Site Specific Application of Fumigants to Minimize Input, Reduce Cost, and Protect the Environment

Project No.: **07-ENVIR8-Upadhyaya**

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Objectives:

The goal of this research is to use a High Performance Global Positioning System (HPGPS) to apply fumigants in the neighborhood of future tree planting sites on a site-specific (tree planting-site-specific) basis to reduce the amount of fumigants applied which in turn reduces cost and protects the environment. After last year's successful trial using the first prtototype, following specific objectives were targetted for this year:

1. Further enhance both hardware and software to make tree planting site-specific fumigant application completely automatic, and
2. Develop of a tree planting site marking system.

Interpretive Summary:

During the 2006 season we retrofitted a TriCal fumigant applicator shown in figure 1 with a HPGPS receiver (accuracy in the range of 10 to 20 cm) and an embedded controller to read the GPS data and actuate a solenoid value to implement tree planting site-specific fumigant application. Figure 2 shows a schematic diagram of the system. The unit was tested in the vicinity of the Western Center for Agricultural Equipment on the UC Davis campus and we found that when the system was properly adjusted, it had a RMS error in position of about 13.2 in. Although this error was higher than desirable, even at this level of accuracy the amount of fumigant applied can be reduced by nearly 50% thus realizing significant cost and environmental benefits. The equipment was successfully tested in an orchard that belongs to Paramount Farming (Columbia Ranch), Firebaugh, CA.

Figure 1. TriCal fumigation tractor with subsoiler shanks.

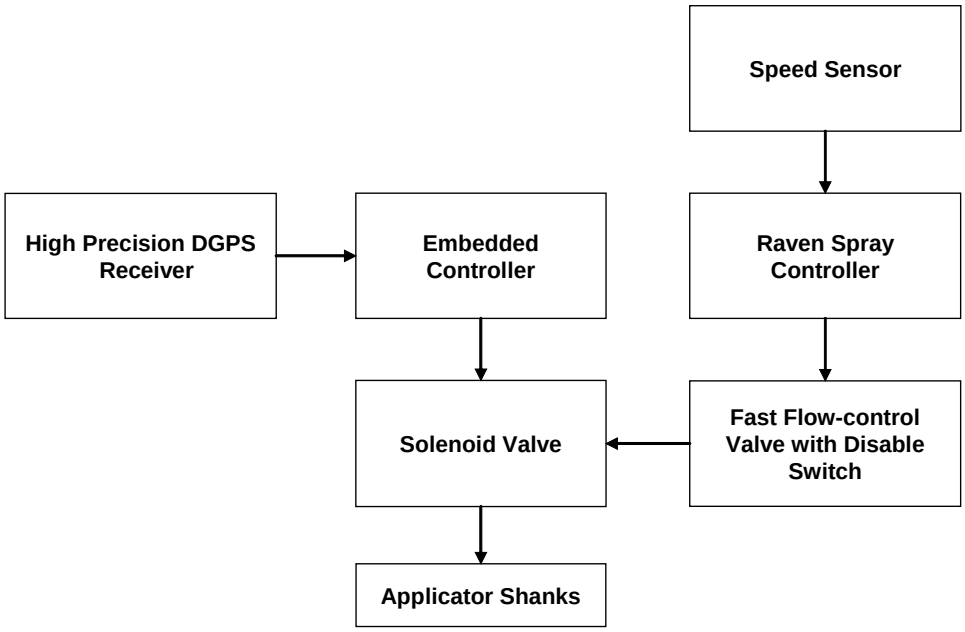

Figure 2. Schematic diagram of the tree-planting-site fumigant application system

During the 2007 season we decided to upgrade the sytem to obtain better accuracy. The proposed system is shown in figure 3. The new system replaced the embedded controller which was slow to perform all the necessary computations in real-time with a higher speed cotroller which is termed “Fumigant Precision Controller (FPC)” in figure 3. Moreover, it repaced the fast acting flow control valve and the solenoid valve with a Pulse Width Control Module (PWM) and solenoid actuated nozzles to provide desired rate on demand. In addition an inclination sensor was added to the system to let the FPC know if the shanks are raised or lowered. This information is used for searching trees to be treated as explained later. This new system was put together by Dr. Duane Needham of Holatz Needham Development, LLC. Furthermore, tree gridding program was updated so that output of the tree gridding program was compatible with the requirements of the FPC. The system worked as follows:

1. The tree gridding program generates tree location data using the locations of four corner trees, spacing between the trees in a row, spacing between rows, and the pattern of planting (i.e., diagonal or square). Figure 4 shows a gridding partial pattern created by this program for an orchard in Madera, CA.

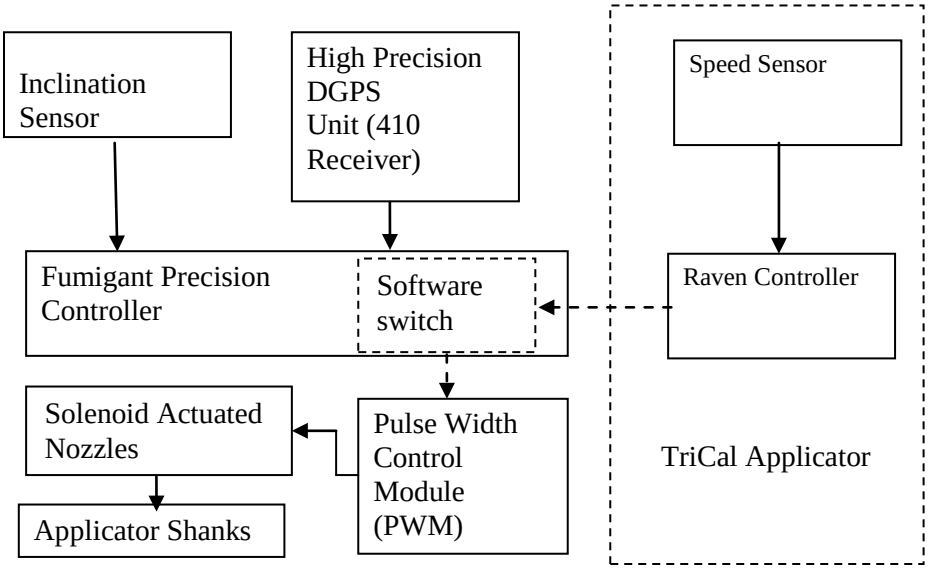

Figure 3. Schematic diagram of the improved site-specific fumigant application system

2. The tree gridding data values are uploaded to the Fumigant Controller, which performs the following tasks – (i) if the inclination sensor indicates that the applicator shanks are in a raised configuration, it continuously performs a global search to determine which tree it is approaching. Once the shanks are lowered and the applicator enters the treatment zone, FPC connects Raven Controller to to PWM through a software switch (see fig.3). In fact it takes into account the hydraulic system response time and fumigator speed and anticipates when it will arrive at the treatment zone in making the decision (i.e., uses an appropriate look-ahead value), (ii) similarly it disconnects the PWM form the Raven controller when the fumigant applicator exits the treatment zone using an appropriate look-ahead value, (iii) after the planting site of first tree is treated, it searches the neigbors of this tree (maximum of eight trees) to determine the next tree planting site to be treated. The treatment procedure is similar to the one used for the first tree, (iv) once the first and second trees in a row are identified, it recognizes the direction of travel and determines rest of the trees in the row using the planting pattern (i.e. no more search), and (v) the tree planting-site-specific application will continue until the inclination sensor indicates that the equipment is raised (eg. at the end of the row).

The procedure repeats from step # (i), when the inclination senor indicates that the shanks are raised (eg. when the fumigator exits the current row).

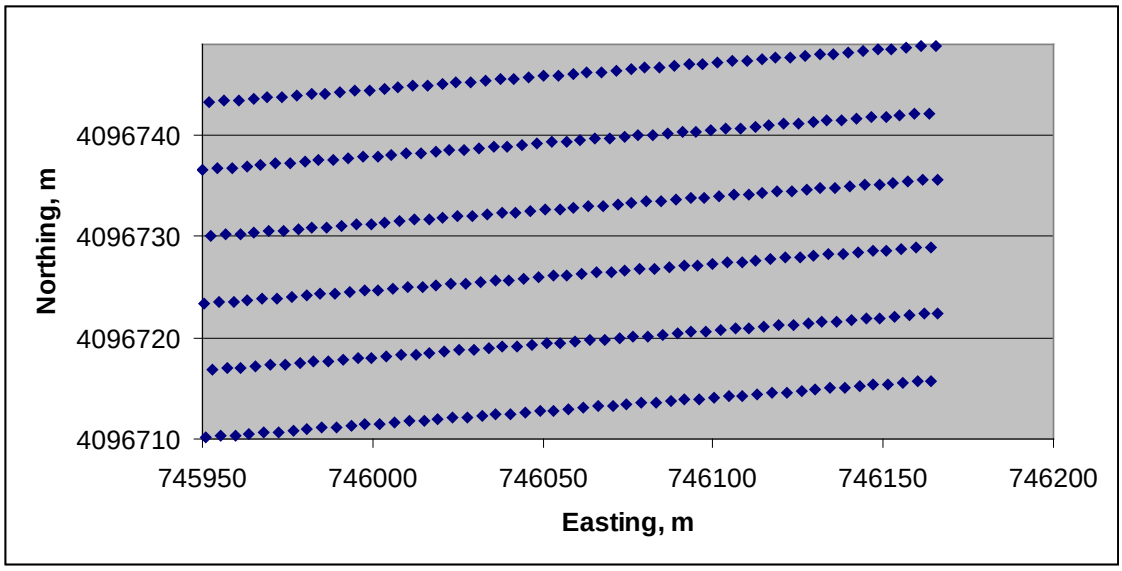

Figure 4. A partial tree planting map for an orchard in Madera, CA

The system was tested for proper look-ahead valves and accuracy using eight accurately marked spots on a road near the Western Center for Agricultural Equipment on the UC Davis campus. The look-ahead value for turning on the system was 329 ms and turning off the system was 317 ms. The RMS accuracy was 4.6 in for turning on the system and 5.6 in for turning off the system. A field test was also conducted using 30 grid points arranged in six rows and five columns. The application zone length in all these tests was 7 ft. The actual average application zone length in North-south direction was 7.25 ft and the RMS error was 3.6 in. In the East-West direction the application zone was again 7.25 ft and the RMS error was 5.5 in. There was a 10 in shift (turning on as well off of the applicator nozzles). This was associated with the marking system (a colored liquid spray system) alignment problems. A re-test on the road indicated that there was no such shift. Finally the system was tested for application rate accuracy. The application rate error was found to be 6.6, 1.5, and 5.3% respectively at 2, 3, and 4 mph travel speeds. These results were thought to be very good. The fumigant applicator is being utilized in three orchards (one each in Arbuckle, Madera, and Parlier) for tree plnting-site-specifc treatment by the Co-PI, Dr. Greg Browne. Arbuckle test is now complete and the Madera trial is going on. The results are promising so far. During these trials the application zone length is 7 ft and only three shanks are used. ***So the expected reduction in chemical application is 70% compared to strip application.***

Our next step is to integrate the tree gridding program with the Precision Fumigant Applicator. This would allow us to generate the planting grid in the field. We also plan to work on a navigation system that would assist in revisiting the treated zone of each tree for planting (basically navigating back to the planting site). We expect to achieve these objectives before the next planting season.