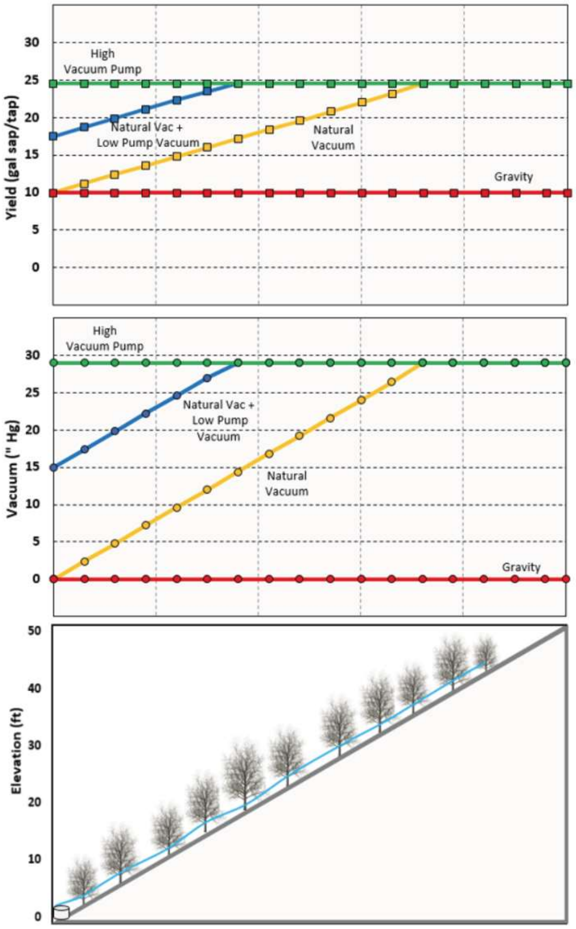

The University of Vermont PROCTOR PAGE
News from the University of Vermont Proctor Maple Research Center

Hitting the slope

Explaining the relationship between slope position, vacuum and potential yield in 3/16" tubing systems

By TIMOTHY PERKINS
Ph.D. – Research Professor and Director
And ABBY K. VAN DEN BERG
Associate Professor
University of Vermont Proctor Maple Research Center

The decisions maple producers make with respect to the type of tubing systems, whether to use pumped, natural vacuum, or a hybrid system, and the management of the system overall have a large influence on the vacuum level in the system. Because sap yield from a tree is linearly proportional to the difference in pressure inside a tree compared to the pressure outside (in the tubing system), such decisions will impact the overall yields from trees greatly. The general rule is that for each 1" Hg additional vacuum, a tree will produce 5-7% more sap.

We are frequently asked about how slope position affects vacuum in 3/16" tubing systems. More correctly, it is not actually slope, but rather the difference in elevation at a particular point in the tubing system and where the sap exits the 3/16" tubing into a tank or mainline that is important.

Although the exact numbers will vary depending upon the slope somewhat due to friction, to the sap flow rate from the trees (related to the flow rate from each individual tree at each point and from other trees above and below that point), the gas production rate from the tree, and the number of taps on the line, in general producers can expect about 0.8" Hg vacuum for each foot of elevation.

In simple gravity systems, there is no vacuum. Sap flows out of the tree due to stem

The University of Vermont PROCTOR PAGE
News from the University of Vermont Proctor Maple Research Center

pressure until the pressure has dissipated, at which point stem pressure equals air (barometric) pressure. In essence, we can think of it as 0" Hg additional external sap driving force. In the figure, the RED symbols represent that scenario. It doesn't matter where the tree is position along the slope (or the elevation) – the vacuum remains essentially the same at each spot. Let's assume for example that these trees using gravity collection produce on average about 10 gal/tap.

In pumped vacuum systems, the vacuum level attained is determined by the capability of the pump. Again, for simplicity sake we will ignore frictional losses, introduction of air in mechanical releasers, number of taps on the line, leaks in the tubing, and gases generated by the tree.

In this case, the vacuum level is relatively constant across the tubing system, but at a far higher level. In the diagram, with a pump of sufficient capacity and a tight tubing system, the vacuum can be quite high. This situation is depicted by the GREEN symbols as 28" Hg. What is clear is that the vacuum level does not appreciably change regardless of the tree position on the slope. If the pump is less capable, the vacuum would be similar, but at a different level, and a small amount of natural vacuum might keep the vacuum at the maximal level. Given that all the trees on this system experience the maximum vacuum of 28", and assuming a 5% increase in sap yield per 1" Hg, these trees would produce, in this example, on average, 24 gal/tap across the entire tubing system.

In 3/16" systems, the situation is more complicated. The vacuum level varies along a continuous scale from the point where sap exits the 3/16" system up the slope. As elevation increases, so does the vacuum level, until the maximum vacuum level is attained. In general, depending upon several factors, when the sap is running, the vacuum level ranges from about 0.6-0.8" Hg vacuum per foot of elevation gained, until the maximum vacuum level based upon barometric pressure, elevation, tree gas production, and leak status is reached.

Typically, this is around 28-29" Hg, rivaling the vacuum levels attained by the most capable pump. Calculating our 5% increase in sap (over gravity conditions) per 1" Hg, and a starting yield of 10 gal/tap under gravity conditions, the yield from trees experiencing 28" Hg would be approximately 24 gal/tap.

Note that this is only for trees at an elevation of about 35 ft and above the 3/16" tubing exit point. Trees lower down on that line will experience a vacuum level that is lower and proportional to the elevation difference from the sap exit point (into a tank or mainline) and the elevation position of the tree.

Trees along the slope in a natural 3/16" vacuum tubing system would experience a vacuum level as shown by the ORANGE symbols in the diagram, thus trees at the bottom would not experience any vacuum and produce 10 gal/tap, while trees higher than about 35' would experience 28" Hg and yield about 24 gal sap/tap. If all the trees were evenly distributed elevationally across the slope, the average yield for the entire system would be 17 gal/tap, assuming the tubing stops at about 35 ft above the slope bottom.

If we add more trees to the line higher up, where we have already reached maximal vacuum levels, those individual trees will produce 24 gal sap/tap, and we will see an increase in average sap yield based upon the number of trees on the line at or above that elevation (until we have reached the maximum tap carrying capacity of the tubing).

In hybrid systems (3/16" natural vacuum on a pump), the relationship between elevation and vacuum level follows a similar trend, but the vacuum level is offset somewhat higher lower down the slope. In the case of hybrid systems, the contribution to vacuum by each of the two vacuum components (natural 3/16" vacuum or pump) is additive. In the example shown, a diaphragm pump pulling 15" is attached to a 3/16" system.

At the bottom of the hill, the pump provides all the vacuum. As we progress higher in elevation, natural vacuum is added to the system at the same rate as in a pure 3/16" natural vacuum system. In this way, trees reach maximum vacuum at a position lower on the slope than with natural 3/16" vacuum alone. In the example shown, trees need only be about 16 ft above the elevation of the pump/tank to experience the highest level of vacuum possible. Calculating out the sap yield shows that trees at the bottom of the slope (at 15" Hg) would produce 17.5 gal/tap, while trees 18 ft and higher above the pump would produce 24 gal/tap, with intermediate trees producing yields in between based upon their position on the hill.

Again, assuming an even distribution of trees across the slope, this scenario would produce a total average for that tubing line of approximately 20.8 gal/tap. As more taps above 16 ft are added, an increase sap yield in sap yield will also be observed.

It should be noted that this is only a simple model of elevation, vacuum, and sap yield under different broad categories of sap collection scenarios. Adding additional parameters complicates the results and the outcomes – note again that projected sap yields are estimates of potential yields only.

Actual sap yields will depend upon several important factors such as spout and tubing sanitation, tree size and tapping practices, tubing system design, installation, and operation, and leak detection/correction.

Understanding the differences and relationships among these variables will allow producers to make informed decisions on where to best focus their attention and resources to reach their production goals.