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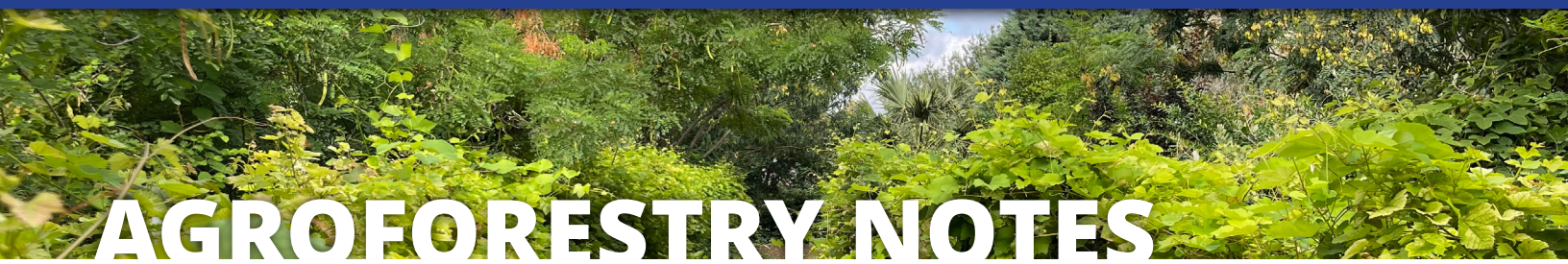

AGROFORESTRY NOTES

Alley Cropping in Vineyards

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Introduction

Alley cropping consists of growing crops between rows of woody perennials and can involve many types of crops, including grapevines. In vineyard alley cropping systems, vines can sometimes be considered the overstory component, with understory crops grown between vine rows. Alternatively, vines can be considered the understory component, grown between rows of overstory trees or shrubs. This technical guide discusses the latter option: vineyard alley cropping systems in which rows of grapes are interspersed with widely spaced rows of trees or shrubs, to create an integrated system with environmental and production benefits.

In any type of alley cropping system, including vineyard alley cropping systems, care must be taken to reduce competition between species for resources like water, nutrients, and light. If these resources are managed intentionally through proper planning, design, and management, alley cropping can help vineyards produce high-quality grapes, increase resilience, and provide a variety of other benefits.

A vineyard alley cropping system in Mendoza, Argentina, with Malbec grapevines and olive trees. Olive trees provide a secondary source of income to this vineyard. USDA Forest Service photo by Katherine Favor.

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Banner Photo: Trees intercropped with table grapevines in Austin, TX. USDA Forest Service photo by Katherine Favor.

Benefits

Alley cropping can provide growers in grape-growing regions an opportunity to achieve production and quality goals while simultaneously improving the broader environment. It can be particularly beneficial for modifying the microclimate and helping vineyards increase their climate resilience.

Benefits of alley cropping in vineyards include:

- Increasing the overall production of the farm by integrating a second crop
- Diversifying production for economic stability
- Preventing frost damage at certain times of the year
- Enhancing habitat for beneficial insects, spiders, bats, and birds, for improved pest control and to reduce reliance on pesticides
- Cooling the microclimate to improve grape quality, especially in wine grapes
- Improving certain wine quality indicators including brix, density, and total acidity
- Improving infiltration capacity and soil water holding capacity
- Reducing runoff and erosion
- Improving soil microbial diversity
- Improving air quality by intercepting pesticide and herbicide drift, particulate matter, and dust
- Decreasing offsite movement of nutrients and chemicals
- Enhancing habitat for wildlife
- Sequestering carbon dioxide from the atmosphere

Some of these benefits are identified in the purpose sections of the U.S. Department of Agriculture, Natural Resource Conservation Service's Conservation Practice Standards for Alley Cropping (311).

Adapting to Climate Change: Alley cropping can help vineyards adapt to climate change in several ways as well.

- Temperatures are rising in many grape-growing regions of the world (IPCC 2023, USGCRP 2023), and grape quality—particularly wine grape quality—is suffering as a result. High temperatures can reduce grape quality by causing shriveling, raisining, sunburn, bitter flavors, reduced acidity, reduced color and aroma, increased alcohol content, and increased undesirable "jammy" flavor profiles (Mira de Orduña 2010, Oliveira et al. 2014). Moderate shade from trees can prevent some of these reductions in quality.
- Very high temperatures can reduce grape yields by reducing photosynthesis and even causing clusters to abscise from vines in extreme cases. By providing shade, trees can reduce heat stress and improve production.
- Climate change models project higher springtime temperatures in many grape-growing regions (USGCRP 2023). This can cause grapevines to break bud earlier, often before the last frost date. Trees in alley cropping systems can limit frost damage early in the growing season by absorbing heat during the day and radiating it out to surrounding vines at night (Gosme et al. 2019).
- Pest pressure may increase in the coming years as climate change causes pest ranges and mating patterns to change (USGCRP 2023). Trees can provide habitat for beneficial insects, mites, birds, and bats, which can lead to improved pest control by natural enemy predators and parasitoids (Favor et al. 2023). Natural enemies often need habitat with specific characteristics to thrive, like vertical structure, floristic diversity, a year-round food source, year-round shelter, and continuous vegetation. Trees in alley cropping systems can provide these requirements.
- Disease pressure may increase in the coming years with increased temperatures (IPCC 2023). With an alley cropping configuration, trees and shrubs help to spatially separate disease vectors from grapevines, which can lead to reduced transmission of certain viruses and bacterial diseases (Favor et al. 2023, Keesing and Ostfeld 2021).
- Drought is projected to intensify in many grape-growing regions in the coming years (USGCRP 2023). Trees in alley cropping systems can slow wind, leading to reduced vine evapotranspiration for improved water use efficiency within the vineyard (Pienaar 2005).

Climate Change Mitigation: Trees in alley cropping systems, including in vineyard alley cropping systems, can help mitigate climate change by sequestering carbon dioxide from the atmosphere and storing it in aboveground woody biomass and belowground soil organic matter and roots. Additionally, trees in alley cropping systems can help reduce soil erosion, which allows more carbon to stay in the soil.

Planning and Design Considerations

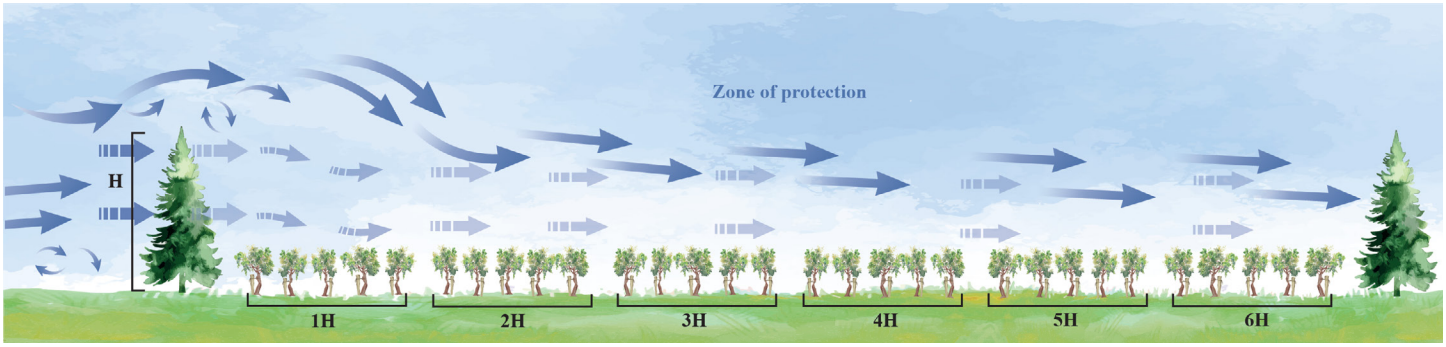
Establishment: Alley cropping can be established in existing vineyards by removing one or two rows of vines at desired intervals and planting rows of trees in their place. Trellis systems may need to be removed as well. In established vineyards, the orientation of tree rows will be driven by the orientation of the existing vine rows, which will vary by site depending on grower goals, slope, equipment, soil type, wind direction, growing degree days, amount of sunlight available, trellis system, grape varietal, and more.

If designing a new vineyard, trees and vines may be planted at the same time. When other grape grower goals and terroir influences do not take precedence, the alley cropping system can be designed to maximize light. Most grapes are grown between 30 and 50 degrees of latitude in both the Northern and Southern Hemispheres. In this degree range, a north-south row orientation for vines and trees is often preferable because it exposes vine canopies to more direct and uniform sunlight (Grifoni et al. 2008) while also casting even shade from trees. For a new vineyard, it is typically more efficient to install vine trellis systems before planting vines and trees.

Spacing: Alley cropping can benefit vineyards in many ways if designed and managed well, and spacing between rows of trees is an important design consideration. The precise amount of space between tree rows will vary depending on goals.

Spacing to Manage Competition: Researchers have found yield decreases in vines within 13–16 feet of tree rows due to competition between species for resources like water, nutrients, and light (Grimaldi 2018, Trambouze and Goma-Fortin 2013). To reduce the number of vine rows that are in direct competition with trees, vineyard alley cropping systems can be designed to have ample spacing between tree rows, as trees can provide many benefits to vineyards even when spaced widely.

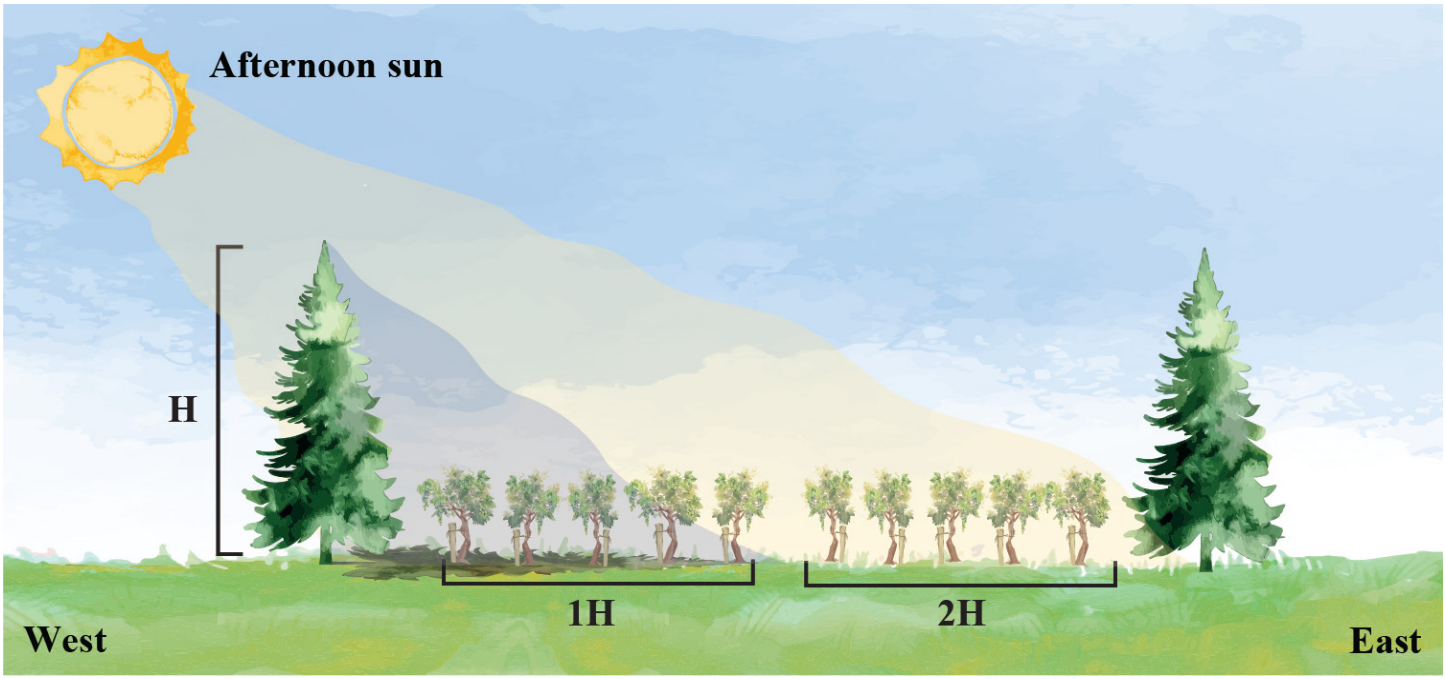
Spacing for Wind Protection: High-value crops like grapes are susceptible to wind damage. If providing protection from wind is a goal, tree rows should be spaced at intervals of six to eight times the height of the trees (Finch 1988). For example, if trees are 20 feet tall, trees rows should be spaced every 120 to 160 feet. Spacing of trees within tree rows is another important design consideration. To effectively slow wind, trees should be spaced close enough together within rows to achieve a density of 50–80 percent (Finch 1988).



To protect grapevines from wind, tree rows can be spaced at six to eight times the height (H) of trees. USDA Forest Service graphic by Mia Sakamoto.

Spacing for Protection from Heat: In areas where grapevines regularly experience extreme heat that impacts quality and production, trees may be used to modify the microclimate and reduce heat stress. If modifying the microclimate by providing protection from extreme heat is a goal, tree rows can be spaced to provide moderate levels of indirect shade to vines during the heat of summer. Vines require ample sunlight and cannot tolerate high levels of shade, but indirect shade from tree shadows that move throughout the day can benefit vines that are experiencing heat stress.

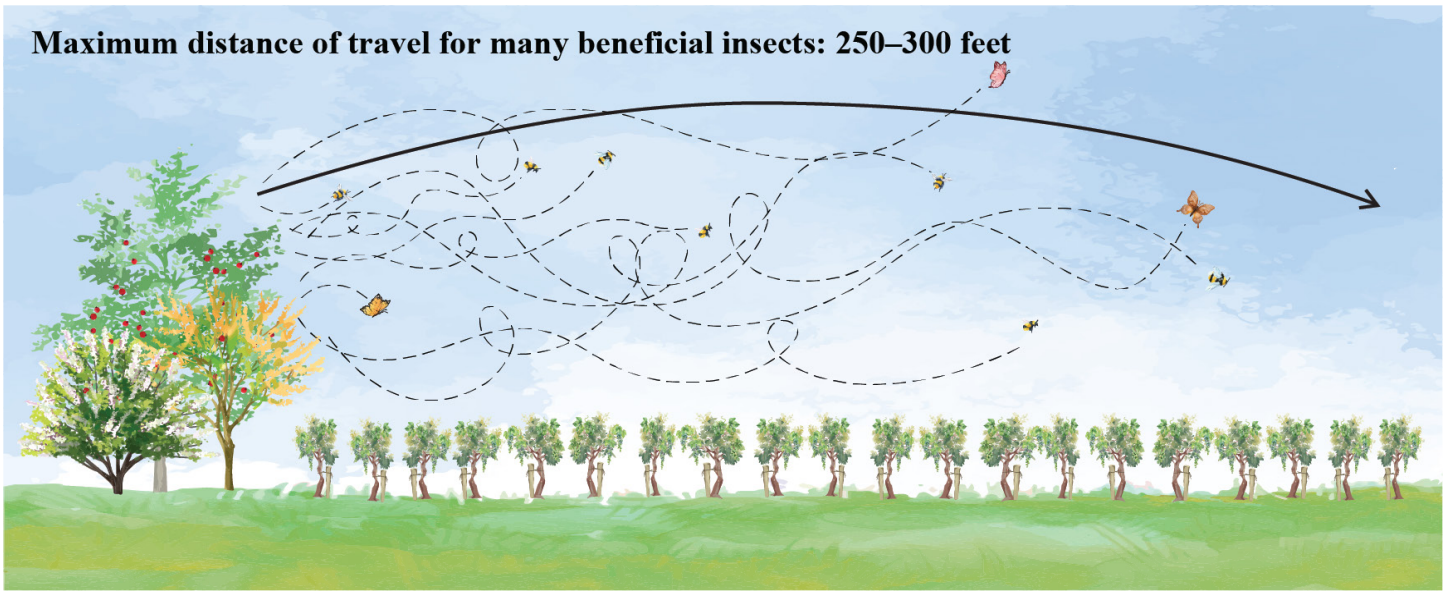
Vineyard agroforestry research sites in France have found success with 65-foot spacing between tree rows when modifying the microclimate is a goal (Bourgade et al. 2020). One method for estimating optimal tree row spacing for a given site is to calculate the length of tree shadows cast during midsummer, when temperatures are the highest. During midsummer, in midmorning and midafternoon, trees typically cast shadows with lengths similar to the height of the tree. For example, a 30-foot tree would cast a shadow roughly 30 feet in length during midsummer, in both midmorning and midafternoon. Most grapes are grown between 30 and 50 degrees of latitude in both the Northern and Southern Hemispheres. At these latitudes, if the tree rows are in a north-south orientation, a shadow will be cast 30 feet to either side of a 30-foot-tall tree row as the sun moves across the sky. Therefore, in this example, tree rows would be spaced roughly at every 60 feet (double the length of 30 feet of shade) to provide indirect shade to vines during the heat of summer. It is important to note that spacing trees close together to reduce heat stress is advisable only in areas where grape production and quality are significantly impacted by extreme heat. No matter what the goal, tree row interval spacing should be wide enough to accommodate vineyard equipment and infrastructure.



To protect grapevines from extreme heat, the distance between tree rows can be calculated by estimating shadow length based on tree height (H) during the hottest parts of the growing season. USDA Forest Service graphic by Mia Sakamoto.

Spacing for Improving Integrated Pest Management: If promoting natural enemy pest control is a primary goal, tree rows should be spaced at intervals no greater than 250 to 300 feet, as this is the maximum distance that many natural enemies can travel (Pryor et al. 2024). Fungal diseases such as powdery mildew and Botrytis can affect grapevines, and their prevalence can be impacted by tree spacing as well. Fungal spores are often spread by wind, so when trees are spaced close enough to create a windbreak effect, the spread of disease can be slowed (Schroth et al. 2000). However, if trees are spaced too densely and wind is slowed down too much, humidity can increase, and fungus can proliferate faster. Making modifications to grapevine canopy vegetation through management strategies such as pruning, leaf pulling, shoot thinning, and topping vines is the most effective way to address fungal incidence should it occur.

A vineyard alley cropping system in Mendoza, Argentina, with Malbec grapevines and olive trees. The olive trees provide habitat to owls, bats, and hawks, which perform much of the pest management in this system. USDA Forest Service photo by Katherine Favor.



To promote integrated pest management in vineyards, tree rows can be spaced at intervals no greater than 250–300 feet, as this is the maximum distance that many natural enemies can travel. USDA Forest Service graphic by Mia Sakamoto.

Species Selection: Matching grapevines with the right species of tree is important. Grapevines require high levels of sunlight, so it is important to match grapevines with trees that won't overshade vines. When trees with less dense foliage are selected, they provide a moderate amount of shade that reduces grapevine heat stress without significantly reducing photosynthesis (Grimaldi et al. 2017, 2019). For example, mesquite (Prosopis spp.), sorb tree (Cormus domestica), olive (Olea europaea), apple (Malus domestica), and willow (Salix spp.) are trees with less dense foliage that may be suitable in vineyards in some areas.

Grapevines rely on red light for photosynthesis, so pairing them with trees that absorb different wavelengths of light than grapevines is another way to reduce competition for light. Conifers, for example, absorb more blue light than red light; if paired with grapevines, conifers can allow enough red light to filter through to grapevines below (Krueger 1981). Stone pine (Pinus pinea) is one example of a conifer that has been successfully alley cropped with grapevines in France (Trambouze and Goma-Fortin 2013).

Vines nearest to tree rows may experience competition for nutrients, especially nitrogen (Dupraz et al. 2009, Grimaldi 2018, Trambouze and Goma-Fortin 2013). In other alley cropping systems, a common way to reduce competition is to pair deep-rooted trees with shallow-rooted understory crops, but in the case of vineyard alley cropping systems, both trees and vines have deep roots. In vineyard alley cropping systems, competition can be minimized by selecting nitrogen-fixing trees, like mesquite (Prosopis glandulosa), as the tree component in the alley cropping system. The extra nitrogen provided by trees may prevent excess competition from occurring in these rows (Nair 1993a, 1993b).

Economic considerations are also important to keep in mind when selecting species. To avoid losing production space by planting trees in the vineyard, growers can select trees that produce a harvestable crop with an economic value, like fruit, nuts, or timber, to generate a secondary income. Growing multiple economically valuable crops in an alley cropping system can also increase the economic resilience of the vineyard; for example, if grape yields or quality go down because of climate stress or another factor, having another type of crop can help maintain a healthy profit for the farm. Planting trees and grapevines on the same piece of land can also maximize the productivity of the system by utilizing vertical space. While yields of the individual crops may decrease slightly in alley cropping systems, the yield of the whole farm often increases. If trees with an economic value are chosen, however, it is important to ensure that the management and harvest labor tasks associated with their upkeep do not interfere with the timing of vineyard management and harvest tasks. For example, grape harvest often occurs in late summer to early fall and can be very laborious. Pairing grapevines with trees that also produce a harvest in late summer to early fall can put labor strains on growers. It is more advisable to pair grapes with trees that yield a crop at other times of the year. Examples of economically valuable tree and shrub species that have been intercropped with vines around the world include olive (Olea europaea), peach (Prunus persica), plum (Prunus domestica), maple (Acer spp.), fig (Ficus carica), ash (Fraxinus spp.), poplar (Populus spp.), and elm (Ulmus spp.) (Lelle and Gold 1994).

Regardless of the tree and shrub species selected, care should be taken to ensure that they do not serve as alternative hosts or overwintering host sites for harmful grape pests. Knowing what grape pests affect a given area and researching what tree and shrubs might support their populations is always a good practice. Avoiding trees with allelopathic chemicals (compounds that inhibit the growth of surrounding plants), like eucalyptus (Eucalyptus urophylla), is also a good practice.

Challenges and Considerations

While there are many benefits to growing grapes with trees in an alley cropping system, there are also challenges to consider and manage. Growers should weigh these tradeoffs before implementing alley cropping in vineyards.

Managing Competition Between Species: Many of the management decisions in alley cropping systems center around managing competition between species for water, nutrients, and light, as competition can reduce grape yields. In mature vineyard alley cropping systems, growers have reported yield decreases in wine grapes within 13–16 feet of tree rows (Grimaldi 2018, Trambouze and Goma-Fortin 2013). As trees grow over time, the amount of competition for these resources will change; therefore, management strategies will need to be modified as well.

Competition for belowground resources like water and nutrients is common in vineyard alley cropping systems in grapevine rows closest to trees. This competition is often somewhat balanced out by the soil moisture benefits and nutrient cycling benefits that trees provide to the system. However, management strategies can aid in reducing competition even more. To reduce competition for water and nutrients, some growers have found success with applying more water and fertilizer in vine rows within 13–16 feet of tree rows. Monitoring soil moisture levels and vine nutrient levels in these rows can help determine how much additional water and nutrients to apply. Another strategy to manage competition for water and nutrients is to space trees within tree rows widely apart from one another, or to thin trees once they become large. “Root pruning”—the process of cutting tree roots with a deep-tined subsoiler once a year to encourage roots to grow downward instead of out into alleys where grape roots are—is also an effective strategy if done when trees are young (Dupraz et al. 2009). Planting nitrogen-fixing cover crops between vine rows can also reduce competition for nutrients. In California, cover crop options might include clover, bell beans, vetch, and peas.

Several management strategies can be used to reduce competition for light as well. Regularly pruning tree canopies is important, because maintaining an open canopy will allow more light to pass through to the crop. Thinning trees is another way to allow more light to reach grapevines. With proper monitoring and management, growers can minimize competitive interactions between trees and grapevines.

Balancing Yield and Quality: Competition between grapevines and trees for resources like water, nutrients, and light can reduce yields in rows closest to trees, but grapes can benefit from slight competition for water when it is well managed. In wine grape production, for example, water scarcity is often induced intentionally through “deficit irrigation” strategies, in which water is restricted from grapes to balance fruit yield and quality. Moderate levels of stress trigger grapevines to distribute resources like sugar and nutrients to grape clusters as opposed to shoots and leaves, which can improve grape quality. Moderate water stress can also help produce a small berry size, which leads to more concentrated flavors in wine. Because of this, growers have observed improvements in wine grape quality in grapevines planted close to trees in vineyard alley cropping systems, including higher brix levels and higher total acidity. However, while competition in vineyard alley cropping systems can increase wine grape quality, it can also cause reductions in yield. Deciding whether to prioritize yield or quality is a decision that each wine grape grower must weigh for themselves.

Managing Pests: Pest management in alley cropping systems can be complex. While trees and shrubs often support beneficial natural enemy bird, bat, insect, and mite populations for improved pest control, they can also support certain pests, especially pest birds. Because trees often support birds of prey in addition to pest birds, pest birds are often kept in check in alley cropping systems. Even so, management strategies such as putting up bird netting and utilizing other bird-scaring tactics can help to exclude pest birds. Similarly, while trees can attract natural enemy populations that keep insect pests in check, they can also support insect pests. Integrated pest management practices may still be beneficial, and pesticides may still need to be applied. Many growers already employ integrated pest management and exclusionary strategies such as the use of bird netting, so they may not need to significantly modify their existing practices when implementing alley cropping in vineyards.

A peach and wine grape alley cropping system in New Mexico. Trees provide habitat for beneficial insects and bats, which help control many grape pests. USDA Forest Service photo by Richard Straight.

Water Availability: Water availability is another important factor to consider before determining whether to implement alley cropping in a vineyard. Alley cropping in vineyards can lead to improved overall water use efficiency and lower water usage per crop (Favor and Udawatta 2021). However, the total amount of water used per acre will still likely increase, so alley cropping may not be appropriate where access to water is limited.

Labor Considerations: While growing both grapes and a secondary crop in vineyard alley cropping systems can have economic benefits for growers, managing multiple crops and multiple enterprises requires additional skills and knowledge, which can be time consuming. Additionally, both trees and grapevines take years to yield a harvest, delaying income for several years, and planning for this delay in income is important.

Conclusion

Integrating trees into vineyards can be a proactive step to protect grapevines from the climate risks that many grape-growing regions may face in the coming years. Widely spaced trees can provide moderate shade, frost protection, wind protection, habitat for beneficial insects, and more, to reduce stress and improve grape quality, especially in wine grapes. Trees can also induce moderate competition that can improve grape quality if competition is controlled through thoughtful design and intensive management. Trees can provide these production benefits to vineyards while also benefitting the broader environment by sequestering carbon dioxide from the atmosphere and providing habitat for wildlife. Integrating trees into vineyards does not come without its challenges, so planning, design, and management decisions must be made thoughtfully.

Additional Information

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