Session F. Vegetable Crops
San Rafael Room
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Precision Cultivation to Improve Cultural Weed Control Practices in Vegetable Production

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A major limitation of mechanical cultivation for weed control in vegetable production has been the ability of tractor drivers to keep cultivating equipment accurately centered on the crop rows. Very close cultivation can lead to serious crop damage when the cultivator operator gets the cultivator off the crop row. Damage to vegetable crops due to close cultivation is often referred to as cultivator blight or iron disease. In Europe some cultivators have actually had an operator on the cultivator trying to steer the cultivator using a steering system built into the cultivator. These systems have been suited to relatively small farms and have not been widely accepted.

A variety of automatic tractor steering systems for tractors have been developed over the years but none have been particularly successful. Most of these systems used some sort of feelers or a device in the furrow to control the tractor steering and were difficult to adjust and maintain and in most cases were not accurate enough to cultivate with.

In the 1980's Dr. David Slaughter at the University of California, Davis developed a system which used a video camera to observe the row and then fed the picture into a computer where it was compared with images of weeds and crop plants. The system guided on the plant row successfully and was demonstrated in several crops including tomatoes and lettuce.

The lettuce demonstrations were in Salinas and were arranged by the author who at that time was with the University of California Agricultural Extension service. Unfortunately Dr. Slaughter's system never reached the private sector and the technology was not available to growers.

In 2000 high accuracy GPS automatic tractor steering systems were introduced by several manufacturers and were a highlight of that year's World Ag Expo in Tulare, California. These systems use RTK technology with a secondary base station to automatically steer tractors with sub inch accuracy. Although cultivation is not a primary use of these systems, they have a memory system which allows the tractor to follow the same path through a field time after time. If a grower plants or transplants using a tractor equipped with one of these systems he can then cultivate using the system since the tractor will follow the exact same path through the field as it did when the field was planted. At least one manufacturer has a kit for the GPS steering system which allows the system to be easily moved from tractor to tractor thus allowing additional use of the basic system. The limitations are the initial cost of the system and that the system must be used for both planting and cultivating.

The best steering system for cultivating is one in which the system observes the plant row and then controls the cultivator so it follows the row accurately. A Danish company, ECO-DAN introduced such a system into the United States market in 2002 at World AG Expo. The system works on the same principles as Dr. Slaughter's system but is more sophisticated and utilizes

digital information processing technology. It consists of two different elements; a plant camera and a laser camera. The system is operated through a monitor panel mounted in the tractor cab. The monitor is multilingual and user friendly.

For cultivating, the plant camera is mounted on the cultivator and looks at the plant row in two dimensions, height and width, identifying the vegetation as it moves through the field. The vision computer then analyzes the picture and uses a mathematical algorithm to distinguish the living plants from the soil or plant residue. The quantity of green is estimated and the vision computer analyzes the information to see if the plants appear to be in a row structure. If so a "valid signal " message is displayed on the control panel. If the camera is looking at bare soil or the weed density is so high that a row structure is not visible the picture is then classified as "invalid" and the operator must reset the camera.

If the camera moves off the row as it goes through the field an electrical signal is generated which moves the camera and therefore the cultivator back on the row using a hydraulic side shift on the cultivator or a steering coulter which can move the cultivator from side to side. The side shift on the cultivator can be a simple three point hitch A frame with a hydraulic sideshift on which the cultivator is mounted or a pivoting toolbar on which the cultivating tools are mounted which is connected to a fixed toolbar and is pivoted back and forth with a hydraulic cylinder.

The system operates under a wide range of conditions at speeds of up to 11 miles per hour. The minimum row spacing is 9 inches and the maximum plant distance in the row is 12 inches. Since the system senses color it does not work in crops such as red lettuce. With plants over 8 inches tall, movement of the plants in windy conditions can cause the plant camera to offset the row. This can be corrected by adjusting the offset on the monitor panel. Since the camera is looking down on the row dust and foggy conditions do not affect the operation of the system. Operation is limited to a half an hour after sunrise to one half hour before sunset since the system uses natural light. For nighttime operation special artificial light is needed.

The second element of the system is the laser camera. A laser is located in the camera housing and when the beam runs across a furrow made in the field, the laser line is deflected and the camera can see this deflection and generates an electrical signal which is used to control the same type of side shift mechanisms as used with the plant camera. A good example of the use of this system would be the application of a premergence herbicide. When the crop is planted a furrow is made by a marker attached to the planter. By following the furrow the laser camera can keep the spray nozzles centered over the seed lines allowing the width of the spray bands to be narrowed reducing the amount of herbicide needed and at the same time providing better weed control since the spray band is always centered over the crop row. The furrow must be at least two inches wide and two inches deep to be detectable by the laser camera and must have these dimensions at the time the camera is being used.

This system has the potential to make highly accurate cultivating and band spraying both faster and easier than current technology. It may allow growers to reduce herbicide use and reduce the amount of chemicals being released to the environment. The system has been proven in Europe and the manufacturer has received numerous awards including being the grand prize winner in the European IST competition in 2002.

A dealer network is being established throughout the country with initial emphasis being placed on the Southwestern vegetable industry.