Project Title: **Improving the Efficiency of Planting, Tending and Harvesting Farm Grown Trees for Energy**

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Congressional District: 6 (Equipment Building Location: Big Lake, MN)

MILESTONE 11 - SUMMARY REPORT

11a: Completion of Purchase of Automatic Position Control for Planter
11b: Completion of Update of design drawings, installation, and testing

Executive Summary:

The planter's tree position control system consists of the John Deere AutoSteer system with the GreenStar 2 Pro control module and the Starfire ITC receiver/transmitter Global Positioning System (GPS) coupled with the ALMACO GPS signal take off trigger controller called the SkyTrip system. The system was integrated through associated wiring changes and additions, and the SkyTrip controller was mounted in the tractor cab. The output of the combined system was wired to an Allen Bradley computer that triggered the planter. The John Deere system maintained the rows within the 5 ft checked spacing pattern and GPS position on successive rounds, while the ALMACO system kept the tree spacing and position within the rows producing a checkered pattern with a 5 x 5 ft spacing. Problems with the John Deere AutoSteer controller caused several days of erratic operation and had to be replaced. After replacement the GPS guided AutoSteer system worked flawlessly. The updated software with the new controller included

a functioning Quick-Start system that allowed the system to recalibrate to the previous day's GPS positioning thus eliminating any overnight drift. However, the ALMACO system could not use the John Deere Quick-Start system and was unable to compensate for over-night or weekend drift. As a result we saw errors up to half the in-row spacing or 2.5 ft until adjusted.

Since several areas of research were going on simultaneously, some requiring in-field mechanical changes, it was very difficult to afford each area the downtime and focus they needed. Many smaller problems such as leaky cylinder piston seals were identified and corrected on site.

The planter trigger worked largely as conceptually specified with the AutoSteer system, but deviated over time and did not give the operator the field setup flexibility required for commercial tree planting. Accuracy within 1 day was good, but not over several days. This identified a need for a field quick-reset type of software modification as well as a larger, faster and more stable controller. ALMACO representatives believe the modifications necessary to make the system commercial will not be very difficult and could be available next year assuming sufficient demand. ALMACO is interested in further collaboration with EPS on developing this more user friendly, robust system with increased accuracies that will match those of John Deere's.

Technical Progress

11a – Completion of purchase of automatic position control for planter.

After reviewing the literature and working with the John Deere GPS guidance personnel, it was decided to contact ALMACO who was doing work for one of John Deere's contractors. ALMACO builds test planters for different grains and also builds very accurate grain test plot harvesters. Their SkyTrip System was designed for use on the planting and harvesting of short rows over short periods of time. They have used their GPS guided SkyTrip system successfully on these plots and were willing to commit resources to modify the system for test planting trees. ALMCO brought their computer and the associated wiring to Big Lake to install and test it on our tractor and planter. Because of a wiring harness change made by the John Deere factory to the StarFire transceiver, several days of testing passed without successful integration. Only after talking with three different JD dealers did we find the problem. The dealer in Lichfield, MN had a similar problem due to the an un-documented wiring harness change. Once ALMACO became aware of the problem, a quick change was made and the system began working. Fig. 1

shows the SkyTrip components that were then wired to the planter to allow satellite triggering of the planter. EPS and ALMACO are talking about commercial terms for modification and the long-term use of their systems on EPS planters.

Figure 1. Components of the SkyTrip system that triggers the planter.

11b – Completion of update of planter design drawings, installation, and testing.

The planter was moved to a farm near the 2nd planting site near Graceville, MN on Saturday June 2 on a 36 ft trailer and attached to the tractor (Fig. 2 & 3) for in-field testing of the automatic position control and all other planter operations. Hauling of the planter on the trailer posed no problems with respect to passing under bridges, stoplights and signs along the roads between Minneapolis and Graceville, MN.

Figure 2. The 10,000 pound planter loaded on trailer for hauling to the Graceville, MN planting site on June 2, 2007.

Figure 3. Attachment of planter to tractor and off-loading from trailer.

The preliminary trials of the modified planter were performed on June 5, 2007 on the edge of the field, because most of the field was too wet. These tests were a follow-up to and re-evaluation of functions of the planter previously tested and reported in Milestone report # 5. Test firing of each individual injection system was performed first. It was immediately recognized that some of the metal fingers previously installed to assist in maintaining the correct orientation of the hybrid poplars cuttings were not functioning properly. The result was that the tree slips were still getting broken and some of the metal fingers were getting bent. Inspection suggested that some of the fingers were not shaped according to specification. The fingers were reshaped in the field and pieces of wood were glued inside the horizontal ram to assist in guiding the cuttings until the fingers could take over. This temporary fix in the field made it possible to help the re-shaped fingers work properly and prevent most slips from being broken.

The first simultaneous firing of all six planter rams at the Graceville field site, was accomplished with mixed success. Three slips were injected deeply without damage and three slips were bent (Fig. 4).

Figure 4. Slip injected properly after firing of slip injection system into hard, dry soil.

Since the finger guides were working properly, it was decided that some of the feeder pistons needed further adjustment of some settings. Those adjustments were easily made in the field. The preliminary firing also showed that the hydraulic system used on the planter worked as expected, but still did not allow enough flow of hydraulic fluid to operate the system at the planned speed. Consequently, the injection system had some timing problems resulting in small slips getting broken. The solution will be to install larger hydraulic pumps and accumulators and to redesign the cylinder pistons to reduce seal leakage. Efforts were made to do this immediately, but the inability to obtain the necessary parts limited that option. Given that the ram and feed cylinders were not specifically designed for this application, they worked reasonably well, and the small seal failures would not be expected on a new cylinder design. The energy storage and lock and load functions of the installed hydraulic system operated as expected, so planting could proceed, albeit at a slow pace.

Additional problems encountered during the machine planting trials are described as follows:

(1) There were skips in the planting of slips. The reason for this was probably a combination of mechanical issues with timing and the inexperience of the persons sitting on the planter feeding the slips in to the injection ram system. Feeding the slips fast enough took concentration, and some of the labor hired to do this task were more diligent than others in remaining focused. A planned future design modification is to have an automatic feeder system, which will hopefully eliminate the need for people to do this job. Also it is anticipated that as individuals become more experienced with the planter, fewer problems of that nature would occur.

(2) Many of the slips supplied by Hraymor nursery did not meet specifications, which contributed to the occurrence of broken cuttings. One entire bag of 500 cuttings was measured. The length specification of 9 inches was met most of the time, however a relatively high proportion (about 13%) did not meet the minimum specification of a diameter no less than 5/16 inches. Based on the analysis of 1 bag, 13% were below the diameter specification and another 1% were non-standard in that they were bent, curvy or damaged in some way. Of those cuttings that did meet specification, a large number were on the small side. This can be attributed to the relatively poor growing season in 2006 in Michigan where the Hraymor nursery is located. It was probable that the order for 150,000 cuttings could not have been met without inclusion of the smaller size material. It was noted that all of the broken cuttings observed post planting were right around the 5/16" to 3/8" size category. Many hybrid cottonwood/poplar cuttings are now specified to be 3/8" or greater by the paper timber industry. For hard dry soils, the EPS planter will require cuttings to be not less than 3/8" diameter in the future.

Successes with new design elements of the EPS 6 row planter:

(1) The mechanical trigger mechanism performed flawlessly when made to specification.

(2) There were no failures of the injection ram. The injection ram was a redesign from one previously designed for a two-row planter. The ram on the 6-row planter was made of hardened steel and heat treated.

(3) The skids in front of the injection ram functioned very well to insure that there was no trash accumulation interfering with the injection of the cuttings into the soil (Fig 5).

(4) The manually settable gage wheels worked okay under both muddy and dry conditions. They are positioned at the ends of the 33 ft beam.

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(5) The manual operator interface with the injection system worked well.

(6) The 3-point hitch and weight distribution between the planter and tractor seemed to mesh perfectly – which helped to keep the tractor from getting stuck in softer parts of the field. 90% of the 10,000 lbs of the planter weight was on the tractor and about 10% of the weight was on the gage wheels. This allowed planting in the field at least a couple of days before farmers planting corn and soybeans were able to work in adjacent fields.

(7) Due to the high weight of the planter, 10,000 lbs and it's height (12 feet) there was some worry that the tractor would not be able to pick-up the planter (since the tractor was only rated for handling 8,000 lbs). However, that was not a problem and the front-end loader on the tractor helped to provide a counter balance (Fig 6).

(8) The front-end loader also functioned well as a means of carrying extra cuttings into the field.

(9) The location and size of the cup hopper used for loading the cuttings worked well without any apparent plugging.

(10) The planter was able to plant the portions of the field that remained relatively wet. If a traditional design had been used, which opens a slit into which cuttings are dropped, then the planter would have bogged down and planting would have been further delayed.

(11) The ergonomics of the planter design seemed to work well for the people sitting on the planter. The seats, and boxes holding the cuttings were at an appropriate height, and the protection panel between the people and the injection ram prevented any concern about injury to the people sitting on the planter.

(12) Most importantly, the great majority of the slips established with the planter were injected deeply, without breakage or end damage and were producing sprouts (Fig 7), to be further discussed in Milestone 12.

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Figure 5. Curved skid attached to bottom of injection slot. Mud on tractor tires shows field was too wet for planting on June 5, 2007.

Figure 6. Planter weight is balanced by front-end loader on tractor.

Figure 7. Machine planted cutting showing deep planting and healthy sprouts.

Additional Milestones:

Completed

M1 – Annual Land Rental (first year); report submitted April 2006, payment made.
M2 – Design & Test Planter Injection system; report submitted July 2006, payment made.
M3 – Tree Slip Purchase & Tractor Purchase; report submitted April 2006, payment made based on lease assumption.
M4 – Basic Planter Design and Fabrication; report submitted 12/6/06, payment made.
M5 – Test Planter; report submitted 12/7/06, payment made.
M6 – First 80 acre Planting; revised report submitted 12/6/06, payment made
M7 - Tree Harvester Testing; work on completing the harvester has been delayed.
M8 – Post Planting Tending and Monitoring; report submitted March 2007, payment made.
M9 - Annual Land Rental (second year), report submitted July 2007, payment made.
M10-Tree Slip Purchase for Second Year and Tractor Rental, report submitted August 2007.

In Progress

M12 – Second 80-acre Planting and Commercial Spray Rig Modification, work completed, report being submitted.

Legal Notice

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