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Title: "Asymmetrical canopy architecture due to prevailing wind direction and row orientation creates an imbalance in irradiance at the fruiting zone of grapevines"

By: J. Tarara, J. Ferguson, G. Hoheisel and J. Perez

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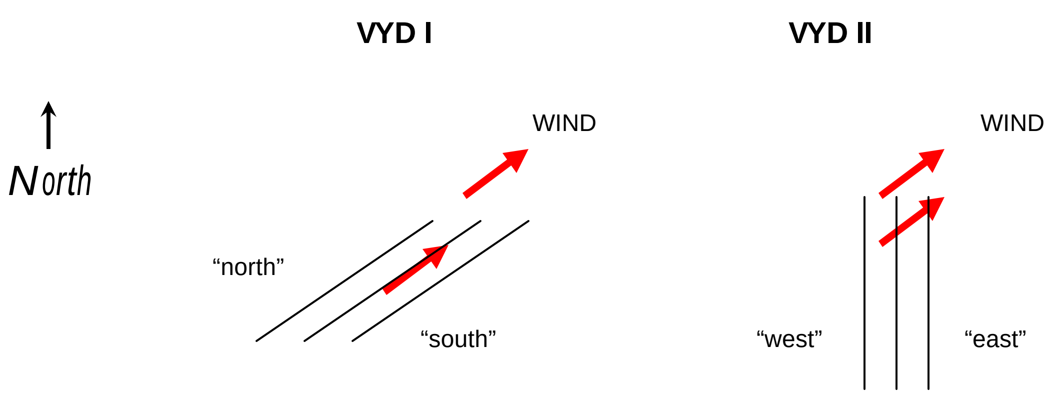
In this article, the authors compare how two different row orientations in a very windy location affect solar radiation and shoot growth. This is an effort to find out which row orientation is best in vineyards subjected to strong winds.

- The study location is the Columbia River Gorge, near Paterson,Washington, an acclaimed wind surfing center and electricity-producing area through the use of wind turbines. The prevailing winds blow approximately from SW-NE, with an average velocity of 3.3 meters per second (7.4 mph) –not that fast, but sustained. Two Merlot sprawl vineyards were studied: 1) Vineyard I, with rows parallel to the wind (SW-NE), and 2) Vineyard II, with rows oblique to the wind (N-S).



- Combining the two row sides of each of these two orientations, the authors classify vine shoots into 4 categories: 1)"North shoots", 2) "South shoots" (both present in vineyard I), 3) "West shoots" and 4) "East shoots" (both present in vineyard II). Because vineyard II is the one oblique to the wind, west shoots are also called "windward shoots", and east shoots are "leeward shoots". These categories are also referred to as "aspects". For example, "west aspect shoots" are those facing west in the N-S orientation, or against the wind, also called "windward shoots".

- For a set of five sample vines, and for each row orientation (SW-NE and N-S), the authors measured 1) **solar radiation** in each side of the canopy using a tube solarimeter. They also measured 2) **shoot morphology** (shoot length, number of internodes), as well as **3) shoot tip displacement** due to the wind.

- To get an estimation of shoot tip displacement, the authors constructed a large protractor with which they measured two types of angles. They measured: 1) the angle that each shoot formed with the geographical north (which is called azimuth), and 2) the angle of elevation of each shoot from a horizontal plane. With these two angles, and some trigonometry, the authors were able to calculate the difference between the actual location of a shoot and the potential location the shoot would have had had it grown in the absence of any external forces. They called this difference the "change vector". What this vector represents is the magnitude and direction of shoot curvature due to all the combined external forces, such as gravity, wind, and phototropism.

- By studying "change vectors", the authors came across three main findings. 1) Shoots oriented parallel to the prevailing wind were longer than those in the rows oriented at an oblique angle. In rows oblique to the wind direction, windward shoots were about 30% shorter than leeward shoots. This change was due to a reduction in the number of nodes, not to a reduction in the length of the internodes.

- The authors also found that 2) the change in direction of shoot growth differed between shoot classes. In rows parallel to the wind, there was a down-the-row streamlining on both sides of the row. In rows oblique to the wind, windward shoots (west aspect) moved upward and eastward, whereas leeward shoots (east aspect) streamlined to the north. Thus, wind direction strongly determined shoot displacement and the ultimate shape of the canopy.

- But perhaps the most important finding is what the authors observed when they measured solar radiation throughout the day: 3) whereas the maximum solar radiation in rows parallel to wind (SW-NE) happened around 11 am (Local Standard Time), **maximum radiation in the west aspect of rows oblique to wind (N-S) happened at the time of day when ambient temperatures were at a maximum, around 2pm.** As berry temperatures can easily exceed ambient temperatures by 6-8 ^{o}C, this can have enormous consequences on the incidence of sunburn, as well as the biosynthesis of compounds associated with fruit quality.

- The most important part of this article is its implications. Basically, what the authors are warning us about is the very detrimental additive effect that wind can have on west-aspect fruit when that wind is coming from the west (or has some west component). This is particular true in the very porous canopies of regulated deficit irrigation vines in semi-arid climates. In other words, when trying to make the best decision on row orientation, **both wind direction and compass direction need to be considered.**

- Indeed, when the wind has a southern or western aspect, the canopy asymmetry that takes place in rows that are oblique to the wind can have very detrimental effects, because the fruit would get exposed to a more intense radiation, and for longer time than in the absence of wind-induced asymmetry. On the other hand, **when the wind has a northern or eastern aspect, wind-induced canopy asymmetry may in fact be desirable**. This is because it could compensate for the higher irradiance on the opposite (leeward) side, and so give the vine a better balance of total irradiance on both sides of the canopy.

So how do we place rows in windy locations? As the authors point out, there is not single prescriptive solution. **Orienting rows oblique to the wind** would work if the wind comes from the north or the east. This would balance the intensity and radiation on both sides of the canopy, which would tend to maximize solar radiation without excessive heat accumulation in the fruit. The drawback here would be an increased daily water use. But orienting rows oblique to the wind would not work at all if the wind comes from the south or the west, because this would only worsen the tough situation already in-built in west aspect fruit. In this later case, **orienting rows parallel to the wind** would be the way to go, which would have the added benefit of symmetrical canopies about the cordon, as well as of lower transpiration rates. As the authors point out, this latter is an important consideration in semi-arid climates with drip-irrigated vineyards.

At the end of the article, the authors mention some corrective actions if you are "stuck" with both wind and the wrong row orientation. These include retrofitting the trellis to alleviate shoot displacement (like adding wires to hold shoots in place), more irrigations early in the season to counteract the shorter shoots, and performing more "aspect-specific" pruning. When asked what aspect-specific pruning meant, the first author explained "you could instruct the pruning crew to leave more spurs on the windward side compared to the leeward side, you could leave more 3-bud spurs on the windward side and 2-bud spurs on the leeward side, or you could position the shoots and/or shoot thin only on the leeward side".

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