SOME INVESTIGATIONS OF CAUSE AND CONTROL OF WINTER PEAR STORAGE ROTS IN THE ROGUE RIVER VALLEY OREGON

by

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ABSTRACT

A survey of inspection records of Anjou and Bosc pears shipped to market between November 1, 1956 and March 30, 1957 show storage rots to be an important problem of the Rogue River valley pear industry. Considerably more rot occurred in the Bosc than in the Anjou pears.

Tissue isolations from the common blue mold and gray mold rots consistently yielded Penicillium sp. and Botrytis sp. respectively.

Isolations showed Cladosporium sp. to be almost always associated with a brown, superficial rot of Anjou and with a brown-black rot of Bosc pears.

Packing-house tests of three concentrations of Stop-Mold B showed it to be an effective rot-preventative. An apparent improvement in the control of rots with increased concentration of Stop-Mold B solution occurred in one lot of pears. Another lot showed an apparent decrease in control of rots with increased concentration of this fungicide.

Packing-house tests of fungicides for prevention of rots were conducted in 1958 and 1959. Of the nine fungicides tested, Busan 50 was the most effective for rot control but resulted in a severe, brown skin discoloration. The commonly used post-harvest-dip chemical, Stop-Mold B, ranked high in all of the tests and is considered to be the best of the fungicides tested.

The high percentage of storage rot spots with a broken surface indicates the importance of handling fruit carefully to avoid injury.

Penicillium was the most prevalent rot of the pears examined during these investigations. Next was Cladosporium rot, then Botrytis rot.

Cladosporium rot is shown to be a major storage rot of winter pears in the Medford area and is not necessarily associated with skin breaks.

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INTRODUCTION

Approximately one-sixth of the pears for the fresh fruit market in the United States is produced in the Rogue River Valley, Oregon (1). The city of Medford is the business center of the pear industry and the site of the major packing houses. The pears are grown on approximately 10,000 acres; Bartlett 4,000, Anjou 3,000, Bosc 2,000 and 1,000 acres of Comice, Winter Nelis, Seckel and minor varieties (3). Winter pear varieties, principally Anjou, Bosc, Comice and Winter Nelis, are grown on more than half of the pear acreage. The 10 year average annual packout (1951-1961) of winter pear varieties is:

Anjou	830,039	packed boxes
Bosc	547,723	" "
Comice	91,273	" "
Winter Nelis	18,300	" "

The Rogue River valley grows approximately one-third of the total winter pear production in Washington, Oregon and California (18).

Pears for the fresh fruit market are harvested from August until the end of October, depending on variety and held in cold storage at 29°F to 31°F until shipped. Most of the crop is sold and sent to market by May of the following year, however, some small shipments are often made as late as June 15.

In the past, extreme losses from pear storage rots caused by fungi were reduced in the Medford area, as in other Pacific Northwest tree fruit growing districts (5) (6) (9) (11) (12) by use of pre-harvest sprays (2)

(10) (17), copper-oil impregnated paper wraps (4) (12) (13) and post-harvest chemical dips (7) (8) (15) (16) (19). In 1956, however, pear shippers and fruit inspectors in the Medford area reported continued losses from Penicillium rot and Botrytis rot and of losses, especially in the Bosc variety, from a small, up to one-half inch in diameter, brown to black rot spot of the skin and underlying tissue. The same type of brown rot was reported to be frequently associated with skin breaks.

At the request of the Medford Pear Shippers Association, an association of Rogue River Valley pear packers and shippers, many of whom also own and operate pear orchards, the investigations herein reported were started in January, 1957. The major phases of the investigations were:

1. Determine the incidence of storage rots in the 1956 crop of winter pears.
2. Determine the organisms associated with the major rots.
3. Determine the value of the commonly used post-harvest-dip chemical Stop-Mold B* when used at several concentrations, in reducing storage rots.
4. Packing-house tests of other fungicides as post-harvest treatments for storage rot control.

* Active ingredient sodium orthophenylphenate. Manufacturer, Vis-Ko Inc. Sumner, Washington.

METHODS

Isolations: standard laboratory techniques were used throughout. The detail is described in Experiment 1.

Tests of fungicides in packing houses: standard packing-house techniques of treating the fruit with a fungicide were used in all experiments. Differences in technique are described for each experiment.

HISTORICAL REVIEW

Pertinent literature concerning pear rots published up to the year 1940 has been thoroughly reviewed by English (5). Wolfe (20) has reviewed the literature concerning the agricultural use of o-phenylphenol (Dowicide 1) and its sodium salt (Dowicide A). No attempt has been made to duplicate the reviews, instead they have been repeatedly referred to and more recent literature added in some cases.

INCIDENCE OF STORAGE ROTS IN SOME OF THE 1956 CROP OF BOSC AND ANJOU PEARS

In the Medford area, pears are harvested into lug boxes, trucked into the packing houses, treated with Stop-Mold B solution, graded for size and quality then boxed and placed in cold storage (29°F-31°F). During the shipping period from November to June as the boxes are removed from cold storage for shipment, usually by refrigerated cars, the fruit is inspected for maturity, decay and other defects by Federal-State fruit inspectors. Decay is caused principally by storage rot organisms, however, occasionally, it is the result of low temperature injury to the pears while in storage. Depending on the size of the fruit, the inspector will open and inspect from 10 to 40 boxes per carlot and record the percentage of pears showing decay. To determine the incidence of decay in stored Bosc and Anjou pears, the following data listed in Table 1

were compiled from the inspection reports of carlot shipments from six major packing houses for the period November 1, 1956 to March 30, 1957.

Table 1. Incidence of decay in Bosc and Anjou pears inspected November 1, 1956 to March 30, 1957.

BOSC

House	Rating*	No. of boxes in inspected carlots	Boxes decayed**	Average per cent decayed pears per carlot inspection
A	1	44,554	226	.51
B	2	47,320	473	.99
C	3	96,327	1,189	1.20
D	4	7,952	134	1.60
E	5	30,720	1,047	3.40
F	6	20,525	910	4.40

ANJOU

C	1	56,744	72	.12
A	2	30,720	80	.26
D	3	72,414	193	.26
F	4	47,595	191	.4
E	5	84,579	394	.46
B	6	78,836	640	.80

* Rating of each house based on average per cent decayed pears in carlots.

** Represent the number of boxes considered to be decayed in the inspected carlots e.g. if 2% decay occurred in a carlot (768 boxes) we recorded 15 boxes of decayed pears. Carlots having less than 1% decay were not included in the calculations.

Based on the average per cent decayed pears per carlot inspection there was little relationship between packing houses and the given rating

for both varieties. An exception was packing house E which rated fifth for both Anjou and Bosc.

The amount of decay found in the Bosc variety was considerably greater than that in the Anjou variety. Decay in the Bosc variety varied from .51% to 4.4% (average 2.02%) and in the Anjou variety from .12% to .8% (average .38%).

Equivalent or increased incidence of decay can be expected in the pears held in cold storage until May and June. Fruit inspectors estimate that the per cent of rot in a carlot will increase at least two-fold by the time the fruit reaches eastern markets (14).

FUNGI ASSOCIATED WITH STORAGE ROTS

Fruit inspectors and others in the pear industry are familiar with blue mold rot (PLATES VII and VIII) and gray mold rot (PLATES IV, V and VI) caused by Penicillium sp. and Botrytis sp. respectively.

The cause of the small brown to black rot reported to be causing considerable losses, especially of the Bosc variety, was unknown to the trade and was called by several names, "spot rot", "brown rot" and "Alternaria rot".

Experiment 1

Materials and Methods

In January, 1957, as fruit was being inspected prior to shipment, a collection was made of twenty-seven Bosc and four Anjou pears with a total of thirty-eight brown to black rot spots.

Most of the rots of the Bosc pears had occurred through apparently unbroken skin. The rot was a brown to black, firm, shallow lesion, up

to one-half inch in diameter (PLATE I). The affected tissue beneath the surface of the rot was a brown to black. Below the surface of some of the rots the affected tissue had pulled away, leaving a cavity. A brown to black rot was associated with skin breaks on some of the pears (PLATE II).

On the Anjou pears the rot was a superficial, brown, firm lesion, irregular in shape (PLATE III). The rot had occurred through apparently unbroken skin.

Isolations were made from the thirty-eight rot spots in this way: the section of pear to be isolated from was disinfected with 5% Clorox. By the use of sterile instruments the skin of the rotted area was lifted and a small piece of tissue removed from the edge of the lesion and placed in a petri dish containing Difco potato dextrose agar.

Results and Discussion

The following species of fungi were isolated

Cladosporium sp. from 28 rots

Cladosporium sp. plus Pullularia sp. from 3 rots

Cladosporium sp. plus Alternaria sp. from 2 rots

Cladosporium sp. plus Penicillium sp. from 2 rots

Penicillium sp. from 3 rots

The prevalence of Cladosporium sp. in these isolations indicates that it is the cause of the rots. Cladosporium sp. has been reported as a storage rot of pears in Washington by English (5) and Fisher (9) and in Oregon by Kienholz et al (16). Cladosporium rot was reported by English and Kienholz et al as a minor storage rot usually found associated with breaks of the skin.

Fisher reported "On pears Cladosporium rot is sometimes an important storage disease and apparently infects the fruit through the lenticels. We have observed Winter Nelis fruits literally "peppered" with tiny rot spots."

Shippers and fruit inspectors report that Cladosporium rot is a major storage rot of winter pears grown in the Rogue River valley.

Numerous isolations from typical gray mold and blue mold rots on pears collected by the fruit inspectors confirmed the presence of Botrytis sp. and Penicillium sp. respectively.

CONTROL OF STORAGE ROTS BY SEVERAL CONCENTRATIONS OF STOP-MOLD B

Stop-Mold B, a 34% solution of sodium ortho phenylphenate in combination with surfactants and safeners was developed by the Vis-Ko Inc., Sumner, Washington, to replace Stop-Mold A as a post-harvest treatment of apples and pears for the prevention of storage rots.

Stop Mold A (40% solution of sodium chloro-2-phenylphenate plus surfactants and safeners) was in general use throughout the Pacific Northwest from its introduction in 1948 until it was replaced by Stop-Mold B in 1952. Vis-Ko Inc. reported that 10,000 carloads of apples and pears were treated with Stop-Mold A in the Pacific Northwest during the 1949-50 packing season. Complaints of objectionable odor, tingling of finger tips, rashes and dermatitis from the women on the grading machines were the major reasons for stopping the use of Stop-Mold A as a post-harvest-dip.

Experimental work by English and Fisher (6), English (7), English et al (8), Kienholz (15) and Kienholz et al (16) showed that

Stop-Mold A was an effective preventative of pear rots. With the introduction of Stop-Mold B in 1952, no comparable experiments were run to determine its efficacy for controlling pear storage rots. The first tests of Stop-Mold B as a post-harvest treatment for the prevention of pear storage rots in Oregon, are herein reported.

The tests were established to evaluate Stop-Mold B for control of rots and to compare rot-prevention by two concentrations of Stop-Mold B with the 0.6% solution recommended by the manufacturer.

Experiment 2

Materials and Methods

With the assistance of packing-house personnel the concentration of Stop-Mold B for one grading machine was set at 0.3%, 0.6% and 0.9%. On September 6, 1957, pears were run through each treatment until approximately 50 boxes of graded fruit (Fancy Pack) were packed, using copper-oil-impregnated paper wraps (Hartman wrap). The check lot was sprayed with clean water.

The pears were dumped from orchard lugs into a fresh water tank, conveyed by belt through a metal enclosure where they were sprayed with Stop-Mold B for 28 seconds, carried on a conveyor belt for 23 seconds, then spray-rinsed with fresh water. The fruit was individually wrapped and packed immediately after treatment and placed in cold storage at 29°F to 31°F.

On January 10, 1958, ten boxes of the check lot were opened and examined.

Results and Discussion

Only four spots, all Cladosporium rot, were found in the 225

pears examined. Because of the low incidence of rot in the check lot, the readings were discontinued.

Experiment 3

Materials and Methods

One hundred and seventy-eight orchard lugs of selected cull Bosc pears were treated. Culls, rather than graded-out fruit, were used to increase the possibility that the incidence of storage rots, especially in the untreated lot, would be high.

Most of the pears had been culled because of pear scab, stony pit, insect, small size, shape, skin breaks and other defects. Culls selected for treatment were reasonably free of skin breaks, scab and stony pit.

The pears were divided into four equal lots and run through a packing-house grading machine, on September 11, 1957. Three were treated with Stop-Mold B; the check lot was sprayed with water. The fruit was dumped onto a conveyor belt which carried the fruit through an enclosure where it was sprayed from above with Stop-Mold B then spray-rinsed with fresh water. The Stop-Mold is recirculated from a tank. The fruit was under the Stop-Mold B spray for 28 seconds, travelled along the conveyor belt for 25 seconds and then was sprayed with fresh water for four seconds. The pears were picked up wet from the grading belts, put into polyethylene bags in orchard lugs and placed in cold storage at 29°F to 31°F. The necks of the polyethylene bags were closed by "Twist'ems".

Approximately one-half of the pears were removed from cold storage and examined on March 3 and 4, 1958; the remainder was examined April 8 and 9. Each pear was examined and a record made of the number of pears

with rot and the number free of rot. The results are summarized in Table 2 and Table 3.

Results and Discussion

Table 2. Per cent of pears with rot when Stop-Mold B was used at three concentrations. Pears examined March 3, 4, 1958.

Treatment*	Actual Concentration**	No. Pears Treated and Examined	Per cent of Pears With Rot
Check	None	1,225	27.1
Stop-Mold B .3%	0.23%	1,130	16.4
Stop-Mold B .6%	0.51%	1,163	14.4
Stop-Mold B .9%	0.71%	1,348	13.8

Table 3. Per cent of pears with rot when Stop-Mold B was used at three concentrations. Pears examined April 8, 9, 1958.

Treatment*	Actual Concentration**	No. Pears Treated and Examined	Per cent of Pears With Rot
Check	None	1,337	33.9
Stop-Mold B .3%	0.23%	1,268	18.4
Stop-Mold B .6%	0.51%	1,409	15.7
Stop-Mold B .9%	0.71%	1,350	21.7

* Packing house personnel, following their usual procedures, prepared the three concentrations of Stop-Mold B.

** The actual concentration of the Stop-Mold B solutions as determined by titration.

The data in Table 2 and Table 3 show that Stop-Mold B is an effective storage-rot preventative and support its general use in packing-houses in the Medford area.

Table 2 shows an apparent improvement in the control of rots with increased concentration of the Stop-Mold B solution, but this was not

the case for the pears examined on April 8 and 9, Table 3.

TESTS OF FUNGICIDES FOR STORAGE ROT CONTROL

Experiment 4

Materials and Methods

On September 22, 1958, one hundred orchard lugs each of selected Bosc and Anjou culls were divided into ten approximately equal lots and treated with a fungicide or fungicide combination as they were run through a packing house grading machine. The 225 gal. tank normally used to hold the re-circulating Stop-Mold B solution was charged with fungicides in the sequence listed in Table 4. The tank was washed with fresh water between treatments.

Table 4. Chemicals tested for control of storage rots. 1958-59

	Treatment*	Concentration of Fungicides
1.	Check - water only	
2.	Captan 80W	2.5 lbs. per 100 gal. of water
3.	Phaltan	4.0 " " " " " "
4.	Thylate	4.0 " " " " " "
5.	Cyprex	2.0 " " " " " "
6.	Captan 80W plus	1.25 " " " " " "
	Thylate	2.25 " " " " " "
7.	Captan 80W plus	1.25 " " " " " "
	Cyprex	1.0 " " " " " "
8.	Stop-Mold B	.61% solution by titration
9.	Busan 50	.6% solution (approximate)
10.	Purex	300 ppm (approximate)
11.	Ziram**	4.0 lbs. per 100 gal. of water

* See List of Active Ingredients on Page 25.

** Used only in the test with Bosc pears.

Each lot of pears was sprayed for eight seconds with a fungicidal solution or suspension as the pears passed below on a conveyor belt, picked up wet and placed in polyethylene bags in lugs, then placed in

cold storage (29°F to 31°F). The necks of the bags were twisted and tucked down the side of the lug to keep them closed.

On March 7 and 8, 1959, the fruit was removed from cold storage and examined.

Results and Discussion

The results are summarized in Tables 5 and 6.

Table 5. Anjou. Control of storage rots by post-harvest application of fungicides.

Treatment	No. pears treated and examined	Per cent of pears with Cladosporium rot	Penicillium rot	Botrytis rot	Other rots	Total per cent Pears rotted
Busan 50	1067	.1	0	.2	0	.5
Stop-Mold B	1041	2.3	.4	2.4	.1	4.8
Captan 80W plus Cyprex	1031	.6	0	4.7	0	5.5
Captan 80W plus Thylate	999	2.5	.5	3.9	.4	6.2
Cyprex	1009	1.0	0	6.3	.7	8.0
Captan 80W	942	3.0	.3	7.2	2.2	11.7
Thylate	762	2.4	.2	10.2	0	12.4
Phaltan	921	1.9	.2	18.1	1.5	21.1
Purex	1079	2.3	0	19.6	1.3	22.9
Check	1061	16.0	.6	7.5	1.0	22.9

The high incidence of Botrytis rot resulted from severe Botrytis "nesting" (PLATE VI). In commercially packed Anjou pears "nesting" is controlled by the use of copper-oil impregnated paper fruit wraps (Hartman wrap). If the Hartman wrap had been used in this experiment the amount of Botrytis rot and subsequently the total per cent of pears

with rot, especially in the lots treated with Thylate, Phaltan and Purex, undoubtedly would have been reduced.

Cladosporium rot was the most prevalent rot of the check fruit.

Best control of storage rots based on the total per cent of pears with rot was obtained with Busan 50. This fungicide, however, produced a brown-black skin discoloration of many pears.

Good control of all rots was obtained with Stop-Mold B which ranked second to Busan 50 in lowering the total per cent of pears with rot.

The data indicate that fungicides Busan 50, Stop-Mold B, Captan 80W plus Cyprex, Captan 80W plus Thylate, Cyprex, Captan 80W and Thylate should be considered for future testing.

Table 6. Bosc. Control of storage rots by post-harvest application of fungicides.

Treatment	No. pears treated and examined	Per cent of pears with Cladosporium rot	Penicillium rot	Botrytis rot	Other rots	Total per cent Pears rotted
Captan 80W plus Cyprex	1887	6.0	0.1	5.2	0.1	11.1
Stop-Mold B	1274	11.1	1.0	3.1	0.3	13.3
Busan 50	1244	11.2	0.7	2.7	0.0	13.6
Cyprex	1675	8.1	0.9	5.7	0.0	13.7
Thylate	1683	12.8	0.5	4.8	0.0	16.4
Ziram	497	12.2	3.8	3.6	0.6	18.1
Phaltan	1344	10.2	0.6	7.6	0.0	18.2
Captan 80W	1356	13.9	1.1	5.8	0.2	18.5
Captan 80W plus Thylate	1413	9.9	0.7	9.2	0.3	18.8
Purex	1052	16.0	5.8	35.0	1.5	49.6
Check	1321	17.7	4.6	24.3	1.8	39.7

Some Botrytis "nesting" occurred in many of the lots but was severe in the check treatment and most severe in the Purex treatment. The increased "nesting" in Purex treated pears over check fruit is a matter for conjecture. One may speculate that Purex caused some physical change in the pear's surface conducive to rot development, however, experimental data would be needed to verify this.

In these trials as in the trials with Anjou pears (Table 5), the incidence of Cladosporium rot was high. Cladosporium rot was the major rot in all except the check and Purex treated lots. Botrytis rot, Penicillium rot and other rots ranked next in order of decreased incidence.

Best control of rots was obtained by the use of Captan 80W plus Cyprex. This combination was the most effective in controlling both Cladosporium and Penicillium rot.

Stop-Mold B, Busan 50 and Cyprex were next, and essentially equal in effectiveness as measured by total per cent of pears with rot.

Relationship of Rots to Skin Breaks

While making counts of the types and numbers of rots summarized in Tables 5 and 6, the broken or unbroken condition of the surface of the rots was noted. The data are summarized in Table 7.

Other workers (5) (9) have reported Cladosporium rot of minor importance and occurring principally in association with skin breaks. The data in Table 7 show Cladosporium rot to be a major rot of pears in the Medford area, and that it is not necessarily associated with skin breaks.

Table 7. Broken or unbroken surface of rots of Bosc and Anjou pears.

	Cladosporium rot		Penicillium rot		Botrytis rot		Other rots	
	Anjou	Bosc	Anjou	Bosc	Anjou	Bosc	Anjou	Bosc
Total broken spots	130	1516	23	160	114	501	35	30
Total spots	558	2254	30	272	899	1539	173	71
Per cent broken spots	23.2	67.2	76.6	58.8	12.6	32.5	20.2	42.2

Many of the Botrytis rots with unbroken surfaces were the result of the rampant growth of the fungus and resultant "nesting" in many of the orchard lugs.

The high percentage of Penicillium rots with broken surfaces is misleading. Because of the large size and softness of many of these rotted spots, breaks occurred from natural stress and from handling during the examinations. For the same reasons breaks occurred in the Botrytis rot surfaces but they were fewer because of the firmness of the rots. Because of the small size and firmness of Cladosporium rots, breaks from stress and handling were infrequent.

The numbers of all rot types which occurred at skin breaks shows the importance of handling pears with care to avoid injuries.

Experiment 5

Materials and Methods

On October 22, 1959, 70 orchard lugs each of selected Bosc culls and orchard-run Anjous were removed from cold storage, divided into seven approximately equal lots and treated with fungicides in the same machine and in the same way as in Experiment 4. An additional 18 orchard lugs of pears were used in the trials with the Anjou variety, at the request

of a chemical company representative.

Bosc culls were selected from fruit harvested on October 2, 1961, then placed in cold storage at 29°F to 31°F to await treatment. The Anjou pears had been harvested on September 18 and kept in cold storage at 29°F to 31°F until October 22. Treatments are listed in Table 8.

Table 8. Chemicals tested for control of storage rots. 1959-1960

Treatment*	Concentration of Fungicides
1. Check - water only	
2. Captan 80W	2.5 lbs. per 100 gal. of water
3. Cyprex	2.0 " " " " " "
4. Captan 80W plus	1.25 " " " " " "
Cyprex	1.0 " " " " " "
5. Captan 80W plus	1.25 " " " " " "
Thylate	2.25 " " " " " "
6. Busan 50	.3% solution (approximate)
7. Stop-Mold B	.65% solution by titration
8. Niacide M	2.5 lbs. per 100 gal. of water

* See List of Active Ingredients on Page 25.

On March 9, 10, 11, 1960, pears were removed from cold storage and examined.

Results and Discussion

The results are summarized in Tables 9 and 10.

Table 9 Discussion

Penicillium rot was the most prevalent rot in the test; next was Cladosporium rot, then other rots. In the check fruit, the incidence of Penicillium rot was higher than that of any rot.

The Niacide M treatment gave an increase of Cladosporium rot over the check treatment.

The first six fungicides as measured by total per cent of pears with rot rank in the same order as in the 1958-59 tests with Anjou pears (Table 5).

Control of rots was best in the Busan 50 treatment, however, again, a brown-black skin discoloration occurred. The number of discolored pears (3%-5%) although fewer than in the previous test when Busan 50 was used at twice the concentration, indicates that this fungicide is probably unsuitable for use as a storage rot preventative.

Stop-Mold B gave as good control of all rots with the exception of Botrytis rot, as did Busan 50.

Table 9. Anjou. Control of storage rots by post-harvest application of fungicides.

Treatment	No. pears treated and examined	Per cent of pears with Cladosporium rot	Penicillium rot	Botrytis rot	Other rots	Total per cent Pears rotted
Busan 50	1379	0.5	0.3	0.1	0.1	0.94
Stop-Mold B	1275	0.5	0.3	0.4	0.1	1.2
Captan 80W plus Cyprex	1600	1.3	1.4	0.7	0.1	3.4
Captan 80W plus Thylate	1339	1.3	2.8	0.2	0.1	4.0
Cyprex	1459	3.4	2.1	0.2	0.3	5.9
Captan 80W	1570	2.5	3.5	0.2	0.8	7.0
Niacide M	939	5.8	3.1	3.0	3.5	13.2
Niacide M	926	13.1	3.3	1.7	4.4	21.3
Check	1715	3.8	21.6	1.3	0.3	25.1

Table 10 Discussion

Some of the pears in this test were soft and spongy as a result of excessive low temperature during storage. The injury occurred almost uniformly throughout the lots and affected the examinations of only the check fruit. The almost complete disintegration of the check fruit from

low temperature injury and high rot incidence prevented examination of the fruit for rots.

Cladosporium rot and Penicillium rot were the prevalent rots of the fruits examined.

Botrytis "nesting" occurred in many of the lots but was most severe in the check lot and was a major cause of the almost complete rotting and disintegration of the pears.

Best control of rots was obtained by the Busan treatment, however, skin discoloration occurred. Captan 80W plus Cyprex and Cyprex were next, and essentially equal in effectiveness as measured by total per cent of pears with rot. Stop-Mold B ranked fourth in effectiveness. In the 1958-59 tests (Table 6) with Bosc pears, Stop-Mold B ranked second to Captan 80W plus Cyprex.

Table 10. Bosc. Control of storage rots by post-harvest application of fungicides.

Treatment	No. pears treated and examined	Per cent of pears with Cladosporium rot	Penicillium rot	Botrytis rot	Other rots	Total per cent Pears rotted
Busan 50	1076	10.0	4.2	4.6	.6	17.1
Captan 80W plus Cyprex	1026	10.7	6.9	2.3	0.0	19.3
Cyprex	1356	7.4	9.8	4.4	.07	19.6
Stop-Mold B	1137	13.4	8.8	1.3	.5	21.6
Captan 80W	1309	9.8	14.3	7.9	.2	27.1
Captan 80W plus Thylate	917	18.0	24.1	5.6	.2	41.3
Check	1098*	*	*	*	*	93.1

* Pears almost completely rotted, no readings on types of rots were taken.

Relationship of Rots to Skin Breaks

During the examination of the pears, the broken or unbroken condition of the surface of the rots was noted. The data are summarized in Table 11.

Table 11. Broken or unbroken surface of rots of Bosc and Anjou pears.

	Cladosporium rot		Penicillium rot		Botrytis rot		Other rots	
	Anjou	Bosc	Anjou	Bosc	Anjou	Bosc	Anjou	Bosc
Total broken spots	351	472	103	275	10	73	37	2
Total spots	453	1047	724	972	98	352	117	24
Percent broken spots	77.5	45.1	14.2	28.3	10.2	20.8	31.6	8.3

The data, in support of the results of Experiment 4 (Table 7) show Cladosporium rot to be a major pear rot in the Medford area and that it is not necessarily associated with skin breaks.

Breaks in the surface of the Penicillium and Botrytis rot spots occurred from natural stress and handling.

DISCUSSION

Losses Caused By Storage Rots

Losses caused by storage rots are an annual drain on the economics of the Rogue River valley pear industry. It is difficult to make an accurate estimate of the total loss resulting from decay of pears since there are many kinds of losses: decayed fruit; rejection of carlots in markets, requiring an adjustment in price; the forcing of fruit onto the market even though the maturity of the fruit is suitable for a longer storage period; repacking before shipping to market; decay after the fruit is purchased by the consumer and subsequent influence on consumer buying practices in relation to competitive fruits.

Fungi Associated With Storage Rots

Penicillium rot and Cladosporium rot were the most prevalent rots in the check or treated lots in three of the four tests of fungicides (Experiments 3 and 4). In the 1958 test of fungicides in which Anjou pears were treated, Botrytis rot was the most prevalent. In this test Botrytis "nesting" was severe. "Nesting" is the result of the growth of the mycelium from one fruit to another. The resultant mass of fruit and mycelium holds together in a "nest".

The writer suggests the possibility that the present high incidence of Cladosporium rot resulted from the introduction in 1954 of the practice of placing pears into polyethylene bags in boxes, however, experimental data would be needed to verify this.

Fungi isolated from the rots classified as "Other rots" were Neofabraea sp., Pullularia sp., Alternaria sp., Rhizopus sp., Candida sp.

and unidentified fungi.

Relationship of Rots to Skin Breaks

The high percentage of Penicillium, Cladosporium, Botrytis and other rots with a broken surface indicates the importance of the careful handling of pears to avoid injuries. Although injuries may be reduced by handling fruit carefully, the elimination of injuries is remote because of the number of times each fruit is handled.

Reduction of Storage Rots by Chemical Washes

Stop-Mold B was shown to be an effective rot preventative (Experiment 3). The data confirm the use of the .6% solution recommended by the manufacturer. Because of the importance of reducing costs, further tests of concentrations of Stop-Mold B should be considered.

Busan 50 gave best control, as measured by total per cent of pears rotted, in all tests of fungicides, except the 1958 test with Bosc pears. Busan 50, Stop-Mold B, and Captan 80W plus Cyprex, resulted in best control of rot in three of four tests. Because of the discoloration of pear skin resulting from the use of Busan 50, this fungicide appears to be unsuitable as a post-harvest wash of Anjou and Bosc pears.

The combination of Captan 80W plus Cyprex was considered for future testing, however, in 1960 the manufacturer of Captan 80W recommended that it no longer be used as a post-harvest fruit wash.

Because of Busan 50 phytotoxicity and the recommendation of the Captan 80W manufacturer, Stop-Mold B ranks first as a post-harvest wash for control of pear storage rots.

SUMMARY

1. Federal-State fruit inspectors records of decay in Anjou and Bosc pears for the period November 1, 1956 to March 30, 1957 show that storage rots are an important problem of the Rogue River valley pear industry. The amount of decay found in the Bosc variety was considerably greater than that in the Anjou variety.

2. Isolations from an unidentified brown rot of Anjou and brown-black rot of Bosc pears indicate the causal organism to be Cladosporium sp.

3. Stop-Mold B was shown to be an effective rot-preventative. The results of a comparison of three concentrations of Stop-Mold B for the prevention of storage rots was inconclusive.

4. Busan 50 gave best control of storage rots but resulted in a severe brown discoloration of the skin of many pears.

5. Of the fungicides tested, Stop-Mold B ranks first as a post-harvest fruit wash.

6. Penicillium rot and Cladosporium rot were the prevalent rots in the check or treated pears in three of four fungicide tests.

7. Botrytis "nesting" was severe in one fungicide test in which Anjou pears were treated.

8. The high percentage of storage rot spots with a broken surface indicates the importance of handling fruit carefully to avoid breaks in the skin.

9. Cladosporium rot is a major storage rot of winter pears in the Medford area and is not necessarily associated with skin breaks.

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LIST OF ACTIVE INGREDIENTS OF FUNGICIDES

Busan	25%	potassium orthophenylphenate
	25%	dipotassium ethylenebisdithiocarbamate
Captan	80%	N-trichloromethylthiotetrahydro-phthalimide
Cyprex	65%	dodecyl guanidine acetate
Niacide M	48%	manganous dimethyldithiocarbamate
	12.4%	thiram
	2.4%	manganous benzo-thiazil mercaptide
	2.2%	dithiobis benzothiazole
Phaltan	75%	N-trichloromethylthiophthalimide
Purex	16%	sodium hypochlorite
Stop-Mold B	34%	sodium orthophenylphenate
Thylate	65%	tetramethylthiuramdisulphide
Ziram	76%	zinc dimethyldithiocarbamate

LIST OF TABLES

LIST OF PLATES

In presenting this thesis in partial fulfilment of the requirements for an advanced degree at the University of British Columbia, I agree that the Library shall make it freely available for reference and study. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by the Head of my Department or by his representative. It is understood that copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Iain C. MacSwan

PLATE I Cladosporium rot through apparently unbroken skin of Bosc pears.

PLATE II Cladosporium rot in box bruises. Bosc pears.

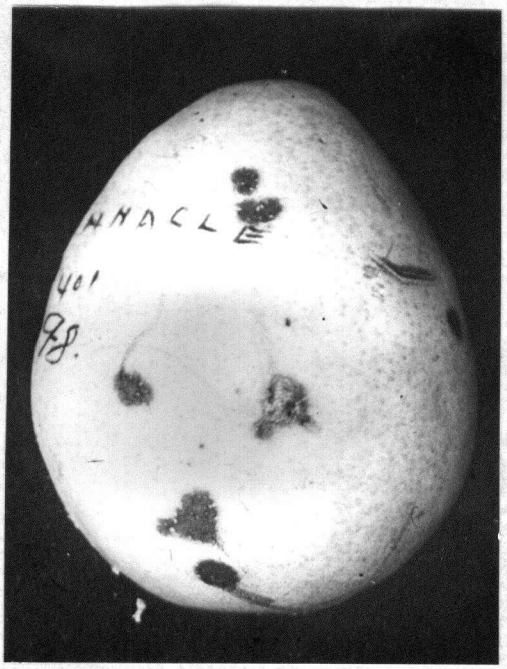

PLATE III Cladosporium rot in apparently unbroken skin of Anjou pear.

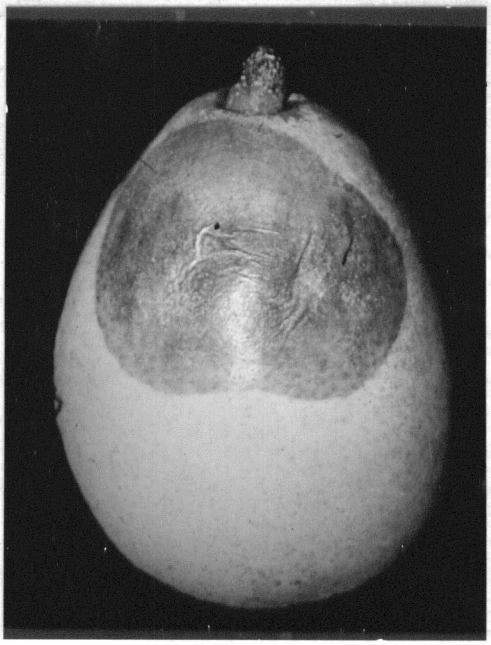

PLATE IV Botrytis (gray mold) rot on Anjou pear.

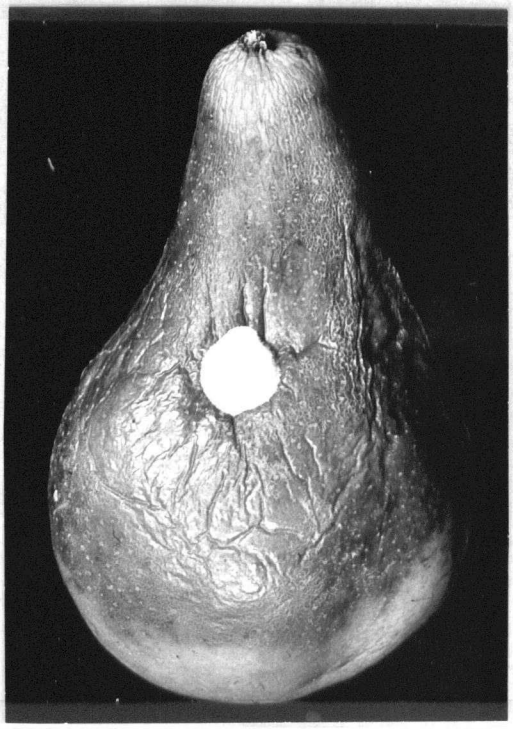

PLATE V Botrytis (gray mold) rot on Bosc pear.

PLATE VI Twenty-four rotted Anjou pears from a Botrytis "nest".

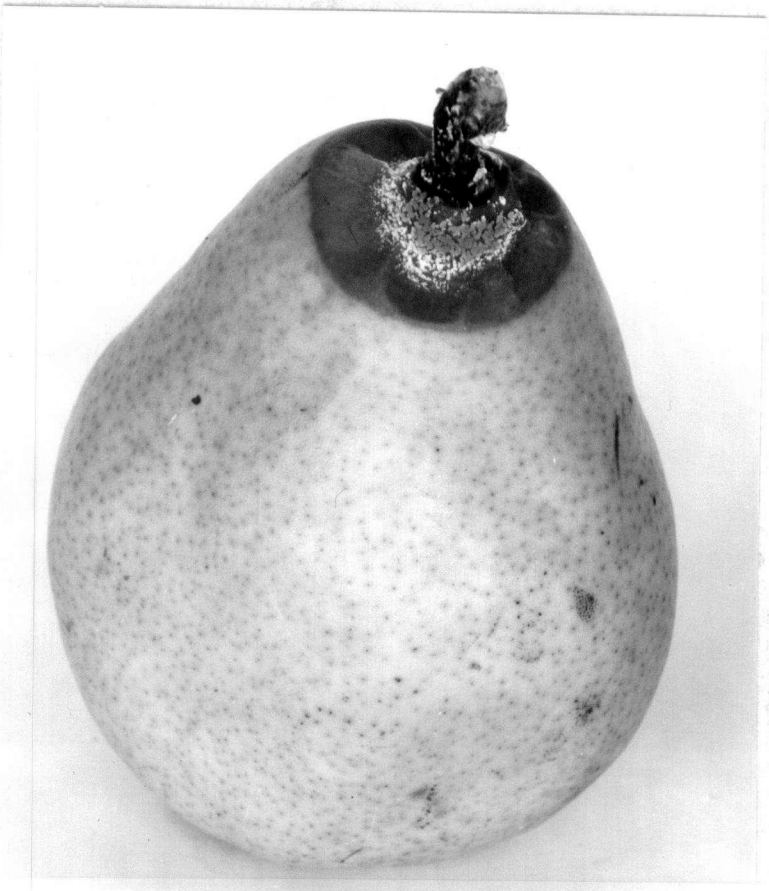

PLATE VII

Penicillium (blue mold) rot on stem end.
Anjou pear.

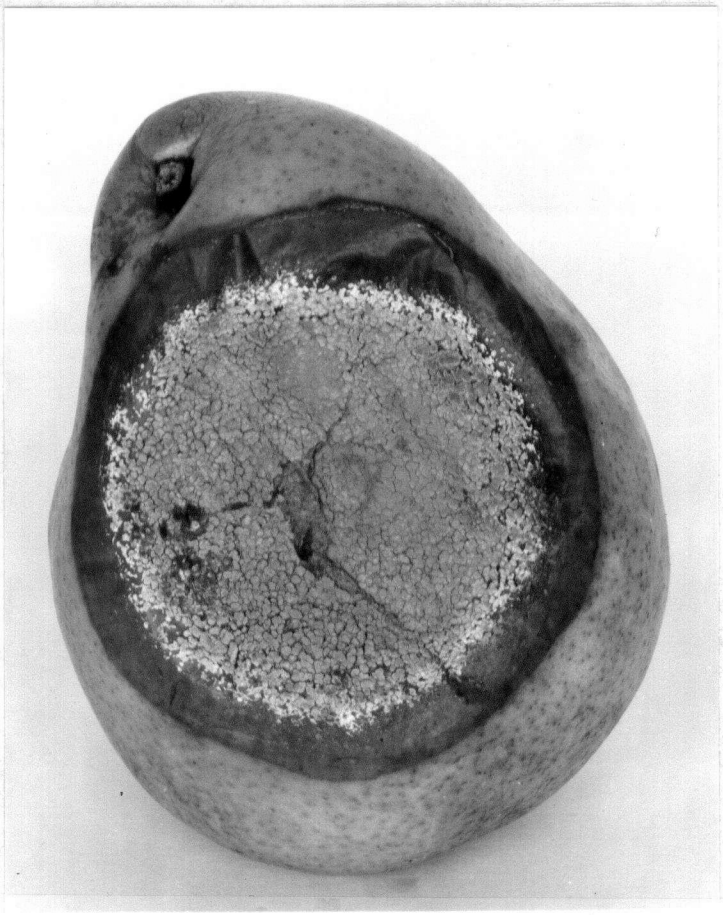

PLATE VIII Penicillium (blue mold) rot on Anjou pear.

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