PROGRESS REPORT ON ENVIRONMENTAL FACTORS AFFECTING SOFT ROT OF POTATO[1/]

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Introduction

An investigation was begun July 1, 1966 on the bacterial soft rot problem in railroad car shipments of potato tubers. The objectives were to determine the causal agent(s), to determine environmental factors involved and to develop control measures.

To determine the extent of the problem a survey was made of reinspection certificates of potato shipments from the state of Washington for 1965 and 1966.[3/] Tuber decay as reported on the certificated include soft rot, slimy soft rot, water rot and leak. It is not known if slimy soft rot caused by bacteria and water rot caused by a fungal organism were always properly distinguished in the reinspections. Leak caused by a fungal organism has somewhat similar symptoms to water rot; therefore, these two may not have been properly separated. There was also a question as to whether of not slimy soft rot was another disease or merely an advance stage of soft rot which is caused by bacteria. Therefore, for the purpose of this investigation, soft rot, slimy soft rot, water rot and leak were placed in one category under the heading "tuber decay." "Black spot", a tuber defect for which the cause is not known, was a second category.

A survey of the reinspection certificates issued between July 1 and November 19, 1965 and for a corresponding period July 1 to October 31, 1966, revealed that 686 cars in 1965 and 984 cars in 1966 were rejected for tuber defects.

Table 1. Railroad Car Shipments and Rejections 1965 and 1966

Total Cars Shipped		Total Cars Rejected[1/]		Percent Cars Reject.	
1965[2/]	1966[3/]	1965	1966	1965	1966
8,009	8,045	686	984	8.6	12.2

1/ Based on Reinspection Certificates Only.
2/ By 31 Shippers from July 1 to November 19, 1965.
3/ By 29 Shippers from July 1 to October 31, 1966.

1/ This investigation was made possible through grants supplied by the Washington State Potato Commission.
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3/ Based on records provided by Mr. W. J. Irey, Supervisor, Fresh Products Inspection, Federal-State Inspection Service, and Mr. Fred Ramsey, Manager, Washington State Potato Commission.

This represented an increase in car rejections from 8.6% in 1965 to 12.2% in 1966. There were additional unknown numbers of cars with serious tuber defects for which prices were readjusted at the terminal markets without reinspection and, therefore, not reported.

The survey showed that black spot was responsible for 43% of the rejections in 1965 and 48% in 1966. (Fig. 1.) Rejections for soft rot dropped from 36% in 1965 to 17% in 1966. Car rejections with combined tuber defects, black spot and soft rot, increased from 21% of the total rejections in 1965 to 35% in 1966. These figures show the seriousness of the tuber decay and black spot problems.

Environmental factors such as moisture, temperature and oxygen as well as food supplies play important roles in the growth of micro-organisms; a study of these factors as they relate to tuber decay seemed appropriate. The usual manner in which potato tubers are harvested, washed, sorted, packaged and loaded into railroad cars results in wounds an bruises through which micro-organism may enter and a wet and warm environment for their growth, especially during the summer and early fall when embient temperatures are high. The tubers may remain warm and wet for several days after sorting before the ice in the car reduced temperature to a point where decay processes were greatly reduced or prevented. Once the decay process has begun, water released from the initial decay will provide moisture for further decay, provided temperature is suitable. Weaver and Merrill[1/](1965) reported that it took 54 hours for the temperature to drop from 63° to 50° F. in a pre-iced car after the car doors were closed. (Fig. 2.) It required 72 hours for the temperature to drop from 65° to 50°F. in a second car not pre-iced and using 1/2 stage ice (bunkers 1/2 full).

Preliminary studies were begun with the following 2 experiments on the environmental factors affecting bacterial soft rot. These experiments are preliminary in nature. Implications from results should not be considered a recommendation for control.

Experiment No. 1-Oxygen Depletion by Potato Tubers in a Closed Chamber

OBJECT:

To determine the rate of oxygen depletion depletion by tubers in a closed chamber.

Introduction

Micro-organisms are known to vary in their oxygen requirements. Potato tubers during transit or storage are constantly using oxygen from the surrounding atmosphere. At present no information is available on the rate of oxygen depletion by tubers in closed containers. It is important that the effects of oxygen concentrations on tuber decay be established.

1/ Weaver, M. L. and T.A. Merrill. Amer, Potato J. 42:223-239.1965.

Materials and Methods

Twenty-five pounds of tubers were taken from a 35°F. cold room and with no further treatment were placed in double 8" x 10" x 24" polyethylene bags and tightly sealed. Four such "bags" were placed in each of 4 rooms at temperatures of 35°, 50°, 60° and 70°F., respectively. An asperating type oxygen analyzer, Beckman Model D, was used to measure the oxygen in each bag at various intervals.

Results

After 24 hours the oxygen content of the air in bags of tubers stored at 70° and 60°F. was reduced from 20.5% to about 5% oxygen, and in those stored at 50° and 35°F. the oxygen content was 10% and 16%, respectively. After 72 hours all bags contained less than 3% oxygen except those held at 35° which had about 8% oxygen. (Fig. 3) These results indicate that oxygen may be depleted in a relatively short period of time. This depletion of oxygen could affect soft rot decay caused by bacteria.

Experiment No. 2-Effect of Moisture, Temperature and Oxygen on Tuber Decay

OBJECT:

To determine the effect of various environmental factors on tuber decay Materials and Methods.

Potato tubers. The tubers (4-8 oz.) utilized in these studies were stored in a cold room, 35°F. for 3 months prior to testing. They were taken directly from the cold room and dipped in tap water so that all were uniformily wet. Eight tubers were placed in each chamber and the chambers were placed in their respective temperature rooms.

Temperature rooms. Four temperature rooms were designed to provide temperatures of 50°, 55°, 60° and 70°F., respectively.

Oxygen treatments. Each temperature room was inter-connected with atmospheric air and nitrogen gas manifolds. A needle valve regulated the flow of air or gas to each chamber. The chambers were sparged with air to represent an atmosphere level of oxygen (about 20.5%) and with nitrogen gas to represent a low level of oxygen (about 2%). The flow of air or nitrogen gas entering the chamber was observed by bubbling it through water in a flask placed inside each chamber.

Environmental chambers. Environmental chambers, herein called "chambers" were devised to control moisture and oxygen surrounding the tubers. Each chamber consisted of an 8" x 19" x 24" polyethylene bag supported at the outside by a wire frame. The chamber was placed upon a 9" x 14" tray for ease of handling. A wire frame 8" x

9" x 2" with wires 2" apart across the top, was placed within the chamber to support and to facilitate aeration of the tubers when required.

Moisture treatments.

Touching water. Five hundred milliliters of tap water were added to the bottom of each chamber. After placing the tubers in the water it was approximately 3/4" deep.

Sponge. Tubers were arranged under and on top of a sterilized cellulose sponge, 3" x 4" x 1-1/2", previously soaked in tap water. All tubers were arranged so they touched the sponge. The tubers and sponge were placed upon a wire frame within the chamber. A continuous film of moisture enveloped the tubers with drops of moisture hanging on the under side of lower tubers. After 5 days, 20 ml. of tap water were added to the sponge in the chamber by means of a 50 ml. syringe with a 3" needle. Some of the water ran off, indicating the sponge was filled to capacity. This sponge treatment represents a "water-soaked" spot in a sack of tubers in transit or storage which is often initiated by the water rot fungus.

Dry. Tubers were placed on a wire frame within the chamber and no moisture was added. After 24 hours the tuber surfaces were dry under the 4 temperatures tested.

Replication

Each treatment for atmospheric level of oxygen, low level of oxygen, touching water (wet), sponge and dry was replicated 4 times in each of the 4 temperature rooms. The experiment was replicated twice and the average data reported.

Tuber decay measurements.

Tuber decay was determined by applying pressure with the fingers on the surface. Each tuber was rated on a "0" to "5" scale, where "0" indicated no decay and "5" indicated 3/4 to all of the tuber decayed. Tubers which were just beginning to decay were given a "1" rating. The results were determined after 8 days for treatments held at 70°F. because of rapid symptom development at this temperature. Remaining data were recorded after 11 days for treatments held at 50°, 55° and 60°F.

RESULTS

Tubers receiving the dry treatment did not break down at any temperature or oxygen level. (Fig. 4). At a temperature of 50°F. tuber decay was prevented regardless of the moisture condition or oxygen level. Decay was much less at 55° and 60° than at 70°. Most of the decay at 55° and 60° was at sites of old cuts and bruises. Some of the

tubers receiving the touching water treatment at 70° showed no symptoms of decay while others in the same chamber were partially or totally decayed. Most of the decay in tubers touching water was in that portion of the tuber which was submerged. There was significantly more rot in the tubers touching water than in those touching the 1/ wet sponge. Tuber decay was significantly less at atmospheric level of oxygen than at the lower level of oxygen. (Fig. 4.).

SUMMARY

Potato tubers were tested at 4 temperatures, 50°, 55°, 60° and 70°F., under 3 moisture conditions, touching water, sponge and dry and with 2 oxygen levels, atmospheric and low oxygen (about 2%).

Tubers with dry surfaces did not decay under any temperature or oxygen level tested.

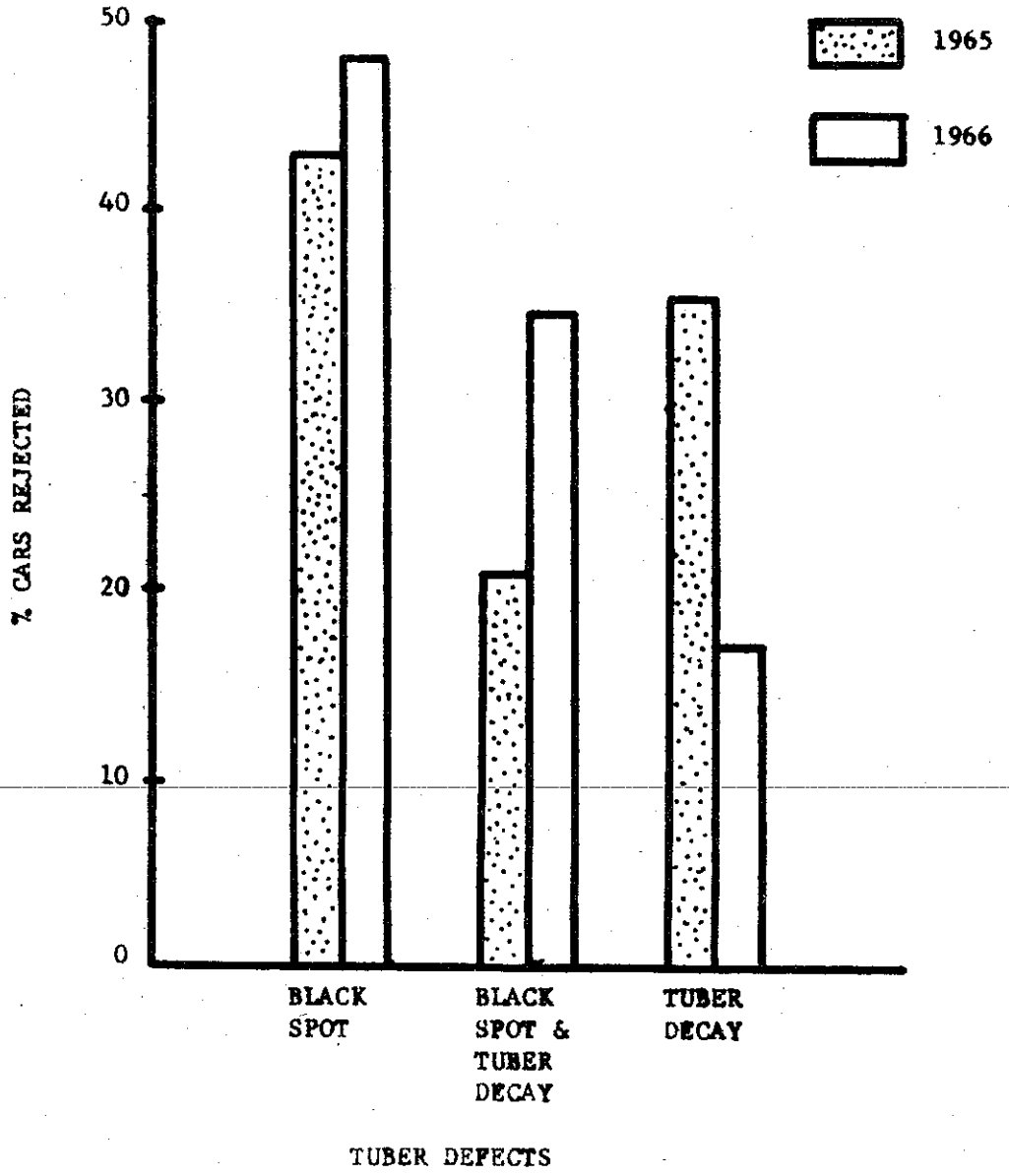
A temperature of 50° prevented tuber decay under all moisture conditions and oxygen levels tested. Temperatures of 55° and 60° greatly reduced decay over temperature of 70°.

Sound tubers were more resistant to decay than those with cuts and bruises.

Atmospheric level of oxygen decreased tuber decay over low oxygen level.

1/ Statistical data not reported.

FIG. 1 PER CENT OF CARS REJECTED DUE TO TUBER DEFECTS IN 1965 AND 1966.[1/]



[1/] BASED ON TOTAL CARS REJECTED AND NOT TOTAL CARS SHIPPED.

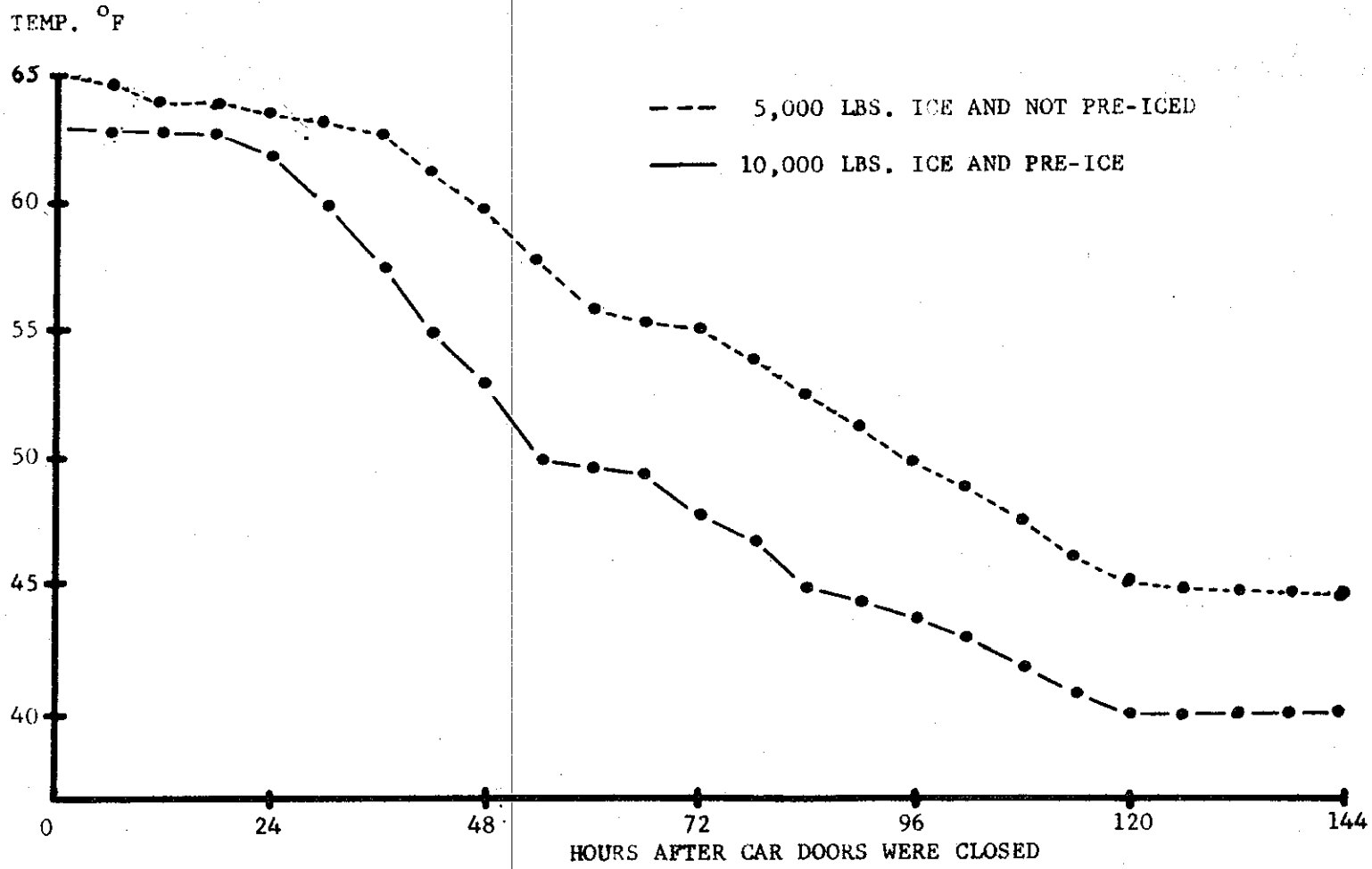


FIG. 2[1/] THE EFFECT OF ICE ON TEMPERATURE IN LOADED POTATO CARS

1/ Reproduced from Weaver, M. L. and T. A. Merrill. Amer. Pot. J. 42:223-239. 1965.

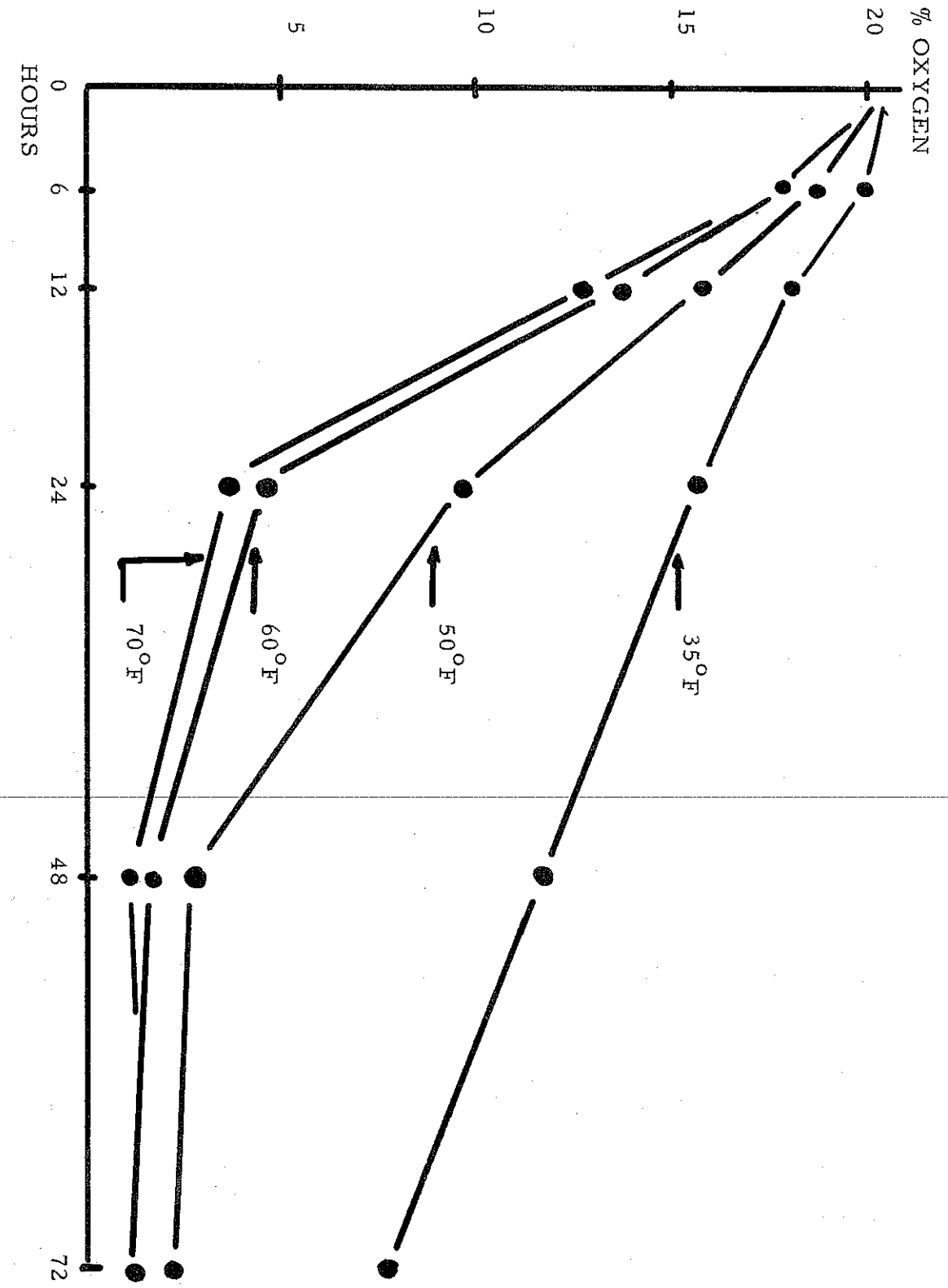


FIG. 3 THE EFFECT OF TEMPERATURE AND TIME ON OXYGEN DEPLETION BY TUBERS IN A CLOSED CONTAINER.

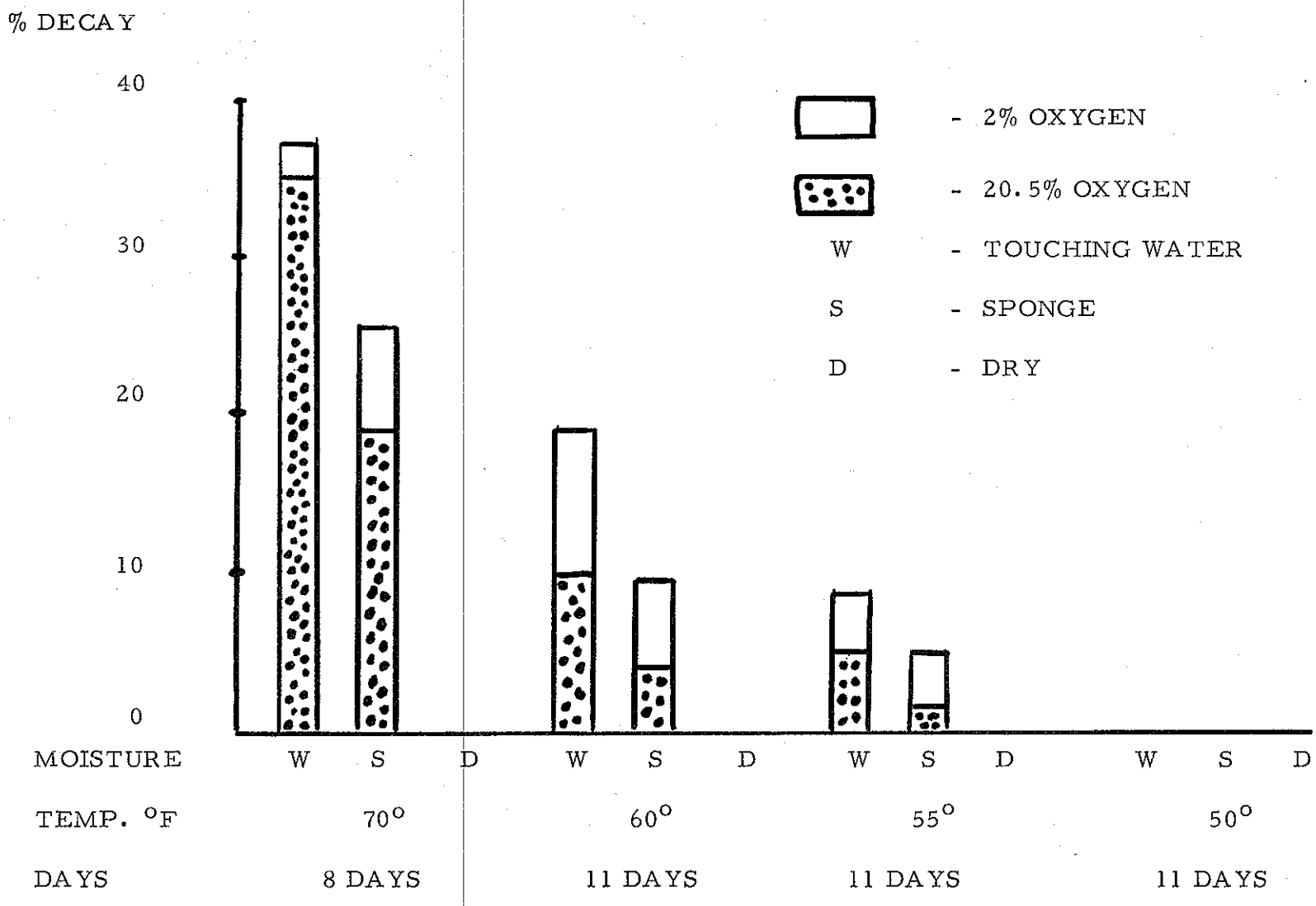


FIG. 4 EFFECT OF TEMPERATURE, MOISTURE, AND OXYGEN ON TUBER DECAY