POOR VENTILATION INJURES STORED POTATOES.

SUMMARIZED BY
F. H. HALL,
FROM BULLETIN BY
F. C. STEWART AND A. J. MIX.

PUBLISHED BY THE DEPARTMENT OF AGRICULTURE.
BOARD OF CONTROL.

Governor Charles S. Whitman, Albany.
Commissioner Charles S. Wilson, Albany.
Parker Corning, Albany.
Frank M. Bradley, Barkers.
Charles C. Sackett, Canandaigua.
Alfred G. Lewis, Geneva.
John B. Mulford, Lodi.
Irving Rouse, Rochester.
C. Fred. Boshart, Lowville.

OFFICERS OF THE BOARD.

Commissioner Charles S. Wilson, President.
William O'Hanlon, Secretary and Treasurer

STATION STAFF.


Joseph F. Barker, M.S., Agronomist.
Reginald C. Collison, M.S., Associate Chemist (Agronomy).
William W. Baer, B.S., Assistant Chemist (Agronomy).
Everett P. Reed, B.S.A., Assistant Agronomist.
Robert S. Reed, Ph.D., Bacteriologist.
Harold J. Conn, Ph.D., Associate Bacteriologist.
Fred C. Stewart, M.S., Botanist.
Walter O. Gloyer, M.A., Associate Botanist.
Mancel T. Munn, M.S., Assistant Botanist.
Lucius L. Van Slyke, Ph.D., Chemist.
Rudolph J. Anderson, B.S., Arthur W. Clark, B.S.,
John C. Baker, Ph.D., Associate Chemists.
Morgan P. Sweeney, A.M., Otto McCreary, B.S.,
Richard F. Keefer, A.B., William F. Walsh, B.S.,
Walter L. Kulp, M.S., Assistant Chemists.
George A. Smith, Dairy Expert.

Frank H. Hall, B.S., Vice-Director; Editor and Librarian.
Percival J. Parrott, M.A., Entomologist.
Hugh Glasgow, Ph.D., Fred Z. Hartzell, M.A. (Fredonia), Associate Entomologists.
Harold E. Hodgkiss, B.S., Bentley B. Fulton, B.A., Assistant Entomologists.
Ulysses P. Hedrick, Sc.D., Horticulturist.
George H. Howe, B.S.A., Joseph W. Wellington, B.S.,
William C. Stone, M.S., Assistant Horticulturists.
Orrin M. Taylor, Foreman in Horticulture.
F. Atwood Srrrine, M.S. (Riverhead), Special Agent.

Jessie A. Sperry, Director's Secretary.
Frank E. Newton, Willard F. Patchin, Lena G. Curtis,
Mae M. Melvin, Maude L. Hogan,
Emily L. Dronesky, Clerks and Stenographers.
Elizabeth Jones, Computer and Mailing Clerk.

Address all correspondence, not to individual members of the staff, but to the New York Agricultural Experiment Station, Geneva, N. Y.
The Bulletins published by the Station will be sent free to any farmer applying for them.

*Connected with Grape Culture Investigations.
POOR VENTILATION INJURES STORED POTATOES.

F. H. HALL.

A few years ago a diseased or abnormal condition of shipped potatoes was found to be due to overheating during a delay in transit. The centers of the potatoes became deep brown or black, so the name "blackheart" was applied to the trouble. Bartholomew, the investigator of this condition, found that, to avoid danger of frost when the shipped potatoes were delayed, the car had been heated excessively; and he was subsequently able to reproduce the blackening of the potato flesh by subjecting the tubers to temperatures from 100° to 113° F. He gave, as a secondary cause that might produce or intensify the trouble, lack of oxygen from insufficient ventilation.

It was accidentally found at this Station that potatoes allowed to receive only small quantities of air showed the same appearance, tho exposed only to temperatures far below those mentioned by Bartholomew. Extensive and long continued series of experiments begun by the Station botanists in consequence of this discovery have proved that poor ventilation, even when temperature conditions are normal, may lead to serious injury from blackheart. This fact has a very important bearing on the problem of proper storage for potatoes.

In the earlier Station experiments jars were used. Experiments with tubers in jars.

Weighed quantities of clean, dry tubers were placed in the jars with known proportions of air and the jars hermetically sealed. Different lots of these were kept for varied periods of time at temperatures within and above the range of those occurring in storage, extending to 70° F.

These tests proved conclusively that potatoes can not long stand close confinement with limited quantities of air. The lower the

* This is a brief review of Bulletin No. 436 of this Station, on Blackheart and the Aeration of Potatoes in Storage, by F. C. Stewart and A. J. Mix.

Those specially interested in the detailed account of the investigations will be furnished, on request, with a copy of the above-mentioned bulletin. The names of those who so request will be placed on the Station mailing list to receive future bulletins as issued, either Popular or Complete edition as desired.
temperature and the greater the proportion of air, the longer would
the injury be averted or the less serious would it be; but unless allowed
nearly twenty times their volume of air the tubers thus hermetically
sealed would not sprout normally in the jars and were liable to show
typical blackheart.

With equal volumes of tubers and air, confinement for ten or twelve
days at a temperature of 70° caused the tubers in the jars to become
moist over some or all of their surfaces. When the potatoes are re-
moved from the jars, these moist areas turn brown, and the flesh at the
center of the tuber changes to pink and then to black—blackheart.
Reduction of the temperature at which the jars were held to 55° or
60° F. delayed the appearance of the moist areas and the accom-
panying development of blackheart to 20 days; and tubers held at
40° remain uninjured for from 23 to 40 days. When the jars are
only one-half or one-quarter full of potatoes, thus increasing the
proportion of air, the development of the injury is delayed; but it
appears before the normal length of time for storing potatoes is
reached.

Until ten times as great a volume of air as of tubers was enclosed
in the jars, little or no sprouting of the potatoes took place; but with
about nineteen times as much air the tubers sprouted normally
and showed no other signs of injury.

As these jar tests indicate that lack of air soon
results in injury to tubers or their death, it was
evident that improper storage conditions might
lead to the same trouble. Accordingly, many tests
were made with potatoes stored in tall, slender,
upright metal tanks, closed at the bottom but usually open at
the top. Each of the tanks was nine inches in diameter, but they
were made of various heights, ranging from 6\(\frac{1}{2}\) to 10\(\frac{1}{2}\) feet, and
wire-netting separators were placed in the tanks as they were filled
with tubers thus dividing them into sections so that the effect of
the various conditions imposed could be easily determined for the
potatoes at different depths. Altho these tanks, with sides impervious
to air, do not imitate exactly the conditions in piles or bins of potatoes
of different depth, it is believed that they approximate them so
closely that the results are a good guide to proper storage con-
ditions.

Seven experiments were carried thru, using from one to four tanks,
and in some cases sealed or unsealed jars were also used as checks
or guides. In all the tests the conditions outside the tanks were
quite like those actually surrounding stored potatoes, and in one case
the tanks were placed in a cellar used for storage of apples, potatoes
and roots. Careful records were kept of temperatures and only
slight differences in readings were found between thermometers
surrounded by the potatoes and others placed at corresponding
heights outside the tanks.
Plate I.—Blackheart of Potatoes Caused by Exclusion of the Air.
Tubers confined in a full sealed jar ten days at 70° F. and afterward exposed to the air seven days.
PLATE II.—BLACKHEART OF POTATOES CAUSED BY EXCLUSION OF THE AIR.

Tubers confined in a full sealed tank 16 days at 53°-68° F. and afterward exposed to the air 27 hours.
The results secured in the different tanks and different tests do not show strict uniformity and there were noticeable differences between individual tubers under the same conditions in each tank; yet the very plain teaching from the tests is that it is not safe to pile potatoes more than six feet deep, if they are to be held for some months, even if the temperature remains below 40° F. If to be stored more than three or four weeks where temperatures rise above 50° the tubers should not be piled more than three feet deep.

The injury to the potatoes in the tanks is very similar to that of the tubers in the sealed jars, often with the addition of rotten spots due to the action of fungi and bacteria. In general, tho, they show the same collection of moisture on the surface, external discoloration when exposed to the air and frequent occurrence of typical blackheart. Like the potatoes in jars those in tanks failed to sprout normally when held long at any considerable depth even if the temperature favored germination.

Potatoes in “pits.” After these studies were begun it was learned that potatoes stored in “pits” (i.e., piled in conical heaps on the ground and covered with coarse manure, stalks, straw, etc., and soil), sometimes showed blackheart; so a study was made of three such pits. No injury to the potatoes resulted altho conditions were apparently quite favorable to occurrence of the trouble. This would indicate that ventilation in “pits” is better than would be supposed from the conditions.

Cause and appearance of blackheart. There is no doubt that blackheart may be caused, as Bartholomew states, by overheating potatoes, especially if poorly ventilated, but it is equally clear that lack of air alone produces an almost identical condition at quite low temperatures. That it is to lack of air, or oxygen, not to the accumulation of carbonic acid gas which the potatoes exhale, that the trouble is due is proved by two tests. In these tests the potatoes were enclosed in sealed receptacles and chemicals were placed below the tubers, but not in contact with them, to absorb this gas as it was produced. In spite of the withdrawal of this possibly harmful gas the tubers developed blackheart as markedly as those under similar conditions but with the gas present.

Blackheart produced by heating and that caused by lack of oxygen are very similar, so far as the flesh of the tuber is concerned; but the skin of heat-blackhearted potatoes shows no signs of injury, while those affected with blackheart from the lack of oxygen are more or less browned or discolored.

In both types of the injury the flesh first turns pink, then brown and finally black, and in extreme cases the discolored portion may become tough and leathery and so shrink that considerable cavities are formed.
PLATE III.—SPROUTING OF POTATOES AT DIFFERENT DEPTHS.
(1) At top of tank (2) at depth of 27 inches. Compare with Plate IV.
PLATE IV.—SPROUTING OF POTATOES AT DIFFERENT DEPTHS.

Tubers from same tank as those producing sprouts shown in Plate III. (1) At depth of 54 inches; (2) at depth of 80-107 inches.
Blackheart potatoes for seed. The production of blackheart by lack of air is accompanied by a loss of vitality of the eyes, so that such blackhearted potatoes will not sprout normally, putting out very small, short stems or none at all. These sprouts, however, are not like those in "spindling sprout"—long, and very slender—but are merely dwarfed or miniature sprouts. Unless the trouble is so serious that the surface of the tubers is discolored, the sprouting ability of the potatoes is not greatly affected. Sprouting may be delayed by the small supply of oxygen while the tubers are in storage, but on free access of air normal sprouting occurs unless the internal injury has gone so far that evidence of it shows on the surface.

With heat-blackhearted tubers, decay usually follows severe injury, and germination is not greatly affected unless the internal injury is severe; so the same rule applies: If potatoes in the same lot with those showing blackheart do not present some external evidence of the trouble, either discoloration or decay, they may probably be safely used for seed. In cutting the seed it may be well to reject those tubers showing very extensive areas of blackened flesh.

The results of this investigation emphasize the importance of providing ventilation for potatoes in storage. The need of ventilation depends very largely upon the temperature. As the temperature rises the volume of air required increases rapidly. At low temperatures, potatoes may be stored in deep piles for long periods of time. At high temperatures, it is necessary to avoid deep piling or else provide special means of ventilation. If the temperature is kept below 40° F. potatoes may be piled in bins and cellars to a depth of six feet without any ventilation except that provided thru free access to the air overhead. Under such conditions, potatoes may be stored with safety for at least six months and perhaps longer. It is probable that no harm will result if the temperature goes up to 45° F. for a few days. But a long period of storage followed by a two weeks' exposure to a temperature of 50° F. or higher is liable to result in the ruin of most of the tubers below a depth of about three feet. Potatoes stored in deep piles should be carefully watched in the spring as the temperature rises. A few days of high temperature may cause much loss.

It is not in the province of this bulletin to discuss the means by which the ventilation of potatoes may be secured. The methods to be employed will vary according to circumstances. The principles to be kept in mind are as follows:

1. Potatoes stored at high temperatures require more ventilation than those stored at low temperatures.

2. Better ventilation is required for potatoes which are to be stored for a long period than for those which are to be stored for only a short time.
(3) Until more accurate determinations are made, six feet should be regarded as the maximum depth to which potatoes may be piled without special provision for ventilation when stored for six months at temperatures below 45° F. If greater depths than six feet are employed ventilators should be provided and so arranged that none of the tubers will be more than six feet distant from an abundant supply of air.

(4) At temperatures of 50–70° F. potatoes should not be piled over three feet deep if they are to be kept longer than about three weeks.

(5) No kind of ventilation is sufficient to prevent the occurrence of blackheart in potatoes kept for even a few days continuously at a temperature above 100° F.

(6) Complete exclusion of the air will ruin potatoes at any temperature.

(7) Small potato pits do not need ventilation; but some provision should be made for the ventilation of large pits.