

# **PRECISION AGRICULTURE IN ORCHARDS AND VINEYARDS IN THE PACIFIC NORTHWEST**

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## **INTRODUCTION**

Orchard owners and crop advisors serving those interests have always been interested in variations that occur across semi-permanent plantings of vines and orchards. Managing plant inputs such as nutrients and chemicals have always been a challenge in orchards. The soil and landscape environments in which many of these orchards in the PNW have been established are extreme. Many of these orchards are planted on steep terrain with slopes commonly greater than 25%. Soils can range from deep well drained very productive, to shallow to bedrock or practically cobblestone all within the same block. Crop protection techniques must also be adapted to a corresponding understanding of infestations that occur as a resulting change in microclimates that occur between similar blocks of trees and within the same block.

The knowledge and understanding of how to address a specific problem comes from both a formal and practical education. However, the tools to manage those site-specific occurrences have only recently been developed or are being developed now. With powerful portable computers, software packages that are easily used by busy field advisors, satellite imagery, and local weather stations that are tied into pathogen prediction models, have all moved advances of orchard and vineyard managing into a realm of science that was not possible even a few years ago. These changes are a revolution for North American orchard managers that might rival changes of the industrial age. Combine this technology with plant genetics and you truly have a precision agriculture age.

To an orchard manager who deals with thousands of trees in many blocks, site-specific agriculture is the ability to apply his knowledge of technology and the resultant data that is obtained, to manage inputs as close as to where they occur within a given area. This management of field variability is his attempt to improve fruit yield, quality, and income and limit negative impacts on the sensitive environments where he is conducting business.

Understanding horticulture and agronomy is the basic premise for successful implementation of site-specific techniques into orchards and vineyards. The J. R. Simplot Co. Certified Crops Advisors and Certified Horticulturists are some of the best in the business. These local CCA have combined technical knowledge with experience and imagination to move available resource advances forward to an environment where local growers can adopt them. The recognizable value-added performance of a CCA to his growers is not necessarily the products that he offers, but the knowledge he has and the ability to communicate that knowledge in a timely reasonable fashion. The delivery of this information is enhanced by technology, but will never be a replacement of a knowledgeable productive CCA.

## **OBJECTIVES**

- 1) Determine if a need exists in apple management for site specific yield and quality data
- 2) Demonstrate the benefits of GIS for managing and analyzing apple production practices.

## **METHODS AND MATERIALS**

Four 10-acre apple blocks were selected from an orchard in east/central WA. Soil samples (0-12") were collected on one-acre grids across each block. A complete soil analysis was determined for most major and micronutrients. Fertilizer application maps were created that adjusted P and K rates site specifically based on internal soil test correlation data. Variable rate application was applied in February and March using an Ag Pro® PBM Permanent Crop Variable Applicator. In-season (July) tissue samples were also collected across the same grids and at the same GIS coordinates as the soil samples. Aerial photos, including infrared photos were taken in-season to determine any visual crop stress.

During apple harvest, bar codes were attached to each bin as they were being filled in the field. These labels were used to distinguish each harvested area of a block. They would also be used to track through the processing sheds.

### **GPS and Yield Mapping of Each Block**

A premise of this study was to determine if site specific yield data is both necessary and possible to collect under commercial harvest conditions. There were two methods employed to test the feasibility of per bin data collection: 1) Large apple collection units (ACU) with mounted GPS, laptop computers and bar-code scanners and 2) handheld GPS units and handheld Percon® barcode scanners. Because of the logistics of maneuvering the ACU among apple bins and trees, system 1, while reliable could not keep up with the pickers and the rate of apple bin movement. The handheld units were much more mobile and had a greater utility of use with various crew members. Simplot is working with manufactures of handheld picker ID systems to integrate GPS capability.

### **Necessity**

When calculating any property in a natural system, there is a higher variability observed with more intense sampling. Geo-coding individual apple bins allowed for tracking of yield throughout each block within an orchard. There was a high level of variability within areas of < 1 acre. Average yield across the block was 11,100 lbs./acre, with a range from 6,385 lbs./acre to 28,600 lbs./acre in the 40-acre study area. Any yield monitoring in apples should be done with data collection on a per bin basis. This may require integration of GPS receivers with bar-code scanners in the field and a picker ID system.

Yield maps created from per bin data showed significant trends across the 40-acre study area. These maps are geo-referenced in the GIS and can be overlaid with nutrient maps, images, and pest scouting information to determine the effect these variables might have.

Apple quality is also highly variable across the field and because economic return is based on saleable apples, quality must be addressed. Quality parameters were measured per acre, rather than per bin. The principle parameters evaluated were cull %, WA Extra Fancy %, and U.S. Extra Fancy %. Apple size and box count were recorded, but not discussed here.

Maps were overlaid for each of the parameters measured and management decisions made based on these observed differences within each block. Because quality is highly variable across blocks a system needs to be developed that allows individual bins to be tracked through the entire system.

### **Geographic Information System**

The second objective of this study is to demonstrate the value of GIS for analyzing all information about apple operation and help the user make management decisions. A common function of a crop advisor is to analyze soil nutrient information and make fertility

recommendations. With only grid sampling data in the GIS, much can be learned. A basic method is to map individual soil properties such as pH, N, P, K etc., to determine trends that might affect production. Because pH is the dominant force in soils relative to tree fruit production, it can also effect nutrient availability and fruit quality. Using GIS, every grid can be analyzed relative to pH. Correlations were made to determine nutrient interactions. Based on those correlations, changes can be made in managing nutrients. As an example, a strong relationship exists between pH and phosphorus. As the soil pH increases within an apple orchard, there is a decrease in soil test P. With this in mind, a higher P recommendation can be made relative to higher soil pH.

Soil pH can also be related to apple quality. By tracking crop quality within the apple blocks and relating those observations back to individual grids, it can be observed that the % apple culls increase in direct correlation to soil pH. This suggests that both yield and quality are affected by pH. Through precision agriculture techniques, management programs can now be developed to adjust pH on these permanent crops.

### **Image Analysis in GIS**

Image analysis moves from a “look at pictures for indications” to allowing the GIS to analyze the reflectance values (color and intensity) in relation to other properties. These properties might include quality, yield, nutrients, pests and irrigation management. Intensity values can be extracted for each color, blue, green, red, infrared etc., within a single image. Values are extracted from specific locations on the image that are georeferenced to other data such as soil test locations, yield map points or pest maps. By graphically or statistically analyzing this information, true cause and effect relationships can be determined.

As the crop grows and develops they reflect high amounts of NIR light and absorb NIR as they become less healthy. Extracted image values for NIR reflectance correspond to the grid sample collection points within each apple block. These values can be graphed to indicate the relationship between NIR values and all other properties of interest. Where reflectance areas are high the crop is healthy, the % culls are low and corresponding yields are high. Pre-harvest maps can be made predicting where high yields would occur within each block as well as where low % of culls would also occur.

### **Profit Maps**

The final maps to be produced which can be used by the crop advisor to direct efforts of his customers is by making profit maps. These maps are made after harvest and are based on yield, quality and value. These maps can incorporate costs of all variables including fixed costs and gross returns over a small area of the orchard.

## **SUMMARY**

Precision agriculture techniques can aid in management decisions on established orchards. These same principles can be incorporated into other permanent crops including vineyards. This can be accomplished by analyzing site specific information and relating that information back to profit or loss within the orchard. There are currently several thousand acres that are being mapped in this manner allowing orchard owners and advisors to guide in the future direction of these permanent crops.