Research in Plain English

Considerations on Spatial Crop Load Mapping

Research in Plain English provides brief, non-technical summaries of journal articles by Cornell faculty, students, and staff.

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Summary by Janet van Zoeren.

The Takeaway.

- Crop load is a measure of vineyard balance, which is an important factor in producing consistently high-quality fruit.
- Crop load consists of the ratio of reproductive growth (yield) to vegetative growth (canopy size).
- The Ravaz index (ratio of yield to pruning weight) is a common measure of crop load.
- Canopy size and yield are both frequently measured in commercial vineyards. However, in order to utilize these measurements for precision management, they need to be performed on a vine-to-vine basis during the growing season. This makes both factors much more complicated to measure.
- Current research and technological innovation seeks to find ways to non-destructively and cost- and time-efficiently measure both canopy size and yield on a vineyard scale, and to integrate these data to provide a spatial vineyard crop load map.

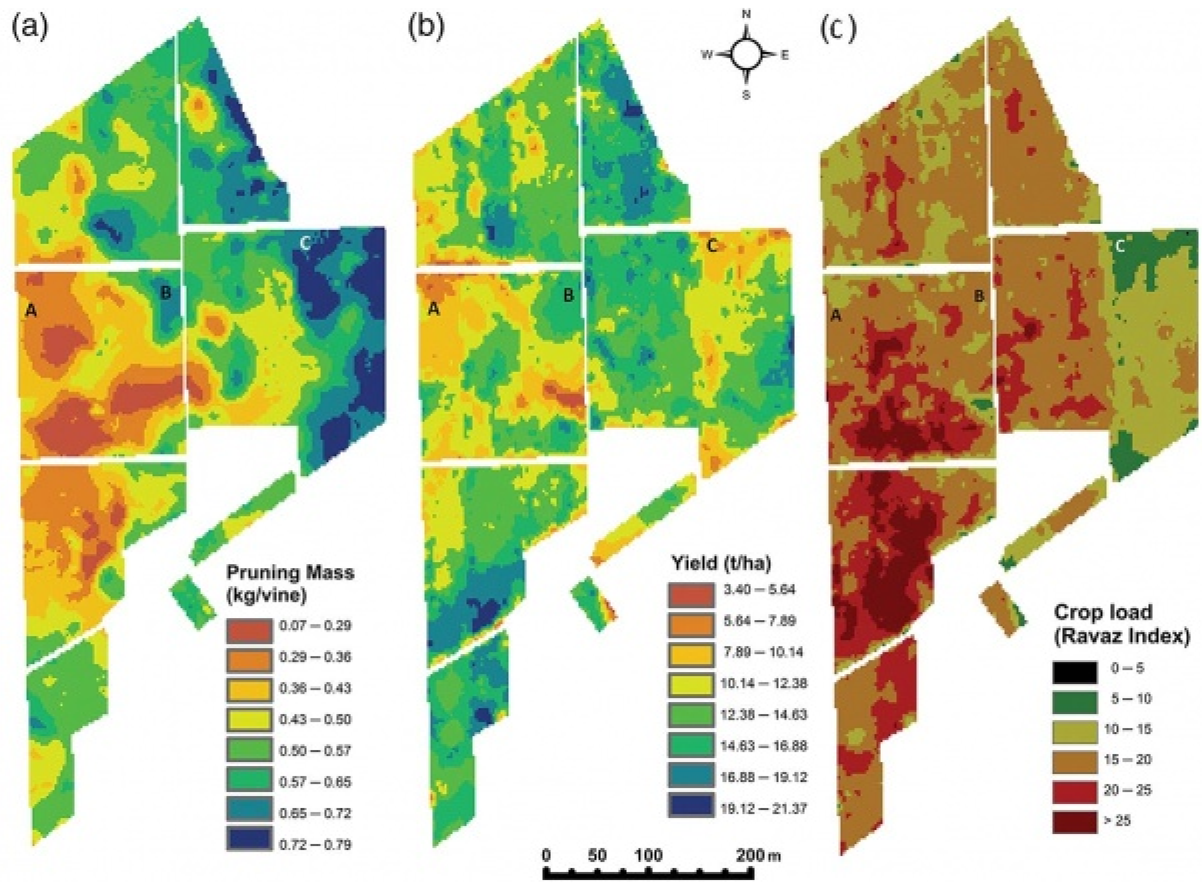
Background.

Vineyard health, in both the long- and short-term, is optimized through a balance of vegetative and reproductive plant growth—often expressed as a ratio of crop to leaf area or a (more easily measured) ratio of yield to pruning weight (Ravaz Index). These measures of crop load indicate whether a vine is overcropped (high crop load), undercropped (low crop load), or balanced. Crop load can be managed in-season through fruit and leaf or shoot thinning. Crop load management is especially important where season length limits the potential for crop ripening (such as is seen in cool climates), and when both quantity and quality are highly important to the value of the crop.

Since the 1990s, precision agriculture has employed sensors to quantify various aspects of cropping systems, including grapevine size and yield. However, despite the development of vineyard-specific sensors, no simple method to measure and map vineyard crop load exists, nor is there sufficient information about how to use that information. This article reviews (1) the history and current methods of mapping vine size and yield, (2) the importance of variability in space and time on crop load mapping, and (3) knowledge gaps and technological innovations that are expected to drive the future of crop load management.

Current technologies used to measure crop load.

Crop load is quantified in terms of either yield per dormant pruning mass, or leaf area per fruit mass. Therefore, in order to map vineyard crop load, you would need to be able to overlay a map of *yield* (or fruit mass) on a map of *canopy size* (pruning mass or leaf area).



Outputs from the authors' spatial measurements of canopy size (a), yield (b), and the ratio of yield to canopy size (Ravaz index, c).

Measuring yield. Total vineyard yield is measured in all commercial vineyards, generally as gross harvest mass (eg. Tons per acre or Tonnes per hectare).

However, yield commonly varies throughout the vineyard. Vine-by-vine yield monitors are available and can be mounted on mechanical grape harvesters. These record the site-specific yield throughout the vineyard. However, this yield information can only be collected at harvest, whereas crop load management should take place during the growing season, when changes can be made to affect vine health.

Estimating yield mid-season using a calculation of clusters/vine x average berries/cluster x historical weight/berry is time consuming, and not very accurate. Smartphone apps and dedicated image-based sensors are in development to perform those calculations more time-effectively.

Measuring canopy size. Paralleling the discussion above, the most convenient measurement of canopy size, pruning mass, is taken post-harvest, and so does not provide information during the growing season. In-season methods are often time-consuming, such as calculating shoots/vine x average leaves/shoot x average mid-rib leaf length, or total light interception through the canopy.

An alternative is to measure canopy vigor using an optical sensor that measures light reflected from the canopy in the visible/near infrared spectrum. These can be mounted on a smartphone, tractor, drone or satellite, making them convenient to use. However, the direct read-out from these devices is only useful if calibrated to pruning mass or leaf area for the specific vineyard.

The importance of spatio-temporal variability in crop load.

A review of the limited literature that does look at yield and canopy size variability within vineyards shows that both may be highly variable, and that the ratio of the two (crop load) is likely to also vary significantly within a vineyard. This indicates that it is important, when using crop load to make vineyard management decisions, to generate a crop load map across the vineyard, instead of managing the entire vineyard based on an average crop load value.

Previous studies have shown that vine size tends to be similar from year to year. We recommend that growers assess vine size approximately every six years in a mature vineyard, and use the information to make management decisions accordingly. However, it should be pointed out that canopy size measurements are mostly taken later in the season when canopies are fully developed. Caution must be used when determining vine size if hedging or shoot thinning are performed mid-season. As vine size is relatively stable, annual variations in crop load are mostly associated with fluctuations in yield (berry mass), which can be highly variable over time.

Conclusions and looking forward (knowledge gaps and technological innovations).

The goal of this research initiative is to ultimately provide a decision support system to help vineyard managers decide the best thinning practices (fruit or leaf/shoot) to optimize crop load for each vine. Some remaining limitations in current technology were identified, which include: (1) in-season yield sensing underestimates yield because it does not account for hidden berries (behind leaves or other fruit), (2) many vegetative indices (e.g. NDVI) exist, but research is needed to determine which has the best predictive power, (3) local calibration is necessary and time consuming, which reduces adoptability, and (4) a research-based predictive model will be needed to optimize the value of these data in a decision support system.

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