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WSU Researchers Find Early Frost Can Strip Grapevines of 50% of Recoverable Nutrients

The work examines how premature leaf drop and removed canes reshape vineyard fertilizer needs from one season to the next.

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Researchers at Washington State University are examining how vineyard leaves, dormant cane removal and weather conditions affect the amount of nutrients grapevines lose from one season to the next, work they say could help growers build

more accurate fertilizer budgets and use nutrients more efficiently.

The research is aimed at a basic but costly question for vineyards: how much of a vine’s nutrient supply is stored inside the plant for next year, and how much of that supply is lost before the vine can recover it. According to WSU, the answer matters for both production costs and fruit quality, because growers need enough fertilizer to support healthy vines without spending more than necessary or applying nutrients that plants will not use effectively.

Dr. Markus Keller of Washington State University said grapevines rely heavily on nutrient reserves stored in their trunks, roots and other permanent parts of the plant. Those reserves play a critical role early in the next growing season, before the canopy is large enough for the roots to become active again in taking up nutrients from the soil.

Keller compared the system to a bank account, saying vines need a sufficient reserve balance to support new growth. He said a grapevine typically does not begin taking up nutrients from the soil until the canopy has developed about five or six leaves per shoot. Until then, the first leaves of the season are produced almost entirely from nutrients that were stored during the previous year.

That makes the end of the growing season especially important. In a normal year, leaves change color and fall gradually, giving the vine time to pull nutrients back out of the leaves and recycle them into reserve tissues before leaf drop. But Keller said that process can be interrupted when cold weather arrives too early.

He said an early frost or sudden drop in temperature can cause leaves to freeze off in September instead of falling naturally later in the fall, closer to November. When that happens, the vine can lose a large share of nutrients that would otherwise have been recovered. Keller said the loss can amount to roughly 50% of nutrients that the vine might have retained under normal seasonal conditions.

That kind of loss can carry into the following year. If early frost events happen repeatedly, Keller said, growers may begin to see nutrient deficiencies develop in their vines. In those cases, he said, more fertilizer may be needed the next spring to replace

what the plant was unable to recover before leaves were lost.

The study also points to another source of nutrient removal: dormant canes that are cut and taken out during pruning. While pruning is a normal vineyard practice, removing canes also removes nutrients that remain in that plant material. Combined with nutrient losses from premature leaf drop, the total effect can alter a vineyard’s nutrient balance more than growers may assume if they focus only on soil tests or standard fertilizer programs.

WSU researchers say the findings support a broader approach to vineyard nutrient management, one that looks at the whole annual cycle of the vine instead of treating fertilizer as a single spring decision. That includes paying attention to leaf retention late in the season, the timing and severity of frost events, and how much plant material is removed from the site during winter pruning.

The work comes as growers in many regions are dealing with less predictable weather patterns. For vineyards, shifts in the timing of fall cold can directly affect how much nutrient capital a vine carries into the next season. A vine that enters dormancy with weaker reserves may face a slower start in spring and a greater need for outside nutrient inputs.

The implications extend beyond farm management. For wineries and other parts of the beverage sector that depend on a steady grape supply, better nutrient planning could help vineyards manage costs and maintain fruit quality more consistently. In regions vulnerable to early cold snaps, more accurate estimates of nutrient loss may also help growers make decisions that support long-term vineyard health and reduce unnecessary fertilizer use, with potential effects on operating expenses and sustainability goals.

Washington State University said the goal of the research is to give growers a clearer picture of when and how nutrient losses occur so they can adjust fertilizer programs to actual vine needs rather than relying only on routine schedules. Keller said the timing of leaf loss is central to that calculation, because the earlier leaves are frozen off in the fall, the more fertilizer growers may have to apply the following spring to make up for nutrients the vine did not have a chance to store.