2003 BELTWIDE COTTON CONFERENCES, NASHVILLE, TN – JANUARY 6-10

MISSISSIPPI COTTON YIELD MONITOR: BETA TEST FOR COMMERCIALIZATION

Ruixiu Sui and J. Alex Thomasson
Agricultural & Biological Engineering Department
Mississippi State University
Mississippi State, MS
Robert Mehrle and Matt Dale
Agricultural Information Management
Sumner, MS
Calvin Perry and Glen Rains
Coastal Plain Experiment Station
University of Georgia
Tifton, GA

Abstract

Based on a novel cotton-flow sensor, the Mississippi cotton yield monitor has been under development at Mississippi State University since 1999, when one prototype of the yield monitor was field tested in Mississippi. Three prototypes were constructed and field tested in Texas, Georgia, and Mississippi in 2000. Five prototypes of an improved version were fabricated and field-tested in 2001. All three years' testing results were promising. In 2001, Mississippi State University and Agricultural Information Management, LLC., signed a licensing option agreement to prepare for the eventual manufacture and marketing of the Mississippi cotton yield monitor. Research towards commercialization of the Mississippi cotton yield monitor was conducted in 2002. In this beta test, ten prototypes of the Mississippi cotton yield monitor were built and extensively tested on commercial and research farms during the 2002 cotton harvesting season. Harvesting was conducted with both cotton pickers and strippers. The yield monitor system's accuracy was evaluated on a load-by-load weight basis. Reliability was tested under commercial harvesting conditions. All systems performed well during the tests. Each one was easy to install, maintain and operate. No hardware problems occurred. The system's average absolute error was 3.8%. Cotton yield maps created with the data collected by the monitors realistically exhibited yield variations within the fields. Evaluator's suggestions, mainly related to software performance, are to be addressed in the commercial version of Mississippi cotton yield monitor.

Introduction

Background

Precision agriculture, an emerging and important technology for improving farm profitability, is the use of detailed site-specific information within agricultural fields to manage input decisions on a spatially variable basis. Localized crop yield measurement is the principle requirement in determining profit on a spatially variable basis. Yield monitors that incorporate GPS tie crop yield to specific field locations so that yield maps, and ultimately profit maps, can be made.

Optical cotton yield monitor systems have been researched and tested for several years (Wilkerson et al., 1994 and Thomasson et al., 1999). The following companies have commercialized such yield monitors, with the first beginning in 1997: FarmScan (Perth, Western Australia), Micro-Trak® (Eagle Lake, MN), Zycom/AGRIplan (Stow, MA), and AgLeader® (Ames, IA) (Myers, 2000). These cotton yield monitors have been evaluated under field conditions (Durrence et. al., 1998; Perry et. al, 2001; Roades et. al., 2000; Sassenrath-Cole et. al., 1999; Wolak et. al. 1999, and Wilkerson et al., 2002). Results of these evaluations varied from poor to excellent under the given conditions.

The cotton-flow sensors used in all the cotton yield monitor systems mentioned above are based on the same principle and are similar in configuration and operation. Each sensor unit has two main parts, a light-emitter array and a light-detector array mounted opposite each other on a cotton harvester's pneumatic ducts. The sensors measure light attenuation caused by cotton particles' passing through the ducts. The light attenuation signal is then converted by the data acquisition system to an amount of cotton passing the sensor cross-section. The light-emitter array functions as the light source, and it consists of LEDs (light-emitting diodes) in some configuration. The light-detector array functions as light receiver, and it consists of photodiodes in some configuration. Each LED in a light-emitter array must be lined up with a photodiode in the corresponding light-detector array.

In 1999, Thomasson and Sui (2000) designed and fabricated a novel optical cotton-flow sensor to be used as part of Mississippi cotton yield monitor system at Mississippi State University (MSU). The sensor includes energy sources and detectors mounted in one housing unit on the same wall of a picker/stripper duct, thus requiring only one port to be cut in the duct for sensor installation. All cotton-flow sensors of commercially available cotton yield monitors include one housing for detectors on one side of the duct and one housing for light sources on the opposite side of the duct. Thus, their installation requires two ports to be cut in a duct instead of one, and proper alignment of light sources and detectors. This creates difficulties in installation and possible misalignment over time due to vibration of the sensor; such is not the case with the cotton-flow sensor of Mississippi cotton yield monitor.

A first prototype of the Mississippi cotton yield monitor was field tested in 1999 in Mississippi. The test results were promising: the cotton-flow sensor showed high fundamental accuracy, insensitivity to dirt and dust buildup, and the ability to measure trash content in the seed cotton. In 2000, three prototypes were constructed and field tested in Texas, Georgia, and Mississippi on about 1300 ac of cotton. Different varieties with large yield variations were harvested (Sui and Thomasson, 2001). Based on the 2000 test results, a new version of the Mississippi cotton yield monitor was designed to include anti-stray-light and temperature-stabilization features (Sui and Thomasson, 2002a). Five prototypes of the new version were fabricated and field tested in 2001 on three cotton pickers and two cotton strippers at five locations in Georgia, Texas, and Mississippi. A total of 3040 ac of cotton were harvested with the yield monitors from September to December of 2001 (Thomasson et al., 2002). Considering all three years' data, the average measurement error of the Mississippi cotton yield monitor on a cotton picker was less than 5%, and the latest prototype appears to be improved over previous versions. The tests also indicated that the system was reliable and easy to install, operate, and maintain (Sui and Thomasson, 2002b).

In 2001 MSU and Agriculture Information Management, LLC. (AIM) signed a licensing option agreement to prepare for the eventual manufacture and marketing of the Mississippi cotton yield monitor. Research towards commercialization was conducted in 2002. For this beta test, ten prototypes of the Mississippi cotton yield monitor were built and extensively tested on commercial and research farms. The test results are reported herein.

Objectives

The objectives of the beta test of the Mississippi cotton yield monitor were as follows:

1. To evaluate its field accuracy and reliability;
2. To evaluate its ease of installation, operation and maintenance.

Materials and Methods

System Description and Operation

The beta test version of the Mississippi cotton yield monitor consists of two cotton-flow sensors (Figure 1), a data acquisition box, a Compaq iPAQ pocket PC (personal computer) with expansion memory, and a GPS receiver. Each cotton-flow sensor includes energy sources and detectors mounted in one housing unit on the same wall of a picker duct, thus requiring only one port to be cut in the duct for the sensor installation. During operation, sensors detected the cotton flow in the duct and provide an output signal to the data acquisition box, where the signal was amplified and conditioned. A cable was used to connect the data acquisition box to the pocket PC. The pocket PC collected the signal from the cotton-flow sensor and spatial data from the GPS receiver, processed and recorded the data, and displayed an "on-the-go" yield map and other information on its screen. Two kinds of GPS receiver were used with the system: (1) a Navman GPS receiver designed for use with the Compaq iPAQ pocket PC, and (2) any standard external GPS receiver such as a Trimble AgGPS 132. When the Navman was used, the pocket PC was placed into the Navman GPS sleeve, and all data were stored in a compact flash card in the GPS sleeve. Use of the Navman GPS receiver required the addition of a small external antenna and transmitter, the signal from which was collected and transmitted to the Navman by a re-radiating antenna within the harvester's cab. When an external GPS receiver was used, the pocket PC was placed into a dual-slot expansion pack. One slot was used as a serial I/O port socket to transmit the external GPS signal to the pocket PC, while the other slot was occupied by a PCMCIA data storage card. In both systems, a 16/32 Mb data card was used to store the data, and it could be removed for downloading the data. The GSA and RMC sentences from the GPS receivers were used to provide PDOP (position dilution of precision), location, and speed data. In the beta test, there were six Mississippi cotton yield monitors with external GPS receivers and a dual-slot expansion pack. The other four monitors used Navman GPS receivers.

Software for the Mississippi cotton yield monitor was developed for the pocket PC, and it included a graphical user interface (GUI) with two main components: (1) a calibration program and (2) a data collection program (Figure 2). Upon clicking the "COLLECT CALIBRATION DATA" button on the screen, the system would start collecting data for calibration. When a calibration load had been completed, the sum of the sensor signal corresponding to that calibration load was displayed on the screen. After the user recorded the signal sum, the next calibration load could then start. Once a desired number of calibration loads had been collected, the program prompted the user to input the signal sum and the scale-weight for each calibration load (Figure 3). Then a calibration coefficient was calculated and stored in the program for yield calculation. Data files for each calibration load were saved separately, and users were able to retrieve them if necessary. In the program for yield data collection, the user entered parameters including field name (Figure 4), swath width, and an estimate of the maximum length of the field. The field name entered would be used for creating a data file name. The swath width was used for yield calculation, and maximum field length would be used for proper scaling of an on-the-go yield map on the screen. In addition to displaying the yield map on the screen, instantaneous and average yield, and harvested acreage were displayed on the screen as well.

Test Sites and Procedures

Table 1 shows the beta-test locations of the ten yield monitor systems. Different organizations were chosen to be involved in the test so that the different objectives of the project could be met. Research institutions (such as University of Georgia at Tifton, USDA-ARS at Lubbock, TX, and MSU's Delta Research and Extension Center at Stoneville, MS) usually harvest small experimental fields/plots, because they have the resources to do meticulous work such as weighing every harvested load to evaluate the accuracy of the system. On the other hand, producers do not like spending time weighing many loads to evaluate a system's accuracy, but they have larger acreages to harvest, which is ideal for testing a system's reliability.

Accuracy was evaluated on a per-load basis for beta test systems 1, 3, and 4. Each basket load was weighed with a boll buggy either equipped with a load-cell weighing system or resting on truck scales (Model PT300, Intercomp). A data file was created within the yield monitor system to store sensor output data corresponding to each basket load, so that cotton weight could be calculated by the cotton yield monitor. System accuracy was evaluated by comparing the calculated weight with the scale weight of each basket load. The seven remaining beta test systems (2, 5, 6, 7, 8, 9, and 10) were used mainly to test the system's reliability, ease of installation, operation, and maintenance under commercial operation conditions.

Since the cotton-flow sensor used during the 2002 harvesting season was the same as in the 2001 tests, the 2002 installation method was similar to that of the 2001 tests and reported previously by Thomasson et al. (2002). On a picker, the yield monitor's two sensors were installed in the middle section of two ducts (Figure 5), while on a stripper, the two sensors were installed at appropriate locations on the collective chute (Figure 6). For each sensor installation, only one 3-in. diameter hole was required to be cut in the duct or chute (Figure 7). In a picker, the hole was made at the bottom of the duct, while in a stripper, the hole was cut at the back side of the chute. The data acquisition box (Figure 8) and the pocket PC with Navman sleeve or expansion pack (Figure 9) were installed in the harvester's cab. The data acquisition box was mounted on a wall inside the harvester's cab. Each sensor was connected to the data acquisition box through a 25-ft long cable. The iPAQ pocket PC, with Navman sleeve or expansion pack, was affixed in the cab through a bracket specially designed for the iPAQ pocket PC (Figure 9). The antenna of the DGPS receiver was mounted atop the cab, and the receiver's output was connected to the data acquisition box so that location information could be collected.

Data Post-Correction Method

A cotton yield monitor's accuracy is closely related to the method used for calibration and data processing. Research results have indicated that cotton yield monitors should be calibrated in each field to maintain high accuracy (Sui and Thomasson, 2001; Rains et. al., 2002; Wilkerson et. al., 2002). In an actual production situation, however, producers are usually unwilling to devote much time to calibration. Most producers will calibrate the system only once at the beginning of the harvesting season, which will result in higher error as other fields with different conditions are subsequently harvested. Thus, a more practical method for processing the yield data needs to be developed.

Since 2001, a method for post-processing the yield data has been recommended for data obtained with the Mississippi cotton yield monitor (Thomasson, et. al., 2002). This method uses the total field weight as measured at the gin, and the integrated sensor output for the field, to calculate a ratio of cotton weight to sensor output, which is known as the calibration coefficient. Then yield at each field location is calculated with the calibration coefficient prior to generating final yield maps for a field. This yield data post-correction method is the most accurate one for producing yield maps, and it is also practical in light of recent experience in a commercial setting. This method requires good record keeping and a small amount of data processing after harvest, and it does not provide for accurate yield output in real time, which some producers wish to see. An option that can be incorporated with post-processing is to develop an estimated calibration coefficient by weighing a few basket loads in the field at the beginning of the season, and using the weights to calculate a real-time calibration coefficient. Adopting this option allows the producer to have a display of estimated yield in real time, and a significantly more accurate measurement of yield after post-correction. During the 2002 cotton harvesting season, the beta test involved the post-correction method in processing data from all ten Mississippi cotton yield monitor systems.

Results

Accuracy Test

Results of the load-by-load tests are given in Table 2. The tests in Lubbock are not yet complete, so the data shown include only results obtained in Mississippi and Georgia, which included 18 loads from an experimental field with various experimental plots in Mississippi, and 24 loads from three fields in Georgia. The maximum error over all 42 loads was 12%, and average absolute error was 3.8%. Of all the loads, 67% had an absolute error less than 5%, and 95% had an error less than 10%. These results were consistent with those obtained from the tests in 2001 (Sui and Thomasson, 2002b). Figure 10 is a plot of the cotton weight determined by the cotton yield monitor versus the weight measured by scale. There was a very strong correlation between the monitor weight and the scale weight (R^2=0.99).

Reliability
No hardware failures were observed during testing. Both the cotton flow sensor and data acquisition box performed well under commercial harvesting operations. One minor hardware issue occurred: early in the testing period, it became a challenge to properly affix the iPAQ pocket PC in the cab. The suction mount supplied with the Navman GPS receiver was inadequate in rough conditions to hold the iPAQ pocket PC and the GPS expansion sleeve. This was solved by adopting a mount with a vacuum-suction cup attached to a snap-in molded case with a clip to hold the bottom cable securely in the iPAQ (Figure 9).

Based on feedback from users, the software for the Mississippi cotton yield monitor system was upgraded twice during the tests to make it more practical and user friendly. The function to display "instant yield," "average yield," and "harvested acreage" was added as a supplement to displaying the on-the-go yield map in color. Test results demonstrated that the latest version of the software performed as expected.

Installation and Maintenance
Because of its novel design with respect to all other commercially available cotton yield monitors, an important advantage of the Mississippi cotton yield monitor is ease of installation. Only one hole was required to be cut in a duct or chute for installing each cotton-flow sensor (Figure 7). About 15 minutes were required for one person to install one sensor, and the entire Mississippi cotton yield monitor system, including two sensors and all other components, could be installed by one person in less than two hours.

The only routine maintenance required for the Mississippi cotton yield monitor system was to clean its cotton-flow sensor once per day, a process that takes less than three minutes per sensor and can be done during the harvester's routine maintenance in the morning before harvesting. Sensors will continue to operate even if not maintained properly, but as small amounts of residue build up on the surfaces over time, system sensitivity will decline, necessitating this requirement. There is also a requirement to power on the yield monitor 20 minutes prior to harvest. This is also easily done during routine maintenance in the morning before harvesting.

Yield Maps
Many cotton yield maps have been created from data collected with the Mississippi cotton yield monitors during the beta test. Four of them are presented as Figures 11 through 14. The field shown in Figure 11 was about 300 acres in size, and its average yield in 2002 was 953 lbs of lint cotton per acre. Researchers have been conducting several projects in this field, and the yield information from the Mississippi cotton yield monitor has been used as a principal input for their research. In Figure 12 several high-yield zones with a rectangular shape can be observed in the upper-middle of the field. These zones related to plots in which researchers from MSU conducted unrelated experiments, and it is apparent that the yield monitor data delineate their effects quite well. Yield from one of the fields used in Georgia is shown in Figure 13. A great deal of yield variation was evident in this 139-acre field. The average yield was 1778 lbs of seed cotton per acre. The other yield map (Figure 14) presented here is from one of the test fields in Alabama. A gradual change in yield from west to east is evident across this 45-acre field. This observation is a good example of the value of an accurate yield map in drawing a producer's attention to a possibly manageable problem. In general, all of the yield maps generated in the beta test realistically exhibited the yield variations within the field, according to producers' and consultants' expectations regarding information such as soil type, soil moisture, soil fertility, etc. Furthermore, yield maps were of similarly high quality from both picker-type and stripper-type harvesters.

Summary and Discussion

Summary
Three years' of design, fabrication, testing, and modification of the Mississippi cotton yield monitor gave very promising results leading up to 2002. In 2001, Mississippi State University and AIM signed a licensing option agreement to prepare for the eventual manufacture and marketing of the Mississippi cotton yield monitor. Research towards commercialization was conducted in 2002. During this beta test, ten prototypes of Mississippi cotton yield monitor were built and extensively tested on both cotton pickers and strippers at commercial and research farms. During testing, the system's accuracy was evaluated on a load-by-load basis, and its reliability was tested under extensive commercial harvesting conditions and all ten systems performed well. Installation, maintenance and operation were simple and no hardware problems were experienced. The average error of the system was 3.8%. Cotton yield maps created with data collected from the monitors realistically exhibited yield variations within the fields. Evaluators' suggestions mainly related to the software performance will be properly addressed in the commercial version of Mississippi cotton yield monitor.

Discussion
Obtaining user feedback was a very important part of the beta test. Valuable comments and suggestions about the Mississippi cotton yield monitor were received from the users, and most relate to system software. Some of these are given here:

1. On-the-go yield maps may not be necessary. If maintained, auto-scaling to the field size would be helpful.
2. Display needs to provide some indication that system is working.

3. Display needs to indicate the number of the field currently being harvested.
4. Filename editing capabilities would be helpful.
5. Some provision should be made for adjusting swath width on the go.
6. It would be helpful if the software maintained parameter entries from previous fields, allowing the operator to change them only as necessary, rather than having to enter them anew in each field.
7. It would be helpful to have an automated procedure for post-correcting field data.
8. Field calibration should be made simpler, with the ability to allow weights to be collected and entered at any time.
9. It would be helpful to have the yield monitor power on for warm-up automatically when the picker starts; this would remove the requirement for the operator to remember this item during morning maintenance. Also, some indication of progress during the warm-up period would be helpful to the operator.

Disclaimer
Mention of a commercial product in this manuscript is solely for the purpose of providing specific information and should not be construed as a product endorsement by the authors or the institutions with which the authors are affiliated.

Acknowledgements

The authors would like to extend special thanks to the following people for their help in this research project:

Mr. Alan Brashears, Cotton Production and Processing Unit, USDA-ARS, Lubbock, TX.
Mr. Patrick English, Delta Research and Extension Center, Mississippi State University, Stoneville, MS.
Mr. Rick Parsons, Fewell Planting Co., Vance, MS.
Mr. Sirmon, Sirmon Farm, Orange Beach, AL.
Ms. Debbie Waters, Innovative Crop Technologies, Tifton, GA.

This project was funded by Mississippi Space Commerce Initiative (MSCI).

This manuscript was approved for publication by Mississippi Agricultural and Forestry Experiment Station (Approval No. PS10275).

References

Durrence, J. S., C. D. Perry, G. Vellidis, D. L. Thomas, and C. K. Kvien. 1998. Evaluation of commercially available cotton yield monitors in Georgia field conditions. ASAE Paper No. 983106. St. Joseph, Mich.: ASAE.

Myers, A. 2000. The AgLeader Technology cotton yield monitor system. In *Proc. Beltwide Cotton Conf.*, P. Dugger and D. Richter, eds., 90-93. Memphis, Tenn.: Nat. Cotton Council Am.

Perry, C. D., G. Vellidis, N. Wells and C. Kvien. Simultaneous evaluation of multiple commercial yield monitors in Georgia. 2001. In: *Proc. Beltwide Cotton Conf.*, D. A. Richter ed., 328-339. Memphis, Tenn.: National Cotton Council of America.

Roades, J. P., A. D. Beck, and S. W. Searcy. 2000. Cotton yield mapping: Texas experiences in 1999. In: *Proc. Beltwide Cotton Conf.*, D. A. Richter ed., 404-408. Memphis, Tenn.: Nat. Cotton Council Am.

Sassenrath-Cole, G. F., S. J. Thomson, J. R. Williford, K. B. Hood, J. A. Thomasson, J. Williams, and D. Woodard. 1999. Field testing of cotton yield monitors. In: *Proc. Beltwide Cotton Conf.*, D. A. Richter ed., 364-366. Memphis, Tenn.: Nat. Cotton Council Am.

Sui, R. X., and J. A. Thomasson. 2001. Field testing of Mississippi State University cotton yield monitor. In: *Proc. Beltwide Cotton Conf.*, D. A. Richter ed., 339-342. Memphis, Tenn.: Nat. Cotton Council Am.

Sui, R., and J. A. Thomasson. 2002a. Test of temperature and stray-light effects on mass-flow sensor for cotton yield monitor. *Applied Eng. Agric.* 18(4):127-132.

Sui, R., and J. A. Thomasson. 2002b. Mississippi cotton yield monitor: three years of field-test results. In *Proc. 6th Int. Conf. Precision Agric.* Bloomington, Minn.: Univ. of Minn. Precision Agric. Center

Thomasson, J. A., R. Sui, C. D. Perry, G. Vellidis, and G. Rains. 2002. Mississippi yield monitor: performance in on-farm testing. In *Proc. Beltwide Cotton Conf.*, P. Dugger and D. Richter, eds. (in press). Memphis, Tenn.: Nat. Cotton Council Am.

Thomasson, J. A., D. A. Pennington, H. C. Pringle, E. P. Columbus, S. J. Thomson, and R. K. Byler. 1999. Cotton mass flow measurement: experiments with two optical devices. *Applied Engineering in Agric.* 15(1):11-17.

Thomasson, J. A., and R. X. Sui. 2000. Advanced optical cotton yield monitor. In: *Proc. Beltwide Cotton Conf.*, D. A. Richter ed., 408-410. Memphis, Tenn.: Nat. Cotton Council Am.

Wilkerson, J. B., J. S. Kirby, W. E. Hart, and A. R. Womac. 1994. Real-time cotton flow sensor. ASAE Paper No. 941054. St. Joseph, Mich.: ASAE.

Wilkerson, J. B., F. H. Moody, and W. E. Hart. 2002. Implementation and field evaluation of a cotton yield monitor. *Appl. Eng. Agric*. 18(2):153-159.

Wolak, F. J., A. Khalilian, R. B. Dodd, Y. J. Han, M. Keshlkin, R. M. Lippert, and W. Hair. 1999. Cotton yield monitor evaluation, South Carolina – year 2. In: *Proc. Beltwide Cotton Conf.*, D. A. Richter ed., 361-364. Memphis, Tenn.: Nat. Cotton Council Am.

Table 1. Distribution of the ten monitor systems for beta test.

Monitor No.	Evaluator	Location	GPS	Harvester
1	University of Georgia	Tifton, GA	external	John Deere picker
2	University of Georgia	Tifton, GA	external	John Deere picker
3	MSU	Stoneville, MS	Navman	John Deere picker
4	USDA-ARS	Lubbock, TX	external	John Deere stripper
5	Innovative Crop Tech.	Tifton, GA	external	John Deere stripper
6	Innovative Crop Tech.	Tifton, GA	external	John Deere stripper
7	Commercial producer	Vance, MS	external	John Deere picker
8	Commercial producer	Orange Beach, AL	Navman	John Deere picker
9	AIM	Sumner, MS	Navman	John Deere stripper
10	AIM	Sumner, MS	Navman	John Deere stripper

Table 2. Results of test based on load weight.

Load No.	Location	Scale Weight (lb)	Monitor Weight (lb)	Error (%)
1	Lott's field, GA	3745	3871	3.4
2	Lott's field, GA	4330	4604	6.3
3	Lott's field, GA	4185	4340	3.7
4	Lott's field, GA	3840	3779	-1.6
5	Lott's field, GA	3800	3344	-12.0
6	Lott's field, GA	760	721	-5.1
7	Carter's field, GA	3660	3586	-2.0
8	Carter's field, GA	2580	2431	-5.8
9	Carter's field, GA	2630	2681	1.9
10	Carter's field, GA	2850	3038	6.6
11	Carter's field, GA	3005	2967	-1.3
12	Carter's field, GA	4220	4218	0
13	Carter's field, GA	2650	2752	3.8
14	Carter's field, GA	3270	3193	-2.4
15	Perry's field, GA	4385	4062	-7.4
16	Perry's field, GA	4325	4221	-2.4
17	Perry's field, GA	4560	4551	-0.2
18	Perry's field, GA	5015	5604	11.7
19	Perry's field, GA	2555	2754	7.8
20	Perry's field, GA	3310	3020	-8.8
21	Perry's field, GA	2535	2626	3.6
22	Perry's field, GA	2420	2392	-1.2
23	Perry's field, GA	2310	2190	-5.2
24	Perry's field, GA	2185	2180	-0.2
25	Exp. Plots, MS	1600	1728	8.0
26	Exp. Plots, MS	1350	1239	-8.2
27	Exp. Plots, MS	685	677	-1.2
28	Exp. Plots, MS	680	673	-1.0
29	Exp. Plots, MS	645	616	-4.5
30	Exp. Plots, MS	600	623	3.8
31	Exp. Plots, MS	635	629	-0.9
32	Exp. Plots, MS	595	605	1.7
33	Exp. Plots, MS	175	175	0
34	Exp. Plots, MS	2285	2280	-0.2
35	Exp. Plots, MS	1955	1900	-2.8
36	Exp. Plots, MS	665	673	1.2
37	Exp. Plots, MS	725	717	-1.1
38	Exp. Plots, MS	625	679	8.6
39	Exp. Plots, MS	605	607	0.3
40	Exp. Plots, MS	630	638	1.3
41	Exp. Plots, MS	410	378	-7.8
42	Exp. Plots, MS	1630	1658	1.7

Average absolute error for all loads: 3.8%.

Figure 1. Mississippi cotton-flow sensor.

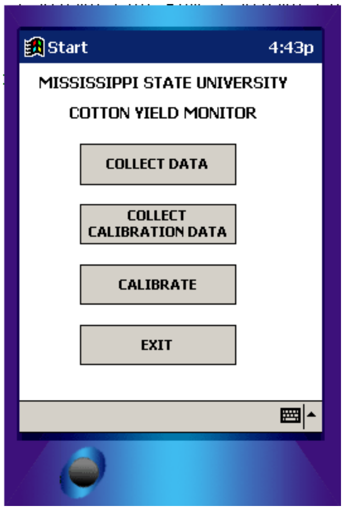

Figure 2. Display screen of Mississippi cotton yield monitor.

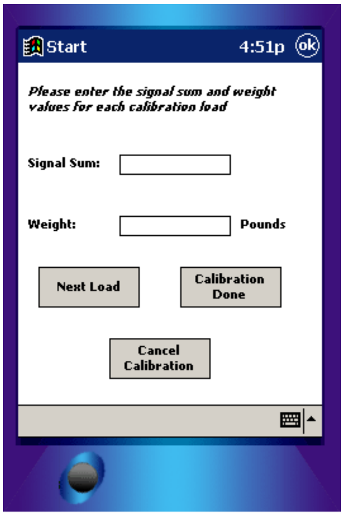

Figure 3. Screen for system calibration.

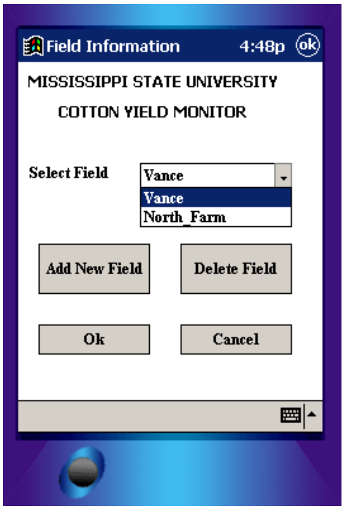

Figure 4. Screen of Setting up for yield data collection.

Figure 5. Mississippi cotton-flow sensor installed on a cotton picker.

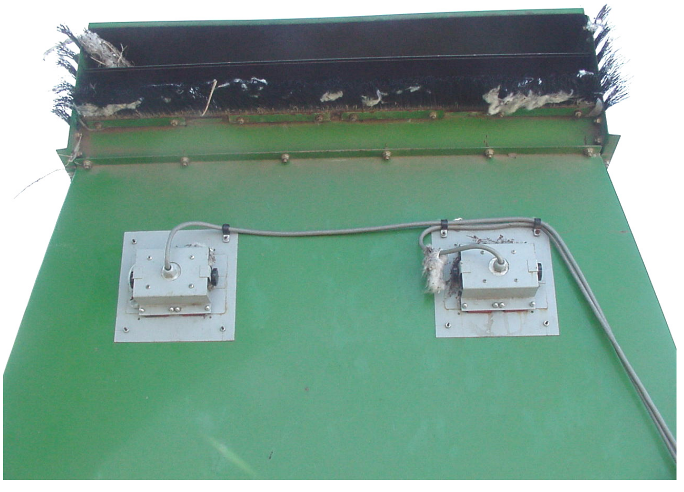

Figure 6. Mississippi cotton-flow sensor installed on a cotton stripper.

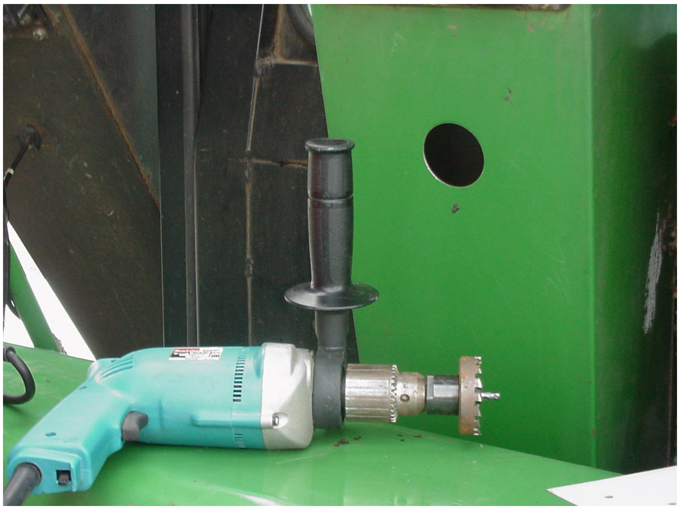

Figure 7. One hole was cut for installing one Mississippi cotton-flow sensor.

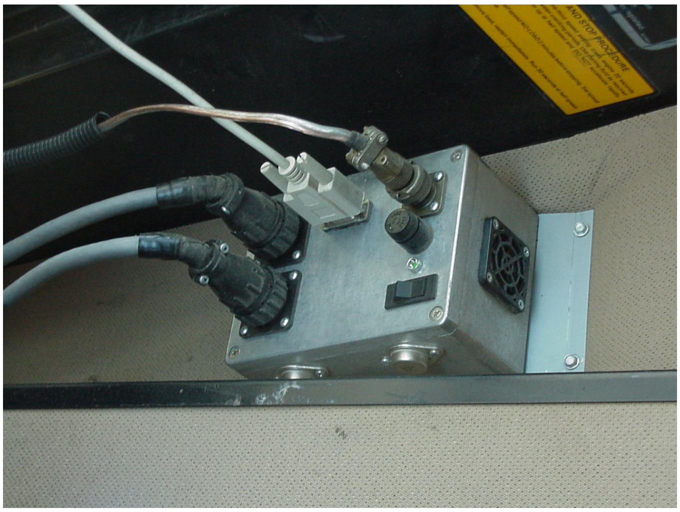

Figure 8. Data acquisition box installed in cab

Figure 9. The iPAQ pocket PC with Navman GPS receiver installed in cab

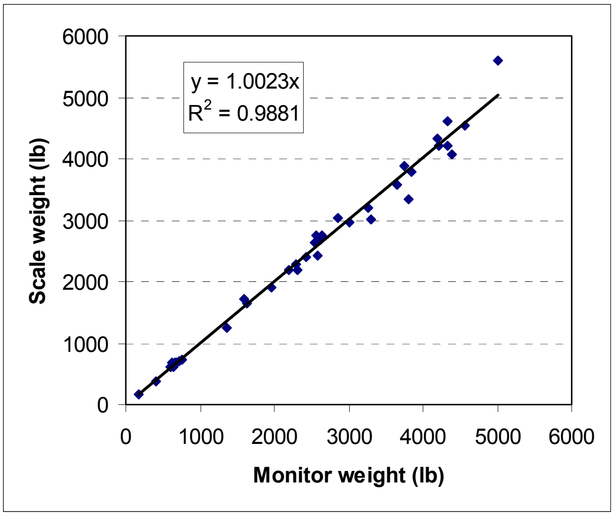

Figure 10. Correlation between the yield monitor weight and the scale weight.

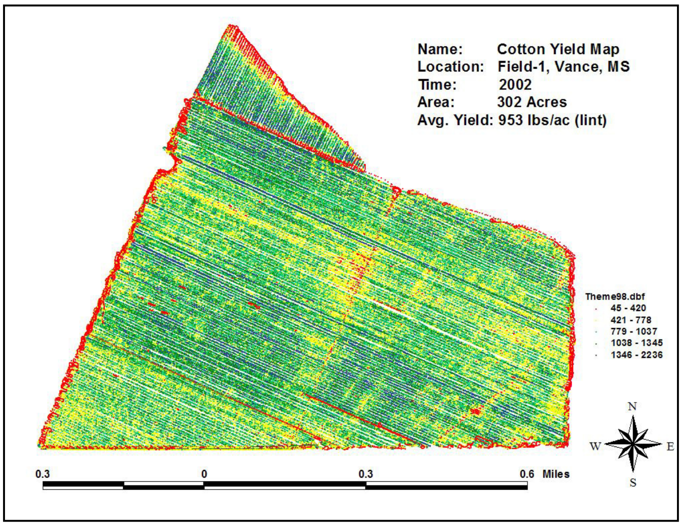

Figure 11. Cotton yield map of commercial field in Mississippi.

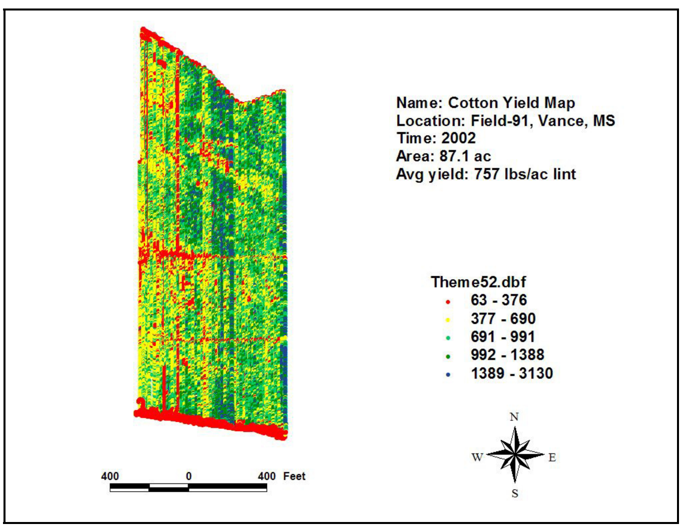

Figure 12. Cotton yield map of commercial field in Mississippi.

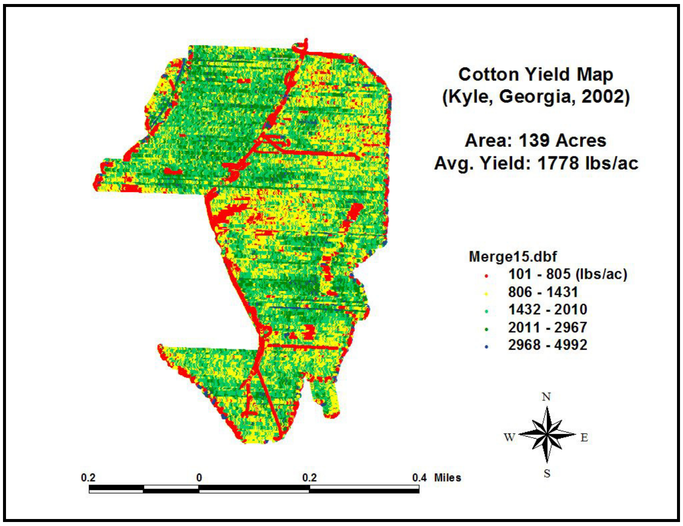

Figure 13. Cotton yield map of commercial field in Georgia.

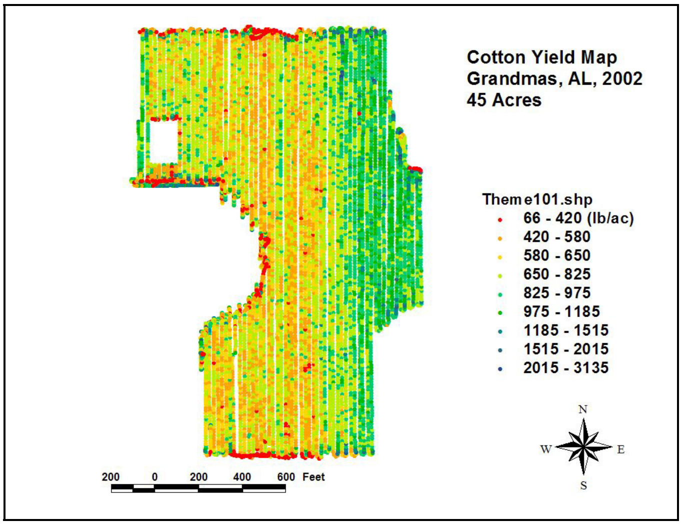

Figure 14. Cotton yield map of commercial field in Alabama.