Effect of Temperature on Rate of Rotting of Sugar-Beet Tissue by Two Storage Pathogens[1]

JOHN O. GASKILL AND CARL E. SELISKAR[2]

Species of *Rhizopus* have been reported as causing rotting of commercially stored sugar beets, *Beta vulgaris* L., under certain conditions in Russia (6, 7)[3]. Morochkovsky (6) listed several species associated with sugar beet storage rots and named *R. nigricans* Ehr. in particular as being very destructive at high temperatures. Savitsky (7) also mentioned the genus *Rhizopus* in this connection, indicating that it is pathogenic at 15° to 18° C. (59° to 64° F.).

In the western hemisphere, references to the genus in connection with sugar beet storage rots have been meager. Hodges (3) reported that *R. nigricans* attacked beet roots stored at room temperature, but its relation to commercially stored roots was not clear. As a part of a study of a field root rot of sugar beets, Hildebrand and Koch (2) compared three species of *Rhizopus* for pathogenicity to mother beets planted in compost soil and held at different temperatures. All three species were found to be aggressive pathogens, *R. nigricans* being favored by the lowest temperature (57°-61° F.) of the series and *R. arrhizus* Fischer and *R. oryzae* Went et Pr. Geerligs being most active at the highest temperature level (102-106° F.). These writers suggested the possibility that species of *Rhizopus* constitute a potential threat to stored sugar beets.

Isolates of *Rhizopus* have been obtained in different parts of the United States from sugar-beet storage piles in which rotting had reached the "heating" stage[4], but insofar as the writers are aware, it has not been clearly shown heretofore that *Rhizopus* species actually are directly responsible for rotting in storage piles in this country.

Early in 1951 routine tests for pathogenicity were made with a number of fungus cultures which had been isolated from rotting sugar beets obtained from commercial storage piles in northern Colorado late in 1950. Cultures of a species of *Rhizopus*[5] were among those isolates which were classed as active pathogens on interior tap-root tissue at room temperature. However, at approximately 45° F. this fungus was practically non-pathogenic as compared with others, such as *Botrytis cinerea* Fr. and *Phoma hetae* Frank, which were quite active at both temperatures.

A simple experiment was conducted in order to obtain more information regarding the relation of temperature to pathogenicity of *Rhizopus* sp. One culture of this fungus was used, together with a culture of *B. cinerea,* a recognized sugar beet storage pathogen (1, 4, 5, 6, 7), which was included

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[2] Plant Pathologist, Division of Sugar Plant Investigations, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture, and Assistant Plant Pathologist, Colorado Agricultural Experiment Station, Fort Collins, Colorado, respectively.

[3] Numbers in parentheses refer to literature cited.

[4] A. R. Downie, American Crystal Sugar Co., J. O. Gaskill, U. S. Dept. of Agriculture, and C. E. Seliskar, Colorado Agricultural Experiment Station (unpublished).

[5] After the manuscript had been submitted to the printer, the fungus was identified as *Rhizopus oryzae.*

as a standard. Thick transverse slices from sugar beet tap roots were placed in moist chambers, inoculated on the exposed interior surface by means of uniform mycelial discs obtained from agar plates, and held for five to 39 days at three temperatures, together with control slices on which sterile agar discs had been placed in a similar manner. At the end of the storage periods, each slice was sectioned as illustrated *in* Figure 1, and the depth of rotted tissue was measured. The fungi used were reisolated consistently from the different temperature sets, with the exception of *Rhizopus* sp. at the lowest temperature where no fungus was obtained from tissue plantings. Contamination was found to be negligible in all sets.

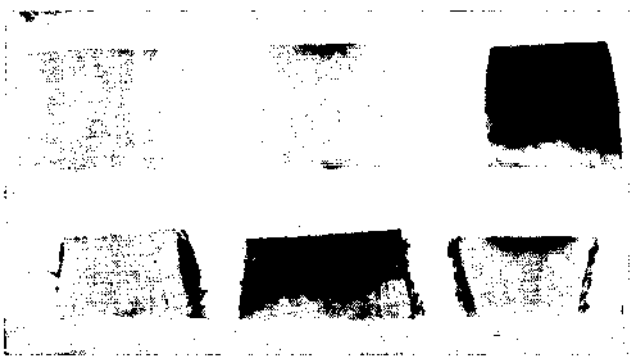

Figure 1. Sections of sugar-beet-root slices showing effect of temperature on rate of rotting by two storage pathogens. Left to right—control, *Rhizopus* sp., and *Botrytis cinerea.* Top—40° F., approximately 39 days. Bottom—83° F., 5 days.

The summarized results (Table 1) indicated that the *Botrytis* culture was active over a wide temperature range, as contrasted with the culture of *Rhizopus,* which was essentially non-pathogenic at 40° F. and extremely aggressive at 83°, where its average rate of rotting was more than four times that of *Botrytis.*

In view of the limited scope of this experiment, the results must be considered with some caution. However, these figures, together with results from the preliminary pathogenicity trials, show conclusively that the species of *Rhizopus* studied is capable of extremely fast rotting of sugar beet tissue at high temperatures and indicate that it is essentially non-pathogenic at temperatures of about 45° F. and below.

From these results it seems probable that the genus *Rhizopus* occupies a relatively important place in the diverse group of pathogens capable of attacking stored sugar beets. Furthermore, since some members of that **group**—e.g. *P. betae* and *B. cinerea*—are known to be quite pathogenic at

Table 1.—Effect of Temperature on Rate of Rotting of Sugar-Beet Slices by Two Storage Pathogens; Measurements Given as Averages of Three Slices—Two Inoculations Per Slice.

Fungus	Temperature, time, and average depth of rot per day		
	40° F., 39 days	60° F., 14 days	83° F., 5 days
	mm.	mm.	mm.
Rhizopus sp.	0.04	2.2	6.4
Botrytis cinerea	0.9+	1.5	1.4

relatively low temperatures (1, 8), and with the extremely rapid rotting ability of *Rhizopus* sp. at high temperatures, the possibility for a succession of such pathogens with rising temperature is readily apparent. Adding weight to this supposition is the fact that the pathogenic type of *Rhizopus* sp. used in these studies was isolated from five of nine specimens taken from a storage pile at Gilcrest, Colorado—a pile which was being removed for processing because of heating at the time the specimens were collected.

Summary

Pathogenicity of a species of *Rhizopus* isolated from rotting sugar beets taken from a commercial storage pile in northern Colorado was compared with that of *Botrytis cinerea*, a recognized sugar beet storage pathogen.

The average rate of rotting of interior tap root tissue by the latter fungus did not vary greatly over the range of temperatures studied, whereas the average rate for *Rhizopus* sp. varied from a negligible amount at 40° F. to 6.4 mm. per day at 83°—the latter rate being more than four times the corresponding figure for *B. cinerea.*

The results indicate that at least one species of *Rhizopus* probably is a direct cause of rotting in commerically stored sugar beets in the United States when temperatures are relatively high.

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