



THE EFFECT OF DATE OF TAPPING ON THE
YIELD OF MAPLE SAP FROM STERILE
AND NONSTERILE TAP HOLES

Thesis for the Degree of M. S.
MICHIGAN STATE UNIVERSITY
James Edward Douglass
1955

THESIS



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THE EFFECT OF DATE OF TAPPING ON THE YIELD OF MAPLE SAP
FROM STERILE AND NONSTERILE TAP HOLES

By

James Edward Douglass

AN ABSTRACT

Submitted to the School of Graduate Studies of Michigan
State University of Agriculture and Applied Science
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Approved

T. D. Stearns

James Edward Douglass

Increased interest in maple sap production in recent years has stimulated research into the many factors which affect the flow of sap. Weather forecast of maple sap weather has been utilized to advantage in determining when to tap. The question still remains: "When is the best time to tap?" This experiment was initiated to determine the effects of various tapping dates on the yield of maple sap in hopes of answering this question.

Baker Woodlot on the campus of Michigan State University supports a stand of sugar maple which typifies a natural sugar bush. This woodlot has been under management for over fifty years and contained trees of the desired size which had never been tapped.

The experimental design was to test the effects of five different tapping dates on the sap flow of sterilely and nonsterilely tapped trees distributed in the four cardinal compass positions. Ten trees were tapped on each tapping date beginning January 10th and approximately every fifteen days thereafter. Each tree was tapped twice in the designated compass position, once sterilely and once nonsterilely. The nonsterile tap corresponds to the type of tapping done in a commercial sugar bush, while the sterile tap was an experimental tap designed to prevent or minimize contamination of the tap hole so as to determine as nearly as possible the

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maximum possible flow.

The nonsterile taps were hung with either a plastic bag or a metal bucket, the purpose being to determine whether either affects the volume of yield. Data of sap flow in pounds and percent of sugar was collected each day that the sap flowed.

At the completion of the sap collecting season, it was found that as trees were tapped earlier, the yield from trees tapped sterilely increased and the yield of the trees tapped nonsterilely decreased. From the earliest tapping to the latest tapping, the difference between sterile and nonsterile sap yields decreased. Sterile yields by tapping date were not significantly different at the five percent level. Nonsterile yields by tapping date were not significantly different at the five percent level. The difference between sterile and nonsterile total yields was highly significant. The difference in yields of the January 10th tapping date was significant at the one percent level; the differences in yields of the January 25th and February 10th tapping dates were significant at the five percent level; and the yields of the February 25th and March 10th tapping dates failed to show significance.

The largest sap yield from trees tapped nonsterilely was obtained on the February 25th tapping date. It appears

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that the best measure of when to tap in the future is to follow the forecast of sap weather and to catch the first good sap run.

No significant difference was found in sap yield from plastic bags and metal buckets.

There was no significant difference in sap yields between compass positions of trees tapped sterilely or between compass positions of trees tapped nonsterilely.

There was a difference between sterile and nonsterile tapping yields by compass position. For the West compass position, the sap yield from sterile tapplings was significantly greater than the yield from the nonsterile tapping.

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The author wishes to express his sincere thanks to Professor P. W. Robbins of the Forestry Department, Michigan State University, who suggested the investigation and under whose inspiration, constant supervision and unfailing interest this investigation was undertaken.

Greatful acknowledgment is also due to Dr. T. D. Stevens, Head of the Forestry Department, Michigan State University, for many helpful suggestions and criticisms.

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THE EFFECT OF DATE OF TAPPING ON THE YIELD OF MAPLE SAP
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James Edward Douglass

INTRODUCTION

Brown (1) states that earliest written records indicate the American Indian was producing maple sirup and sugar as early as 1673. Settlers quickly adopted the Indian methods of making maple sirup and sugar and improved on their techniques. Early investigations were carried on primarily to devise new techniques of refining the maple sap and to improve the woodlot silviculturally to obtain maximum yield.

The commercial maple sap area of the United States extends westward from New England to Minnesota and southward to Kentucky. Here are the ten states listed by the Bureau of Agricultural Economics as producing a major part of the maple crop (8). Willits and Porter (20) state that maple sirup is not a major agricultural commodity in any of these states, but that in each there are areas where it is an important part of the economy. In 1955, more than 151,000 pounds of maple sugar and 1,657,000 gallons of maple sirup were made, representing a cash crop of more than 8.4 million dollars (11).

Moore, Anderson, and Baker (12) state that in Ohio for the period 1946 to 1949, average production cost per gallon

2.

of maple sirup was \$2.94 and average price received by producers was \$4.69 leaving an average net income of \$1.75 per gallon. Bull (4) operating the Michigan State University "sugar bush" made \$1.20 per gallon net profit on 275 gallons of maple sirup during the 1954 sap season.

Maple sirup production occurs at a season of the year when other farm activities are at their lowest ebb. Operation of the farm woodlot for the production of sirup offers the opportunity to transform otherwise unproductive time into an income from the farm woodlot.

Increased interest in maple sap production in recent years has stimulated research into the many factors which affect the flow of sap. Weather forecasts of maple sap weather have been utilized to advantage in determining when to tap. The question still remains, "when is the best time to tap?" An experiment to determine the effects of various tapping dates on the yield of maple sap was initiated in hopes of answering this question.

This problem was conceived with the knowledge of the availability of thousands of woodlots in Michigan for the production of maple sirup and sugar and with the intention of allowing maximization of profits by determining the most profitable time for tapping the trees.

REVIEW OF LITERATURE

The exact time to tap has been discussed at length by several authors. It has been the consensus of opinion that it is highly desirable to tap at the beginning of the first run of the season, and those operators who miss the first run lose a considerable portion of their potential yield.

Cope (7) states that sap will flow anytime after the first thaw following the fall of leaves in autumn, and that usually March and April are the best sugar making months, but occasionally a good run is obtained in February. He further states that, "the tapping should be done early enough to catch the first run of sap. In fact, because of acute labor shortages, many producers are tapping ahead of the first run. Reports indicate just as much sap obtained as when tapping is delayed."

This view is also supported by Collingwood and Cope (5). However in earlier work by Collingwood, Cope and Rasmussen (6), they had reported that "tapping should be done early enough to catch the first real run of sap, but not a day earlier as every hour tends to dry up the tap hole and to decrease the amount and quality of the sap flow."

Bryon (2), and Bryon, Hubbard, and Sherwood (3) reported that it is a good policy to tap early in the season in order to obtain the earliest runs of sap, which are generally the

sweetest and therefore the best sugar producers. They report producers have lost half and even more of their crops many seasons by not being prepared for the first runs.

Robbins (17) reports from his investigations that tapping the maple tree at the proper time influences greatly the quality and quantity of sap produced. He further states that sap weather forecasting of the first run is one of the greatest services that may be rendered the sirup producer to increase the quality and quantity of maple sirup production.

In his experimental work on early tapping, Morrow (13) found that the early sap runs were of high quality which may be attributed to low bacterial activity during the first part of the sap season. The early tapped trees were sometimes the first to stop flowing, but they also produced the greatest total sap flow. During the middle and last part of the season, the early tapped trees produced less sap than did the late tapped trees. "While early tap holes tend to flow less than late tap holes late in the season, sizeable early runs have more than made up for the loss with more and better quality sap."

Early work on the side of the tree in which the tap hole was bored indicated that the compass position of tapping has little effect on sap yield. Experiments conducted by Robbins (16), Jones, Edson, and Morse (10), and

5.

Tressler and Zimmerman (19), show that yield of sap for the entire season is about the same regardless of the direction in which the bucket is hung.

DESCRIPTION OF THE AREA STUDIED

The area utilized for the experiment was approximately six acres of Baker Woodlot. This area was selected for the experiment because it supported sugar maple trees of the desired size which had never been tapped and because it represented a typical "sugar bush".

The area is level to undulating in topography. It is composed of two soil types which are very similar. The soil types present are Miami and Hillsdale.

Baker Woodlot, formerly known as Woodlot 17, contains 68.4 acres and was part of the original grant to Michigan State University in 1855. Early records of the woodlot date from 1894, when, as a result of a meeting of the State Board of Agriculture, the head of Agriculture and Forestry were to begin management of all forest lands "in the most up to date methods".

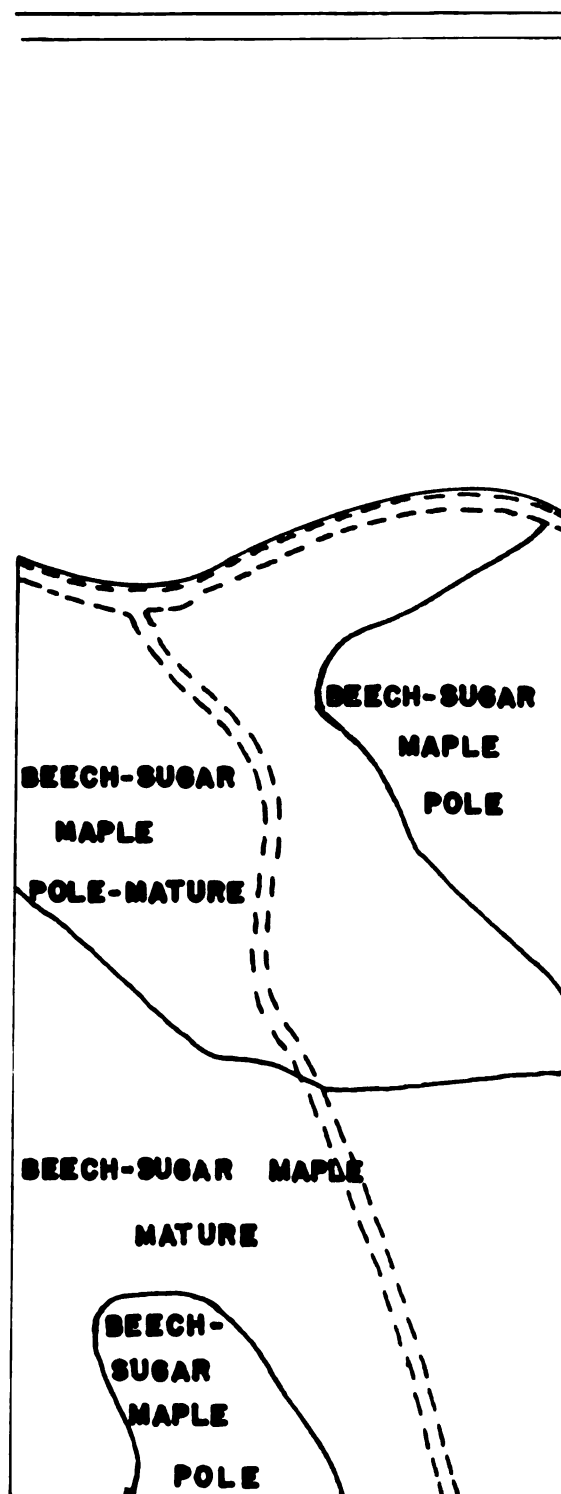
At that time Baker Woodlot was in such poor condition, as a result of severe cuttings and burnings, that it was recommended that the land be cleared for agricultural purposes. The stand consisted of a poorly stocked stand of seedlings and saplings. Forest management dates from this time.

The area was put under good fire protection and some planting was done. By 1928, the woodlot was growing at

the rate of 2.2 Standard cords per acre annually. Fuel wood was the chief crop removed from the area during this time.

During the winter of 1938-39, an improvement cut, removing some overmature and decadent trees, was made. A selective logging was conducted in 1947 and experimental wildlife cuttings over portions of the area were made in 1950.

At present the woodlot is managed for student instruction and for research problems conducted by faculty and graduate students in the field of conservation. The map on the following page shows the present forest types currently on the experimental portion of Baker Woodlot.



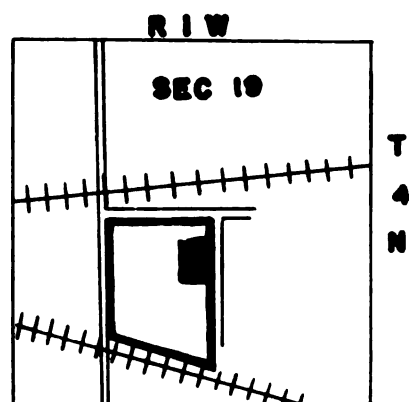
TYPE MAP
EXPERIMENTAL PORTION OF
BAKER WOODLOT



SCALE
 1" = 132'

LEGEND

- IMPROVED ROAD
- - - WOODS ROAD
- · - · - TYPE LINE



BY R.N. WESTVELD

APPARATUS AND METHODOLOGY

The experiment was statistically designed to determine the effect of five different tapping dates on the yield of sap from plastic bags, metal buckets, and sterile containers distributed in the four cardinal compass positions.

The amount of time, equipment, and personnel available limited the number of trees used in the experiment to 50. The 50 trees utilized were 16 inches in D.B.H. or larger which had never been tapped. Ten trees were tapped on each of five tapping dates, one of which was the normal date of tapping for the region. Tappings were at approximate fifteen day intervals beginning the 10th of January. Subsequent tappings were made on the 25th of January, 10th of February, 25th of February, and 10th of March.

Trees to be tapped and position of tapping were determined by utilizing a table of randomly assorted digits. On each tapping date, a minimum of two trees were tapped in each compass position. Each tree was tapped twice in the designated compass position, once with a sterile tap and once with a nonsterile tap.

The sterile tapping technique was performed to determine the effect of bacteria on the flow of sap. The technique for sterile tapping was modeled after that of Holgate (9) and Naghski (14). Bits, seven-sixteenths inches in diameter,

were wrapped in paper and sterilized in an autoclave. The spile assembly consisted of a rubber stopper for a five gallon can, which had an inverted glass U-tube plugged with cotton to equalize air pressure, and a short piece of straight glass tubing which was connected to a spile by a short length of rubber tubing. The spile (closed type especially designed for the experiment) was inserted into the end of the rubber tubing, wrapped in paper, and sterilized in an autoclave. The neck and opening in the five gallon can were covered with gauze. Then the can was sterilized in an autoclave.

In conducting the actual sterile tapping, a section of the tree approximately two and one-half feet above the ground, in the desired compass position, was selected and a layer of outer bark was removed with a draw knife at the point of tapping. This area was then saturated with alcohol, ignited, and while still burning, a seven-sixteenths inch hole was drilled with the sterile bit to a depth of two and one-half inches. The tree end of the spile was poked through the paper without being touched with hands and hammered into the tap hole by tapping on a screw driver held against the shoulder of the spile. The gauze was removed from the opening of the can and the paper from the rubber stopper which was immediately inserted into the opening of the can. By utilizing sterile techniques and precautions throughout, the tap hole remained in as sterile a condition as possible

throughout the season. These techniques were not sufficient to keep the tap holes sterile for the entire season. Contamination was probably caused by changing the sterilized can when full of maple sap and by expanding ice which pulled the connecting hose loose. Knowledge was gained whereby techniques can be improved for future experiments which will eliminate these sources of contamination.

The nonsterile tapping technique was essentially the same as performed by sugar bush operators. The tap was made approximately two and one-half feet from the ground with a seven-sixteenths inch bit. A Soule spile was inserted into the tap hole and tapped snugly into place.

Either a plastic bag or bucket was hung on the spile as determined by random selection. Naghski and Willits (15), and Sproston and Lane (18) found that the contamination of sap in plastic bags was considerably less than contamination of sap in metal buckets. To determine whether this difference in contamination causes any difference in sap yield of trees hung with plastic bags and metal buckets, one-half of the trees was hung with plastic bags and one-half with metal buckets.

Collections of maple sap was conducted each day that the sap flowed and the weight in pounds of sap and percent of sugar were recorded. Sugar percent determinations to the nearest one-half percent were made utilizing a refractometer.



PLATE 1. A TYPICAL MAPLE TREE TAPPED STERILELY AND NONSTERILELY

FINDINGS AND INTERPRETATIONS

An analysis of data failed to show a significant difference between sterile sap yields by date of tapping or between nonsterile sap yields by date of tapping.

Sterile Tapping

The difference between the highest and the lowest flow of sterile taps by date of tapping was 595 pounds or an average of 74.4 pounds per tree as shown in Table 1. This difference was between the tapping dates of January 10th and February 10th. It is thought that the low yield of the trees tapped on February 10th was a reflection of low producing trees and not attributed to the date of tapping, an assumption that can not be substantiated by present data, but is supported by visual inspection of the trees.

Nonsterile Tapping

The greatest difference between the highest (January 10) and the lowest flow (February 10) of nonsterile tapping by date of tapping was 676 pounds of sap or an average of 84.5 pounds per tree. This large difference, although not significant is also attributed to low yielding trees.

Sterile vs. Nonsterile

The volume of flow from sterile tap holes was greatest on the earliest tapping date, and the yield of subsequent tapings was progressively less, with the exception of the

February 10th tapping. The opposite was true of the non-sterile tapping. The yield of maple sap from the non-sterile tapping was lowest for the earliest tapplings and generally increased with each tapping date. Figure 1 and 2 illustrate the relationship between yields from sterile and nonsterile tapplings and date of tapping. Apparently the earlier the tree was tapped, the greater the length of time in which contamination could occur before the heaviest sap flow.

TABLE I

SAP FLOW OF STERILE AND NONSTERILE TAPPINGS
BY DATE OF TAPPING¹

Date of Tapping	Sap Flow in Pounds		% Increase in Yield by Sterile Tapping
	Sterile	Nonsterile	
Jan. 10	2165	1238	74.9
Jan. 25	1959	1346	45.6
Feb. 10	1570	1118	40.4
Feb. 25	1916	1794	6.8
Mar. 10	1581	1498	5.5

¹ Based on 40 sterile and 40 nonsterile taps.

This greater period of time in which contamination and increase in number of contaminating bodies occurred was thought to be the reason for reduced yield of sap for

FIGURE 1 - SAP FLOW OF STERILE
AND NONSTERILE TAPS BY
DATE OF TAPPING

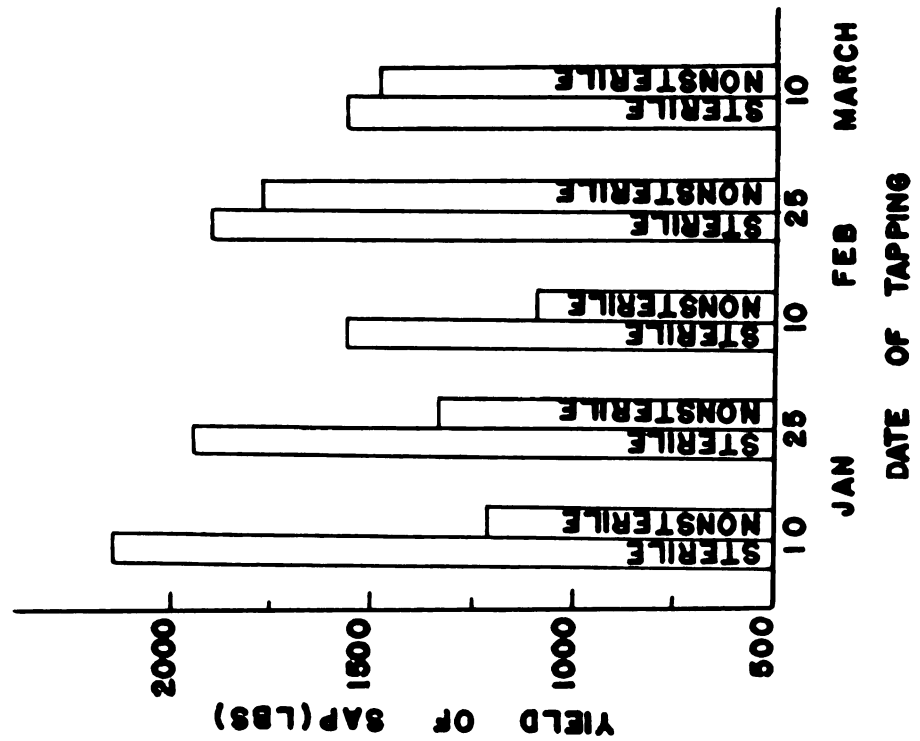
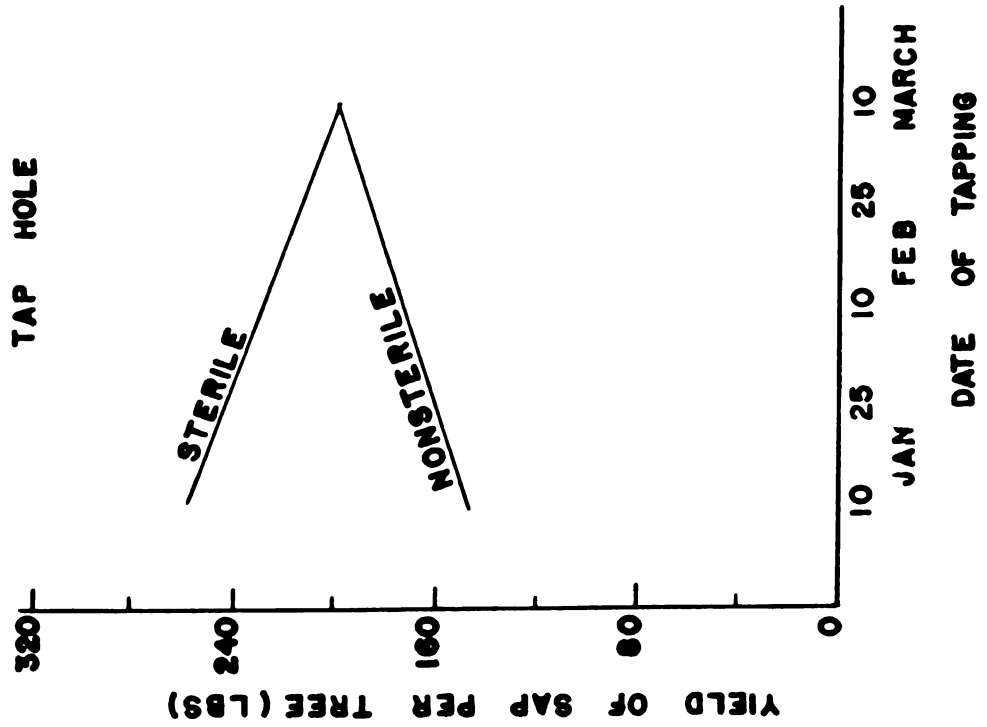


FIGURE 2 - STATISTICAL CURVE OF
SAP FLOW BY TYPE OF
TAP HOLE



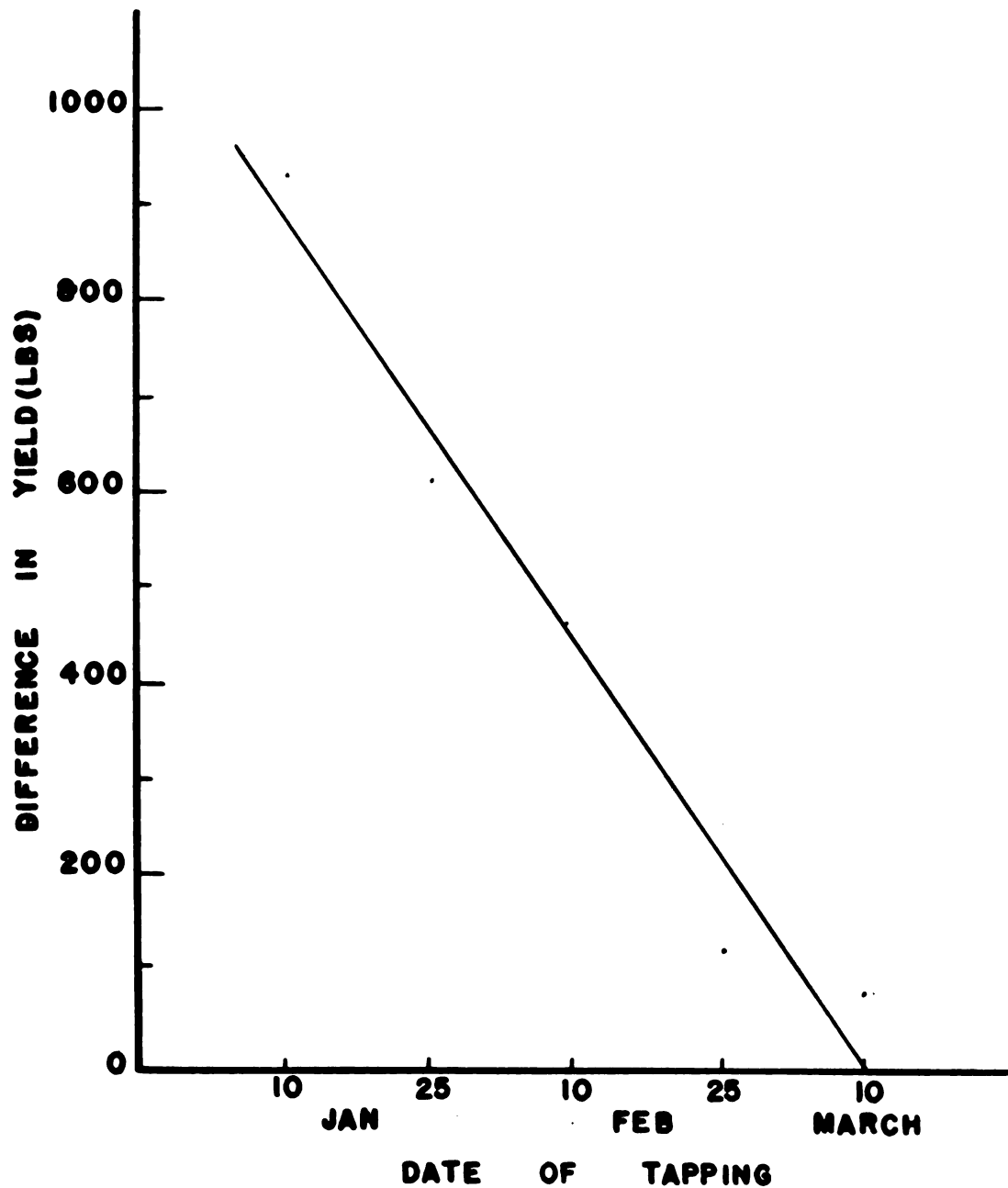
tappings prior to the first run compared with first run
tappings.¹

Analysis of sap yields of sterile and nonsterile tap-
pings by dates shows a highly significant difference between
the yields of sterile and nonsterile tapplings. For January
10th the difference between sterile and nonsterile tapping
yields was significant at the one percent level; for the
January 25th and February 10th tapping the differences be-
tween yields were significant at the five percent level;
and for the February 25th and March 10th tapplings, there
was no significant difference between yields. Differences
between sterile and nonsterile yields were greatest for
the earliest tapping date and progressively decreased with
each succeeding tapping. These differences for the five tapping
dates from earliest to latest tapping were 927 pounds, 613
pounds, 452 pounds, 122 pounds, and 83 pounds respectively.
(See Figure 3).

The difference between sterile and nonsterile sap
flow was statistically fitted into a straight line curve.
Figure 3 shows that the earlier the tapping, the greater
the difference in yield between sterile and nonsterile sap

¹ Unpublished data collected in conjunction with this experi-
ment by the Bacteriology Department, Michigan State Univer-
sity, substantiates that as contamination increases, volume
of flow decreases.

**FIGURE 3- CURVE OF DIFFERENCE IN POUNDS
BETWEEN STERILE AND NONSTERILE
SAP YIELDS BY DATE OF TAPPING**



flow. Although the analysis showed no significant difference between yields by tapping date, it is believed that for the 1955 season early tapping increased the yield of sterile tap holes and decreased the yield of nonsterile tap holes.

For sap years similar in climatic conditions to the 1955 season, a commercially feasible method of sterile tapping, equal in quality to the experimental sterile tapping, should give a substantially greater yield for earlier tapping dates than for the normal tapping date.

The experiment suggest that February 25th was the optimum time for nonsterile tapping. Tapping before the first run apparently exposes the tap hole to contamination for a longer period of time, and, as in this case, may reduce the yield of sap.

Tapping after the first run may not be as serious as was once thought. The first good run of sap occurred during the February 25th tapping. Trees tapped on this date had 13 days more flowing time than trees tapped March 10th; however, trees tapped on March 10th flowed only an average of 37 pounds per tree less than those tapped on February 25th. This represents an average loss of less than three pounds per tree per day.

Bag vs. Bucket

An analysis shows no significant difference in yields from nonsterile tappings resulting from the type container

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used to collect the sap. On three of the tapping dates (January 10th, February 25th, March 10th), the yield from trees hung with buckets was greater than the yield from trees hung with plastic bags. Trees hung with plastic bags produced more than trees hung with metal buckets on January 25th and February 10th. (See Figure 4.)

Compass Position

There was no significant difference between yields of maple sap by compass position of plastic bags or metal buckets.

TABLE II

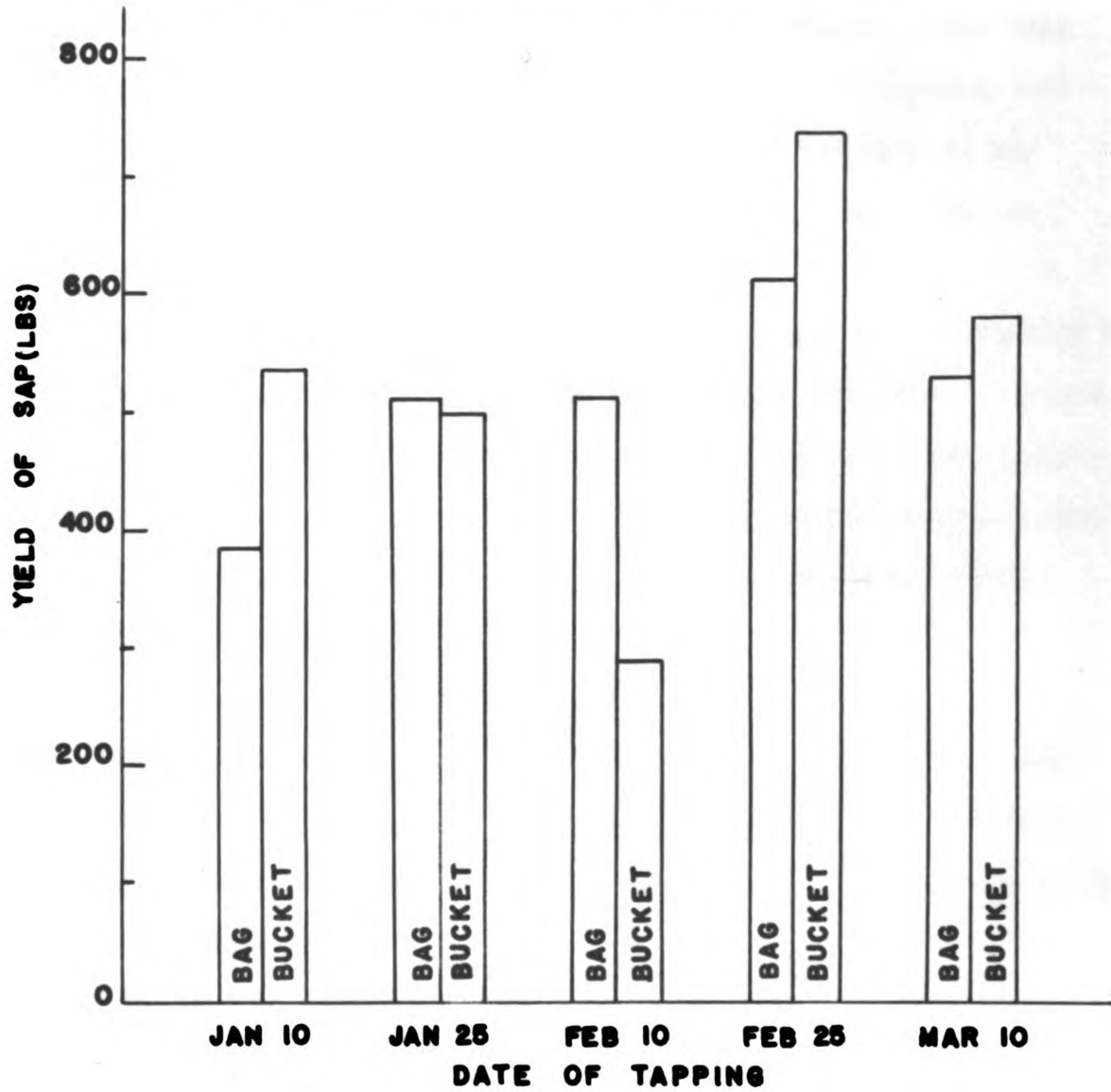
SAP FLOW OF STERILE AND NONSTERILE TAPPINGS BY
COMPASS POSITION¹

Compass: Position	Sap Flow in Pounds				% Increase in Yield by Sterile Tap
	Bucket	: Bag	: Non- Sterile	: Sterile	
	:	:	:	:	
	:	:	:	:	
North	837	797	1634	1884	15.3
East	758	951	1709	2297	34.4
South	1200	668	1868	2430	30.4
West	914	809	1783	2580	44.7

¹ Based on 40 sterile taps and 40 nonsterile taps.

Greatest sap flow from nonsterile containers was from the

**FIGURE 4-SAP YIELD BY DATE OF TAPPING FOR
15 PLASTIC BAGS AND 15 METAL BUCKETS**



South compass position. The lowest yield recorded was for the North position which was 238 pounds less than the yield from the South position.

For the sterile tappings the greatest flow was from the West compass position, followed by the South, East and North positions respectively. The difference in yield between the West and North positions was 696 pounds, or an average of 69.6 pounds per tree. This difference was not statistically significant.

The difference between sterile and nonsterile tappings by compass position was highly significant for the West compass position. The remaining three positions did not show significance at the five percent level. The finding for the nonsterile tappings helps to verify other experimental work conducted on compass position.

Sap Flow by Periods

The greatest volume of sap flow for all tapping dates occurred between March 15th and April 1st for both sterile and nonsterile tappings with the exception of the January 10th nonsterile tapping.

Nonsterile tappings. For the period from March 1st throughout the season, trees tapped on February 25th outflowed all earlier tappings. Between the time when each of the early tappings was made and March 1st, the trees tapped before February 25th yielded slightly more maple sap than

the trees tapped on February 25th. This may be accounted for by the period of possible flow. Trees tapped on February 25th had a period of six days in which to flow while the trees tapped earlier had from 15 to 45 days to flow.

With one exception, the trees tapped before February 25th out flowed the trees tapped on February 25th and March 10th until March 15th. From March 15th until the sap flow ceased, the yield from trees tapped February 25th and March 10th was greater than from the three early tapplings. The total average sap flow for February 25th and March 10th exceeded the average flow of the early tapplings by a minimum of 18 pounds per tree.

Sterile tapplings. During the period from the date of each tapping to March 1st, the earliest tapping produced the greatest sap flow (average), and the average flow decreased for each succeeding tapping.

TABLE III

AVERAGE SAP FLOW OF 20 NONSTERILE TAP HOLES
BY PERIODS OF TIME

Date of Tapping	Sap Flow in Pounds by Period of Time				
	Up to	March 1:	March 15:	April 1	Total
	March 1	to	to	to	Yield
		March 15:	April 1	April 14:	
Jan. 10	37	62	48	8	155
Jan. 25	30	64	69	6	169
Feb. 10	22	52	59	8	141
Feb. 25	18	75	103	28	224
Mar. 10	0	52	104	31	187

TABLE IV

AVERAGE SAP FLOW OF 20 STERILE TAP HOLES
BY PERIODS OF TIME

Date of Tapping	Sap Flow in Pounds by Period of Time				
	Up to	March 1:	March 15:	April 1	Total
	March 1	to	to	to	Yield
		March 15:	April 1	April 14:	
Jan. 10	41	65	121	44	271
Jan. 25	37	63	109	37	246
Feb. 10	24	54	80	35	193
Feb. 25	18	78	104	39	239
Mar. 10	0	52	108	38	198

SUMMARY

This experiment illustrates the effect of date of tapping on the yield of maple sap from sterile and nonsterile tap holes, compass positions, and plastic bags and metal buckets.

(1) There was no significant difference between sterile tapping yields and date of tapping or between nonsterile tapping yields and date of tapping.

(2) The difference between sterile and nonsterile yields is highly significant. The difference in yields of the January 10th tapping date was significant at the one percent level; the difference in yields of the January 25th tapping date was significant at the five percent level; and the yields of February 10th, 25th, and March 10th failed to show significance.

(3) The largest yield was obtained from trees tapped on the February 25th tapping date. The data indicates that the best measure of when to tap in the future is to follow forecasts of maple sap weather and to catch the first sap run, unless a commercially feasible sterile tapping technique can be perfected. Tapping two weeks or more before the first sap run occurs results in a decrease in the yield of maple sap from nonsterile taps.

(4) No significant difference was found in sap yield

from plastic bags vs. metal buckets.

(5) There was no significant difference in yields between compass positions of tap hole for sterile tapplings or compass positions of tap hole for nonsterile tapplings.

There was a difference in yields between sterile and nonsterile tapping by compass position. For the West compass position the sap yield from sterile tapplings was significantly greater than the yield from the nonsterile tapplings.

(6) Tapping sugar maple trees 15 to 45 days earlier than the normal tapping date for the region increases the yield of maple sap from sterile tap holes.

APPENDIX

TABLE V

I. SUMMATION OF DATA BY TAPPING DATE

Type :	Yield in Pounds by					
Tapping:	Date of Tapping					
:	10	25	10	25	10	Average
:	Jan.	Jan.	Feb.	Feb.	Mar.	:
Sterile	286	317	138	215	186	228.4
	335	256	145	195	225	231.2
	210	195	151*	258	110	184.8
	326	169	179	271	248	238.6
	279	184	201	280	196	228.0
	223	363	227	239	175	245.4
	301	322	248	187	117	235.0
	205	153	281	271	324	246.8
	Average	270.6	244.9	196.3	239.5	197.6
Non-Sterile	94	159	182	159	252	169.2
	231	112	52	139	177	142.2
	213	188	87*	279	95	172.4
	225	182	143	300	260	222.0
	97	128	189	319	159	182.4
	83	240	149	155	172	159.8
	80	172	115	175	122	132.8
	215	165	201	268	261	222.0
	Average	154.8	168.3	139.8	224.3	187.3
Grand	Average	212.7	206.6	168.0	231.9	192.4
						202.3

* Values were determined by the lost plot formula.

Lost plot formula:

$$\frac{c(C) - r(R) - G}{(c-1)(r-1)} = 151 \text{ Sterile tapping}$$

$$= 87 \text{ Nonsterile tapping}$$

ANALYSIS OF VARIANCE

A. STERILE VS. NONSTERILE YIELDS BY DATE OF TAPPING

Source	D. F. ¹	Mean Sq.
Total	77	
Date	4	9,098 ²
Tapping	1	60,335**
D X T	4	7,747
Error	68	3,815

- ¹ D. F. remaining after deducting two D. F. for lost plots.
² There is no significant difference between yields of sterile and non-sterile taps by tapping date.
 ** There is a highly significant difference between sterile and non-sterile yields.

B. STERILE YIELDS VS. DATE OF TAPPING

Source	D. F. ¹	Mean Sq.
Total	38	
Between	4	8,298 ²
Within	34	3,732

- ¹ D. F. remaining after deducting one D. F. for lost plot.
² Not significant at the five per cent level.

C. NONSTERILE YIELD VS. DATE OF TAPPING

Source	D. F. ¹	Mean Sq.
Total	38	
Between	4	8,547 ²
Within	34	3,897

- ¹ D. F. remaining after deducting one D. F. for lost plot.
² Not significant at the five per cent level.

D. STERILE VS. NONSTERILE YIELD FOR THE JAN. 10 TAPPING DATE

Source	D. F.	Mean Sq.
Total	15	
Between	1	53,708**
Within	14	3,873

** Significant at the one per cent level.

E. STERILE VS. NONSTERILE YIELD FOR THE JAN. 25 TAPPING DATE

Source	D. F.	Mean Sq.
Total	15	
Between	1	23,485*
Within	14	4,017

* Significant at the five per cent level.

F. STERILE VS. NONSTERILE YIELD FOR THE
FEBRUARY 10 TAPPING DATE

Source	D. F. ¹	Mean Sq.
Total	13	
Between	1	15,453*
Within	12	3,196

* Significant at the five per cent level.

¹ D. F. remaining after deducting two D. F. for lost plots.

G. Sterile vs. nonsterile yields for February 25th and March 10th tapping dates were not significant at the five per cent level.

H. Determination of position of straight line curve of differences between sterile and nonsterile tapping yields for Figure 3.

X	Y	Y' ¹
1	927	875
2	613	657
3	452	439
4	122	222
5	83	4

¹ Expected value of Y' is found from the equation:

$$Y' = a + bX$$

$$= 1093 - 218X \quad \begin{matrix} \nearrow \\ \searrow \end{matrix} \quad 84$$

Correlation Coefficient = 0.979**

** The correlation coefficient is highly significant. The computed line is significantly different from a horizontal line.

I. Determination of the position of the straight line curve of yield for the sterile tapping for Figure 2.

X	Y ¹	Y ²
1		260
2		245
3		230
4		215
5		200

- 1 All observations for each tapping date were used.
- 2 Expected value of Y' is found from the equation:

$$Y' = a + bX$$

$$= 275 - 15X \quad \neq 61$$

Correlation Coefficient = -0.338*

- * The correlation coefficient shows the computed line is significantly different from a horizontal line.

J. Determination of position of the straight line curve of yield from nonsterile tapplings.

X	Y ¹	Y ²
1		151
2		163
3		175
4		187
5		199

- 1 All observations from each tapping date were used.
- 2 Expected value for Y' is found from the equation on the following page.

31.

Expected Value for Y'

$$\begin{aligned} Y' &= a + bX \\ &= 129 + 12X \end{aligned}$$

Correlation Coefficient = 0.265

The correlation coefficient is not significantly different from a horizontal line; therefore, Figure 2 is only utilized to aid in clarification of written material. Figure 2 is not a statistically sound curve.

TABLE VI

II. SUMMATION OF DATA BY COMPASS POSITION

Type Tapping	Yield in Pounds by Compass Position				Average
	North	East	South	West	
	:	:	:	:	
Bucket	172	231	300	252	238.8
	268	213	279	260	255.0
	87	97	261	159	151.0
	128	165	172	149	153.5
	182	52	188	94	129.0
Average	167.4	151.6	240.0	182.8	185.4
Bag	95	159	83	177	128.5
	155	139	80	115	122.3
	189	175	201	112	169.3
	143	319	122	240	206.0
	215	159	182	225	195.3
Average	159.4	190.2	133.6	173.8	164.3
Grand Average ¹	163.4	170.9	186.8	178.3	174.9
Sterile	175	335	271	186	241.8
	271	210	258	248	246.8
	151	279	324	215	242.3
	184	153	322	227	221.5
	169	145	195	286	198.8
	110	196	223	225	188.5
	239	195	301	248	245.8
	201	187	281	256	231.3
	179	280	117	363	234.8
	205	317	138	326	246.5
Average	188.4	229.7	243.0	258.0	229.8
Grand Average ²	175.9	200.3	214.9	218.2	202.3

¹ Average of buckets and bags.² Average of buckets, bags, and sterile containers.

ANALYSIS OF VARIANCE

A. STERILE VS. NONSTERILE YIELD
BY COMPASS POSITION

Source	D. F. ¹	Mean Sq.
Total	77	
Type		
Tapping	1	60,335**
Position	3	7,406
P X T	3	2,543
Error	70	4,242

¹ D. F. remaining after deducting two D. F. for lost plots.

** There is a significant difference between sterile and nonsterile containers. There is no significant difference between yields by compass position.

B. YIELD OF BAG VS. BUCKET
BY COMPASS POSITION
(NONSTERILE VS. COMPASS POSITION)

Source	D. F. ¹	Mean Sq.
Total	38	
Position	3	611.7 ²
Containers	1	5880.7 ²
P X C	3	11123.9
Error	31	2282.7

¹ D. F. remaining after deducting one D. F. for lost plot.

² There is no significant difference between positions or containers.

C. STERILE VS. COMPASS POSITION

Source	D. F. ¹	Mean Sq.
Total	38	
Between	3	8945 ²
Within	35	3807

- ¹ D. F. remaining after deducting one D. F. for lost plot.
² There is no significant difference between sterile tapping and compass position.

D. Sterile vs. Nonsterile Yields by Compass Position

(1) NORTH POSITION
STERILE VS. NONSTERILE YIELDS

Source	D. F. ¹	Mean Sq.
Total	17	
Between	1	3,125 ²
Within	16	2,645

- ¹ D. F. remaining after deducting one D. F. for lost plot.
² There is no significant difference between sterile and nonsterile yields for the North position.

(2) EAST POSITION
STERILE VS. NONSTERILE YIELDS

Source	D. F.	Mean Sq.
Total	19	
Between	1	17,287 ¹
Within	18	4,975

¹ There is no significant difference between sterile and nonsterile yields for the East position.

(3) SOUTH POSITION
STERILE VS. NONSTERILE YIELDS

Source	D. F.	Mean Sq.
Total	19	
Between	1	15,792 ¹
Within	18	5,659

¹ There is no significant difference between sterile and nonsterile yields for the South position.

(4) WEST POSITION
STERILE VS. NONSTERILE YIELDS

Source	D. F.	Mean Sq.
Total	19	
Between	1	31,761**
Within	18	3,364

** There is a highly significant difference between sterile and nonsterile yields for the West position.

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