THE EFFECT OF LOW TEMPERATURE ON OPEN BLOSSOMS OF MONTMORENCY CHERRY VARIANTS

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THE EFFECT OF LOW TEMPERATURE ON OPEN BLOSSOMS OF MONTMORENCY CHERRY VARIANTS

Thesis

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THESIS

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Introduction

The location of an orchard, in the temperate regions, is definitely influenced by the factor of spring frost. The yield and successful culture of such orchards are to a rather large extent governed by frost injury at the blossom stage.

It is commonly recognized that certain species of fruit are less susceptible to frost than certain other species. Peach blossoms are generally considered to be somewhat resistant to frost, whereas it is known that the blossoms of the grape are very susceptible; apples and pears probably fall somewhere in between these two.

Varieties of the same fruit have been compared and found to respond differently to the effects of frost. For example, such varieties of apples as Winesap, Delicious, and Stayman are injured more seriously at the same temperature than are either Rome Beauty or Grimes Golden (1)[1].

In recent years there has been introduced to the growers a number of strains of the same variety of fruit. No check of these individual strains from the standpoint of frost susceptibility has been made. Of the group included here peach, apple, pear, and cherry are examples.

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[1]References to literature cited are given at the end of this paper.

During recent years there has been collected from various parts of Michigan a large number of selections of the Montmorency variety of cherry. From this group certain forms were observed either to be more hardy or less hardy to frost than the standard commercial strains available.

It is the purpose of this investigation to compare the resistance to frost of a number of variants while they are in the blossom stage, and if possible find for each variant the lowest temperature at which survival is possible.

Review of Literature

The hardiness of fruit blossoms has been observed and studied by many investigators.

Auchter and Knapp (1) state that the blossoms of Rome, York Imperial, Jonathan, Oldenburg, Grimes Golden, Summer Rambo, and Wealthy have in most years been more resistant to cold than Yellow Transparent, Ben Davis, Delicious, and Stayman Winesap apples.

Paddock and Whipple (12) observed that apple and pear buds, far enough advanced to show color at the tips, were usually only slightly injured by temperatures as low as 25°F. whereas they could seldom withstand temperatures lower than 28°F. when in the full bloom stage. Native plums, either in bloom or with the fruit set, will often endure a temperature of 25°F. (12).

From observations in Iowa, Budd (2) maintains that when

trees of Russian varities of apples, pears, cherries, and plums were subjected to a temperature of 27°F., there was no influence on the following crop even when the trees were in full bloom.

Garcia and Rigney (8) placed the danger point for blossoms of the peach, native plum, apple, and pear at 26°F., while a temperature of 25.5°F., although lasting only a few minutes, killed a large percentage of the opening buds, newly set blossoms and young fruits of the peach. In some cases, however, a temperature of 24°F., lasting only a short time, left about 25 percent of the blooms and nine percent of the newly set fruit uninjured (8).

It is doubtful whether a temperature of 30°F. will injure fruit or buds in any stage. A temperature of 28°F., if of a long enough duration to freeze the tissues solid, will kill peaches either in bloom or after the fruit is set (12). These ideas do not correspond to those expressed by Cross (5), and Dorsey (6). Cross (5) observed that a 26°F. temperature lasting for several hours did not materially reduce a crop of newly set Elberta peaches even though the fruits had a water-soaked appearance. It seemed likely that there was a recovery of at least some of these small fruits. In the observations made by Dorsey (6), which were a study of the recovery of the apple from freezing injury, he states that a set of fruit may come as a result of recovery from,

rather than the fact that there was no injury. After a careful examination of the bloom after freezes as low as 26 or 27°F., it was found that the epidermis was broken away from all of the pistils on the tree. In five or six days the cells began to bridge across the broken areas and within three weeks or so the mending was complete (6).

Following is a table of critical temperatures as given by different authors.

Fruit	Blossoms Closed but Showing Color	In Blossom	Fruit Setting	Later	Authority
Apple	27	29	30	30	(16)[1]
	25	28	29	--	(17)
	27	29	38	25	(11)
Peach	20	25	28	30	(16)
	25	26	28	--	(17)
	29	30	30	28	(11)
Cherry	22	28	29	29	(16)
	25	28	30	--	(17)
	29	30	30	28	(11)
Pear	27	29	29	30	(16)
	25*	28	30	--	(17)
	28	29	29	28	(11)
Plum	30	31	31	29	(16)
	25	28	30	--	(17)
	30	31	31	29	(11)
Grape	30	31	31	--	(17)

* Bosc 27°F.

1. Reference to Bibliography

The rather extensive work of West and Edlefsen (13) may be summarized as follows: (a) Ben Davis apple blooms have experienced temperatures of 25, 26, and 27°F. without injury, but usually 28°F. kills about one-fifth, 29°F. or above is a safe temperature, 25°F. kills about one-half and 22°F. about nine-tenths. On several occasions, however, apples were matured on branches that had experienced 20°F. when the buds were in full bloom. (b) With Elberta peach blossoms 29°F. and above are safe temperatures, 28°F. will usually kill from one-fourth to one-half, 26°F. will kill about one-half, and 22°F. will kill about nine-tenths. Cases in which the temperature was as low as 18°F. have failed to kill all of the blossoms. (c) Twenty-six degrees F. will kill one-fifth of the blossoms of sour cherries, whereas twenty-two degrees F. will kill only two-fifths. (d) Usually 30°F. is a safe temperature for sweet cherry blossoms, with 29°F. killing about one-fifth but temperatures as low as 25°F. have occasionally caused no damage (13).

Blake (4) observed that temperatures ranging from 23 to 28°F., during April 16-18, 1928, killed approximately 50 percent of the blossoms of the apple varieties Maiden Blush, Gravenstein, McIntosh, Grimes Golden, and Rhode Island Greening; when the varieties Stark, Wealthy, Duchess, Henry Clay, Jonathan, and Stayman were hardly affected.

Ellison and Close (7), also working with apples, found a close correlation between temperature and dew point, and

the probability of frost. The dew point, taken the previous afternoon, was used to aid in frost forcasting. They found that when the dew point was 32°F. or higher the severity of any temperature below 32°F. was lessened. A 27 degree temperature, with a one hour duration, effected only limited damage when the dew point was 32°F. or higher, but when the dew point was 10 to 13 degrees, damage was severe if the exposure was only for five minutes.

Wilcox (15) noted that the resistance, of strawberry blossoms and newly set fruits, to frost was definitely influenced by the depth of the individual akenes in the receptacle. Wilcox concluded that it seemed possible that a variety may be resistant at one stage of development and yet be tender at another stage. This idea prevails with a large number of the other investigators.

As has been pointed out by Gardner, Bradford, and Hooker (9) the damage from a given frost is a varying quantity, since some peach trees on which 1,000 peaches would be a good crop may bear 20,000 or more fruit buds. It is obvious that under these conditions an 80 percent loss of the blossoms would not be a limiting factor in production. This would not be the case, however, if the trees in question had been cherries.

West and Edlefsen (14) found that approximately 50 percent of the Elberta peach blossoms survived a temperature of 24°F. when they were showing pink, 25°F. when in full

bloom, and 28°F. when the fruit was setting. Blake (3), in a study of varietal hardiness in the peach, observed that the petals of such varieties as Chili, Greensboro, and Triumph were normal in appearance after experiencing a low temperature at the full pink bud stage, while those of other varieties including Chinese Cling were crinkled by the effect of the cold. It was further stated that no actual killing of pistils or stamens was observed, but differences in the fruit set occured.

Observations following severe frosts, during full bloom, showed marked variation in the resistance of blueberry varieties to frost (10). Johnston (10) lists Rancocas, Rubel, Adams, and Jersey as resistant; while Harding, Cabot, and Pioneer were susceptible to frost. Johnston observed that moderately injured blossoms failed to set any fruit in Jersey and Cabot while a small percentage set in Pioneer and Rubel varieties.

Materials and Methods

This study deals with laboratory tests on the cold resistance of blossoms of Montmorency cherry variants.

There were 15 selections chosen for study; they were numbered: 154, 262, 263, 264, 265, 420, 421, 474, 614, 670, 671, 679, 686, 689, and 783. Of the group just listed, selection number 154 corresponds, in cold resistance as in other features, to the regular commercial strains of cherries now being sold in Michigan. The other selections were considered variants.

Preliminary work was begun in the spring of 1938 and followed by additional work in the spring of 1939. Only the 1939 materials and methods will be discussed here.

The material used in the 1939 tests was obtained from the Graham Experiment Station, located near Grand Rapids, Michigan. The trees were from four to seven years old. The blocks of trees which were four years of age were set in an Isabella fine sandy loam soil at a distance of ten feet each way; this placement had as yet caused no crowding of the trees. The young trees produced a crop during the 1937 season but were practically devoid of fruit during the 1938 season due to the late spring frosts. The trees suffered partial defoliation during the 1938 season because of the spray materials but were free from insect and disease injury.

The previous winter was not extremely cold and the soil moisture was not low at any time, thus we may assume the trees were in a normal vigorous condition.

A number of flowering branches of each variant were collected, either at the stage just prior to full bloom or at an earlier stage, if the variant was a late blossoming type. The samples were tagged, wrapped in moist paper and thus kept for about four hours until they could be placed in containers with water in a 32-36°F. storage. The storage room was used either to hold the samples until they might be needed or to permit the opening of late blossoming sorts at room temperature.

Procedure

Branches with blossoms were taken from the cold storage room, and all blossoms which were either unopened, injured, or otherwise unfit were removed from each sample. An attempt was made to select blossoms of the same stage of development, discarding all of the younger and older blossoms. The blossom branches were suspended by wire hooks from horizontal wooden strips, placed in the low temperature chamber in a manner so that the blossoms were all at about the same level within the chamber. The chamber was closed and allowed to establish an even temperature; gentle circulation of the air by an electric fan accomplished this. Since the electric fan used could not be adjusted to operate as slowly as was desired, it was found necessary to connect the 110 volt fan in series, on a 110 volt power line, with a forty watt electric light bulb; thus the air within the chamber was very gently circulated. The electric light bulb, in the series with the electric fan, was located outside of the cooling chamber. The chamber in which the materials were placed was a regular eight-cubic-foot upright commercial storage type of unit.

The unit was equipped with an automatic thermostatic control mechanism which was accurate to within a $\pm .18^{\circ}F$. The principle of the thermostat involved mercury expansion as the temperature increased. The mercury column moved up-

ward through a small capillary tube to a point where it came in contact with a copper wire, thereby closing an electric circuit which in turn caused a relay switch to be closed, thus starting the refrigerator unit.

The blossoms were allowed to remain in the cold chamber one-half hour. After the allotted time the samples were removed from the chamber, placed in containers with water, and allowed to remain at room temperature for a period of from six to seven hours. The blossoms were then examined and the amount of injury tabulated. Injury to the blossoms was classified into the three following degrees of severity: (1) less than one half of the style killed; (2) more than one-half of the style killed; (3) the ovary killed.

Results

Determinations were made on more than 10,000 blossoms. The selections were ranked according to their performance with the temperatures used, their performance in these tests being the percentage survival. It may be noted, however, that, except for a few reversals, approximately the same order of ranking would be given if performance were based upon the number of ovaries killed. Usually where reversals occur, as in the case of selections 420, 421, and 265, the differences between the selections were relatively small.

A comparison of the results obtained with the three most resistant selections (numbers 265, 420, and 421) reveals that minor variations in the percentages of unaffected blossoms, in the several temperatures, causes one to be ranked above the other in no consistant manner. With selections 265, 420, and 421 there was a certain amount of ovary killing at all temperatures but only serious killing at temperatures below 25.88°F. The term serious killing is meant to imply a reduction in the number of blossoms to such an extent that the crop would be appreciably less than normal.

Selections 262, 679, 689, and 783 were not significantly better than average in resistance, though of the group, selections 679 and 689 were a little better than the other two.

When 78.4 percent of the blossoms of selection 154 were killed by 27.0°F., it required a temperature of 25.16°F. to produce similar results with selections 265, 420, and 421; at the same time, however, more uninjured blossoms remained at the lower temperature, with the three selections, than was the case with number 154 at the higher temperature.

A temperature of 25.16°F. killed practically all of the ovaries of selections 670, and 671 but at 26.6°F. almost one-half of the ovaries remained uninjured.

1939 Results

Table I. The Effect of Low Temperature on The Condition of Blossoms of Selections of Montmorency Cherries. Selections Ranked According to Performance.

(Exposure to low temperatures for one-half hour).

1.	2.	3.	4.	5.	6.	7.
Temperature °F.	Selection Number	Total No. of Blossoms	Condition of Blossoms After Treatment in Percent: Less than ½ of Style Killed	More than ½ of Style Killed	Ovary Killed	Not Injured
24.7	421	276	.3	1.7	77.2	20.6
"	420	266	.6	1.9	89.8	7.7
"	265	250	.8	4.8	92.4	2.0
25.16	265	178	3.9	3.4	75.8	10.8
"	420	497	5.8	4.2	79.3	10.7
"	421	314	3.8	4.1	83.4	8.9
"	264	241	1.2	3.8	87.6	7.5
"	263	83	3.6	---	96.4	---
"	671	84	---	1.2	98.8	---
"	262	51	---	---	100	---
"	670	23	---	---	100	---
25.5	420	106	5.7	1.9	17.9	74.5
"	671	43	9.3	2.3	34.9	53.5
"	421	299	---	1.6	82.3	16.1
25.7	265	168	8.9	8.3	60.1	22.6
"	614	149	1.3	27.5	51.7	19.5
"	263	104	3.8	8.7	73.1	14.4
"	686	21	---	14.3	76.2	9.5
"	679	152	---	5.3	94.1	1.3
25.88	421	299	6.0	16.7	20.7	56.5
"	420	211	14.2	12.8	17.1	55.9
"	689	77	5.2	9.1	76.6	9.1

Table II. The Effect of Low Temperature on The Condition of Blossoms of Selections of Montmorency Cherries. Selections Ranked According to Performance.

(Exposure to low temperatures for one-half hour).

1.	2.	3.	4.	5.	6.	7.
Temperature °F.	Selection Number	Total No. of Blossoms	Condition of Blossoms After Treatment in Percent			
			Less than ½ of Style Killed	More than ½ of Style Killed	Ovary Killed	Not Injured
26.0	474	158	12.0	48.1	19.6	20.3
"	783	12	8.3	16.6	75.0	___
26.24	420	143	2.1	12.6	58.7	25.2
"	689	39	___	___	82.1	17.9
26.6	421	171	9.4	.6	.6	89.5
"	420	147	1.4	15.6	___	83.0
"	265	301	2.3	5.0	22.3	70.4
"	670	134	7.7	23.9	14.4	53.9
"	671	147	4.1	18.4	33.3	44.2
"	679	163	7.4	29.4	28.0	35.2
"	614	159	15.1	42.8	22.0	20.1
26.78	265	442	6.3	7.2	1.6	84.8
"	263	229	3.5	4.8	8.7	82.9
"	474	268	5.2	14.2	.7	80.2
"	686	23	13.0	30.4	13.0	43.5
"	262	64	3.1	42.2	39.1	15.6

Table III. The Effect of Low Temperature on the Condition of Blossoms of Selections of Montmorency Cherries. Selections Ranked According to Performance.

(Exposure to low temperatures for one-half hour)

1.	2.	3.	4.	5.	6.	7.
Temperature °F.	Selection Number	Total No. of Blossoms	Condition of Blossoms After Treatment in Percent			
			Less than ½ of Style Killed	More than ½ of Style Killed	Ovary Killed	Not Injured
27.0	262	60	18.1	23.3	3.3	50.0
"	264	214	6.6	14.0	29.0	49.5
"	679	172	5.2	26.2	41.9	26.7
"	154	111	1.8	14.4	78.4	5.4
27.76	474	169	14.2	8.9	----	76.9
"	265	429	27.7	4.7	----	67.6
"	671	183	10.7	13.1	2.7	64.5
"	686	52	25.0	17.3	----	57.7
"	264	303	34.4	14.0	1.0	51.0
"	614	265	14.0	27.5	16.2	42.3
"	670	239	11.7	32.7	21.3	34.3
"	679	188	10.9	45.3	10.9	32.8
"	154	174	15.5	44.3	10.3	29.9
28.0	421	429	13.2	5.1	5.4	76.3
"	154	196	14.3	9.5	2.4	73.8
"	263	281	13.5	6.4	15.3	65.8
"	679	229	15.3	20.1	34.5	30.1
28.36	679	127	12.6	----	----	87.4
"	264	479	13.6	2.7	----	83.7
"	154	296	7.1	14.2	----	78.8
"	262	141	35.5	5.7	1.4	57.4

Discussion

The results obtained by West and Edlefsen (25), in which a temperature of 26°F. killed 20 percent of the blossoms of sour cherries, and 22°F. killed only 40 percent, indicate a greater degree of resistance to cold than was obtained in this study. West and Edlefsen, however, merely stated that the blossoms were from sour cherry trees and in full bloom, whereas this work was carried out with special selections, probably strains of the Montmorency variety, and the blossoms used were of the same degree of advancement. Furthermore there was notably a more accurate control of temperature in this study than the one conducted by West and Edlefsen.

Resistance to cold varied with the different selections and, to some extent, within the same selection as was evidenced with blossoms in the same bud.

As may be seen from Tables I, II, and III (showing the condition of the blossoms after treatment) it is evident that to rank selections according to their survival may be somewhat misleading when the floral parts have not been injured to the extent that the fruit drops, if these fruits had been previously pollenated and fertilized. Therefore it may be incorrect to assume that none of those blossoms which were injured only slightly would set a crop of fruit. It has been pointed out by Johnston (10) that certain varieties

of blueberries may set a small percentage of fruits even though the blossoms had been moderately injured by frost. Since this condition is evident with certain blueberry varieties, is it not probable that it may be evident with various selections of the same variety of cherry?

There was observed an increase in the number of blossoms affected with slight frost injury when the temperature neared the 28°F. level over similar injuries at lower temperatures. The increase was such as to actually reduce the total number of unaffected blossoms over that of a lower temperature. For example, with selection 421 there was a 13.2 percent increase in the number of blossoms whose styles had been slightly injured by frost when exposed to a temperature 28.0°F., as compared with 26.6°F. at the same time there was a 13.5 percent decrease in the total number of blossoms showing frost injury. These were observed conditions for which no explanation is offered.

Summary

I. More than 10,000 blossoms of 15 selections of Montmorency cherry were tested and compared in their resistance to cold.

II. After exposure to cold for one-half hour, counts were made and injuries classified into three degrees of severity:

(a). Less than one-half of the style killed.

(b). More than one-half of the style killed.

(c). The ovaries killed.

III. The different selections varied in their resistance to cold as much as 2.5 at the full bloom stage and there was some variation within some of the selections.

IV. Selections 265, 420, and 421 were found to be more resistant than the other selections tested; these three selections were also considerably more resistant than the standard commercial strains of Montmorency now used.

V. Temperatures above 25.7°F. would not have greatly limited a crop of cherries on selections 420, 421 or 265.

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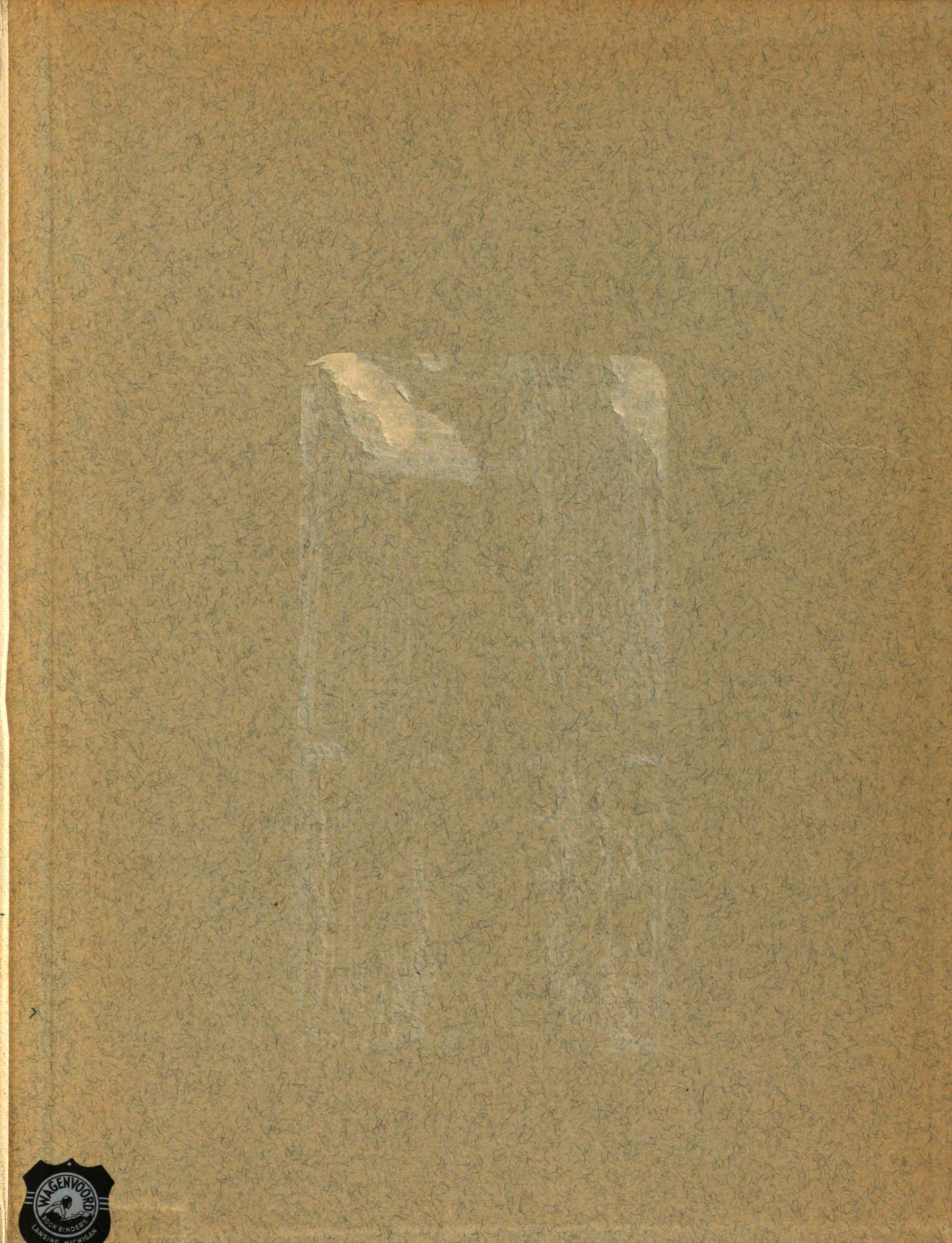
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