new foundation stock 10 percent of the plants had symptoms. The latter doubtless originated from infections during the growing season.

It has also been observed that superficial lesions may form on the underground portion of sprouts from infected propagative stocks (fig. 5). To determine if such lesions are symptoms of russet crack, sprouts with lesions were selected and planted in an observation plot. Forty-one of 42 plants from sprouts with lesions had russet crack compared to 2 of 39 plants from normal sprouts without lesions. The following year a replicated trial was planted with about 100 plants from each of 3 types of propagative stock. At harvest russet crack was in 99 percent of the plants originating from sprouts with stem lesions (fig. 5), in 93 percent of the plants originating from propagative roots with symptoms (figs. 3, 4), and in 5 percent of the plants originating from symptomless sprouts from symptomless propagative roots.

Virus-free Jersey foundation stock used for commercial planting produces a first-year crop having 10 percent or less of the plants with russet crack from current-season aphid transmission. Growers have found that the incidence of russet crack increases dramatically if propagative roots are saved from the first to third year crop of originally virus-free stocks.

We have confirmed this in replicated plots with a total of about 180 plants derived from different propagative sources. One type of propagative stock, dug by hand and saved only from plants that had no russet-crack symptoms, gave 53 and 44 percent russet-crack plants, respectively, when selected from the first or second year crops. Propagative stock consisting of field-run roots free from russet-crack symptoms at harvest gave 47 and 84 percent russet crack plants, respectively, when selected from the first or second year crop. Control plants from virus-free foundation stock had 9 percent russet crack.

The explanation for these observations probably lies in the cross-protection phenomenon. When virus-free propagative material is introduced, the plants are infected during the growing season by either the feathery-mottle virus or the russet-crack agent but these latter infections are late enough in the season that few cause symptoms. The following year, however, symptoms of russet crack develop in plants propagated from the russet-crack-infected roots. On the other hand, in planting stocks that have been grown in the area for many years the russet-crack-infected plants have been culled out and most of the plants are infected with feathery-mottle virus that protects the plants from infection by the russet-crack agent.

New seed that has been purchased is often stored in the same room where field-grown roots are kept. Aphid infestations have been observed on the small sprouts that often develop on the roots when storage is prolonged. After aphid transmission of russet crack had been demonstrated, the possibility that aphids might transmit the russet-crack agent from root to root during storage was tested. Roots showing russet-crack symptoms were placed in lug boxes with roots from virus-free plants. When sprouts had developed, aphids were introduced to some of the boxes. The roots

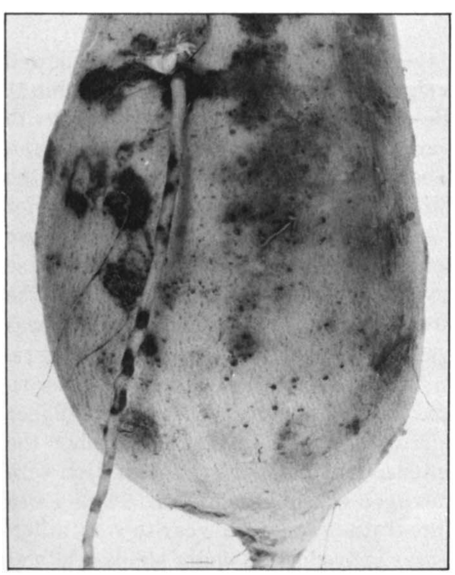

Fig. 3. Small, superficial lesions produced on a storage root from a plant that became infected during the current growing season.

Fig. 4. Dark, superficial lesions on finer roots of a plant that became infected during the current growing season. Note the constrictions produced on root at right.

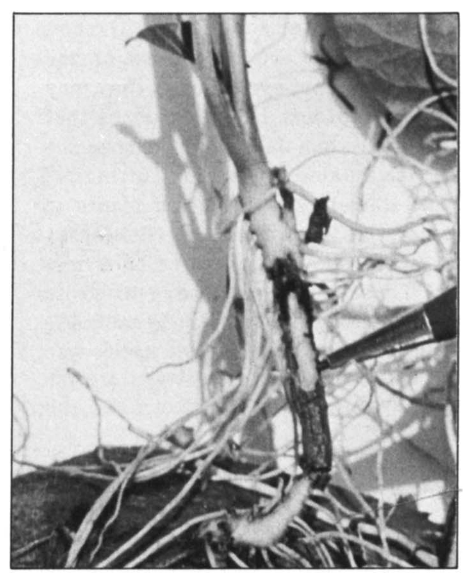

Fig. 5. Necrotic lesion produced on a sprout in the propagating bed. Note that the superficial lesion has been cut away near the pencil point and the underlying tissue is the normal, light color.

that were originally virus-free were sprouted in sand and the slips planted in replicated plots at Davis.

At harvest each plant was examined for russet crack. The originally virus-free roots produced russet-crack-infected plants as follows: 10 of 22 roots kept with russet-crack roots and aphids; 2 of 18 roots kept with russet-crack roots but without aphids; and 2 of 20 roots kept alone without russet-crack roots or aphids. The 10 percent infection rate in the controls probably reflects aphid transmission within the experimental plots during the growing season. The results indicate that infection by russet crack can occur in storage and suggest that clean foundation seed should not be in the same storage as field-grown sweet potatoes.

A critical point in the epidemiology of russet-crack disease is the role of other sweet potato cultivars as reservoirs of the causal agent. In the field an occasional root of other cultivars, such as 779 and Garnet, has been found with russet-crack-like symptoms. Although attempts to graft inoculate from these cultivars to Jersey plants in the greenhouse were inconclusive, it seemed likely that these cultivars could be reservoirs of russet crack. To test this possibility, rooted sprouts of virus-free Jersey were transplanted into several commercial fields planted with other cultivars. In the fall these Jersey trap plants were hand dug and examined for russet-crack symptoms. The appearance of symptoms on the roots of the trap plants was presumptive evidence that the cultivar in the field was the source of infection.

The results show that Garnet, Jewell, and 779 are reservoirs of the russet-crack agent even though they may show no symptoms. Direct evidence that plants other than Jersey can harbor the virus was obtained by taking cuttings of Garnet, Jewell, and 779 from plants in seven of the fields in which the Jersey trap plants showed russet-crack symptoms. These cuttings were grafted to virus-free Jersey plants in the greenhouse and, in each instance, russet crack was recovered. Thus, these cultivars are potential symptomless reservoirs of the russet-crack agent.

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Wheat and barley response to nitrogen

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Wheat and barley are important crops to the Tulelake Basin and other intermountain valleys of northern California. Both bread wheats and durum wheats are grown. Barley is used for malting and as a feed grain. The yields of barley and wheat vary widely from field to field and from year to year, ranging from 2000 to 7000 pounds per acre. These fluctuations are attributed to climatic and soil factors, and to the cultural practices followed.

New varieties are continually being introduced to the area as possible replacements for those currently grown. To assure maximum production and acceptable quality, cultural practices should be evaluated for each variety grown in the area.

Since both irrigation and nitrogen fertilizer rates are known to affect yield and quality, the influence of these factors on several barley and wheat varieties was investigated over a three-year period at the Tulelake Field Station.

The Tulelake Station, located near the Oregon border at an elevation of 4042 feet, is characterized by a short growing season with frost likely any time during the crop growing season. Soils are high in organic matter (approximately 12 percent) and the water table is high (ranges 3 to 4 feet).

Two irrigation methods were studied—flood irrigation, the commonly used method, and sprinkler irrigation, a method growing in popularity. Four nitrogen fertilizer levels (40, 80, 120 and 160 pounds of nitrogen per acre as ammonium sulfate) were used. The irrigation and fertilizer treatments were studied over three barley and three wheat varieties.

The barley varieties included two six-row types (Wocus 71, a feed barley, and Larker, a malting barley) and a two-row malting barley, Klages. The wheat varieties were Leeds, a durum wheat, and two bread or common wheat types—Anza and Bluebird II. Leeds is a tall variety while the other two wheats are shorter and more resistant to lodging.

The experimental area was uniformly cropped, prior to the test, to wheat or barley for one year with no fertilizer applied. Each year the experimental area was divided into a sprinkler- and flood-irrigated section. Varieties and fertilizer rates (supplied from ammonium sulfate) were applied within each section using a split-block design. In 1973 and 1975 the experimental area was preirrigated before fertilization and seeding. Weather conditions prevented preirrigation in 1974.

The flood irrigated section received one or two crop irrigations depending upon soil moisture and weather conditions. This plot received about 8 and 11 acre inches of water in 1974 and 1975 respectively. The sprinkler irrigated section received only three irrigations from a solid set sprinkler system. This plot received about 4, 5, and 7 acre inches of water in 1973, 1974, and 1975 respectively.

Even distribution of water through the sprinkler system was difficult after plants became taller than 30 inches, and sprinkler applications were discontinued at that time. Total water applied from each irrigation system was not the same within or between years; sprinklers applied less than did flood irrigation.

The experiments were drill planted at approximately 130 pounds of seed per acre. Yields were obtained by harvesting a 100 square foot area with a small combine.

Flood irrigation

Average nitrogen response showed a significant curvilinear response (table 1). However, the interaction of nitrogen with varieties and year was also significant. The interaction can be illustrated by the difference in year-to-year performance for Leeds and Anza wheat (table 1). The two varieties showed similar yield response to nitrogen over the first two years of the study. However, performance in 1975 was quite different. Differences in lodging resistance between varieties and differential lodging in some years and at higher nitrogen rates may partially explain the interaction. The variety interaction with nitrogen was not significant. Table 1 also illustrates the larger year-to-year differences in production under similar cultural practices.

Klages gave higher yields at 120 pounds than at 80 pounds nitrogen per acre in some years, but malting quality