Growers in the San Joaquin Valley (SJV) rely on large yields to be profitable. Despite their abundant volume (70% of winegrapes crushed), these winegrapes receive only about 25% of the winegrape farm receipts in California.

Producing high yields may be necessary, but achieving the optimum level of production can be an elusive goal for these growers. If yields are too low, the vineyard will not be financially sustainable. However, if growers retain too many buds at pruning, the vines will become overcropped and out of balance – resulting in an undesirable canopy microclimate, leading to lower fruitfulness and fruit quality in the following year.

Adopting more mechanization is one way growers can lower farming costs. Canopy management practices traditionally done manually, such as dormant pruning, shoot thinning, shoot positioning, cluster thinning, leaf removal, and hedging, have significant effects on vine growth and fruit quality and can be done mechanically with potential cost savings.

Research is needed to test mechanization technologies and determine their short- and long-term effects on vine production and health.

To help growers in the San Joaquin Valley, a four-year trial (2010 through 2013) was established to determine the effects of mechanical canopy management (dormant pruning, shoot thinning, and leaf removal) on vine production. The study will monitor canopy microclimate, cluster architecture, yield components, and ripening in Pinot Grigio and Syrah vineyards.

Results from this study will expand knowledge about growing Pinot Grigio and Syrah, provide information for growers on mechanical canopy management methods, and identify any potential problems for vine health associated with the new mechanized canopy management practices.

**Trial vineyards, treatments, and measurements**

The trial is being conducted with Pinot Grigio (clone 03 on 1103P) and Syrah (clone 06 on SO4) in vineyards planted in 2003 and 1999, respectively. Both vineyards (Arvin, CA) are spaced...
7 x 11 feet (vine x row), trained to bilateral cordon in rows oriented north-south. The vineyards have been under mechanical management since Spring 2008, and the vines now produce consistent yields.

Replicated treatments were imposed to sustain yields of 8 to 9 tons per acre for Syrah and 8 to 10 tons per acre for Pinot Grigio. The vineyards are irrigated weekly by a drip system at 80% of evapotranspiration when mid-day leaf water potential is below -1.2 MPa (12 bars).

All other cultural practices are standard for the San Joaquin Valley and conducted according to University of California Cooperative Extension guidelines.

In each vineyard, the trial is testing the effects of mechanically performed canopy management treatments consisting of two dormant pruning levels, three shoot density levels, and two leaf removal levels in four randomized complete blocks.

Two dormant pruning treatments:
- Hand spur-pruning of vines to retain 24 buds per vine on 12 spurs (3.5 buds per foot).
- Mechanical box-pruning to retain a 4-inch hedge of canes with a density of 15 spurs per foot of vine-row (approximately 2.5 to 3 buds per foot) using the implement in Figure 1.

Three shoot density treatments:
When inflorescence was fully developed, three shoot density treatments were applied using the implement in Figure 2.
- 7 count shoots per foot of vine-row (low shoot density).
- 10 count shoots per foot of vine-row (medium shoot density).
- 15 count shoots per foot of vine-row (high shoot density).

Two leaf removal treatments:
- No leaf removal (control).
- Leaf removal in the fruit zone on the east side of the canopy.

Leaves were removed with the implement (See photos on first page) in an 18-inch zone at 20 days after bloom.

The effects of these mechanical canopy management treatments on shoot density, canopy microclimate, fruit set, cluster architecture, yield, and fruit composition were evaluated. Not all data collected in the trial is presented here, but this report highlights the most important results.

2010 results

Effect of mechanical canopy management on shoot density – In the pruning treatments of Syrah vines, the number of count shoots, non-count shoots, and total shoots per foot retained was not affected by pruning method. However, for Pinot Grigio vines, the numbers of shoots was significantly higher in the mechanically-pruned treatment.

The shoot-thinning implementation was used as needed to apply mechanical shoot-density treatments. In the Syrah vineyard, the density of count shoots, non-count shoots, and total number of shoots per foot of vine-row was influenced by shoot-thinning treatments. Shoot-thinning in the low and medium density treatments reduced the total number of shoots per foot of vine-row by about 30% when compared to high density treatment.

In Pinot Grigio, pruning and shoot-thinning treatments interacted to affect the count, non-count, and total shoots per foot of vine-row. Generally, mechanically box-pruned Pinot Grigio that was not shoot-thinned had the most count, non-count, and total shoots per foot of vine-row. Conversely, spur-pruned Pinot Grigio that was shoot-thinned to low density had the least count, non-count, and total shoots per foot of vine-row.

Effect of mechanical canopy management on canopy microclimate – The canopy microclimate was affected by some mechanical canopy management treatments. Leaf removal as a stand-alone treatment had significant effects on percent photosynthetic photon flux density (PPFD) transmittance, number of leaf layers, and percent canopy gaps in both Syrah and Pinot Grigio.

In Syrah, pruning and shoot-density treatments when applied as stand-alone methods did not affect canopy microclimate. However, when pruning, shoot-density treatment, and leaf removal are combined, the beneficial effects of integrating these three methods are evident in reduction of leaf layer numbers for Syrah. In Pinot Grigio, the integration of mechanical box-pruning and shoot-density treatment improved the PPFD transmit-
tance. This also translated to more canopy gaps for mechanical box-pruning and low or medium shoot density in the Pinot Grigio canopies.

Effect of mechanical canopy management on fruit set – The pruning method, shoot density, and leaf removal treatments did not affect the number of berries per cluster or berry weight at set in Syrah. Leaf removal was the only treatment that increased the number of berries set per cluster in the Syrah. A combination of medium shoot density and leaf removal improved berry set in Pinot Grigio.

Effect of canopy management on cluster architecture – Syrah cluster architecture at veraison was mostly affected by dormant pruning method and shoot density. The number of berries per length of rachis increased by 6% with the medium shoot density treatment, compared to low and high shoot density treatments.

Box-pruned Syrah vines had 11% less berry volume than spur-pruned vines. Increasing the shoot density per foot of vine-row with medium and high shoot density treatments decreased berry volume by 10% and 13%, compared to low shoot density treatment, respectively.

Effect of mechanical canopy management on yield – Mechanical box-pruning of Syrah vines produced higher yields (16%) with smaller berry size (12%) compared to vines spur-pruned by hand. The difference in yield came from the number of clusters that were borne on the shoots retained.

Mechanically box-pruned Pinot Grigio had 72% higher yields, with 13% smaller berry size. This was due to a significantly greater number of shoots per foot.

Mechanically shoot-thinned treatments significantly affected yields. In both varieties, the high shoot density treatment had significantly higher yields. Although there were no differences in yield in the low and medium shoot density treatments in Syrah, the high shoot density treatment had 12% more yield. In Pinot Grigio, the yield increased significantly with each increase in shoot density treatment.

Interactions – There were no effects of dormant pruning method, shoot density control, or leaf removal on the leaf area to fruit ratio of Syrah vines. This was probably due to the vigorous growth habit of Syrah, where long shoots with large leaves usually make up for the removal of shoots by shoot-thinning practices.

Shoot density and leaf removal interacted to affect the leaf area to fruit ratio of Pinot Grigio. High shoot density treatments with leaf removal did not have enough leaf area for the amount of fruit that was borne on the shoots. Conversely, vines receiving low shoot density treatments with no leaf removal had excess leaf area for the amount of fruit that was borne on the shoots.

Effect of canopy management on fruit composition – Hand spur-pruned Syrah vines reached the 24° Brix target one week prior to mechanically box-pruned vines.

During ripening, Syrah vines with low and medium shoot density treatments had higher Brix than those with high shoot density treatment. However, by 24° Brix, there was no difference among the three shoot density treatments. Leaf removal did not affect harvest date.

The hand spur-pruned Pinot Grigio vines had higher total soluble solids throughout ripening, compared to mechanically box-pruned vines, and reached 22° Brix two weeks earlier. Pinot Grigio vines with low and medium shoot density treatments were harvested two weeks prior to those with high shoot density. Leaf removal delayed harvest of Pinot Grigio vines by one week.

Take Home messages

Mechanical pruning is not enough to control yield. Mechanical pruning of the vines did not give adequate control of the shoot number
and production, because the number of non-count shoots was equal to or more than the number of count shoots retained at pruning. Although non-count shoots are not as fruitful, they are likely the cause of overcropping, and cannot be controlled by pruning.

Mechanical shoot-thinning is needed to adequately control yield. Without accurate shoot thinning, there is potential for excessive yields. The ability to mechanically reduce the number of non-count shoots makes achieving vine balance possible through mechanized farming practices.

When vines were mechanically shoot-thinned, the medium shoot density treatment resulted in optimum shoot density for these cultivars: 7 and 10 count shoots per foot for Syrah and Pinot Grigio, respectively.

Mechanical shoot-thinning techniques can be improved. For example, the total numbers of shoots retained were different than the intended treatments for count shoot control.

The three shoot density treatments called for 7, 10, and 15 count shoots per foot and the actual numbers were 12, 13, and 17 total shoots per foot for Syrah, and 17, 20, and 21 total shoots per foot for Pinot Grigio (very difficult to thoroughly thin on a 12-inch wide T-trellis).

**Integrating at least two canopy management practices ensures improvement of the canopy microclimate.** Pruning alone does not adequately control canopy microclimate for either cultivar. For Syrah, integrating pruning, shoot density, and leaf removal ensures fewer leaf layers.

Leaf removal as a stand-alone practice improves PPFD and percent canopy gaps for Syrah. For Pinot Grigio, a combination of dormant pruning and shoot-thinning, or leaf removal as a stand-alone treatment, improves PPFD transmittance or percent canopy gaps. Leaf removal was the only treatment to effectively control the leaf layer numbers for Pinot Grigio.

**Crop load and leaf area had significant effects on ripening.** Mechanically box-pruned vines were slower to ripen grapes than spur-pruned canopies, especially in Pinot Grigio, but there were no adverse effects on fruit composition at harvest.

The only adverse effect of mechanized canopy management was delayed ripening of Pinot Grigio with leaf removal, attributed to the reduced leaf area to fruit ratio achieved by this practice.

Overall, control of yield was achieved by integrating mechanized canopy management. Winegrapes are said to be in-balance when the vine can grow its fruit from flowering to a target °Brix within a given summation of degree days.

The leaf area to fruit ratio of Syrah fell between 1.2 m²/kg for Syrah, and 1.0 m²/kg for Pinot Grigio when these vines were box-pruned, adjusted to medium shoot density, and had leaf removal on the east (morning) side of the fruit zone. These leaf area to fruit ratios are in line with the 0.8 to 1.2 m² leaf area per kg of fruit needed to mature fruit trained to single-canopy trellis systems in the San Joaquin Valley.16

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