Final Report for Project 13-10
Using Radio Frequency Identification Technology for Logistics Management in the Nursery Industry
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Funding for the project was received August 15, 2013, however, we were able to start the project earlier in anticipation of funding. We have purchased all of the equipment necessary for the project, designed and acquired labels and preliminary data on read range for labels and antenna. We have purchased 3 antenna types: a portable 1 Alien ALH 9000 handheld reader/antenna, and a "portal" type or fixed reader with 2 Laird 9025 (~5 inch x 5 inch) and 2 MTI MT-262006 (~12 inch x 12 inch) antennae connected to an Alien ALR 9900 Reader. The fixed antennae systems have longer read ranges and are thus more desirable for inventory tracking. We have developed two methods to make this a portable system by mounting it onto either a portable cart or an ATV.

From December 16-17, 2013 we evaluated the ability of the portal type antennae to track tagged bundles of trees as they were loaded into "pallets". A pallet as used by J. Frank Schmidt (JFS) is constructed of wood with dimensions 8 feet wide by 10 feet long with 2 walls 4 feet high along the long sides (the short sides are open). Trees were bundled and sorted as typically done by the JFS crew. The research team labeled the bundles with the RFID tags with the assistance of the JFS crew.

Figure 1: A RFID label on a bundle of Weeping Higan Cherry

Two antennae layouts were tested:
Layout 1:

Figure 2:
1 MTI antenna 15 feet above the pallet pointing downwards

1 MTI antenna 8 inches above the ground on the long side (reading through the wood wall)

The 2 Laird antennae at 4 feet on either end on the same side of the long wall (reading through the open short side, angled ~45° off parallel with the wall pointing into the pallet)

Layout 2:

Figure 3:
1 Laird antenna at 15 feet

1 Laird antenna at 10 feet

1 MTI antenna at 10 feet

1 MTI antenna unchanged at 8 inches

Three packing densities were evaluated. High density with 178 or 144 bundles per pallet (10 trees per bundle); medium density with 48, 51 or 73 bundles per pallet; and low density with 21, 21, or 19 bundles per pallet were used for layout 1. Medium density with 67 or 54 bundles per pallet were used for layout 2. Additional replicates will be used to provide 3 replicates of all densities for layouts 1 and 2. The RFID system was run continuously as the pallets were being loaded and the data was saved, the system was reset and another reading was taken for at least 1 minute to determine the ability to read a completely loaded

pallet. As the pallets were being loaded, the JFS crew and one of the research team manually counted the bundles as they were placed into the pallet.

Results

Table 1: Effectiveness of the RFID system in tracking tree bundles when continuously reading for the 2 layout patterns.

Pallet #	Density	Tags Used	Tags Scanned	Diff	Crew Count	Diff	Team Count	Diff
Antenna Layout 1								
270	Low	21	21	0	20	1	20	1
419	Low	21	21	0	21	0	21	0
2037	Low	19	19	0	19	0	19	0
10	Medium	51	51	0	51	0	50	1
677	Medium	48	48	0	50	2	50	2
1134	Medium	72	70	2	73	0	71	2
65	High	180	176	4	180	2	178	0
896	High	144	143	1	142	2	144	0
Antenna Layout 2								
1215	Medium	67	65	2	64	3	66	1
2026	Medium	54	53	1	54	0	55	1
Total		677	667	10	674	10	674	7

RFID was very effective in tracking bundles while loading into low and medium density pallets, with an identical number of tags used to tags counted for pallets with less than 48 bundles. For pallets with 54 or more bundles, there was an average of 2 tags that were not counted by the RFID system, so the RFID system was also very effective. Accuracy was equal to that of the JFS crew and slightly lower than the research team. When there was a difference, the RFID system under-counted whereas the JFS crew both under- and over-counted, and the research team under-counted. Data has not been analyzed statistically yet but it is doubtful that differences will be significant. As the pallet was loaded, more tags were missed by all but the antenna placed 15 feet above the pallets. Bundles began to mask the antennae mounted at 4 feet as the pallets reached a full load.

Figure 4: A full pallet showing probable bundle signal interference with the 4 foot mounted antenna.

Table 2: Effectiveness of RFID system in identifying tree bundles after the pallet is loaded.

Pallet #	Density	Tags Used	Tags Scanned	Diff
		Layout 1		
270	Low	21	17	4
419	Low	21	15	6
2037	Low	19	18	1
10	Medium	51	43	8
677	Medium	48	41	7
1134	Medium	72	57	15
65	High	180	69	111
896	High	144	55	89
		Layout 2		
1215	Medium	67	Missing	
2026	Medium	54	40	14
Total		610	355	255

The RFID system was moderately effective in identifying tree bundles for low and medium density in fully loaded pallets but ineffective for high density pallets. So while reading fully loaded pallets does not provide the most accurate inventory, it is a solution to get partial information in the instance where an inventory taken while loading is lost or the data was not properly saved. Improved RFID technology may allow reading fully loaded pallets in the future.

The most effective antenna placement was the MTI antenna at either 10 or 15 feet above the pallet. Only 3 out of the 667 tags that were read by the RFID system were missed by this antenna and placement. The other antennae missed substantially more tags (from 35 to 166) depending on type and placement. Not surprisingly, the antenna that was reading through the pallet wall 8 inches above ground had the poorest performance. Both the wood and bundles decrease the signal transmission and reception from the RFID tags and antennae.

Additional data gathered by the RFID system allowed calculation of the time it took to load the pallets. It took an average of 6:03, 10:11, and 22:18 (minutes:seconds) to load the low, medium and high density pallets, respectively. The data was immediately saved onto the computer eliminating the need for paper tracking and data entry.

RFID appears to be very promising for tracking inventory as it is loaded through a portal type system when continuously operated during the loading period. In Spring and Summer 2014 we will evaluate RFID for container production yards and equipment movement.

Although this is technically the final report for this project the project is on-going since funding was received late and the project not started until August 2013. We will be happy to submit a future report on the project as we gather the data as stated in the proposal.