PRELIMINARY EVALUATION OF COMMERCIAL COTTON YIELD MONITORS: THE 1998 SEASON IN SOUTH GEORGIA

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Abstract

A 1997 study of commercial cotton yield monitors was repeated in the 1998 season. Improved or modified versions of the previous year's systems were obtained from the manufacturers, and their performance was investigated. Changes in the systems' hardware, installation and performance are discussed.

Introduction

With several years of collected data, many precision farming research projects are evolving from sensor development into management studies. There are certain areas of precision farming, however, where reliable instrumentation has not been developed, and this is the unfortunate case for cotton farmers. Cotton continues to be a dominant cash crop in the southern United States, but precision farming practices for cotton have been significantly limited by the absence of a reliable cotton yield monitor.

In 1997, two commercial yield monitors were marketed in the United States, but production was limited. To investigate the performance of these devices, researchers at the University of Georgia acquired the systems and installed them on the same picker for direct comparison. The results of this investigation are reported in Durrence et al. (1997).

Both companies (Zycom Corporation of Bedford, Massachusetts and Micro-Trak® Systems, Inc. of Eagle Lake, Minnesota) were expected to make improvements on their yield monitoring systems based on customer feedback and research reports. As such, the University of Georgia research team decided to continue their testing and report the results for the benefit of potential users as well as the manufacturers. In addition to the previously tested monitors, a third company, Technological Solutions International (TSI) of Ulm, Montana, USA advertised a cotton yield monitor. A TSI cotton yield monitor was ordered for inclusion in the evaluation, but purchasing delays prevented the team from obtaining it before harvest was finished.

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The following report details the UGA research team's experience with the 1998 versions of the Zycom and Micro-Trak® yield monitoring systems. Changes in system hardware, installation, performance and software are discussed. Typical field data are presented as well as a yield map comparison between the two systems.

Harvest Preparation

Yield Monitor Installation

Installation of either cotton yield monitoring system requires a fair amount of labor, as described in Durrence et al. (1997). Physical changes in the systems did slightly modify the installation process.

The most dramatic physical change in the Zycom system was the integration of the display unit and the switch panel/data storage unit. The result, shown in figure 1, was a more user friendly control unit with the added advantage of eliminating one module and cable from the system. This integration also included converting the data storage device. The original storage unit was a proprietary "data key" that required a special cable to transfer the data to a desktop PC. The data key had demonstrated performance problems and communication problems with laptop computers. Zycom replaced the data key with a PCMCIA card drive programmed to handle commercially-available linear FLASH memory cards. This changed eliminated the need for a special cable for data transfer, but did require that a computer with a PCMCIA card reader (standard for laptops, but seldom found in desktop systems) be available for downloading the collected yield data.

Other than the display/control/storage module integration, the revised Zycom system had very few changes in appearance. The sensors (emitter-receiver pairs) were exactly the same as the previous system. One interesting characteristic of using the same sensors in the second year is the need to maintain care in tightening the lock-down screw. In at least one instance, this screw failed when using a screw driver.

In contrast to the Zycom revisions, the new Micro-Trak® system showed very few external changes in display/control modules. A single mounting bracket secured to a window of the picker provides convenient access to the display/control and data storage units.

The Micro-Trak® system changes were primarily in the sensor mounting hardware. In the previous system, the sensor (emitter-receiver pair) installation required sixteen precisely drilled holes in each cotton chute (the pickers used had four chutes each), as shown in figure 2. Drilling these holes was both time-consuming and difficult. Another disadvantage to the previous Micro-Trak® system was that a sensor (emitter-receiver pair) was secured to the chute with a large band clamp, shown in figure 4. The sensors needed to be periodically inspected and/or cleaned during harvest, but removing the clamps would alter the sensor alignment; furthermore, removing and re-installing the clamps was a tedious process. Cleaning the sensors without removing them required extreme dexterity, mirrors and flashlights – all without the assurance that the sensors were completely clean.

To improve their sensor mounts, Micro-Trak® introduced a mounting bracket that could be attached to the cotton chutes without the sensor installed. Instead of drilling holes in the chute, the mounting bracket required a large rectangular hole in either side of the chute as shown in figure 3. These holes were much easier to cut and allowed room for small measurement errors. A possible disadvantage of the large holes is that they may weaken lighter gage metal chutes. On the picker used (John Deere Model 9965), the chute located directly behind the cab is made of lighter gage sheet metal than the other three chutes. The stability of this chute was significantly degraded by cutting the required holes.

With the holes cut in the chute, the mounting bracket was then attached to the chute. The emitter and receiver modules of the sensor were then placed in hinged brackets on their respective sides of the chute. The hinged brackets allowed the sensor modules to be rotated away from the chute, thereby exposing the sensor "eyes" for inspection and/or cleaning (similar in concept to the Zycom system). Plastic tabs were provided to keep the hinged brackets in place during operation. These tabs may need to be replaced with a stronger alternative, because at least one tab failed under normal operation in the first year of service.

Internally, the Micro-Trak® system was upgraded to correct apparent power problems. In a faxed memo from Micro-Trak®, the company noted that their Australian partners discovered that during low power conditions "certain calculations can be interrupted and data corrupted." According to the fax, Micro-Trak® had isolated the problem and it, along with minor "bug" fixes, would be corrected in the upgrade offered for the 1998 harvest season.

Noticeably absent from the two system upgrades were documentation and/or troubleshooting kits. This may have been due to the fact that the documentation had not changed very much; however, details regarding any changes and expected performance enhancements were expected.

An Omnistar™ OS7000 DGPS unit was selected for use with both systems. The same unit had been used in the previous year's harvest. Unfortunately, the revised Zycom system would not allow the use of this unit as the primary receiver. Instead, the GPS engine located in the display/control/storage unit was used with a small antenna provided by Zycom. The RTCM data output from the Omnistar was then interfaced with the Zycom engine to provide differentially-corrected position data. This interface required a custom-fabricated serial cable. The Micro-Trak® system accepted the differentially-corrected position data directly from the Omnistar receiver.

Software Installation

Both Zycom and Micro-Trak® provided updated software for their yield monitoring systems. The Zycom software (Agri-Plan) had been completely overhauled, resulting in a new environment and several new display options. The Micro-Trak® software, on the other hand, was essentially identical to the prior version in general appearance and functions. Since this work focuses on the actual sensor performance, a complete discussion of the two software packages is beyond the scope of this report.

Harvest

The two yield monitoring systems were compared on three fields harvested in September and October of 1998 in South Georgia. The three fields were about 60, 43, and 100 acres, respectively. To monitor the performance of the yield monitors on a per-load basis, a boll buggy was set on commercially-available truck scales (Model PT300, Intercomp, Minneapolis, MN) with 1% accuracy. Five scales were needed to support the four wheels and the tongue of the boll buggy. The buggy was positioned next to a module builder or wagon so that the picker operator could dump a load of cotton and proceed with harvest. The operator had only to pause to log the yield monitor readings. The dump weight was then recorded by a ground crew, and the boll buggy contents were then tipped into the module builder. All presented yield results represent seed cotton with no correction for moisture or foreign material.

In the previous year's harvest, the research team had experienced problems with the sensor eyes becoming either coated with dust or covered with debris. This had been a serious problem, particularly for the Micro-Trak® system. To avoid such problems, the harvest team developed a routine of testing for blockage at each dump and cleaning the sensors if necessary.

The first field, located near Lenox, Georgia, was harvested over three days in late September. This was the first operation of the yield monitors, hence, no prior calibration information was available. For the Micro-Trak® system, the calibration coefficient was set to a value used in the previous year's harvest, and the Zycom coefficient was not changed from the factory default. A full basket was harvested for calibration, and the Mico-Trak® coefficient was adjusted according to the load weight as indicated by the truck scales. The calibration procedure described by the Zycom documentation could not be performed, so the coefficient was not changed from the default value.

Over the three days of harvest, thirty-eight loads of cotton were harvested. Of these loads, eighteen were measured using the truck scales and boll buggy. Table 1 provides a summary of the first field's harvest. The results of these measurements and the respective yield monitor measurements are presented in figures 6 and 7. From these plots, one can see that an additional calibration could have significantly improved the performance of the yield monitors. The Zycom system consistently over-estimated the load weights; hence, a proper calibration would have resulted in much better measurements. Even though the Micro-Trak® system was calibrated, its yield errors were generally larger than the Zycom system. This system also tended to exaggerate the actual yield, so again an additional calibration would have improved the system accuracy.

Another aspect of the yield monitor performance that was investigated was the effect of the size of the load on the measurement error. Figures 8 and 9 show the observed errors with the loads ordered from the smallest to the largest observed values. These plots show that the Zycom system demonstrated fairly consistent errors over the entire range of load weights, but the Micro-Trak® system errors were very unpredictable. No patterns were evident in the sorted results from either yield monitor to imply that the yield monitor results were affected by the size of the basket load.

The second field, located near Ty Ty, Georgia, was harvested over four days in early October. In this harvest, the calibration problems of the Zycom were circumvented by changing the calibration coefficient directly. This required some in-field calculations, but it was successful. The calibration information from the first field was used at the beginning of harvest on the second. Again, a calibration load was harvested and the coefficients were changed. Thirty-one loads were harvested from this field, and twenty-two loads were weighed for comparison with the yield monitor readings. Table 2 provides a summary of the harvest for this field.

The results from the load comparisons performed in the second field are presented in figures 10 through 13. The Zycom yield again provided consistently better estimates of the load weights. Despite the increased efforts to ensure proper calibration, the Micro-Trak® system continued to provide relatively poor results. From figure 10 and 11, one can see that the calibration coefficient could have been adjusted further to improve the Micro-Trak® performance on the first day of harvest because this system consistently overestimated the actual load weight. This would have been counter-productive for the next day, however, because the system then began to underestimate the actual loads. The calibration information appeared to work well on day three, but returned to being inappropriate on day four. Figures 12 and 13 show that the Zycom errors were relatively consistent, even over the full range of load values observed.

The third field, also located in Ty Ty, Georgia, was harvested in late October. This "field" was actually three fields clustered around a center pivot irrigation system. A six-day harvest resulted in sixty-two loads, all of which were weighed for comparison with the yield monitors. Table 3 provides a summary of the harvest for this field.

The results from the third field harvested are show in figures 14 through 17. These results are fairly consistent with those of the second field. Despite extremely poor performance on the first harvest date, the Micro-Trak® system actually performed quite well for the remainder of the harvest. The Zycom system performance was notably poor on the second day of harvest and may have needed re-calibration.

While load weight comparisons provide some information regarding yield monitor performance, they say nothing about the ability of systems to provide accurate spatial yield information. To investigate this aspect, data collected from the systems was imported into the same software package (Surfer, Golden Software, Golden, CO) and plotted. Figures 18 and 19 present seed cotton yield maps created from Micro-Trak® and Zycom data sets, respectively. The field shown is the largest of the three components of the third field harvested, and it is approximately 63 acres. The pivot is located on the west side of this field and covers most of the field area during irrigation.

The Micro-Trak® yield map demonstrates the effectiveness of the run/hold data collection switch of the Micro-Trak® system. In this field, the operator was very reliable in operating this manual switch and the results are seen in very sharp field boundaries. An obvious error in the Micro-Trak® map is seen on the western side of the field. The dark vertical stripe in the map is an incorrect high-yielding area. The most probable cause of this feature is sensor blockage from accumulated cotton or debris in the sensor housing. The Micro-Trak® system map also does not define the yield variability in distinct patterns, and this may be the result of extensive noise in the sensor output.

The Zycom yield map demonstrates a problem with the system's automatic data collection technique. This method, which worked well in the previous year's system, operates by halting data collection if no cotton passes the sensor eyes after a certain time period. The yield maps from the Zycom system showed that data collection continued after the picker was out of the row and often as it approached the boll buggy. The result is an excess of low-yield data around the field edges and often on top of field areas where the boll buggy was parked. This error is also believed to have caused the consistent discrepancy between the harvested area calculations of the Micro-Trak® and Zycom systems (see tables 1, 2 and 3).

Despite the unnecessary data collection, the Zycom yield map does a good job of clearly defining the spatial yield trends withing the field. Notable features of the map include a previous fence row on the east side of the field, several clay soil areas on the north end of the field, and a band of non-irrigated cotton (out of pivot's reach) on the southern end of the field. Even the pivot tracks are visible on the Zycom map.

Summary

In their second year of testing, the two commercial yield monitors showed improvement over the previous year's results. This improvements, however, may not have been entirely the result of system enhancements. The operators' Increased attention to calibration, improved harvest conditions and troubleshooting experience also contributed to better results.

The integrated Zycom control unit with PCMCIA card storage was a definite hardware improvement over the previous system. The calibration routine, however, was flawed, and calibration had to be performed through manipulation of system memory contents.

Micro-Trak® made a great improvement in the sensor mounting hardware. The time required for installation was greatly reduced and the ability to provide sensor maintenance was greatly improved. Unfortunately, this maintenance was still needed as the debris and dust build up was again a nagging problem for this system.

Overall, the Zycom system appeared to detect yield levels to greater accuracy than the Micro-Trak® system.. The Zycom system more closely matched dump weights (as indicated by truck scales) and demonstrated fairly consistent errors over several days of harvest.

The Micro-Trak®, though improved greatly from the previous year, still shows some problems with day to day variability, blocked sensors, failure to maintain calibration and poor accuracy.

The added benefit of fewer parts to install with the Zycom indicate this system is more user-friendly and reliable than the current Micro-Trak® system; however, the production quality with Zycom is lacking. The authors experienced numerous examples of control units that were either non-functional or had some problem making them unusable. Long delays in receiving working control units and sensors were common.

Note: The use of trade names, etc. in this publication does not imply endorsement by The University of Georgia of products named nor criticism of similar products not mentioned.

References

Durrence, J., D. Thomas, C. Perry, G. Vellidis and C. Kvien. 1997. Evaluation of commercially available cotton yield monitoring systems. University of Georgia Extension Service. Cotton research-extension report. 233-245.

Table 1. Harvest summary statistics for the first harvested field.[1]

	Scales	Micro-Trak®	Zycom
Total Yield (lb)[2]	68425	75948	73988
Area Harvested (ac)	N/A	25.89	27.4
Mean Yield (lb/ac)	N/A	2933	2700
Mean Load Error (%)	N/A	12.29	8.19
Max Load Error (%)	N/A	27.92	16.01
Standard Dev. (%)	N/A	8.44	3.03

[1]Data presented constitutes only the harvested loads for which scale weight comparisons were performed.
[2]Yield represents seed cotton yield with no moisture content correction.

Table 2. Harvest summary statistics for the second harvested field.[1]

	Scales	Micro-Trak®	Zycom
Total Yield (lb)[2]	79250	87577	80887
Area Harvested (ac)	N/A	31.06	33.08
Mean Yield (lb/ac)	N/A	2820	2445
Mean Load Error (%)	N/A	16.18	3.6
Max Load Error (%)	N/A	46.68	10.6
Standard Dev. (%)	N/A	12.76	2.97

[1]See note 1 from table 1.
[2]See note 2 from table 1.

Table 3. Harvest summary statistics for the third harvested field.[1]

	Scales	Micro-Trak®	Zycom
Total Yield (lb)[2]	250944	266099	253166
Area Harvested (ac)	N/A	98.39	104.2
Mean Yield (lb/ac)	N/A	2704	2430
Mean Load Error (%)	N/A	11.26	2.98
Max Load Error (%)	N/A	102.1	18.22
Standard Dev. (%)	N/A	16.55	3.11

[1]See note 1 from table 1.
[2]See note 2 from table 1.

Figure 1. Improved Zycom yield monitor control module.

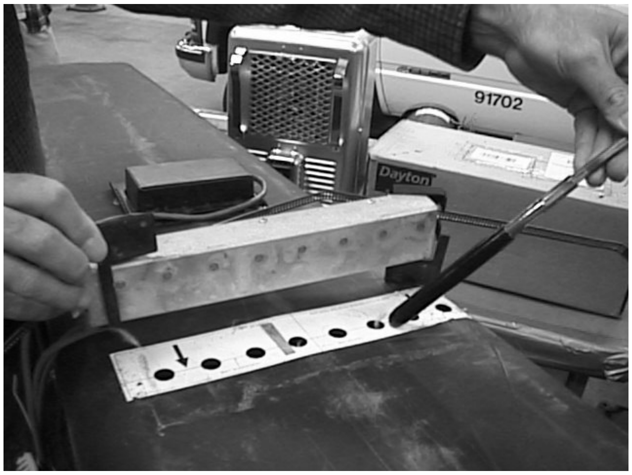

Figure 2. Old Micro-Trak® sensor mount with drilled holes exposed.

Figure 3. Slot required for improved Micro-Trak® sensor installation.

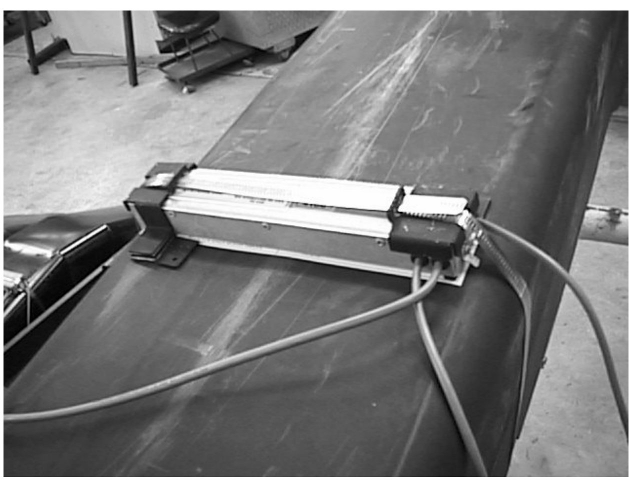

Figure 4. Old Micro-Trak® sensor mount with sensor secured with steel band clamps.

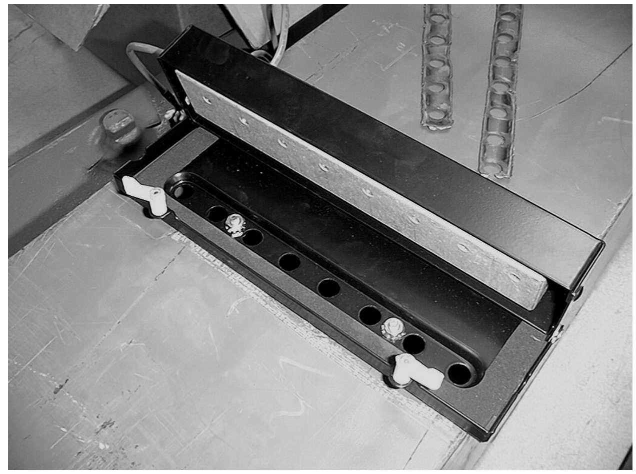

Figure 5. Improved Micro-Trak® sensor mount with sensor exposed for cleaning.

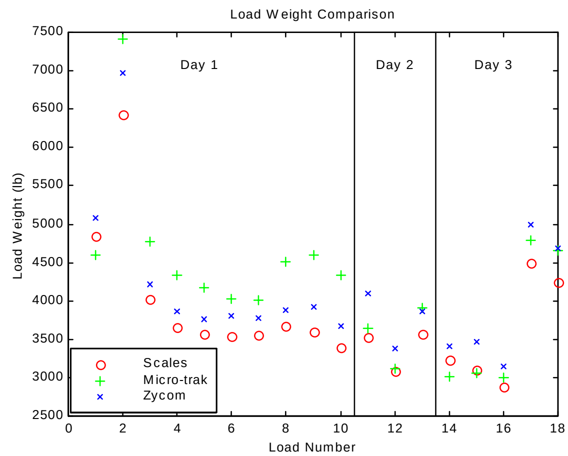

Figure 6. Load-by-load comparison of the first field harvested.

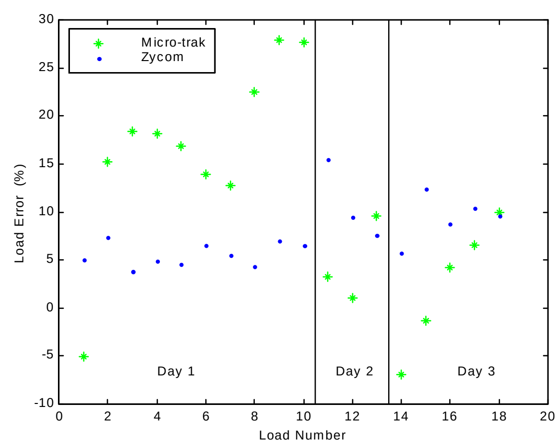

Figure 7. Percent errors for each compared load from the first field harvested.

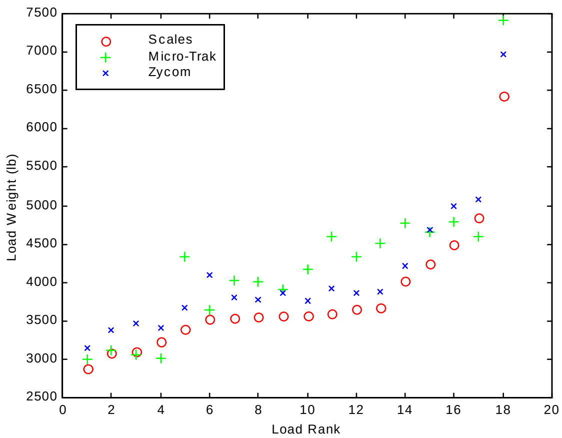

Figure 8. Sorted (ascending) load-by-load comparisons for the first field harvested.

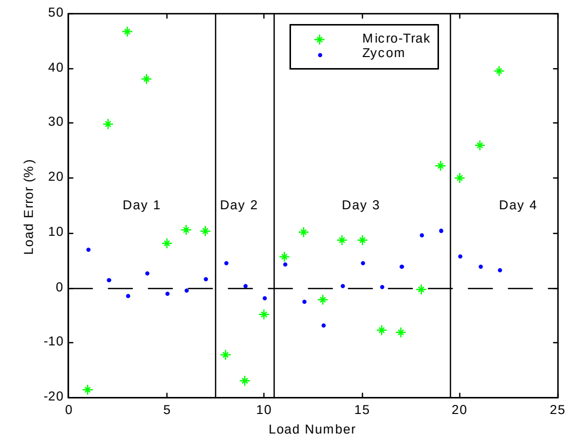

Figure 11. Percent errors from each load comparison of the second field harvested.

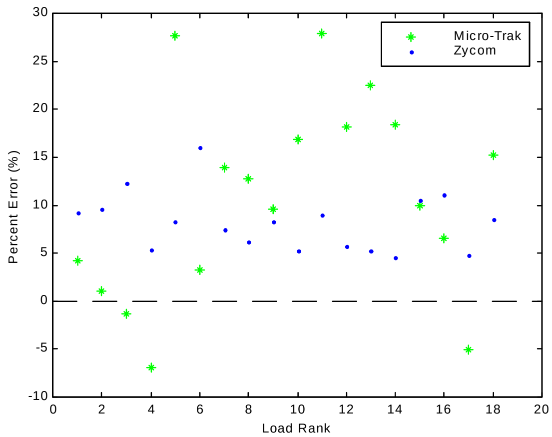

Figure 9. Percent errors of the sorted load comparisons from the first field harvested.

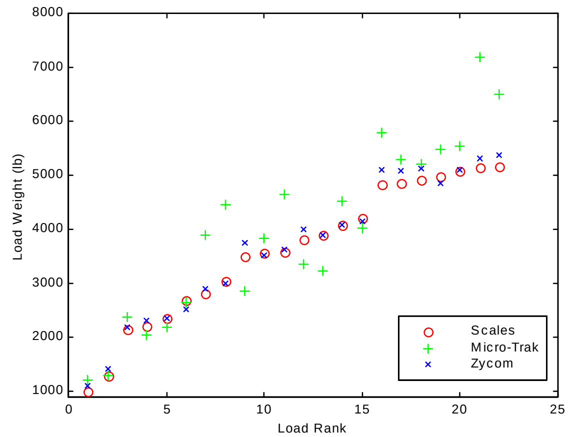

Figure 12. Sorted load-by-load comparisons from the second field harvested.

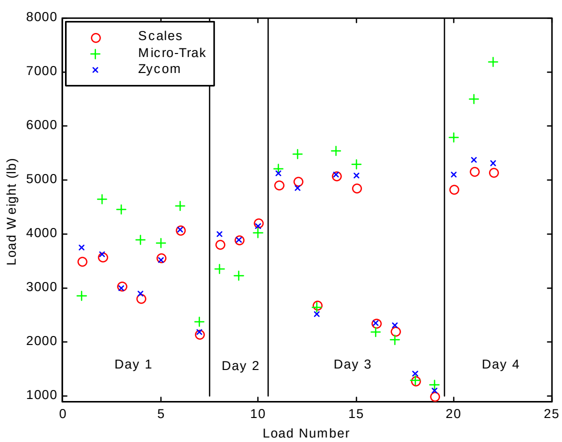

Figure 10. Load-by-load comparisons from the second field harvested.

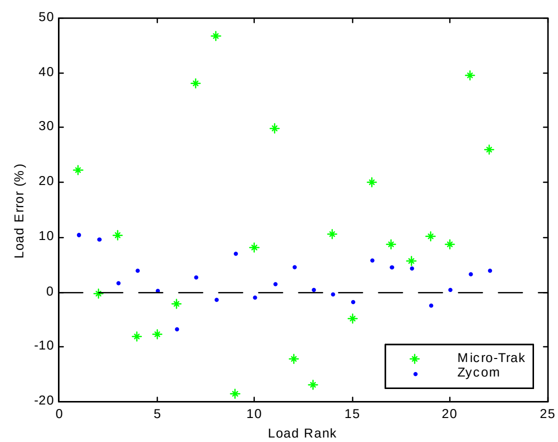

Figure 13. Percent errors for the sorted load-by-load comparisons of the second field harvested.

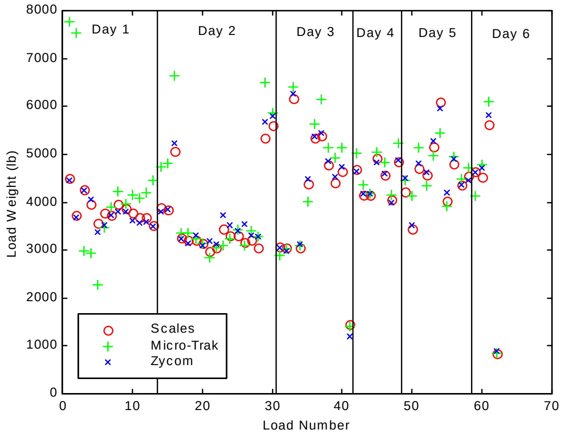

Figure 14. Load-by-load comparisons for the third field harvested.

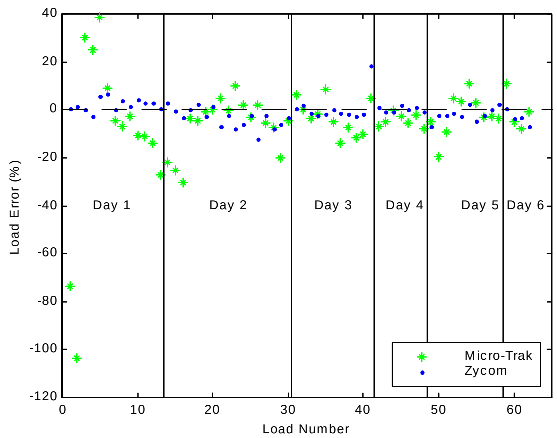

Figure 15. Percent errors of the load-by-load comparisons of the third field harvested.

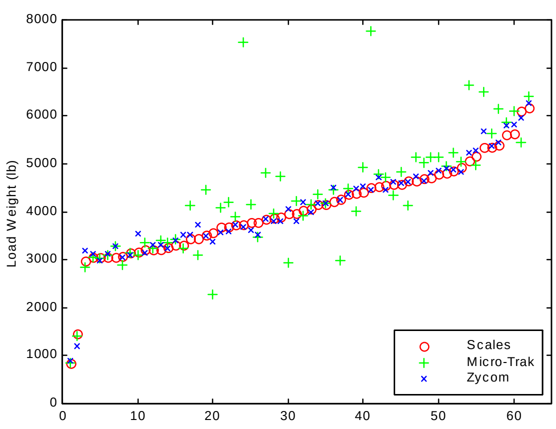

Figure 16. Sorted load-by-load comparisons for the third field harvested.

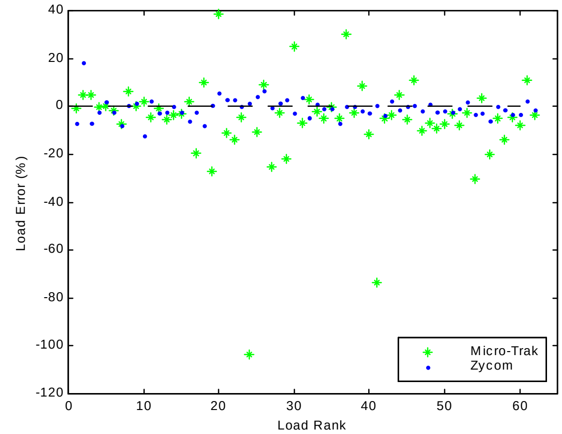

Figure 17. Percent errors for the sorted load-by-load comparisons of the third field harvested.

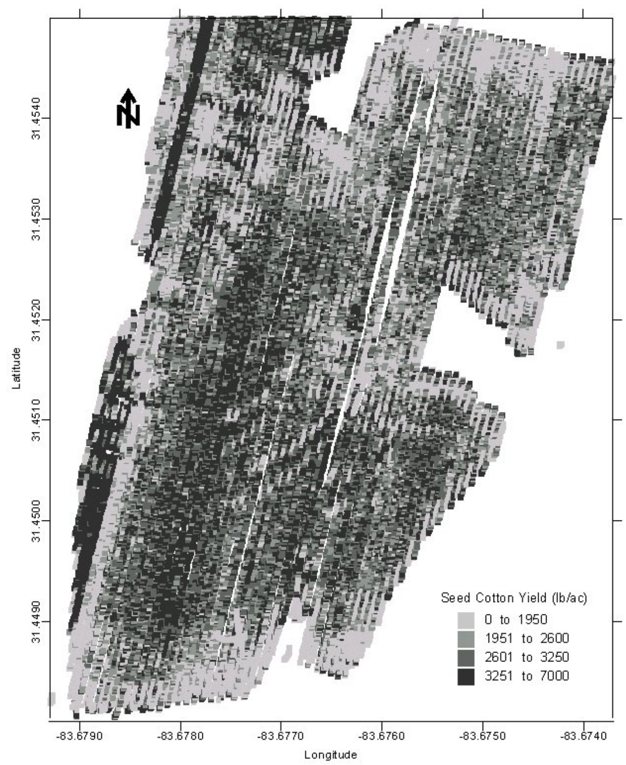

Figure 18. Yield map of the third field harvested created with the Micro-Trak® system data.

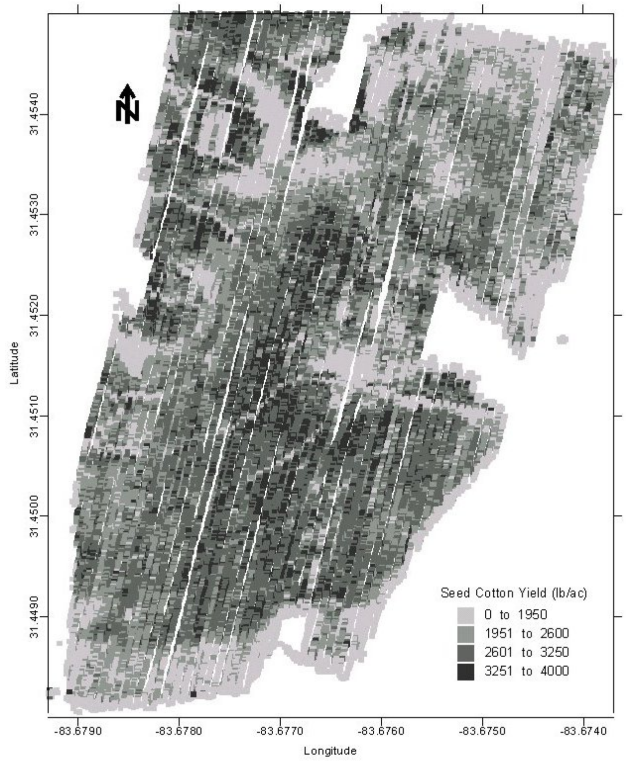

Figure 19. Yield map of the third field harvested created with the Zycom system data.