Optimising subsurface drip irrigation for effective drought defence

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Professor Pete W. Jacoby from Washington State University describes how the innovative use of drip irrigation can enhance vineyard resilience to drought

Global warming threatens agricultural crop production and is a genuine concern to many worldwide, especially in regions dependent on sufficient precipitation during the growing season. The lack of rainfall necessary to produce a given crop within a rain-fed production area is defined as “drought”.

Drought may vary in severity according to the period of dryness or the timing of its occurrence during critical crop development. The Palmer Drought Severity Index measures the severity of drought for specific regions.

If deficiency occurs during sequential years, crop production may be threatened by the lack of natural rainfall or by public policies regulating the release of impounded surface water or pumping from aquifers below ground. Increased global warming may increase both drought severity and frequency of occurrence.

Use of irrigation in vineyards

Vineyard owners in drought-prone regions have employed irrigation to offset water shortages created by lack of rainfall. Wine grapevines generally use lower amounts of water than many other perennial crops, such as almonds.

The grapevine is also unique among woody plants by possessing the ability to employ a process known as hydraulic redistribution. This feature allows the vine to obtain water from a source within the soil via its roots, replenish its needs, and even release water within the upper soil profile to sustain shallow lateral roots.

This feature may not always be well developed in vineyards subjected to frequent irrigation. Descriptive studies have revealed that vines subjected to frequent irrigations of short duration may develop and maintain the bulk of their root biomass within the top 45cm of the soil profile.

Because of their formative development under a dependable source of water availability, these vines may not develop an extensive system of deep roots. A vineyard comprised of vines with shallow root systems would likely be more vulnerable during severe or prolonged drought conditions.

Advantages and disadvantages of surface drip irrigation

The concept of drip or “trickle” irrigation was conceived in Israel by Simcha Blass after the end of World War II and later developed during the advent of extruded plastics during the 1950s.

Drip irrigation uses pressurised water delivered through extruded plastic water lines typically suspended from the bottom trellis wire supporting the grape vines. Water is applied through a pressure-compensated emitter that drips water onto the soil surface beneath each row of vines.

This pressurised system allows water to be distributed uniformly across undulating land surfaces versus the flat topography required for non-pressurised irrigation. Pressurised surface drip irrigation is currently the most efficient system used for global vineyard irrigation.

While the advantages far outweigh the disadvantages of surface irrigation, it is essential to mention that applying water through the small orifice of the emitter allows the accumulation of mineral deposits that can reduce the flow rate over time. Periodic treatments of diluted acids through the system can extend the useful life, depending upon water quality.

Filtration systems are recommended to reduce clogging by water-borne soil particles and biological algae commonly associated with surface water distribution through canals.

Water applied to the soil surface is subject to evaporative loss. The primary losses occur from water use by broadleaf weeds and annual grasses that compete with the vines unless reduced by chemical or mechanical methods, which are sources of expense for the grower.

The advent of subsurface drip irrigation

Applying drip irrigation through buried lines with internal emitters can greatly improve crop water productivity (amount of product per unit of water applied).

Systems are best installed before planting the vineyard and have been reported to remain effective for 20 years or more. Efficiencies are gained from reducing water loss to weeds or evaporation from the soil surface.

Disadvantages involve the intrusion of fine roots through the emitter orifice and soil clogging of emitters owing to direct contact with fine-textured soils. Using copper in the emitter has been one attempt to combat root intrusion.

In addition, chewing damage to buried lines by burrowing rodents is a problem in certain regions. Such damage to buried lines is difficult to detect and repair, which has frustrated growers and slowed or eliminated the use of buried lines in some regions.

Innovation in delivering subsurface drip irrigation

A method for delivering subsurface drip irrigation without the use of buried lines has led to the development of a technique known as “Direct Root Zone” or “DRZ”, which uses rigid plastic tubes to deliver drip irrigation to a desired depth below the soil surface.

Applied research conducted in commercial vineyards and guided by input from growers has been published in international peer-reviewed journal articles. DRZ has been found to alter the vine root architecture by reducing the root biomass in the top 60cm of the soil and increasing root number and total root length deeper within the soil profile.

This alteration enhanced overall physiological activity during periods of high summer temperatures compared to vines receiving surface drip at the same irrigation rate. DRZ achieved desired rates of grape yield while reducing water use by 25-34% of that needed for vines watered by surface drip delivery.

DRZ also enhanced deficit irrigation to improve grape quality for premium wine production, as will be discussed in an upcoming E-book.

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