USDA FOREST SERVICE RESEARCH NOTE NE-137

1971

Northeastern Forest
Experiment Station

FOREST SERVICE, U. S. DEPT. OF AGRICULTURE, 6816 MARKET STREET, UPPER DARBY, PA.

SAP VOLUME FLOW AS INFLUENCED BY TUBING DIAMETER AND SLOPE PERCENT

Abstract.—The amount of sugar maple sap that can move through plastic tubing is controlled by several factors. The most important are tubing diameter and slope percent. Estimates are given of the number of tapholes that can be used with combinations of these variables.

The tubing used to collect sugar maple sap is expensive. The larger the diameter, the higher the cost. A sugar producer who uses tubing could minimize his cost and increase his efficiency if he had a way to estimate the proper size of tubing to use in his sugarbush.

This note offers a way. Data are presented for maximum flow rates for various tubing diameters and slopes. Flow rates in gallons per hour can be related to number of tapholes.

Though these data are only estimates, the information should be adequate for the sugar producer to use in selecting the size of tubing necessary to transport sap from the sugarbush trees to the collection tanks.

Assumptions

Before discussing the tubing size needed for various slopes, we must make three assumptions.

First, the information available for water movement by gravity through plastic tubing can be used for estimating sugar maple sap movement. This assumption is logical because sap is composed of 96 to 98 percent water.

Second, we assume that the maximum sap flow during an excellent flow period would be ½ gallon of sap per hour per taphole. Thus, if a producer were collecting sap from 1,000 tapholes, during an excellent flow period he could expect a maximum of 500 gallons of sap per hour.

Third, we realize that the data estimates in this report are for tubing lines that are filled with a column of water. However, when sugar maple sap moves through tubing, the lines are not completely filled with sap. Some air enters the tubing from leaks in the line fittings, and gaseous compounds (mainly CO_2) are also exudated from the taphole during sap flow. However, we believe that these data should be satisfactory for our purposes.

Slope percentage as used in this note refers to the increase or decrease in land elevation or topography for a given horizontal distance. A 20-percent slope means the elevation rises or falls 20 feet for every 100 feet of horizontal distance.

Normally, tubing installed on a slope will have some bends and crooks. However, the data as used in this paper are more applicable for tubing installed as straight as possible, with a minimum of sharp bends or crooks.

Plastic Tubing Diameters

Picture a tubing system used for collecting sugar maple sap as a network of plastic lines of various diameters. There will be many small lines hanging from tree to tree, with approximately 20 tapholes connected to a single line. The lower end of these small lines will be connected to larger tubing lines, and as the sap moves by gravity down the slope, these lines merge with increasingly larger sizes of plastic tubing (fig. 1 and fig. 2).

The sizes of plastic tubing used by producers for collecting sugar maple sap range from ¼ or 5/16 inch to 2 inches (inside diameter measurement). The smaller tubing is normally used to collect sap from tree to tree, and the lower ends of these small tubing lines are connected

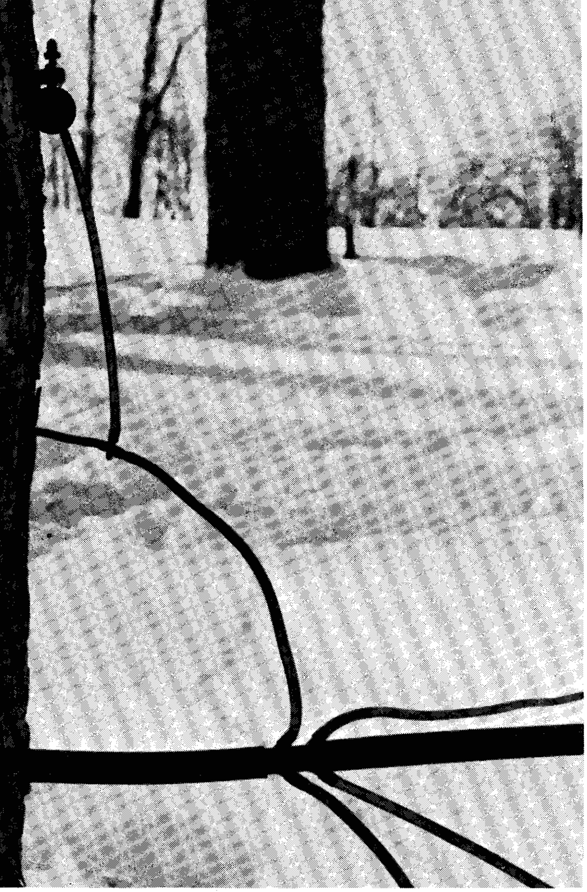

Figure 1.—From the spout in the tree, sugar maple sap is transported through small tubing to larger mainlines.

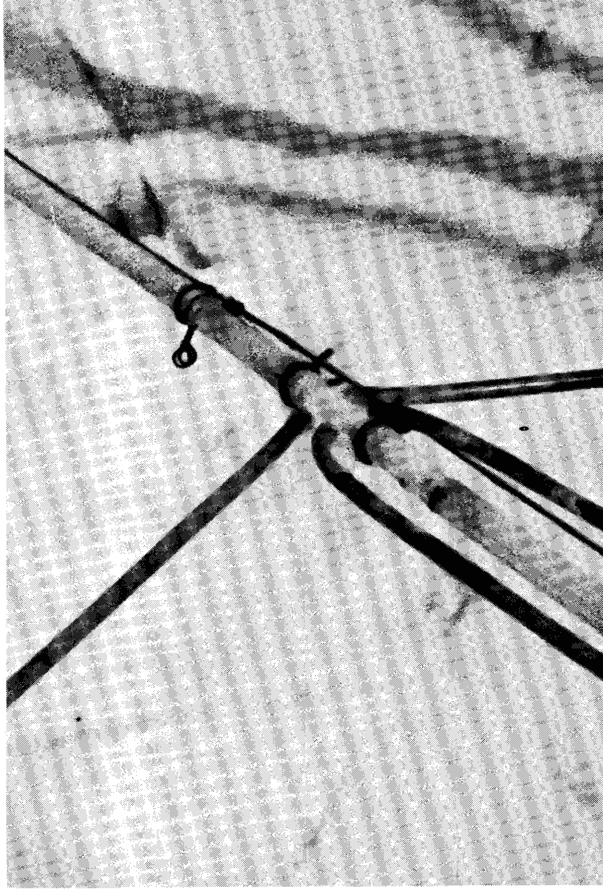

Figure 2.—Feeder lines of 5/16-inch tubing join a suspended line of ¾-inch tubing.

to larger tubing lines. If the tubing operation involves several thousand trees, sap from a taphole may be transported through several sizes of tubing before reaching the collection tank.

Flow Rates

A search was made for information about the flow rates of water through various sizes of pipe and tubing (fig. 3). We were able to use data published by the Republic Steel Corporation (table 1). These data include the number of gallons of water moved per hour through tubing diameters from ½ inch to 2 inches, for each of seven slopes ranging from 6 to 40 percent.

We converted the flow-rate values for these data, given in gallons per hour, to taphole equivalent (table 2). This was done by assuming a maximum sap flow of ½ gallon of sap per hour per taphole. For

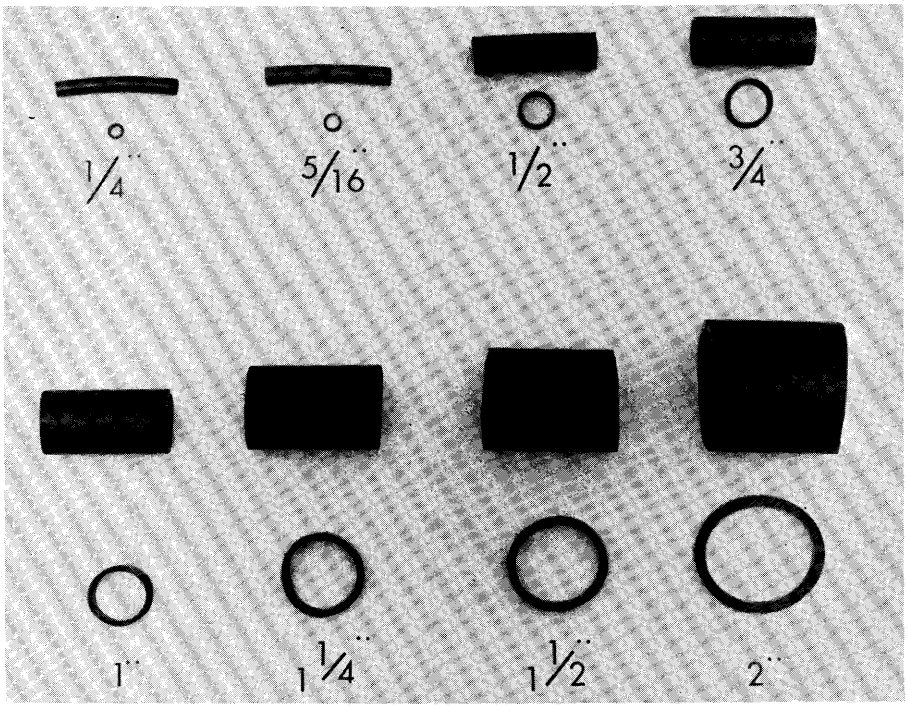

Figure 3.—The plastic tubing used in sugarbush operations ranges from 1/4 inch to 2 inches in diameter.

example, if a given diameter of tubing on a given slope can carry a maximum of 100 gallons of water per hour, we assumed it could handle the peak sap flow from 200 tapholes. This conversion can be easily modified for areas where it is felt that maximum flow rate from a single taphole is more or less than the assumed 1/2 gallon per hour. However, we believe this is a good average estimate for planning purposes.

Application

Using the information in table 2, a sugar producer installing tubing on a steep slope—40 percent—could use 1/2-inch lines for transporting sap from about 900 tapholes (888). At tubing junction points where more than 900 tapholes would be attached to a single 1/2-inch line, the tubing size would be increased to 3/4-inch. On a 40-percent slope 3/4-inch tubing would be adequate for 1,866 tapholes.

Slope percent does influence the gravity movement of sap through plastic tubing. For example, on a 15-percent slope a 1/2-inch tubing line would be adequate to handle the sap from about 500 (516) tapholes.

Table 1.—*Water delivered per hour by gravity movement through plastic tubing of various diameters on a designated slope*
[In gallons per hour]

Slope percent	Plastic tubing diameter, in inches					
	½	¾	1	1¼	1½	2
40	444	933	1,752	3,600	5,400	10,450
30	378	795	1,500	3,120	4,620	8,940
25	342	720	1,350	2,820	4,200	8,040
20	303	640	1,215	2,520	3,720	7,140
15	258	549	1,050	2,160	3,180	6,120
10	207	444	840	1,740	2,526	4,860
6	156	336	630	1,320	1,920	3,720

Source: Republic Steel Corporation, Water delivery tables using Republic flexible plastic pipe, 12 pp., 1956.

Table 2.—*Approximate maximum number of tapholes that can be used for collecting sap by gravity flow using various diameters of plastic tubing on a designated slope.*

Slope percent	Plastic tubing diameter, in inches					
	½	¾	1	1¼	1½	2
40	888	1,866	3,504	7,200	10,800	20,900
30	756	1,590	3,000	6,240	9,240	17,880
25	684	1,440	2,700	5,640	8,400	16,080
20	606	1,284	2,430	5,040	7,440	14,280
15	516	1,098	2,100	4,320	6,360	12,240
10	414	888	1,680	3,480	5,052	9,720
6	312	672	1,260	2,640	3,840	7,440

If sap from additional tapholes were added to this 500-taphole ½-inch line, it would be necessary to change to a ¾-inch line at this point to carry the volume of sap down the slope to the collection tanks. A ¾-inch line on a 15-percent slope could handle the sap from nearly 1,100 (1,098) tapholes.

Data for other slope percentages (6, 10, 20, 25, and 30 percent) and tubing sizes (1-, 1¼-, 1½- and 2-inch lines) are also included in this table, and the applications are similar. To be efficient, a producer should use the diameter of tubing that will adequately transport the maximum amount of sap for his slope and number of tapholes. Tubing that is either too large or too small will result in an inefficient tubing installation.

Although no research information was available on sap movement by gravity through plastic ¼- or 5/16-inch tubing, our experience indicates that 20 tapholes per line appear to work satisfactorily. Some sugarmakers have as many as 75 tapholes on one of these smaller lines. However, we have had good success collecting sap by gravity using 20 tapholes per 5/16-inch line, and we recommend this 20-taphole figure.

Discussion

The gravity sap-flow data indicate the number of tapholes that can be used with a given diameter of plastic tubing installed for several slope percentages. This information is based on the assumption that during a maximum flow period a producer can expect ½ gallon of sap per hour per taphole. We realize that this estimate may not apply to all sugarbushes, and the ½ gallon per hour sap flow may occur only once or twice during a sugaring season. However, the producer must have enough tubing of a given diameter to handle the available sap during a peak flow period.

For using this tubing size-slope-number of tapholes information, several points should be emphasized. The tubing must be installed with a minimum of severe bends or crooks. The sap should move by gravity through the tubing to the collection tank. Average slope percentages should be estimated accurately, because this factor is critical in choosing the correct size of tubing to use. Also, in installation, the slope of the lines should be as uniform as possible to suit the tubing size used.

The basic data in this note should assist new producers who are installing tubing for the first time. The information may also benefit producers who are having problems with their tubing installations, especially if the problem is too many tapholes on a given size tubing line. Successful sugar producers who use tubing say that it is better to have tubing that is too large than tubing that is undersized and inadequate to handle the volume of sap during a peak flow period.

—H. CLAY SMITH

Research Forester
Northeastern Forest Experiment Station
Forest Service, U. S. Dep. Agriculture
Burlington, Vermont

MANUSCRIPT RECEIVED FOR PUBLICATION 28 APRIL 1971.