Executive Summary:

The EPS six-row tree slip planter was tested in the EPS shop with shop hydraulic power, outside behind the shop using the 8130 JD tractor, and at the farm site near Glencoe, MN using the same tractor. Numerous modifications to the planter were made as a result of the testing. Although the testing and modifications required much more time than originally anticipated, the planter is now operationally ready for planting.

Technical Progress:

Three levels of testing of the assembled EPS tree slip planter were carried out. After each set of tests design improvements to the planter were made. The first tests were done in the EPS shop in Rogers, MN using the EPS hydraulic power supply, which allowed testing of row five of the six-row planter. The second set of tests was done outside the EPS shop using the hydraulics from the EPS tractor so that all six rows could be tested. The third set of tests was completed at the field site near Glencoe, MN. The six-row EPS slip planter is shown in Figures 1 and 2. The Milestone 4 report gives a detailed description of the planter.

As reported in Milestone 2, before assembling the six-row planter, preliminary tests of the ram injection system were done first to develop that key part of the planter. As a result of these tests the springs were modified to enlarge the top and bottom shape of the attachment points so that the spring would not pull away from the crossbar and lower fixed rod during loading of the spring. This change required that the metal molds used to cast the springs had to be changed. Also the pre-tension within the spring holes at each end was increased by enlarging the outside crossbar diameter and the bottom fixed rod from 5/8 in. to 3/4 in.
From the tests done in the EPS shop on the assembled six–row planter (described in Milestone 4) using row number 5 for the tests, several design changes were made. The crossbar was lengthened to eliminate chafing on the sides of the spring. The vertical ram was lengthened to give increased slip velocity potential for penetration of harder soils. The impact wheels were raised six inches to eliminate contact with the soil and thus eliminate fouling of the impact surface with dirt. These design changes required numerous dimensional changes in the support structure, ram tube and ram assemblies and shock absorber supports.

The planter was attached to the three-point hitch behind the tractor for the tests done outside the EPS shop, and for the first time the tractor supplied the planter’s full hydraulic load. It was found that the tractor could lift the 10,000 pound 6-row planter off the ground and onto a trailer quite easily. The tractor’s front end loader added the required ballast to counter the rear weighted load of the planter whose center of gravity is approximately 7.5 feet behind the tractor’s rear axle. The planter hydraulics of all six planter assemblies were set up and tested. The full control system was tested and resulted in logic changes and adjustments in the timing. Note the logic truth table shown in Table 1. Slips were fed into the hopper and ejected onto the parking lot where it was observed that the slips were broken. However, because of the high velocities, it was assumed that they were broken on impacting the asphalt which would not be a problem in the field. During the following days of testing it was also noted that the high pressure hydraulic system would drastically drop pressure immediately after a trigger signal. After days of testing, a sticky return valve (one of 12) was considered a likely suspect, but a control problem was later discovered which allowed a return valve to open before the closure of all of the high-pressure valves. The logic and timing was changed to solve the problem.

The 6-row planter was tested in the field near Glencoe, MN for the first time on November 17. The planter was transported to the site on a 30’ long triple axle gooseneck trailer and lifted off the trailer with the tractor and readied for operation. It became apparent that horizontal hydraulic slip feeder was breaking the slips inside the planter instead of the damage previously thought to be created by impacting the parking lot asphalt. Apparently the slips were tipping forward in the feeder passage before feeder piston was actuated. A modification to the feeder passage was done in the field by drilling and torch cutting slots on both sides of the feeder passage to allow the insertion of metal fingers with holding springs that held the slip in place vertically and then spread as the feeder piston was actuated, and this fix allowed smooth operation of the slip feeder.
Table 1. Planter logic control for row 1

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<thead>
<tr>
<th>Planter Control Logic</th>
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<tbody>
<tr>
<td><strong>Inputs</strong></td>
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<tr>
<td>VDN</td>
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<td>VUP</td>
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<td>HIN</td>
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<td><strong>Outputs</strong></td>
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<td>VDN</td>
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<td>VUP</td>
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<td>HIN</td>
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<td>HOU</td>
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</tbody>
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VDN = 3,0 & 4,1
VUP = 3,1 & 4,0
HIN = 1,1 & 2,0
HOU = 1.0 & 2,1

Start-up Ready Mo Move verticles down and horizontals out -- Returns open, Pressures closed
Plant: 1) Move V to upper stop -- close 4, open 3, then close 3 at position
2) Move H to wait -- close 2, open 1, close 1 at position
3) Trigger to start firing sequence
4) Move H to slip drop position, wait 25 milliseconds -- open 2 for 25 ms, close 2
5) Move H to inj ram -- open 1, close 1 in position
6) Move V to top stop -- open 3
7) Move H to wait -- close 2, open 1, close 1 at position
8) Move V to latch position -- wait 500 ms, close 3, open 4 to position, close 4
1) Repeat
Project Status:
The project is on target with respect to components that impact the ability to meet future year milestones, i.e. the land was rented, the cuttings were obtained, and planting was completed at a scale sufficiently large for economic evaluations of planting, tending, and harvest costs. Tree growth the first growing season was excellent.

The delay of completion of the planter was due primarily to institutional constraints including the lack of available overload personnel and design changes that have been necessary to compliment the fabrication capabilities of the area machine shops as well as to adjust to observations that arose during testing. Meeting the deadline for getting the new planter fully designed, tested and operational has been very challenging and was not completed before freeze up of the soil, however the 6-row planter is now ready for planting slips in the spring.

Additional Milestones:
M1 – Annual Land Rental (first year); report completed, payment made.
M2 – Design & Test Planter Injection system; report completed, payment made.
M3 – Tree Slip Purchase & Tractor Purchase; report completed, payment made.
M4 – Basic Planter Design and Fabrication; report submitted 12/6/06.
M6 – First 80 acre Planting; revised report submitted 12/6/06.
M7 - Tree Harvester Testing; work on completing the harvester has been delayed.
M8 – Post Planting Tending and Monitoring; work completed, report in progress.
M9 - Annual Land Rental (second year); In progress.

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