Tubing Cleaning - Methods Used in the U.S.

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INTRODUCTION

Two factors have major influences on maple sap yields: vacuum level achieved at the taphole and taphole drying. Vacuum controls sap yield by increasing the pressure differential between the inside of the tree and the inside of the tubing system, resulting in higher sap flows from tapholes than would be found without vacuum (Heiligmann et al. 2006, Chapeskie and Staats 2006, Wilmot et al. 2007). Good vacuum is primarily a matter of proper tubing system design and installation, vacuum pump capability, and the control of leaks.

Taphole drying, the slowdown or cessation of sapflow which is typically observed in the second half of each sap flow season, and the factor often responsible for determining the time at which sap flow ends, is a direct result of microbial contamination (Naghski and Willits 1955). It has long been recognized that microbial contamination is strongly related to yield in sap collection systems (Sheneman et al. 1959). A multi-year study at the UVM Proctor Maple Research

Center demonstrated that tubing systems show fairly rapid reductions in sap yield as they age as a result of early stoppage of sap flow in the latter part of the season, and that these reductions are primarily due to the level of tubing system contamination (Perkins et al. 2010). Numerous research studies have demonstrated that a wide variety of microbes rapidly colonize maple tubing systems (Lagacé et al. 2004), and that changes made in the tubing system aimed at improving sanitation in the immediate vicinity of tapholes (annually changing spout adapters, new droplines, Check-valve adapters) can significantly increase sap yield (Perkins 2009, Perkins 2010, Childs 2010).

In addition or in place of taphole sanitation practices, many producers employ annual tubing cleaning in an attempt to reduce sap yield losses due to microbial contamination (and to improve sap quality). Effective tubing cleaning consists of two parts. The first is washing or flushing of the system to remove microbes and other particles (dirt, wood chips, etc.). Since washing alone does not kill microbes in the system, the second part of cleaning typically involves the use of chemical agents to sanitize the tubing system. For cleaning to be truly effective, elements of both washing and sanitizing must occur. In some practices these steps are combined into one. In many cases however, only one step is conducted, which probably limits the effectiveness of cleaning.

Several other factors can also limit tubing cleaning efficacy. Biofilms are a major impediment to effectiveness of both flushing and sanitizing tubing, as they are not readily dislodged from tubing, and provide refugia from chemical sanitizers that allow subsequent recolonization and regrowth of microbial biomass. Also, to minimize the effect on sap yield in the subsequent collection season, any recolonization of microbes in the tubing system after cleaning must be low. Microbial kill must therefore either be nearly complete, there must be some residual action to the sanitizing agent, or the conditions in the tubing system must be otherwise incompatible with regrowth.

A wide variety of cleaning techniques are currently used in the maple industry, including rinsing the system with pressurized air and water, or attempts to sanitize with chemical solutions such as peroxide, bleach, or alcohol. However, the effectiveness of these cleaning techniques in reducing microbial populations and increasing annual sap yield is often questionable (Perkins et al. 2010, Lagacé 2011, Childs 2012, Perkins and van den Berg unpublished). In fact, it is possible that many of these practices have limited, or even negative effects on sap yield. Thus by employing these practices, producers could be wasting substantial amounts of money, time, and other resources each year. Since it is thought that the majority of U.S. maple producers do currently employ some method of tubing cleaning, it is imperative that research be conducted to determine which, if any, of these methods are most effective at preventing significant annual reductions in sap yield. This will enable producers to increase their annual revenues by employing a cleaning method with an established ability to improve annual sap yield, and/or by eliminating expenditures on the use of ineffective cleaning practices. The first step in completing this research is to determine the tubing cleaning practices currently in use by maple producers in the United States.

METHODS

Two electronic surveys of maple producers were conducted after the 2011 sap flow season using KwikSurvey. Participants were recruited through the online communication boards MapleTrader.com, Sugarbush.info, and MapleChatter.com. The first survey was aimed at gathering a broad array of information on the attributes of tubing systems, and included several questions on tubing cleaning. The second survey focused almost exclusively on cleaning of tubing systems. After the surveys closed, results were exported and tabulated using Microsoft Excel. In some cases when an insufficient number of responses for a specific method were obtained, results were grouped into similar categories (for example, all chemical sanitizers were grouped).

RESULTS

A total of 81 U.S. producers using vacuum tubing were selected from the first survey for analysis. The number of taps ranged from 1,015 to 70,000 with an average of 4,519 taps. Of these, the majority cleaned their tubing using air/water, either blown in from the bottom of the tubing system or sucked into the drop line (Figure 1). Slightly over one-quarter of producers use the "dry clean" method, in which spouts are pulled with the vacuum pump on, and any residual sap is sucked out of the tubing system. Chemical sanitizer use is relatively low in the U.S., with only 21% of producers employing some type of chemical cleaning agent. Of the producers using chemicals, 67% used a chlo-

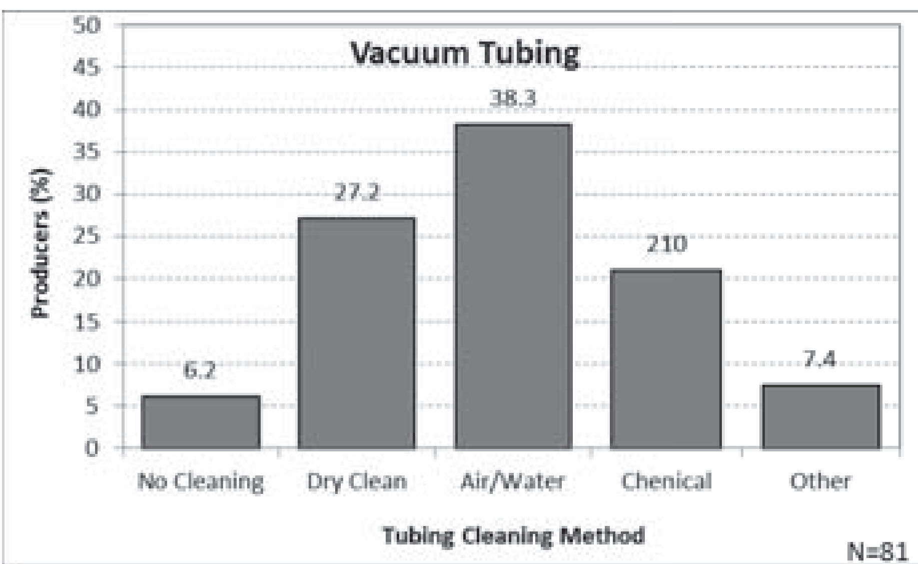

Figure 1. Tubing cleaning methods employed by U.S. maple producers after the 2011 sap flow season. Numbers above bars indicate the actual percentages.

rine-based sanitizer, 20% used hydrogen peroxide, and 13% used alcohol (isopropyl or ethanol). The remaining producers were split between no cleaning and "other" cleaning practices.

In the first survey, producers were also asked to provide their sap yields, which allowed an evaluation of the effect of tubing cleaning (in vacuum systems) on production (Figure 2). Although a variety of producer practices (vacuum level, taphole sanitation, size of operation, etc.) undoubtedly complicates any relationship between yield and cleaning, an analysis of variance revealed no significant effect of tubing cleaning method on sap yield. A well-designed multi-year experiment to explore the primary effect of tubing cleaning on sap yield and quality is sorely needed.

The second survey, focusing primarily on tubing cleaning, had 205 participants from the U.S. who used gravity or vacuum tubing. Of these, 178 were from New England or New York, with the remainder from a variety of maple producing states. The minimum number of taps was 48, the maximum was 70,000, and the average was 3,643 taps.

The general percentages of tubing cleaning methods in the second survey were similar to the results of the first survey. Air/water cleaning was again the most common cleaning method used, followed by "dry clean" (Figure 3). Chemical sanitizers were used by about 20% of respondents. Of those using chemicals, 57.5% used chlorine-based solutions, 15% used hydrogen peroxide, 10% used alcohol (isopropyl or ethanol), 10% used commercial tubing cleaner, and 7.5% used a solution of pan acid. Some producers using chemicals flushed their system with water (38.2%), some let the first sap of the season run on the ground to flush the chemicals from the tubing (54.5%), and some did not flush

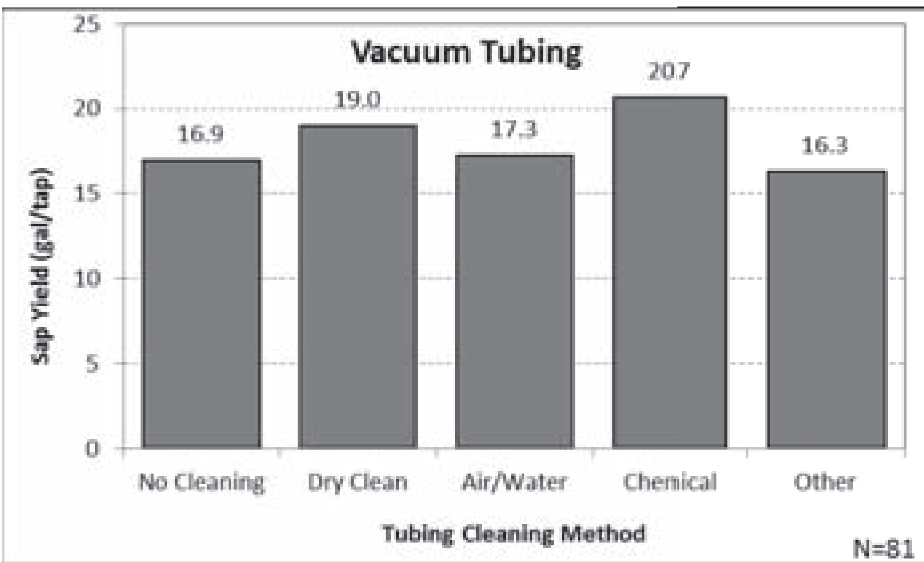

Figure 2. Sap yields by tubing cleaning method. Numbers above bars indicate the average sap yield values. Differences are not significant at α = 0.05.

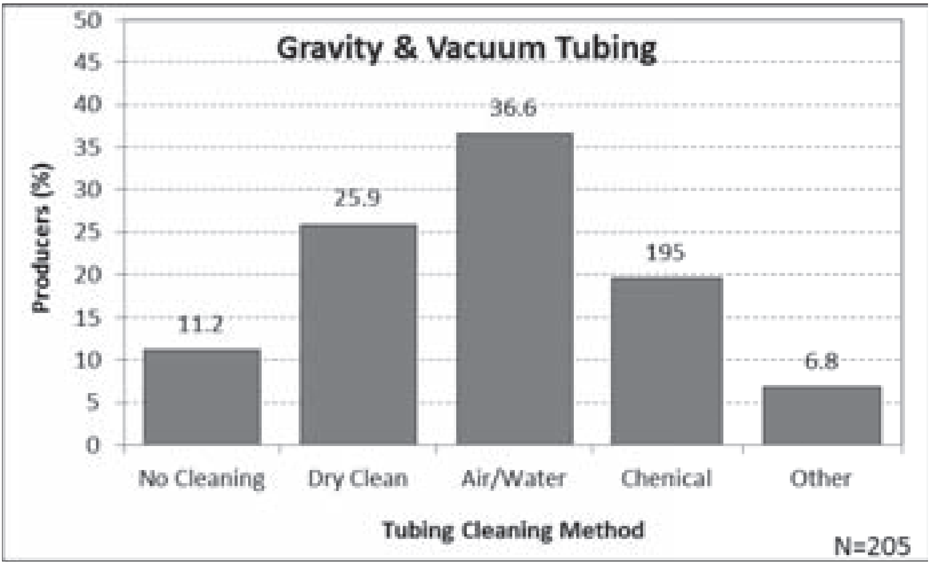

Figure 3. Tubing cleaning methods employed by U.S. maple producers after the 2011 sap flow season. Numbers above bars indicate the actual percentages.

(7.3%). Remaining producers either did not clean tubing (11.2%) or used some "other" method (6.8%).

The average number of taps for producers using the "dry clean" method, which averaged 7,337.5 taps, was considerably higher than that of any of other methods, which ranged from a low of 1,176.8 taps for "air/water" to a high of 3,460.0 taps for "don't clean". Producers using chemical methods had an average of 2,955.0 taps. This demonstrates that U.S. producers with larger operations may be interested in employing some method of cleaning, as long as it is not too costly or time consuming.

Producers who clean spend an average of 30 hours on this activity. The average amount of time respondents reported spending on cleaning (including "no cleaning" responses) was approximately 80 taps per hour. The average cost of cleaning materials (excluding any necessary equipment and labor) for those using chemical cleaners was $0.06 per tap.

We also asked producers how they currently acquired information about how to clean maple tubing (Figure 4). On average, producers were utilizing multiple sources of information to drive their decisions on whether and how to clean, with an average of 2.3 information sources per producer. A high proportion of producers (37.7%) receive information about cleaning tubing from fellow producers. Researchers/Extension Specialists (19.5%), Dealers (17.1%), and the Internet (12.6%) are the next most common sources. Industry publications including the North American Maple Producers Manual (5.6%), Maple Digest (5.6%), and Association Newsletters (1.3%) do not appear to be common sources for information about tubing cleaning.

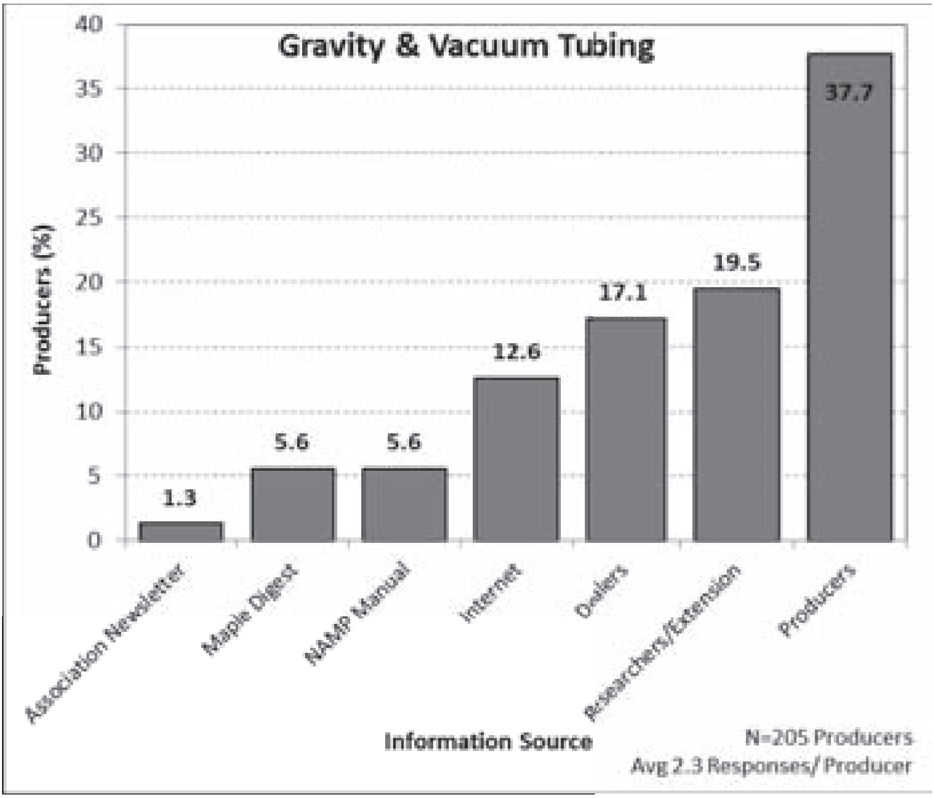

Figure 4. Sources of information about tubing cleaning. Producers were allowed to select multiple responses. Numbers above bars indicate the actual percentages.

DISCUSSION

The wide variety of tubing cleaning methods employed by maple producers and the wide diversity of information sources would seem to indicate that no one method is obviously highly superior to other methods. The lack of clear differences in sap yield among different tubing cleaning methods in this survey reinforces that notion. Interestingly, although it is well known that tubing systems cleaned with air/water suffer rapid and steady losses in yield over time due to increasing levels of microbial contamination (Perkins et al. 2010), it remains the most commonly used tubing cleaning method. It is likely that the "no clean" and "dry clean" methods are no more effective at cleaning tubing as the "air/water" method. Therefore, according to these surveys, nearly three quarters of U.S. maple producers utilize tubing cleaning methods that are ineffective in terms of maintaining high sap yields.

Chemical sanitizers used to clean tubing often suffer from a variety of problems. Although they must effectively dislodge and kill microorganisms at a reasonable cost, such chemicals must also be safe to transport, store, and handle.

In addition, they must be properly applied and tubing should be rinsed in some fashion to avoid contamination of the sap. Finally, chemical cleaners must have little or no harmful impact on the environment. These conditions are not currently met by all available cleaners. Unfortunately, some chemicals in use by the industry at this time do not appear to have any residual action, so cleaning must be done immediately prior to or during the season.

Isopropyl alcohol is widely used in Quebec to clean tubing (J. Boutin, Club d'encadrement technique acéricole des Appalaches, personal communication). Preliminary studies at the UVM Proctor Maple Research Center have shown little effect of chemical sanitizers, including isopropyl alcohol, used on spouts as a way to maintain good sap yields. A similar lack of sap yield improvement in alcohol-cleaned tubing in recent testing in NY (Childs 2012) and the increases in sap yield resulting from using new spouts when compared to used spouts and tubing cleaned with isopropyl-alcohol in Quebec (Lagacé 2011) further demonstrate that considerably more research will be needed to establish the efficacy of isopropyl-alcohol, or other chemical sanitizers, before they can be recommended for adoption in the U.S. maple industry.

In order for cleaning, either with or without chemical sanitizers, to be recommended, the net benefits of cleaning on sap yield and/or sap quality must outweigh the cost of materials, equipment and labor required to clean. Otherwise cleaning is wasteful both financially (money spent where it results in no net profit) and in terms of time lost that could be more wisely spent on other activities.

In conclusion, these results strongly demonstrate the considerable need for further research and information dissemination within the maple industry on the efficacy of tubing cleaning on sap yields and the effects on sap quality, including an economic analysis, with the goal of finding a cleaning method that works and is cost effective, or to provide solid evidence to support a recommendation to forgo tubing cleaning and take alternative approaches.

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