Effects Of The Use Of Paraformaldehyde (PFA) Sterilising Pellets On Sugar Maple Health: A Review

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Introduction

Tree wounds, commonly known as tapholes, are opened in the maple tree wood at the beginning of each sap season late in the Winter, when the weather becomes favorable for maple sap flow. Sap within the xylem wood of healthy trees is free of microorganisms (Edson 1912, Howland 1971, Morselli and Whalen 1991), but a wound opens the way for their penetration. More than thirty years ago, research by Costilow et al. (1962), looking fora germicide which would free the taphole of microorganisms, brought the paraformaldehyde (PFA) pellet into extensive use by the maple sap/syrup industry.

The germicide in the taphole would keep it open longer into the sap flow season, eventually increasing. the volume of sap gathered by the sap/syrup producer.

The researchers were mainly interested in the economical aspects of sap collection (Mac Arthur and Blackwood 1966). Their concern about the effects of paraformaldehyde was limited to its possible residue in maple syrup, the product of sap concentration, which was found not to exceed 2 ppm (Costilow et al. 1962). Recently, Baraniak et al (1988) found residues in maple syrup samples as high as 14 ppm. They also reported that some maple syrup made from sap derived from non-PFA treated tapholes had a low content of formaldehyde (0.74 ppm). They hypothesised that low levels of this chemical "may be representative of typical background levels of formaldehyde in maple syrup". Research did not establish if those syrups had been made with sap from trees previously treated with PFA pellets. Underwood (1971) had found that,

by heating syrup for 3h under vacuum at 250°F, the value of formaldehyde increased by threefold (from 0.45 to 1.50 ppm). These considerations would seriously question the available methods for the detection of formaldehyde in maple syrup and their opinion that all maple syrups may contain some formaldehyde. Furthermore, no one has yet extracted and measured, in time sequence, the levels of formaldehyde in PFA treated and non-PFA treated maple wood tissue. Laing (1989) reported that a substantial portion of the pellet remains in the taphole at the end of the season, unless a vacuum system is used in sap collection.

In a 1962 Maple Research Seminar, scientists meeting at the University of Vermont raised concern at possible damage by the PFA pellet to the maple wood. A few of these scientists had not detected in their own research the alleged increase of sap volume by the pellet usage. Nevertheless, in 1965 (Federal Register) the U.S. Food and Drug Administration (FDA) and the Health and Welfare Canada, without any further testing, approved the manufacturing of the PFA pellet containing 400 mg of paraformaldehyde, later reduced to 250 mg, and set at 2 ppm the tolerance of the PFA residue in maple syrup. The Vermont Department of Agriculture never allowed the use of the pellet in the sugarbush (maple groves), considering it a pesticide.

Research Review

Wounding the wood of trees always represents a normal stress which triggers a natural defence reaction from wood tissues, and tapping maples opens a three inch deep wound which may take a long time to heal. Ching and Mericle (1960) had found that microorganisms invading tapholes were not only physically blocking the sap flow in wood vessels with "gummy" substances, but were also entering the living wood tissues. The researchers thought that those substances were produced by the microorganisms themselves. They had not cited early research by Scott (1950), Laing (1953) and Good et al. (1955) which had hypothesised that those "gums" were produced by the living wood tissues stimulated by the invading microorganisms.

Later, Shigo (1965) and Shigo and Hillis (1973) analysed the cause and extent of wood discoloration, followed by compartmentalisation of wood tissues by gum-clogged vessels. They concluded that such events are a defence response by the tree wood tissues to the invasion of microorganisms after wood wounding or tapping. This process involves the production of phenolic substances by accelerating the catabolic (ageing) processes of wood living cells. Decay by fungi may or may not follow. If a decay area occurs in the compartmentalised wood, it may be either dark or very light in color. These processes block large portions of wood and diminish xylem conductivity (Sperry et al. 1988), hence the translocation of sap and nutrients. Genetically controlled compartmentalisation processes that differ from tree to tree have been suggested by research on poplar clones (Shigo et al. 1977).

Shigo and Laing (1970) became concerned with extensive decay in maple wood from PFA pellet treated tap holes. Their research on trees in Vermont, New York, Michigan, Maine and Pennsylvania showed that, after twenty months from tapping, the vertical columns of discolored and decayed xylem wood in PFA treated tap holes were higher and wider than those found in wood above and below non-PFA treated tap holes (Fig.2. of Walters and Shigo 1978). They concluded that paraformaldehyde inhibits the early response of living tissues to the invasion of pioneer microorganisms, thus delaying wood discoloration and compartmentalisation. It alters the earlier normal successional pattern of microorganisms, facilitating the later invasion by wood decaying fungi. The research recommended that the use of the PFA pellet be discontinued, because its use can seriously harm the maple trees in the long range.

The more extensive decay following the use of PFA pellets in the tapholes were confirmed by Houston (1971). His latest research from 1990 to 1995 at fifteen Wisconsin sugar bushes (Houston 1992, and personal communication) indicates that wood above and below PFA treated tap holes shows longer and wider discolored columns and significantly wider decay areas than wood of non-PFA treated tapholes. Houston got the same results when he analysed wood in which PFA treated tapholes had been flushed with water immediately after the end of the sap flow seasons. However he did not find any difference of proximal cambial damage between PFA treated and non-PFA treated tap holes.

Research by Coradin and Giannasi (1980) found that formaldeldehyde pre-extracts phenolics and flavanoids from plant tissues, actually eliminating plant colors from

herbaria collection plants. These findings would suggest that the PFA pellet may extract phenols from wood living tissues. Therefore, discoloration and compartmentalisation, due to the production of phenols, would not occur in the wood closer to the taphole but much further away. Furthermore, the larger bleached decayed areas found in the PFA treated wood, may very well be produced by the species of decay fungi that grow well only when the concentration of phenols is very low (Tattar and Rich 1973). Earlier it was found that different species of fungi respond differently to varying levels of phenolic compounds (Shortle et al. 1971).

As recently as 1993, both U.S. and Canadian government agencies have denied new registration for the manufacturing of the PFA pellet, under the advice of the North American Maple Syrup Council and the International Maple Syrup Institute. However, unconfirmed information supports that the PFA pellet is still being manufactured, and that three million or more pellets may have been used during both the 1993 and 1994 sap seasons.

Conclusions

The research results cited above should help to convince the maple producers and forest managers that higher and wider discoloration, compartmentalisation and decay in maple wood by the use of the PFA pellet restricts the healthy sapwood areas and diminishes translocation of sap and nutrients. Furthermore, technological advances for better sanitation in sap collection and storage presently in use by the maple industry, tested by research to be safe for maple tree health and syrup quality, have made the use of the PFA pellet unnecessary. The use of the pellet, combined with overtapping and other biological and environmental stresses, could eventually become a greater threat to maple tree health and survival. "Caring for the forest in the 21st Century" should be our motto. Let us keep the maples, with their sap, autumnal red leaves and hardwood timber, alive for future generations of maple syrup producers, leaf peepers and timber users.

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