Evaluation of Alternative Sap Ladders
Summary of 2002-2003 Research Project

Background Information

This research project was established in the spring of 2002 to study the technique of lifting sap with simple "sap ladder" tubing structures. It was conducted during the production seasons of 2002 and 2003 in an operational setting at Wheelers Maple Products in Lanark County, Ontario.

A sap ladder is a simple tubing structure designed to lift sap vertically between a lower and an upper section of mainline. It is essential that the tubing be on a vacuum system for a sap ladder to function. Sap ladders are useful in flat areas and to transfer sap over hills or other obstacles such as roadways or trails as can be seen in Figure 1. Sap ladders may benefit maple syrup producers by:

- providing an inexpensive alternative to an additional pumping station
- introducing vacuum to sections of bush separated from the source of vacuum by a hill
- increasing the yield of good quality syrup due to the introduction or improvement of vacuum into affected areas

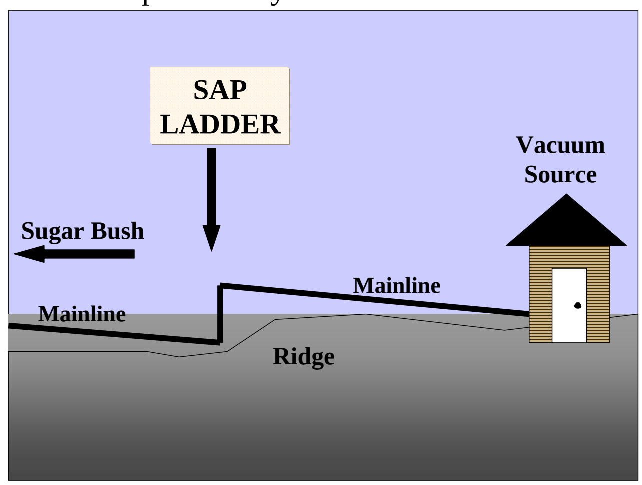

Figure 1. Example of a situation in which a sap ladder may be employed

There are many possible sap ladder structures. Some employ 5/16" lines as the vertical lift between upper and lower portions of mainline while others use one or two sections of pipe as the vertical lift. There was still very little known at the beginning of this field investigation as to the effectiveness and limitations of the various structures.

This project was more of an operational study than a tightly controlled scientific research experiment. The evaluation of the effectiveness of each sap ladder was based on visual observations and readings of vacuum levels on either side of the ladder. Many producers have also been experimenting with sap ladders in their own sugar bushes, contributing additional practical information on the use of the sap ladder technique in sap collection.

This project received financial support from the North American Maple Syrup Council and was conducted with cooperation of the Ontario Maple Syrup Producers Association, the Ontario Ministry of Agriculture and Food, and Wheelers Maple Products.

Objectives

1. To determine and compare the effectiveness of a variety of sap ladder configurations in an operational environment.

2. To determine the benefits and limitations of the sap ladders in the project.
3. To test the usefulness of practices used in conjunction with sap ladders, including a dry line, a bypass line, and venting.


Figure 2. Sap Ladder Research Installation

Methods

The sap ladder installation is located in a section of sugar bush that is separated from the sugar camp by a flat section of land. A vacuum level of 14” Hg was all that could be maintained at the sap ladder in 2002. A new pump house was built in 2003 closer to the installation (approximately 475 feet), providing 18” Hg to the sap ladders.

All of the sap ladder systems work within the same area as can be seen in Figure 2. Two large cedar posts were installed in the ground 16 feet (5m) apart with brace wire running between them to support the ladders. Ball valves are located at the bottom and top end of each ladder so that a single sap ladder can be activated at a time, allowing each ladder to function independently. Vacuum gauges are attached to the 1 1/4 inch mainline at both ends of the sap ladders, so that the performance of each sap ladder can be monitored.

The lift is 8 feet (2.5m) for each of the ladders. The mainline tubing on either side of the sap ladders is 1 1/4 inch food approved black polyethylene pipe. The vertical portions of the sap ladders are made of clear PVC pipe or rigid 5/16” tubing. This allows both sap and air flow to be closely monitored as it passes through the sap ladders.

A dry line from the vacuum system to the sap ladder installation and a line bypassing the installation were installed prior to the 2003 season to test their usefulness.

The five types of sap ladders evaluated in 2002 were:
1. A series of 6-way manifolds with 5/16 inch lines for a vertical lift (Star Ladder)
2. A single piece of 1 1/4” pipe as a vertical lift (Single Pipe Ladder)
3. Two pieces of 1 1/4” pipe (in the same plane) as a vertical lift, one for sap and one for vacuum, with a trap type bottom (Two Pipe Ladder)
4. A single piece of pipe with a smaller diameter pipe contained within it as a vertical lift (Diffuser Ladder)
5. A booster tank at the lowest point, with a vertical piece of 1 1/4” pipe (Booster Tank Ladder)

Three additional sap ladders were included in 2003 in addition to the sap ladders evaluated in 2002, as follows:
1. Two pieces of 1 1/4” pipe (in the same plane) as a vertical lift, one for sap and one for vacuum, without a trap type bottom (Straight Two Pipe Ladder)

2. A two pipe sap ladder with two 1 1/4” parallel pipes on either side of the mainline separated by a tee (Side by Side Two Pipe Sap Ladder)
3. A 45 degree angle single 1 1/4” pipe sap ladder (45 Degree Angle Sap Ladder)

Observations and Results

The main factors of interest in this experiment were the speed, efficiency, and effectiveness of the lift as well as the vacuum transfer across the sap ladders. It is important that a sap ladder lift the sap as quickly as it comes through the line without excessive roll back or churning of the sap. Vacuum transfer is very important to enable vacuum to reach the bush on the other side of the sap ladder. If sap accumulates, blocking off the lift to a large extent, there may not be sufficient vacuum transfer.

Table 1 represents a general ranking of the sap ladders tested in this experiment, with 1 as the highest ranking and 8 as the lowest. The ranking is based on observation from the 2002 and 2003 seasons. The effectiveness of the lift, vacuum transfer, and ease of construction are taken into consideration in the ranking. All of the sap ladders work well, lifting the sap effectively, other than the 45 degree angle and booster ladders. The best sap ladder to install may be influenced by the situation and the needs and preferences of the producer.

Table 1. Ranking of the Sap Ladders Studied in this Project

General Ranking	Sap Ladder	Reasons
1	Side by Side Two Pipe Ladder with Valve	Works very effectively with little to no vacuum transfer loss. Can be used as single pipe lift during low sap flow conditions or as a two pipe lift during heavier sap flow conditions by closing or opening a valve in one of the pipes (Fig. 3). Sap is lifted equally up both pipes when valve is open.
2	Star Ladder	Works very well under wide range of sap flow conditions. A little more work to construct than single and double pipe ladders. Proven to work well from use by producers.
3	Single Pipe Ladder	Works very well. May not function as well (i.e. vacuum transfer) as side by side two pipe ladder under heavy sap flow conditions because only half the lift area. Cheap and easy to construct.
4	Two Pipe Ladder (with trap type bottom)	Lifts sap effectively but second pipe appears to be useless, making the lift essentially a single pipe lift. Second pipe becomes partially filled by sap, essentially blocking it off.
5	Two Pipe Ladder (straight bottom)	Lifts sap effectively but second pipe appears to be useless, making the lift essentially a single pipe lift.
6	Diffuser Ladder	This sap ladder lifts the sap but does not appear to be more effective than the simple single pipe lift.
7	Booster Tank Ladder	There did not seem to be any benefit of having the booster tank, making it an unnecessary expense.
8	45 Degree Angle Single Pipe Ladder	Poor lifting capabilities. Sap tends to roll back in the line and is not lifted as rapidly as in the straight single pipe ladder.

Figure 3. Opening Valve of Side by Side Two Pipe Sap Ladder with Valve

The Two Pipe Ladder with the trap type bottom seemed to be the most promising after 2002. With greater vacuum in 2003 (16-18” Hg), it became apparent that what looked like a pumping action in the second pipe in 2002 was a struggle of vacuum between the two pipes. The second pipe would partially fill with sap, essentially blocking it off. The sap would move up and down due to the vacuum from above trying to lift it. The vacuum from the other pipe would also pull on the column of sap, occasionally lifting it up the first pipe. No sap was lifted up the second pipe in either year. Therefore, there is essentially no difference between this ladder and the single pipe ladder.

The Side by Side Ladder, as can be seen in Figure 3, was added to the experiment in 2003. It was found to be very effective, as sap was pulled quickly and efficiently up both lines. A valve in one of the pipes allows the lift to act as a single pipe lift under low sap flow conditions. The smaller area of a single pipe can lift lesser amounts of sap more effectively without roll back or churning. The greater area of two pipes allows for more sap to be lifted at once and thus greater vacuum transfer under heavier sap flow conditions.

A dry line was installed from the vacuum to the sap ladders to evaluate the effect. With the two pipe lift, the vacuum transfer improved slightly and the functioning of the lift was the same or slightly better. The dry line was not beneficial to the booster tank ladder. In this case, the vacuum from the dry line appeared to compete with the vacuum from the lift pipe, significantly decreasing the effectiveness of the lift.

A section of mainline was installed from the lower mainline (bush side), over the top of the sap ladders, to the upper mainline (vacuum side). This was to evaluate the belief that a vacuum bypass line may aid in the vacuum transfer and effectiveness of a lift. This was found to be ineffective for all of the sap ladders. Some sap would go up the bypass line and the ladder would decrease in effectiveness proportional to the amount that the valve for the bypass line was opened.

The theory that venting (outside air) may increase lift efficiency by preventing air locks was tested with a vent on the lower side of the sap ladders. The same effect was observed with each of the sap ladders. The sap ladder would continue to function but there would be a vacuum loss on the lower side of the ladder of at least 2” Hg. The more the valve was opened, the greater the vacuum loss. Effectiveness of the lift decreased proportional to the increase in the amount of venting.

Conclusions

There are various sap ladder configurations that will lift sap effectively. Producers may experiment in their own bush to determine what suits their needs. It is important to have sufficient vacuum for effective lifting of the sap, preferably 16-18" Hg, as well as sufficient vacuum transfer across the ladder so that all parts of the bush receive vacuum. A valve at the bottom of each ladder would be beneficial to allow for complete drainage of sap from the ladders for cleaning and to prevent damage from freezing.

It is possible that a series of sap ladders may be used to effectively lift sap over greater heights, but this was not tested in this study. Results from other operational investigations suggest that sap ladders located in series can be effective provided that there is good vacuum transfer across the ladders. More study regarding the production of sap ladders in series may be warrented.

Relatively affordable commercial units to lift sap have also become available in the past several years. These may be considered as possible options in addition to those described in this study.

Complete information on this project, including results and lists of materials can be found in the reports from the 2002 and 2003 seasons. For further information contact:

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