2005 Almond Board Project Report

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Project Title: Site-specific application of fumigants to minimize input, reduce cost, and protect the environment.

Keywords: almond, replant disease, replant problem, global position system (GPS), variable rate application (VRA), site-specific application

Commodity: Almond

Problem and its Significance / Background

Replant disease and other replant problems. The research proposed here targets improvement of integrated control strategies for almond replant disease (RD) and related replant problems. Many *Prunus* spp. including almond are subject to diverse replant problems that cause the trees to grow poorly in soil with a recent history of closely related crops. Causes of replant problems include, but are not limited to, nutrient deficiencies and toxicities, improper soil pH, limiting soil physical conditions, poor plant-soil water relations, and root or vascular system disease caused by plant parasitic nematodes, *Phytophthora* species, *Armillaria mellea,* or *Verticillium dahliae*. These factors can act alone or in combination. Even in the absence of the replant problems described above, however, RD can cause almond trees to grow sub-optimally or fail to establish on land cleared from previous orchards on peach rootstock. RD is associated with poor feeder root health, and our previous research indicates that pre-plant spot fumigation at tree sites can prevent severe RD. Less is known about effects of spot or partial-area treatments on other replant problems.

Results of previous research funded by the Almond Board suggest that adaptation of existing navigational and engineering technologies could improve chemical management strategies for RD. It was determined that focused pre-plant tree site fumigation treatments with several alternative fumigants can prevent incidence of severe RD with relatively low rates of fumigant (i.e., $\leq$ 50 lb/orchard acre; Almond Board Research Reports, G.T. Browne, 2001-2004), but tree-site treatments are typically labor intensive. The labor intensity results largely from a need to auger out and replace soil at the tree site locations before planting so that the hand fumigation probe can be inserted into the soil and fumigant dispersal is facilitated in the loosened soil. Additional labor and worker handling of fumigation machinery is involved in administering the fumigation treatments using hand-held probes. Also, conventional tree-site treatments can involve complication in accurately locating the tree sites before the orchard is marked for planting. As will be described below, we think that use of global positioning systems (GPS) technology, combined with adaptation of conventional shank fumigation machinery, can link advantages of focused tree-site treatments (fumigant savings, concentration of fumigant where it is most needed) with those of tractor-pulled shank applications (i.e., labor savings, less potential worker exposure to fumigants, speed of operation, no augering required). Speed in pre-plant fumigation can be critical for growers who are attempting to replant without a year of fallow, because after harvest only a brief window of time is available for pre-plant fumigation. Additional advantages of GPS-driven fumigation, including treatment of operator-selected square or rectangular areas, would be obtainable.

Environmental concerns and resultant regulatory restrictions on fumigant use will require optimized management of RD and other replant problems. This proposal targets improved, site-specific fumigant application methods obtainable through recent advances in engineering technology. During the last decade, we have seen an increasing interest in precision farming or site-specific management, a crop production practice that involves applying just the right amount of inputs at the right location at the right time. Advent of GPS has made it possible to georeference any location to a desired degree of accuracy. Inexpensive hand held GPS units (a few hundred dollars) have an accuracy of 10 to 66 ft (Abidine et al., 2004). These systems either do not use any differential corrections or use WAAS (Wide Area Augmentation System) corrections. On the other end of the spectrum are real-time kinematic GPS (RTK GPS) systems capable on 1 cm accuracy (Ehsani et al., 2004). These systems are quite expensive (tens of thousand dollars). These types of systems are widely used in autoguidance systems that require very high accuracy. In many field applications, a submeter accuracy differential system (DGPS) that cost about $3000 is used. In the last couple of years an improved version of this submeter accuracy GPS system has been developed. These high precision (HP) systems cost about $8000 and are capable of providing 4 to 8 in. accuracy. Moreover, variable rate applicators (VRA) can apply desired amount of chemicals irrespective of the speed of the applicator.

Objectives: The goal of this research is to adapt these new technologies to the chemical applicators in the orchard to enable site-specific application of fumigants. This goal is being accomplished through three specific tasks – (i) software development, (ii) retrofitting Trical fumigant applicator with necessary hardware, and (iii) conducting field experiments to verify the accuracy of the system.

Research Achievements: During the first part of this project, we have mainly concentrated on software development because of the delay in obtaining the necessary hardware and applicator. The Trical applicator was being heavily used up until December and was not available to this project. It was delivered to us in December 2005. Subsequently we put together the system and conducted some preliminary experiments on the UC Davis campus.

Software Development: Developing the software necessary to implement site-specific application is one of the key steps in this research. The software needs to create a fumigant application map from using GPS coordinates of the corners of the orchard, row spacing within the orchard, tree spacing within the row, and the size of the fumigant treatment area around each tree planting site. The GPS coordinates of the corners of the orchard are typically in longitudes and latitudes. Development of the application map involves following steps:

1) Transform the orchard corner points from Geodetic coordinates to UTM (Universal Transverse Mercator) coordinates,

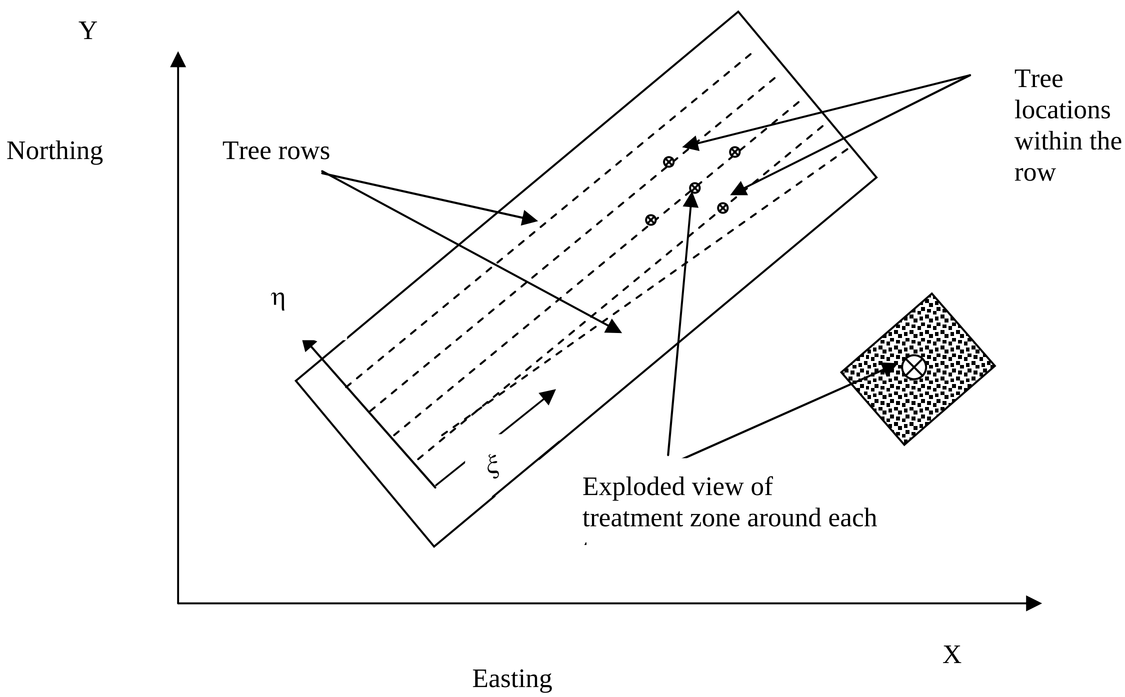

Figure 1. Treatment zone around the planting site of each tree in an orchard.

2) Define a global Cartesian coordinate system that coincides with the true northing (Y) and true easting (X) as shown in figure 1,
3) Establish a local Cartesian coordinate system ($\xi-\eta$ system) such that the tree rows coincide with the ξ direction,
4) Locate all tree planting sites in the local coordinate system,
5) Establish fumigant treatment zone around each tree in the local coordinate system,
6) Transform all coordinates back to the Global XY coordinate system using Eulerian transformation,
7) Transform Global coordinates to UTM and then to longitude and latitude values,
8) Create a shape file of the prescription map for use with the controller.

For successful adoption of this site-specific application map by growers and applicators, the prescription map creation software should be user friendly.

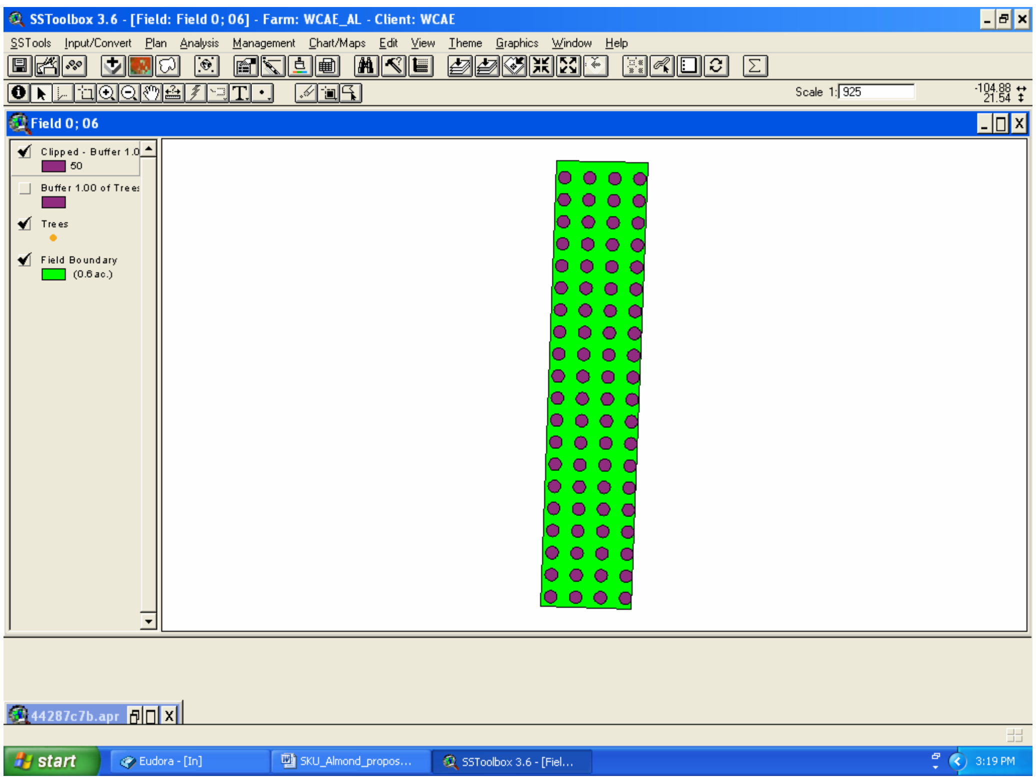

Figure 2. A site-specific fumigant application map developed for a test site on the UC Davis campus in which tress are spaced 18ft apart along the row and rows are spaced 22 ft apart. The fumigant application zone is a circular region of radius 5.5 ft. The data for the map are generated by a special software developed at UC Davis and the map was drawn using SSToolbox (SST Inc.)

We have developed the software to locate trees in a planting site (i.e., first four steps). Once the co-ordinates of the trees are determined, they were brought into SSToolBox software to create a circular application zone around each tree (i.e., steps 5-8 are bypassed now. However, they need to be developed. This will be done during the second year).

An example of this map for a test site on the UC Davis campus in which trees are spaced 18 ft apart and rows are spaced 22 ft apart are shown in figure 2. This prescription treats only about 5.5 ft radius circular region around the tree center. Note that this prescription map would be imported by Raven Office Software and loaded on to the Viper computer system to implement site-specific fumigant application in the orchard.

Retrofitting Trical Fumigant Applicator: As mentioned earlier, the Trical applicator was in heavy use up until December, 2005. We received Trical fumigant applicator shown in figure 3 during the first week of December. Trical Inc. also provided a Viper system, a Raven controller, a High Precision (HP) differential GPS unit (4 in accuracy) a quick response On/Off valve (fast motor assembly) and Raven Office Software for our use to accomplish the goals of this project.

Figure 3. TriCal fumigant applicator

The control system to implement site-specific application of fumigants was retrofitted onto the Trical fumigant application. Figure 4 shows the schematic diagram of the system we developed to accomplish tree planting site-specific fumigant application. Figure 5 shows the key components of the system. Some preliminary tests have been conducted on the UC Davis campus to investigate the performance of this system.

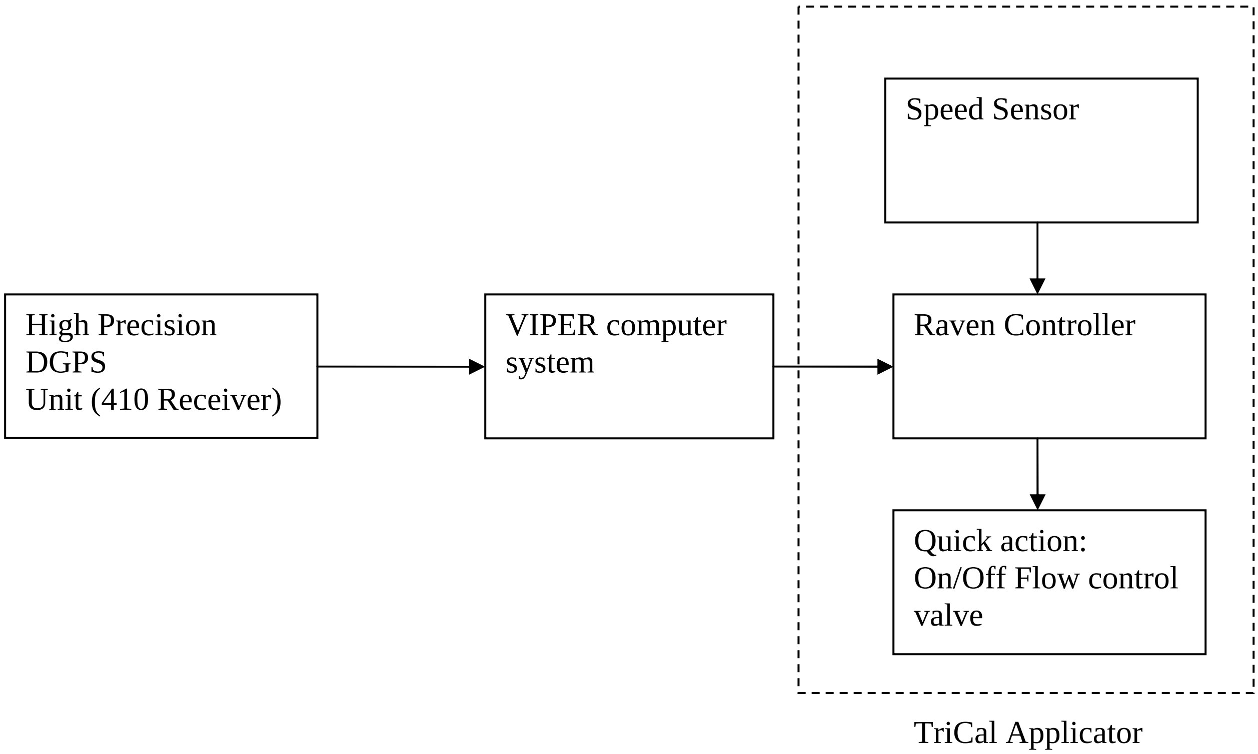

Figure 4. Schematic of the site-specific fumigant application system

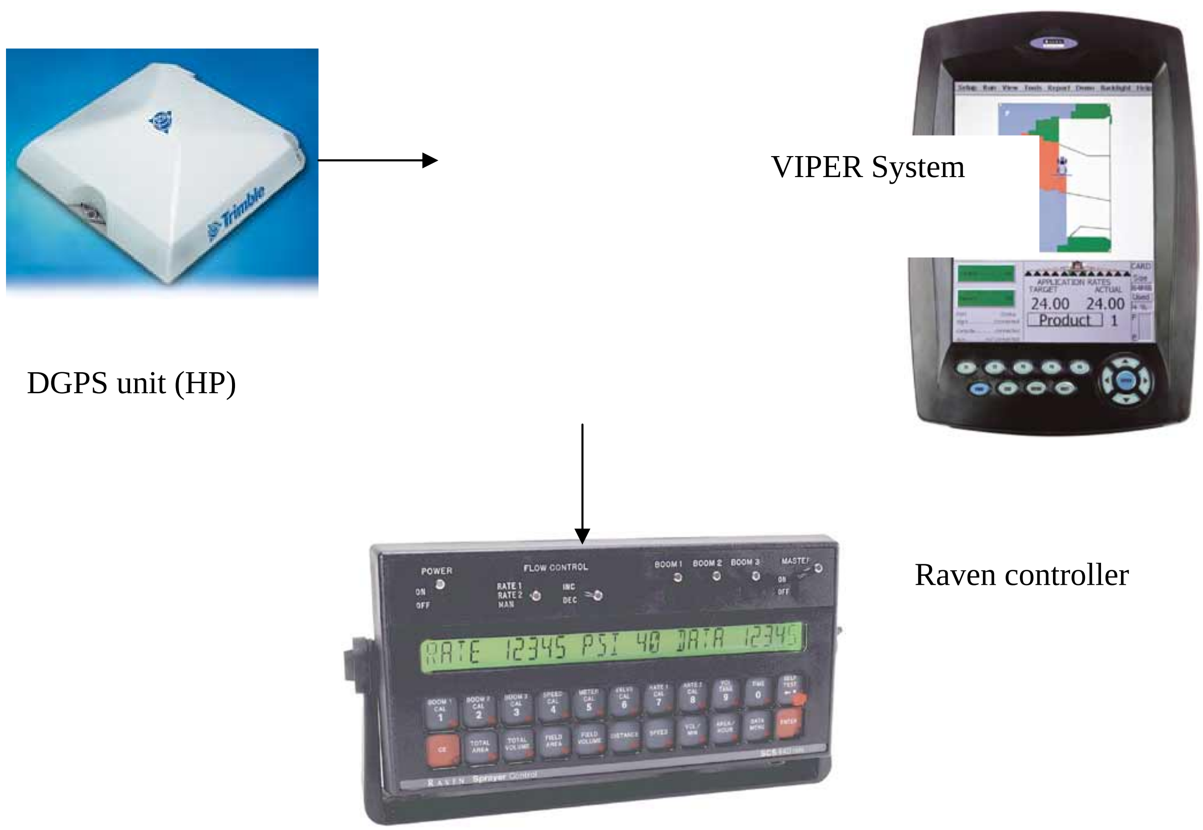

Figure 5. Main components of the system under development.

Verification of the site-specific fumigant application system: We conducted some preliminary tests near the Western Center for Agricultural Equipment (WCAE) on the UC Davis campus to determine the ability of the system to turn on and off fumigant applicator nozzles at desired locations. The system appears to come on and turn off as expected at predetermined locations. The operation of the system was demonstrated to Mr. Bob Curtis and Ms. Gabriele Ludwick, Almond Board Inc. and Mr. Matt Gillis, Trical Inc.

Although the system appears to do the site-specific fumigant application, we have some issues with the response time of the valve and application accuracy. Currently we are in the process of checking the system for response time and accuracy.

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