# Assessing the value of cover crops in vineyards using proximal sensing approaches

James Taylor, Rhiann Jakubowski, Terence Bates, Robert Bates

▶ **To cite this version:**

James Taylor, Rhiann Jakubowski, Terence Bates, Robert Bates. Assessing the value of cover crops in vineyards using proximal sensing approaches. First International Conference on Farmer-centric On-Farm Experimentation, Oct 2021, Montpellier, France. hal-03761789

**HAL Id: hal-03761789**
**https://hal.science/hal-03761789**

Submitted on 26 Aug 2022

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

# Assessing the value of cover crops in vineyards using proximal sensing approaches.

***AUTHORS** : James Taylor (ITAP, University of Montpellier, INRAE, Institut Agro, Montpellier, France); Rhiann Jakubowski and Terence Bates (Cornell University, Cornell AgriTech, Cornell Lake Erie Research and Extension Laboratory, Portland, NY); Robert Betts (Betts' Vineyard Inc., Westfield, NY.)*

**Service of the interest of On-Farm Experimentation** : Illustration of how a grower has engaged to test innovations on-farm using agri-tech

Innovations in Agri-tech and in cover cropping were introduced into the juice grape industry in NY in the early 2010s. To test the effectiveness of cover crops in a grower's commercial vineyard, a stratified design was implemented to minimise the effort needed and the potential effect of the experiment on production. Agri-tech was used to assess the impact of the presence or absence of a cover crop on yield and vine size. The yield sensor and canopy sensors indicated that over four years there was no impact on production from the cover crops, but the grower did notice that the cover crops provided soil and management benefits. The results reinforced the grower's desire to increase the use of cover cropping in vineyard management.

Introduction:

In 2012, a National Grape and Wine Initative (NGWI) project brought investment in vineyard sensing to the Lake Erie viticulture region via a Crop Load project at Cornell's Lake Erie Research and Extension Laboratory (CLEREL). Financial support was made available to growers interested in installing yield monitoring technology (ATV grape yield monitor (GYM), Roslin, South Australia, Australia) on their harvesters. One commercial contract operator and one family-run enterprise in the region took advantage of this offer. In addition to the yield monitoring technology, terrestrial-mounted canopy sensors (N-Tech Greenseeker RT100 (N-Tech Industries Inc, Ukiah, CA, USA) and an apparent soil electrical conductivity ($EC_a$) surveying service (DualEM-1s, DualEM, Milton, Ontario, Canada) were also made available to the growers free of charge through Cornell's Cooperative Extension (CCE) service. Therefore, these two growers very rapidly gained access to information from on-the-go sensors providing high-resolution information on yield, vine size (canopy) and soil variability within their vineyard blocks (while all local growers had access to the vine size and soil data if they wanted to engage with the extension service).

In addition to the interest in agri-tech and precision viticulture at this time, there was a growing interest in the role of cover crops within cool-climate vineyards in North America (Messiga et al. 2015). Interrow cover crops planted mid-summer were being advocated to improve soil quality, particularly by breaking up compaction layers, and to improve trafficability during harvest (September/October) when the soil may be saturated. However, this is offset by a concern among growers that the interow cover crop may compete with the vines to the detriment of production (yield). By chance, the same family-run vineyard enterprise that had invested in the yield-monitoring technology was also interested in using cover crops. In this case, the younger generation was interested in possibilities of the agri-tech innovation, whilst it was the older generation who was interested in the cover crop innovation. These two innovations are complementary in nature, there is no trade-off between them, and the agri-tech sensors provided a potential way of assessing the local site-specific effect of the cover crop on production. To this end an on-farm experiment was designed using precision viticulture technologies to establish and monitor cover crop effects.

Materials and Methods:

The experiment was performed from 2013 to 2017 in a 2.2 ha Concord (Vitis Labrusca) vineyard near Westfield, NY. The vineyard is a single high-wire cordon managed by machine pruning with hand follow up. Vineyard layout is 2.74 m between rows and 2.44 m between vines within rows. Management was done using best management practices as recommended by CCE (Jordan et al. 1981)

2.1 Sensing

Grape yield monitoring was performed at harvest with a load-cell sensor embedded in a false weigh-bridge on the discharge conveyor belt, that has been shown to be accurate and reliable with regular calibration in these vineyards (Taylor et al. 2016). However, the system was not perfect and yield data in 2015 were not able to be retrieved. Canopy sensing in mid to late July was done to map vine size using a side-on approach where cane length in the canopy side wall relates well to vine size in these vineyards(Taylor et al. 2017). Soil surveys were performed in late spring (full soil moisture profile) by CLEREL with a DualEM-1s mounted on a PVC sled and dragged along the inter-rows behind an all terrain vehicle. The Dual-EM recorded the $EC_a$, which is indicative of soil texture differences when performed at field capacity soil moisture. The between row distance (2.74 m) meant that there was little interference from the trellis wires on the $EC_a$ response if the sled was kept central in the inter-row. All these production data layers (canopy and yield)were collected automatically and routinely by the grower during routine vineyard operations. It did not require specialised surveys or additional time.

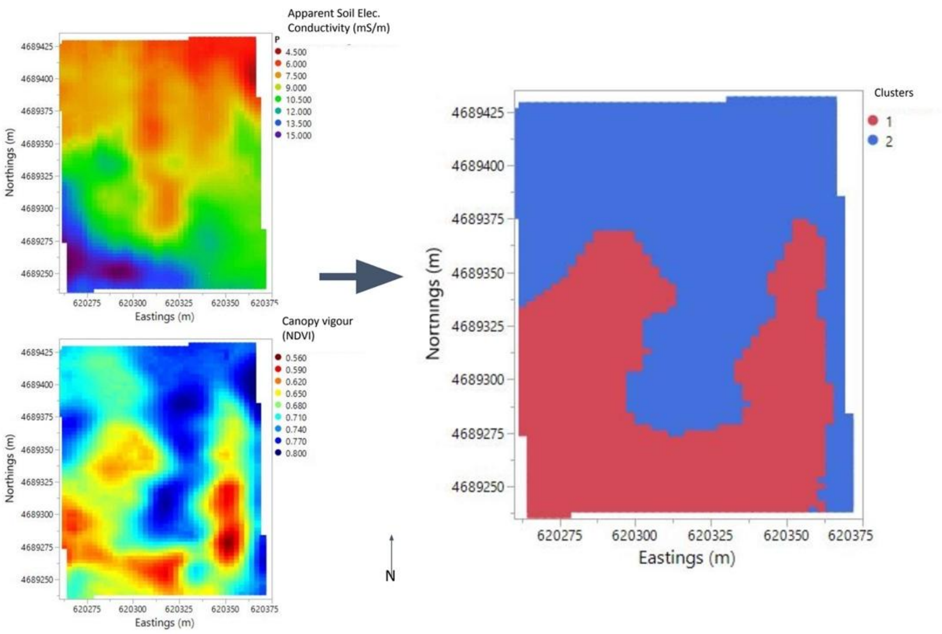


Figure 1: Vineyard maps of soil apparent electrical conductivity ($EC_a$; mS/m) and NDVI (Normalised Differences Vegetation Index) values derived from terrestrial-mounted soil and canopy sensors respectively. These have been fused and classed into two potential management zones (right) using *k*-means clustering. Cluster 1 (red) is a zone of lower vigour associated with a heavier soil texture (higher $EC_a$) while Cluster 2 has higher vigour on a lighter texture soil.

All sensor data were cleaned and interpolated using local block kriging onto a common 2.74 m grid and collated into a spreadsheet for analysis using the general protocol of Taylor et al. (2007).

2.2 Experimental Design.

The interpolated 2013 canopy and ECa data were clustered by staff at CLEREL to form two management classes using *k*-means clustering (see Taylor et al. (2007)). This separated the vineyard block into an area of relatively large vine size on a medium texture soil type and an area of smaller vine size associated with a heavier soil texture (higher $EC_a$).

The vineyard managers were convinced that the cover crop would be beneficial to soil quality in the long-term, even if there was a short-term effect on production, so the default position in the vineyard was to plant the cover crop. Several possible experimental designs were discussed with the two vineyard managers (owners), including a simple half and half split and a complex chequerboard arrangement over the entire field, as well as strip trials and subplots stratified on the mangement classes. The managers were asked to propose alternative designs as well, but did not feel comfortable doing this at this time (i.e. at their first experience with this form of digially-enabled experimentation). Based on their desire to have as much as the vineyard as possible under a cover crop and to understand the response in the lighter and heavier soil texture classes, the managers opted for the sub-plot approach of Whelan et al. (2012) that mininises the treatment area relative to a full strip approach.

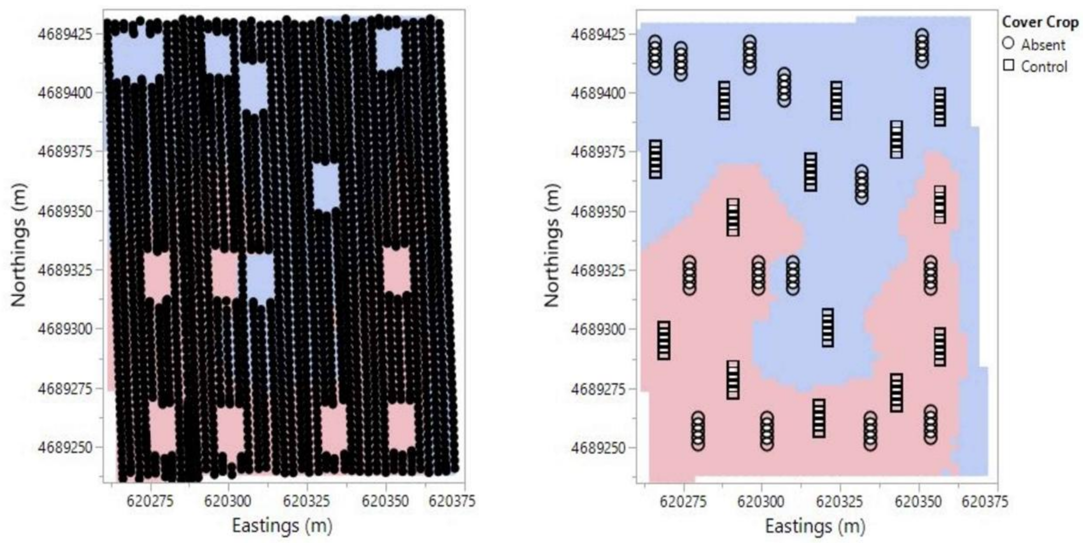


Figure 2: Left: The as-applied prescription map indicating the subplots where the cover crop was not sown each year and; Right: the centre pixels within each subplot (circles) and the paired pseudo subplot cover crop treatment pixels (squares) used for the analysis.

To implement this design, seven sub-plots were identified in each management class where the cover crop was omitted (see Whelan et al. 2012 for full details of the design). These subplots were three panel lengths long (~21 m) and incorporated two interrows, such that the central vine trellis had no cover crop on either side. Three panels was considered long enough to have the sensors pick up any treatment efects. A prescription map was developed and applied that simply omitted sowing the cover crop in the absent treatments (Fig. 2). The remaining area of vineyard inter-row was planted to a predominantly radish cover crop mix (forage and tillage radish; *Brassica sp*.), to help break up the subsoil. Consequently, there was no predefined cover crop treatment area in the design. Instead, seven additional 'pseudo' subplots were randomly selected and the data extracted at these sites to complement the absent cover crop treatments. Having paired treatments like this a) ensured a balanced design for subsequent analysis using classical statistical techniques, and b) made it simple for the grower to understand the comparison. The treatment design was extracted to the spreadsheet containing all the interpolated sensor data. In total there were 35 'pixels' of interpolated data associated with each treatment (Fig 2). Treatment subplot location were kept constant each year (2013-17) to avoid inter-annual effects.

### 2.3 Experimental Analysis

The design above was a balanced stratified block design. Treatment means were calculated and plotted for the period 2013-17 (note that the yield data for 2015 was not available) using JMP (v13, SAS Inc, CA, USA). ANOVA was not performed at this point as the intent was to illustrate trends to the grower for their satisfaction, rather than apply a rigorous scientific analysis.

## Results and Discussion

### 3.1 Experiment implementation and data collection

The growers had a generally positive experience with the agri-tech innovations. As noted, yield data were lost in one of the four years; however the canopy data was routinely collected by the grower during general vineyard operations with little issue (only once runnning the sensor by accident into a fence post, which it survived). This is not to say that the technology was perfect or that it did not require care in acquisition. However, the younger manager was engaged with the technology, which made acquisition reliable. The sowing of the cover crops was also a positive experience using the prescription map and a variable rate actuator on the planter. It is noted that this was fairly simple, as it was just a binary cut-off system, and more complex rate changes may introduce more problems.

### 3.2 Data Analysis

The preprocessing and mapping (interpolation) of the data was performed by a trained research associate at CLEREL. Data processing tools are not yet at the stage where the growers themselves could easily engage with the analysis itself. However, simply plotting the trends and response curves was accessible to the grower and useful to their decision process. These plots are shown in Fig. 3.

Firstly, the difference between the high (blue) and low (red) vigour areas was clear in both the yield response and the NDVI response. It was also clear that the difference between subplots, with or without cover crop, was very consistent over the four years (2014-17). The high vigour subplots with cover crop had ~0.5 tn/ac (~1.1 Mg/ha) higher yield than the absent cover crop subplots at the start of the experiment. Conversely, in the low vigour area, the absent cover crop area started with ~0.5 ton/ac (~1.1 Mg/ha) advantage. In both cases, this advantage was maintained regardless of the treatment type. This indicated, based on the sensor data, that the cover crop was having very little impact on production potential. The same conclusion can be drawn from the canopy vigour (NDVI) plots.

So, the experiment clearly indicated that the cover crop was not adversely competing with the vines. There did not appear to be a negative effect on vine size or on yield from adding the cover crop to the vineyard management. However, anecdotally, the cover crop was providing an ecosystem service by improving soil structure (less compaction noted), both through the action of the roots and by reducing the impact of farm machinery trafficking in the vineyards. In the latter case, there were also other benefits reported by the grower associated with improved vehicular access and trafficability.

This reassured the growers that extending cover cropping to all their vineyards (i.e. upscaling from 2.2 ha to ~90 ha) would not result in any major financial setback to production.

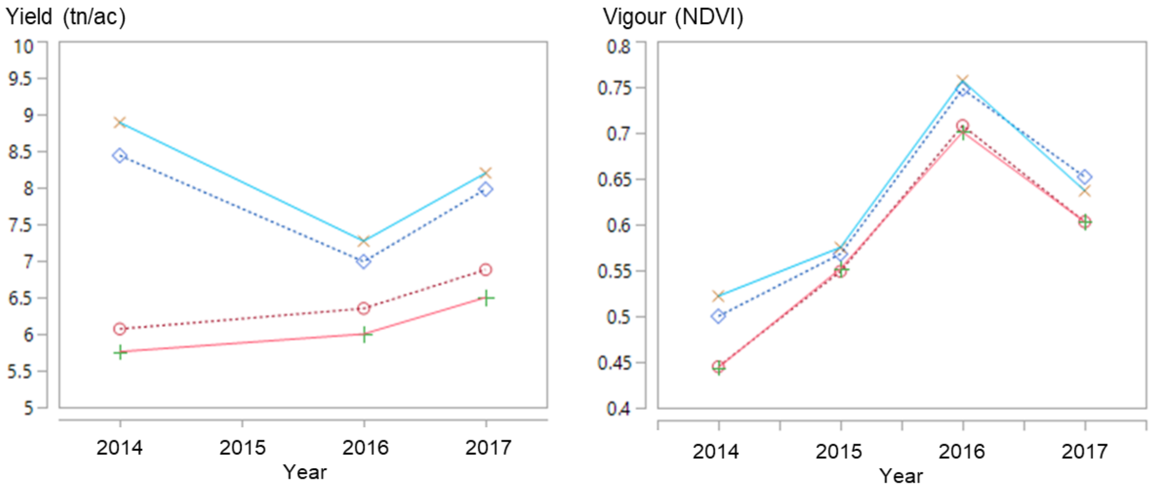


Figure 1: Plot of treatment means over time for the real (absent cover crop) and pseudo (present) treatment pixels in Figure 2. Line colour follows the zone delineation in Fig. 1 - red = low vigour and blue = high vigour. Dashed lines indicate where the cover crop was absent and the solid line indicates that the coer crop was present (pseudo treatments) (Note imperial units as provided to a US grower.)

Conclusion:

A grower's interest in the effect of inter-row cover crops on the bottom-line of the vineyard's production was assessed using an experimental design that was monitored using embedded routine sensing systems. The design allowed the grower to define the question and test their belief (i.e. the default was a presence of cover crop, not an absence). Monitoring using sensors showed that vine size and yield did not appear to be affected by the presence of the cover crop. Implementing the experiment and collecting data was relatively straightforward; however the analysis and the design still requires expert intervention. The skills needed for this would be a limitation to wider application of this approach. The agri-tech required is not a limitation provided care is taken with the use of the agri-tech.

**Acknowledgement :** This work was supported by the National Grape Research Alliance (NGRA) (formerly NGWI). We would like to express our gratitude to NGRA and its supporting viticulture organizations. Additional financial support was also provided by the New York Grape and Wine Foundation and the USDA-NIFA Specialty Crop Research Initiative Award No. 2015-51181-24393. T

**References :** Messiga AJ, Sharifi M, Hammermeister A, et al. (2015). Soil quality response to cover crops and amendments in a vineyard in Nova Scotia, Canada. Scientia Hortic. 188:6-14.

Jordan TD, Pool RM, Zabadal TJ, et al. (1981). Cultural practices for commercial vineyards. Miscellaneous Bulletin 111. New York State College of Agriculture and Life Sciences, Geneva, USA

Taylor JA, Link K, Taft T, et al. (2017). A protocol to map vine size in commercial single high-wire trellis vineyards using 'off-the-shelf' proximal canopy sensing systems. Catalyst. 2:35-47 (doi:10.5344/catalyst.2017.16009)

Taylor JA, Sanchez L, Sams B, et al. (2016) Evaluation of a grape yield monitor for use mid-season and at harvest. J. Int. Sci. Vigne Vin. 50(2):57-63 (doi:10.20870/oeno-one.2016.50.2.784)

Taylor JA, McBratney AB, Whelan BM (2007). Establishing management classes for broadacre grain production. Agron. J. 99(5):1366-1376 (doi:10.2134/agronj2007.0070).

Whelan BM, Taylor JA, McBratney AB (2012). A 'small strip' approach to empirically determining management class yield response functions and calculating the potential financial 'net wastage' associated with whole-field uniform-rate fertiliser application. Field Crops Res. 139:47-56 (doi:10.1016/j.fcr.2012.10.012)