FERTILIZATION OF SUGARBUSHES PART II. SAP VOLUME AND SWEETNESS

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BACKGROUND

In previous articles we described the nutrition of sugar maple (Wilmot 2000) and an experiment to examine the physiological effects of fertilization (Perkins et al. 2004). In this segment, we describe the effects of fertilization and liming on sugar production in maple stands.

While several studies have shown that nutrient deficiencies can impact stand growth and health, few studies have examined the results of fertilization (see review in previous article). Little research has been published on the effects of fertilization on maple sap production (although see Barry and Robichaud 1996).

It is important to keep in mind that not all sites are suitable for fertilization. Sugar maples may respond when a soil amendment corrects a deficiency, but are not likely to respond when soil nutrition is already adequate. Fertilization should not take the place of proper stand management, and should not be considered a remedy when the site is suffering from overtapping, logging damage, or improper growing conditions such as wet soil. Crowded stands will probably benefit more from thinning than fertilization. Adding the wrong type of fertilizer may only exacerbate already existing nutrient deficiencies. Nevertheless, a proper fertilization regime applied correctly may improve stand performance (Wilmot and Perkins 2004).

STUDY AREA AND FERTILIZATION TREATMENT

As in our previous report, the primary study site (Clark) was located adjacent to the Proctor Maple Research Center in Underhill Center, Vermont with a western exposure on the slope of Mount Mansfield in the Green Mountains at approximately 1350 ft elevation. The site was a former sugarbush that had been abandoned several decades ago. While the majority of the stand was composed of sugar maple, some yellow birch, beech, and hemlock also occupied the site. The majority of trees were > 100 years old and visibly healthy, with > 75% intact crowns.

Ten irregular plots consisting of 10-14 taps each were delineated within the study area and randomly assigned to one of five treatment groups, with two replicate plots per treatment. A buffer strip of varying width encircled each plot. Treatments consisted of: 1) control plots (no fertilization), 2) a commercial 10:10:10 NPK (nitrogen, phosphorus, potassium) at a rate of 270 lbs/acre, 3) a cation mix, consisting of potassium sulfate, calcitic lime, and Epsom salt (designed to supply the soil with potassium, calcium and magnesium) at combined rate of 400 lbs/acre, 4) the cation mix plus 10:10:10 at the rates given above, and 5) cations plus supplemental lime at 3000 lbs/acre. All treatments were applied in May 1999 by hand as a single dose spread evenly throughout the plots.

METHODS

In late 1997, rigid polyethylene tubing was run between the dominant trees in all plots, which were tapped with one or two spouts (7/16") depending on tree diameter. At the base of each plot, the tubing extended to the bottom of the slope, where a small shed was located which served as a collection point. Trees were tapped at the start of each sugaring season (usually late-February) from 1998 to 2003. For the first season, sap flowed into 30 gallon containers within the shed. Depth was measured periodically and converted to sap volume. Sap sweetness was monitored at the same time with a handheld refractometer. Starting in the second season (1998), a flow-through sap volume and sweetness monitoring system was installed (Figure 1). This system consisted of ten 6" diameter PVC vessels, one for each of the separate plots. A ball valve allowed sap to flow directly into the vessel, where a pressure sensor connected to a datalogger monitored sap depth. When a preset sap level was reached in any vessel, the datalogger recorded the sap volume and triggered the ball valve to rotate and empty all the vessels, after which the valves rotated into the normal position so that the vessels could refill. Periodically, another small valve would open on each individual vessel and allow a small amount of sap to run through an automatic refractometer where sugar content was measured and recorded. Sap depth and sugar content was checked on occasion using a ruler and handheld refractometer to ensure that the system was functioning correctly. The system was fully automated, and typically would run the entire sap season without problems. The data were downloaded from the datalogger every few days throughout a season onto a portable computer.

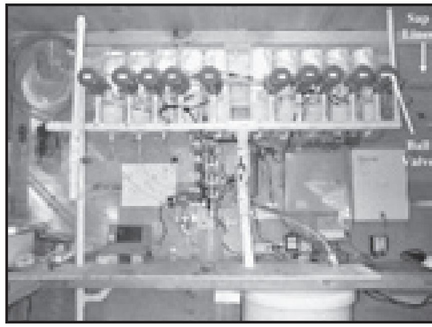

Figure 1. The inside of the Clark site shed showing the sap volume and sugar content monitoring system. Sap from each plot flowed into the shed on the upper right side, through the ball valves and into one of the PVC vessels. When full, depth was measured by a pressure sensor near the bottom of each vessel, and the ball valve turned to allow sap to drain through the pipes into the storage tank at the bottom of this photo. The entire system was operated via a datalogger and relays. A portable computer was used to periodically retrieve the data.

Sugar production from each plot was calculated by multiplying sap volume and sugar content and totaling for the season. Prior to any fertilization we measured sugar production for two seasons to allow the cross-calibration of individual plots, so that we could separate changes in sap production resulting from fertilization with those due to seasonal influences. Sugar production was then measured for four years following fertilization. Sugar production for each treatment was averaged for the two replicate plots and compared to unfertilized control plots.

RESULTS

Over the entire time period and all plots, trees averaged 2.8 Brix sugar content produced an average of 8.2 gallons of sap per tap per year.

All fertilization and liming treatments resulted in increased sugar production at this site. Sugar production in general resulted from increases in sap volume, with a small portion of the increase being attributable to changes in sap sugar content. Sugar production in the first season post-fertilization showed a very modest increase; however, by the second and third years after fertilization, sap production was typically 15% above that of control plots (Figure 2). By the fourth year, sugar production had started to decrease. We project, based upon previous studies of fertilization on maple stands (Wilmot et al., 1996, Wilmot and Perkins, 2004), that the effects of fertilization will gradually taper off, with the increases in sugar production from a single application lasting about seven years.

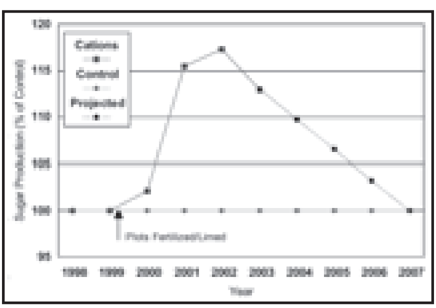

Figure 2. Time course of cation fertilization effects on sugar production (sap production multiplies by sugar content). All results are standardized to unfertilized control plots (diamonds at 100%). Actual measured production from 2000-2003 appears as squares with a solid line, Circles with the dashed line are projected results.

Although all fertilization and liming produced positive results, there were slight differences in total sugar production depending upon the treatment. Whereas most treatments showed about a 9-10% increase in sugar production, the combination of cations plus liming yielded an increase of 5.6%, mainly because of a small decrease in sap sugar content which was partially offset by increased volume.

An economic analysis based upon the cost of the fertilizer, but not including labor, shows that the known increase in sugar production over four years (not including the projected increase) yields approximately 8.6% in additional profits per year (Figure 3).

DISCUSSION

While fertilization and liming are not cure-alls for low production, soil amendments can improve the nutrition of trees on marginal to moderately fertile sites. In this study we present evidence that improved nutrition

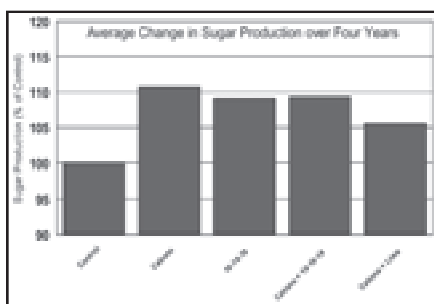

Figure 3. Average effects of fertilization on sugar production (sap volume x sap sugar content) in the Clark study site.

can lead to improved sugar production. Proper sugarbush management, including regular thinning, control of defoliating insects, and minimizing human impacts on the stand remain necessary tools to improve sugar production in maple stands. However, in sites where soils may lack adequate levels or the proper balance of nutrients, or stands where soil pH is low enough to impede proper nutrient uptake, a fertilization program using appropriate methods may improve sugar production.

LITERATURE CITED

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