PERFORMANCE EVALUATION OF NEW GENERATION COTTON YIELD MONITORS

Calvin Perry
George Vellidis
University of Georgia - Tifton Campus
Tifton, GA

Abstract

The performance of the new generation Ag Leader cotton yield monitoring system, based on the Insight display, was evaluated for yield accuracy and ease of use during the 2007 harvest season. A four-sensor Ag Leader Insight system was installed on a grower-owned John Deere 9996 cotton picker in south Georgia and was used to harvest his 25 fields. Basket load, module, and field total weights were compared to yield monitor weights to evaluate accuracy. The grower's experience with the system was used to evaluate ease of use. After proper initial weight calibration, the system under-predicted actual weight with a percent error of approximately 12% when comparing basket loads, modules or field totals. Nevertheless, the predicted weight values were fairly consistent and the resulting yield data produced yield maps that represented field variations quite well. Once re-calibrated later in the season, the system began over-predicting cotton weight and the percent error reduced to approximately 7%. Ease of use was very good with the grower able to navigate menus and settings easily.

Introduction

Yield monitors are an essential component of a successful precision agriculture program in cotton production. A yield monitor is basically a sensor or group of sensors installed on harvesting equipment that dynamically measures spatial yield variability. Usually this yield measurement is coupled with accurate location data from a GPS receiver to create a yield map. Yield monitors, and the yield maps they produce, have been referred to as the “entrance exam and the exit exam” for precision agriculture. Producers can use a yield map to guide their management decision-making process at the beginning of a season and then use the yield map to evaluate if their efforts over the season were successful.

Since the mid 1990's, cotton yield monitoring systems (YMS) have been available from a number of vendors (Rains et al., 2002; Vellidis et al., 2003) with varying levels of performance accuracy and/or commercial success (Perry et al., 2004). Currently, commercial cotton YMSs are available primarily from three vendors - Ag Leader, Agriplan, and John Deere, with systems from Ag Leader and John Deere making up the bulk of systems being sold today. In the past, the performance of two of these (Agriplan and Ag Leader) has been evaluated extensively by researchers around the country. The University of Georgia (UGA) Precision Ag Team installed a John Deere cotton YMS on a producer’s picker in 2005 and evaluated its performance over a limited number of loads, but we were not able to conduct a thorough evaluation.

Recently, both John Deere and Ag Leader announced major upgrades to their cotton YMSs. John Deere has developed the GreenStar 2 system which includes a new color touchscreen display and microwave-based flow sensors. Ag Leader has begun marketing the Insight console which includes a color touchscreen display as well. Ag Leader has incorporated controller area network (CAN) technology in this new generation system which provides for less complicated wiring and improved dependability. The Ag Leader system uses optical sensors (emitters/receivers) for flow measurement. As both of these systems are new to the market, no objective evaluations have been conducted.

This paper presents results of recently completed testing designed to evaluate the performance of these new generation of cotton YMSs from Ag Leader and John Deere. Unfortunately, the John Deere system was not installed until late in the season due to internal administrative delays and thus was not operated on ample acres to fully evaluate the system. Therefore, this paper will present results from only the Ag Leader Insight-based cotton yield monitoring system.

Materials and Methods

Experimental Apparatus

An Ag Leader cotton YMS was obtained from Ag Leader Technologies. The system consisted of 4 flow sensors, Insight display, header height sensor, and associated brackets and cables. A Trimble AgGPS 114 DGPS (WAAS-based) receiver was used for position data. Ag Leader's latest version of SMS Basic software (v. 7.5) was used for initial processing of raw data files.

A cooperating grower allowed the Ag Leader system to be installed on his 2006 John Deere 9996 six-row cotton picker. The four sensor pairs (receiver/emitter) were mounted on the air ducts attached to row units 1, 3, 4, and 6 (Fig 1-2). The Ag Leader Insight display was mounted in the cab of the picker within easy reach of the operator (Fig 3). The system was installed following the procedures given in the Ag Leader installation manual.

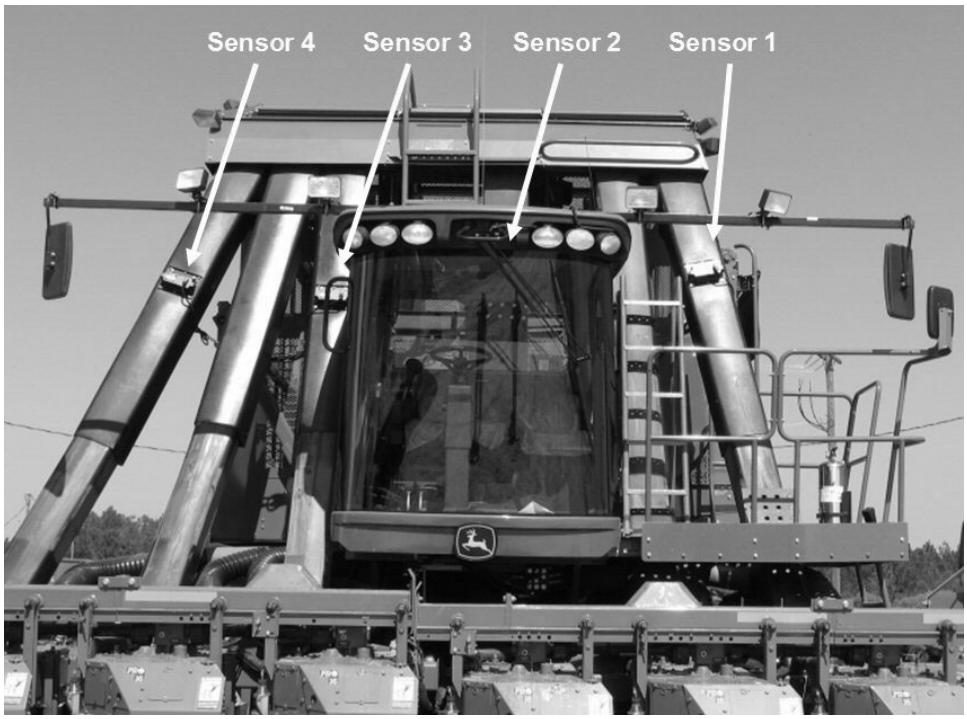

Figure 1. Ag Leader cotton flow sensors installed on 9996 cotton picker.

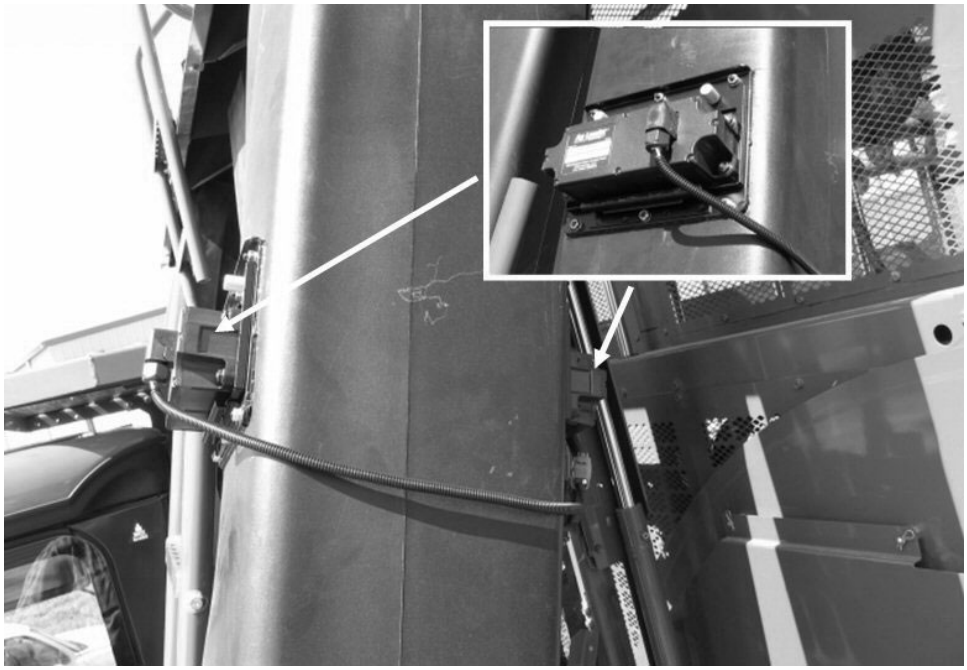

Figure 2. Closeup of Ag Leader cotton flow sensor installed on air duct 1.

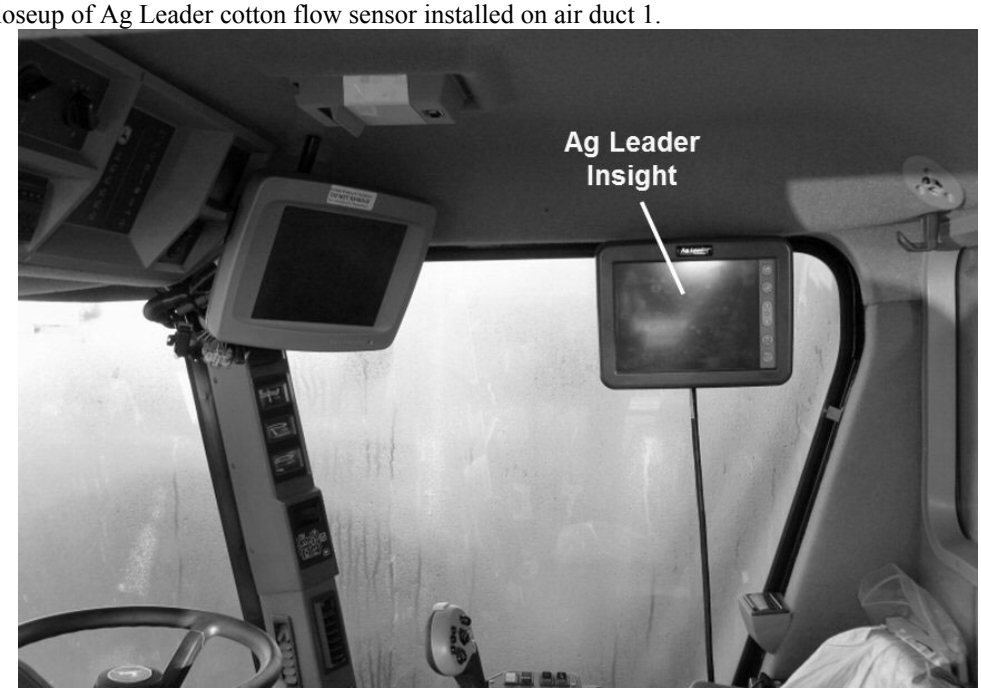

Figure 3. Picker cab with Ag Leader Insight display mounted.

The Insight console is a 10.4" color, touch-screen, ruggedized display that serves as the sole user interface to the YMS. Based on experience from this project and information from Ag Leader, the Insight offers adjustable backlighting, on-screen keyboard with contextual help, compatibility with a wide variety of precision hardware, including most NMEA GPS receivers and the most popular controllers, large internal memory (no keycard required), and a sealed enclosure.

Testing Methodology

The cooperating grower produced cotton in 25 fields in Tift and Colquitt Counties in southwest Georgia (a combination of grower-owned and rented). With the exception of a few acres of 'refuge' cotton, the grower planted DPL 555 RR/BG variety in his fields and had a combination of irrigated and non-irrigated acreage. The grower was an experienced and progressive producer and had used older versions of YMSs from both Ag Leader and John Deere.

Prior to harvest, the grower performed a new cotton configuration by which his particular picker was defined and configured, sensors were configured, GPS was configured, and crop was defined and configured (including gin turn-out). The grower also configured how he wished for yield maps to be displayed (units, legend, etc.).

In the first field the grower harvested (Sept. 26), the Ag Leader system was calibrated following Ag Leader procedures. The speed sensor was calibrated by marking a known distance of 100 ft and driving the picker over that distance while the console recorded calculated distance. Once the distance was driven, the calculated distance was set to actual distance to calibrate the sensor. The header height sensor was calibrated by setting the maximum (raised) height of the picker row units followed by the minimum (lowered) height of the row units. Then the row units were raised to a trip point height to start/stop data collection.

The weight calibration is a key step in properly configuring a cotton YMS as this will determine how accurately the system calculates seed cotton yield from that point forward. Basically, the weight calibration determines a "multiplier" or "coefficient" by which the YMS converts sensor signal values to seed cotton weight, which then combined with area determines yield. The Ag Leader system allows for a single "load" or multiple "loads" to be used in the weight calibration. (Ag Leader now refers to "regions" rather than "loads" in their vernacular). Based on conversations with Ag Leader technical support, four "regions" were used in the initial weight calibration. Before each "region" was harvested, the grower selected a "region" name and then selected a flag to indicate the "region" was to be used for calibration. The four calibration "regions" were then harvested and the grower was instructed to harvest four different size basket loads (medium to full basket loads).

Figure 4. Boll buggy resting on portable truck scales used to weigh cotton load.

The calibration loads were weighed by first placing the grower's boll buggy on portable truck scales (wheels and tongue) (Fig 4). Then the scales were tared and the grower dumped a basket load into the boll buggy. Actual weight was then determined from the truck scale value. Once weight was determined, the operator dumped the boll buggy into an adjacent module builder. For this test, the calibration loads ranged from 3700 lbs to 5500 lbs (actual weight). Once all 4 calibration loads or "regions" were harvested and weighed, the weight calibration screen was selected. On this screen the grower entered each "actual" weight for the respective "region". Then the grower selected "Perform Calibration" instructing the Insight console to use the 4 "regions" to determine a calibration coefficient. For this calibration, the Insight display reported an average error of 3.8% and a maximum error of 5.4%. The researchers' goal was to use an initial calibration and follow the system for the rest of the season.

At that point, the grower was instructed to continue harvesting in his normal manner of operations in that field and the remaining 24 fields. After calibration, the research team planned to take basket load weights ("check" weights) in as many fields as logistically possible over the rest of the harvest season to compare YMS weight to actual weight. Approximately 10 days after initial calibration, the first "check" weights were taken. To help with data collection, the grower noted that he would begin assigning the module ID to the "region" name. This would allow the researchers to later match Ag Leader weight to module weights and thus obtain much more test data. The researchers also took "check" weights periodically throughout the harvest season, which ended in mid November. One change in the testing was made when the Ag Leader system was re-calibrated on Nov. 2.

Resulting yield data was processed and analyzed using Ag Leader SMS Basic v. 7.5 software. The Insight system produces a .ILF file which requires the newest version of SMS software to process. Older PF3000 systems produced a .PFL file. Yield maps were created with the SMS Basic software.

Results

Weight Accuracy

The accuracy of the Ag Leader YMS in determining seed cotton weight was evaluated using three sets of weight comparisons. The largest set of data to compare with was module gin weights. As mentioned earlier, the grower usually named a "region" the same as the module number he was building from seed cotton harvested in that "region". For the 9996 six-row picker, the grower usually put 3 basket loads into one module. Therefore, gin module weight could be directly compared to the "region" weight from the YMS. The second set of data was weights from "spot checks". These weights were actual weights of individual basket loads of seed cotton as measured in a boll buggy on portable truck scales. These weights were obtained on 5 occasions during the harvest season. The final set of data was total field weights. In seven of the grower's 25 fields, module weights were not kept distinctly separate in the Ag Leader YMS. The field as a whole was stored so this total weight was compared to gin weights from all modules from that particular field.

Figure 5 shows the module weight comparisons in terms of percent error between Ag Leader calculated weight and gin module weight for 81 modules harvested throughout the first part of the season (Sept 26 - Nov 2), after initial calibration. The average error was -11.7%. For each module weight comparison, the Ag Leader under-predicted the actual weight. Note that module weights for the field harvested during initial calibration are not included as the grower had not begun naming "regions" as module IDs. Figure 6 shows the module weight comparisons after the Ag Leader YMS was re-calibrated on Nov 2. The average error after re-calibration was 5.7% and the Ag Leader usually over-predicted the actual weight.

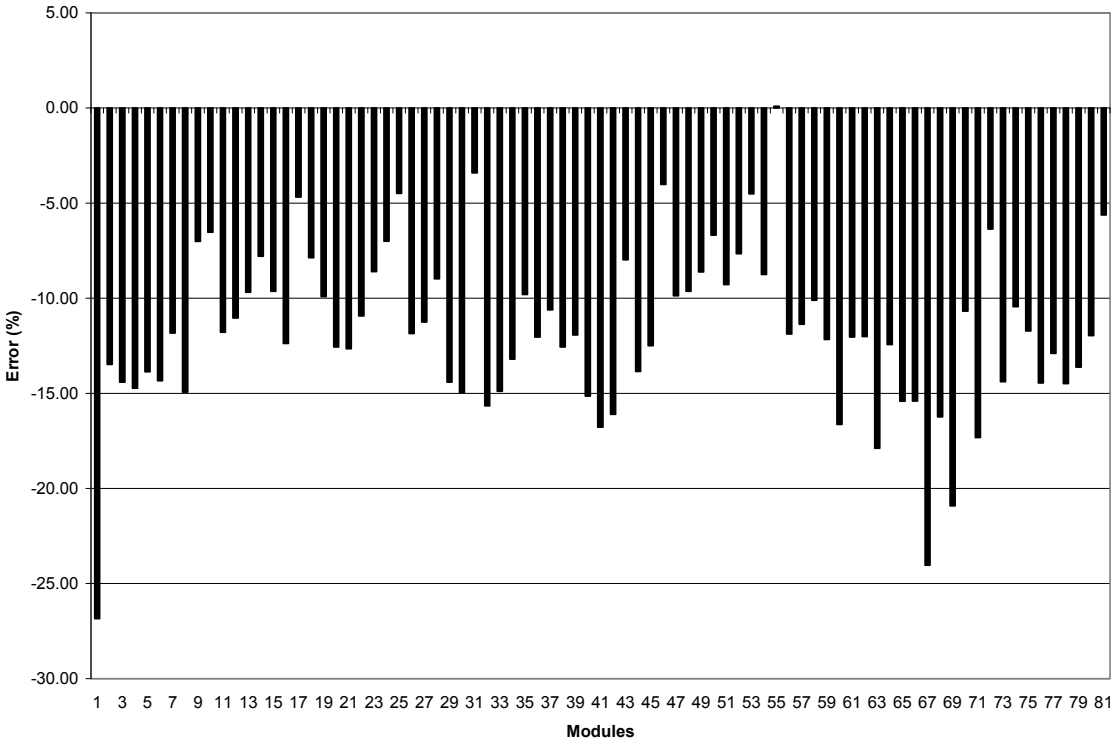

Figure 5. Percent error for 81 comparisons between Ag Leader yield monitor and gin module weight. Data represents modules harvested after initial calibration but prior to re-calibration. Average error = -11.7%.

In Figure 7, data from "spot checks" is presented for the period after initial calibration and after re-calibration. The average error after initial calibration was -12.4% and, again, all yield monitor weights were less than actual weights. The average error after re-calibration was 2.1% and nearly all yield monitor weights were greater than actual weights.

Figure 8 shows total field weight comparisons (percent errors) for 7 fields, including the first field harvested. The four field weight errors from the period after initial calibration averaged -13.9% and, again, indicated that the YMS was under-predicting actual weight. For the 3 field weight errors after re-calibration, the average error was 6.8%.

Yield Maps

A typical cotton yield map created from Ag Leader YMS data in SMS software is shown in Figure 9. The map units shown are "lint mass yield" which in the Ag Leader system is calculated by multiplying the seed cotton mass by a pre-set gin turnout value. The cooperating grower selected 40.5% as his turnout. The SMS software offered much flexibility in how the yield map could be displayed and data analyzed. The SMS software allows for ESRI shapefile export that gives the user the ability to work with the yield data in other software, such as ESRI ArcView.

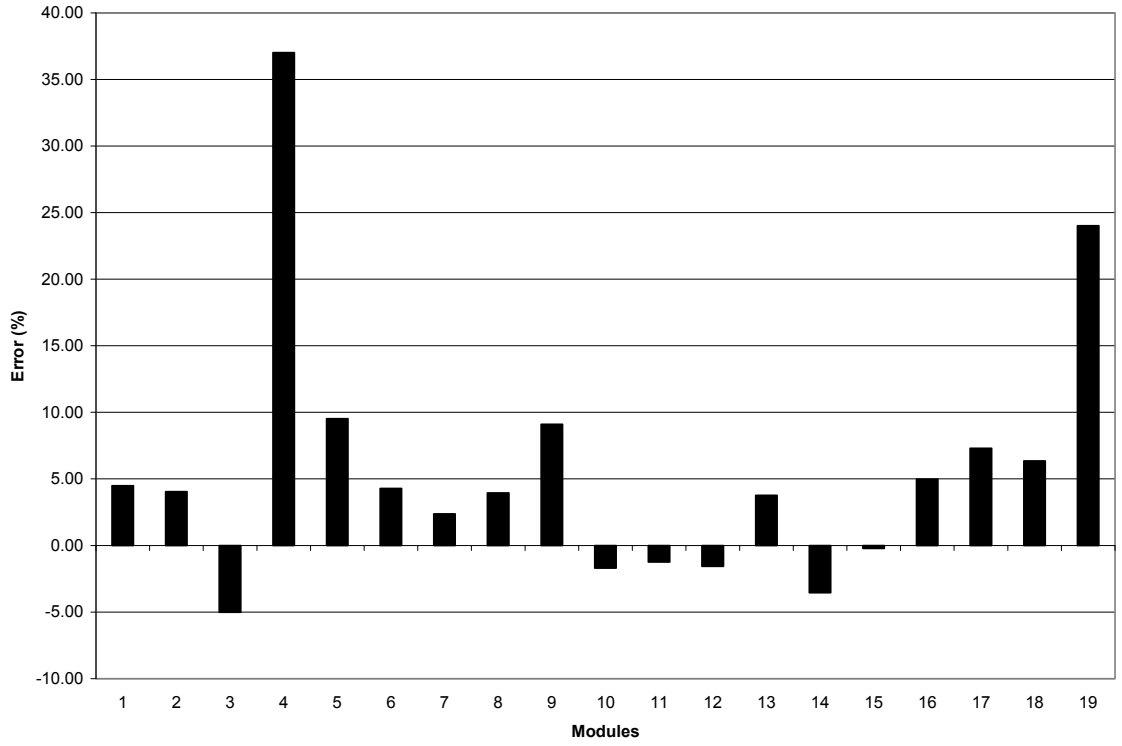

Figure 6. Percent error for 19 comparisons between Ag Leader yield monitor and gin module weight for modules harvested after re-calibration. Average error = 5.7%.

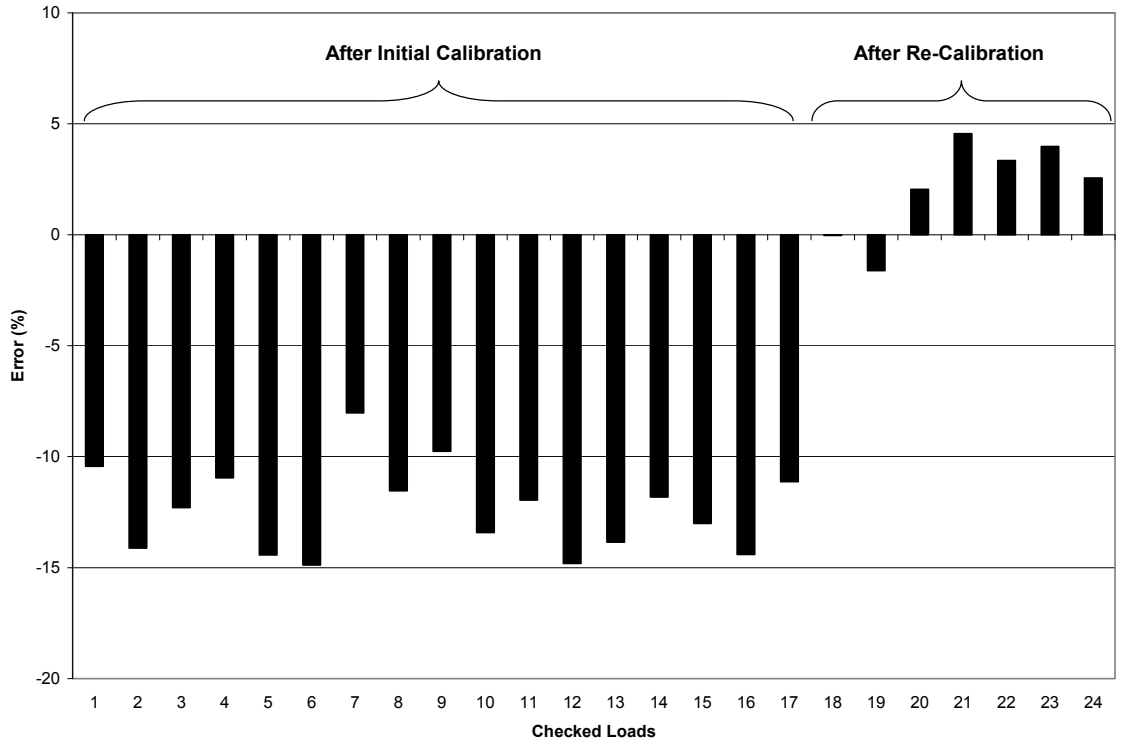

Figure 7. Percent error for 24 comparisons between Ag Leader yield monitor and "spot check' weights. Average error after initial calibration = -12.4%. Average error after re-calibration = 2.1%.

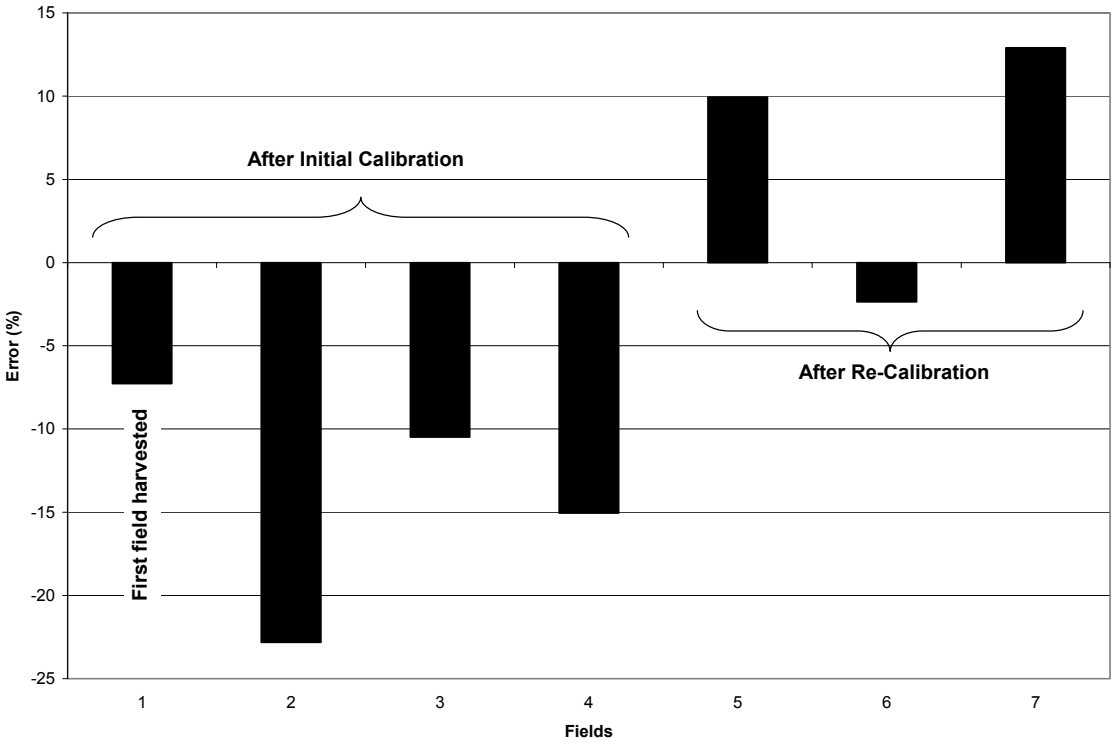

Figure 8. Percent error for 7 field-total comparisons between Ag Leader yield monitor and gin module weights (total for field). Average error after initial calibration = -13.9%. Average error after re-calibration = 6.8%.

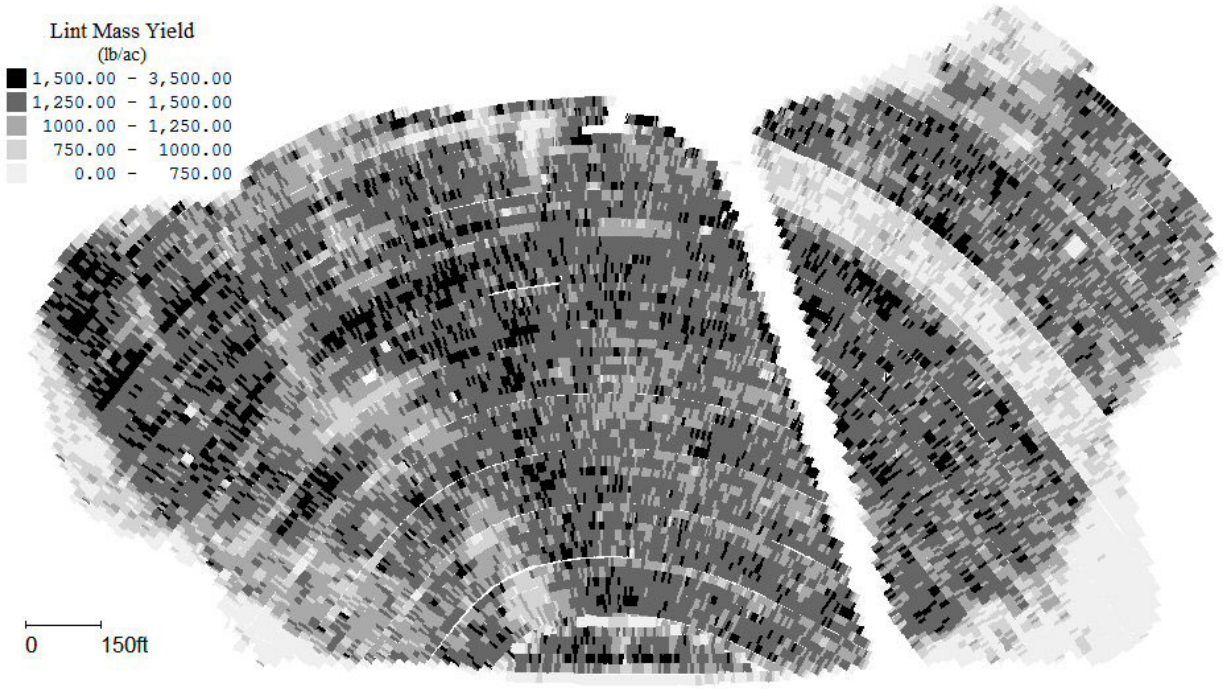

Figure 9. Typical cotton yield map created in Ag Leader SMS software. Lower yielding strip on East side of field is from a section of "refuge" cotton of a lower yielding variety than rest of field.

User Experience

As mentioned earlier, the cooperating grower had previous experience operating older YMSs from both John Deere and Ag Leader and knew the basic functions and data that should be offered in the new generation systems. For the Ag Leader Insight-based system, the grower's overall experience was very positive. He noted that, from first use, the system was easy to navigate and operate, had fairly intuitive layout of screens and information, was visually easy to view, had a responsive touch screen, and appeared to be rugged enough to handle the picker cab environment. He found that he had to refer to the user's manual only occasionally.

The grower did note some functions / features he thought would make the system better for him. These included a tone to indicate seed cotton weight in basket had reached a pre-set level, a default setting to have the display return to a "medium" contrast level upon start-up, and a display of memory card "% Full" on the Run screen. He also noted that under the SUMMARY System Navigation feature, the Insight system only shows Grower and associated Field names to select from. If a Grower has two Farms with the same Field name, there will be no easy way to distinguish between Fields. The grower cooperator would like for the Summary screen to prompt for Grower and Farm before Field.

The grower expressed three primary concerns about the Ag Leader system. First, he noticed on many occasions that the weight value continued to increase when he was not actively harvesting cotton. This usually occurred when he stopped while harvesting (and left heads down and fan running) to check on the picker or clear an obstruction in one of the picking units. Second, he believed the default flow sensor signal strength setting (at which an audible/visual warning starts) was too low. After consulting with Ag Leader, the setting was increased. The grower also learned to open and clean the sensors when the new warning level occurred. Third, the grower was disappointed with the accuracy of the YMS after it was carefully calibrated in his first field. However, the grower noted that the accuracy, though off by 12-14%, was fairly consistent. The re-calibration later in the season boosted the grower's confidence in the accuracy of the system.

Conclusions

The new generation Ag Leader cotton yield monitoring system, based on the Insight display, is a very capable tool as part of a broader precision agriculture program in cotton production. The system was straight-forward to install and easy to learn and operate by a fairly skilled (in ag electronics) grower. However, the accuracy of the system in calculating seed cotton weight, while consistent, was lower than anticipated.

After a proper initial calibration, for some unknown reason the system accuracy degraded and stayed at an error of approximately -12%, underpredicting actual weight in each comparison (load, module, field). When re-calibrated near the end of the harvest season, the system accuracy immediately improved to approximately 7%, indicating an over-prediction of seed cotton weight.

As other research with optical-based cotton yield monitors has shown, calibration or accuracy "drift" can often occur with these yield monitoring systems, even after a proper calibration. If a grower is determined to have yield data as accurate as possible, then re-calibration will be the only recourse. If "regions" represent modules, then this re-calibration will be fairly easy to accomplish. However, if the grower is more interested in relative differences in yield in a specific field, then the grower may choose to calibrate once at the beginning of the season.

Disclaimer

Acknowledgements

The authors wish to thank the grower, Brian Ponder, for his participation in this study. We appreciate the efforts of Gary Murphy and Dewayne Dales for their technical assistance with this project. Finally, we wish to thank Cotton, Inc. for funding this project.

References

Perry, C., G. Vellidis, N. Wells, R. Hill, A. Knowlton, E. Hart, and D. Dales. 2004. Instantaneous accuracy of cotton yield monitors. In *Proc. 2004 Beltwide Cotton Conf.*, Memphis, Tenn.: National Cotton Council. Available online (www.cotton.org) or on CDROM.

Rains, G.C., C.D. Perry, G. Vellidis, D.L. Thomas, N. Wells, C.K. Kvien, and H.D. Dales. 2002. Cotton yield monitor performance in changing varieties. ASAE Paper No. 021160, ASAE, St. Joseph, MI.

Vellidis, G., C.D. Perry, G. Rains, D.L. Thomas, N. Wells, C.K. Kvien. 2003. Simultaneous assessment of cotton yield monitors. *Applied Engineering in Agriculture* 19(3):259-272.