## SIMULTANEOUS EVALUATION OF MULTIPLE COMMERCIAL YIELD MONITORS IN GEORGIA

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### Abstract

Three commercially-available cotton yield monitors were tested in five grower-owned fields in south Georgia during the 2000 harvest season. Each harvested load was weighed and compared to the three yield monitors. Yield maps from each yield monitor were also produced by the respective software packages and compared. Feature comparisons of each monitor were included.

### Introduction

As reported in previous Beltwide proceedings, there is a great need for a reliable, accurate cotton yield monitor due to increased interest in precision farming by growers (Searcy and Roades (1998), Valco et al. (1998), Durrence et al. (1999), Sassenrath-Cole et al. (1999)). This interest in precision farming techniques has been piqued by the need for increased efficiencies in production agriculture. Precision farming offers the grower new tools to aid in the decision-making process all growers face yearly. However, the absence of a reliable cotton yield monitor has hampered the efforts of these growers.

Since 1997, the Precision Farming Team at the University of Georgia Tifton Campus has been evaluating cotton yield monitors - both commercially-available as well as prototype systems. In 1997, yield monitors from Zycom Corp. (Bedford, MA) and Micro-Trak Systems (Eagle Lake, MN) were purchased and installed on a typical four row picker (John Deere 9965) with sensors on all four air ducts. Both of these systems used optical sensors to detect cotton flow. In 1997 and 1998, the Zycom and Micro-Trak systems were evaluated by harvesting several hundred acres of grower-owned cotton in south Georgia (Durrence et al. (1998), Perry et al. (1998), Durrence et al. (1999)). In 1999, Computronics, a Bentley, Western Australia firm, developed a cotton yield monitoring system - also optical based. A beta version of this system (called FarmScan) was added to the picker alongside the Zycom and Micro-Trak systems previously installed. The FarmScan system required sensors on only two of the four air ducts. During the 1999 season, approximately 200 acres were harvested and mapped with the three systems. Results indicated that the Zycom system maintained the best accuracy during harvest followed by FarmScan and then Micro-Trak. Both FarmScan and Micro-Trak showed problems with day to day variability, blocked sensors, failure to maintain calibration and poor accuracy (as compared to actual dump weights).

For the 2000 season, another new cotton yield sensor came on the market. AgLeader (Ames, IA) began manufacturing a cotton yield sensor (optical based) under license from Case Corporation (Racine, WI). The cotton sensor interfaced to AgLeader's PF3000 console to provide a complete cotton yield monitoring system. However, the 2000 AgLeader system was offered only for Case pickers. The Precision Farming Team was able to obtain a system to be installed on the Team's John Deere 9965 picker on a "research" basis. This system, like the FarmScan, required sensors on only two of the four air ducts. It is unclear if patent restrictions or lack of thorough testing on John Deere models prevented AgLeader from offering the sensors for the Deere pickers. Also new for 2000 were redesigned FarmScan flow sensors and updated Zycom flow sensors.

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Prior to the 2000 harvest, the Team evaluated the current status of the Zycom (now Agriplan, Inc., Stow, MA), Micro-Trak, and FarmScan cotton yield monitors. It was evident that Zycom and FarmScan had made upgrades available for their respective systems. Micro-Trak apparently had made no significant changes since the Team last updated the installed Micro-Trak system in 1998. Therefore it was decided that in 2000 the Team would harvest and map with AgLeader, FarmScan and Zycom systems.

This report provides results of the Team's simultaneous field testing of the AgLeader, Computronics/FarmScan, and Agriplan/Zycom cotton yield monitors during the 2000 harvest season in south Georgia. The unique ability to simultaneously operate all three yield monitors on the same picker allowed for direct comparisons of the three systems over the same harvest areas. Typical field maps as well as data will be compared.

### System Description/Installation

**AgLeader**

The AgLeader cotton yield monitor consisted of the following parts: PF3000 console, two pairs of flow sensors, head height switch, GPS input, fan speed input, ground speed input, power input and wiring harness. The standard PF3000 console (Figure 1) required installation of new cotton firmware by AgLeader. This prevented the user from operating the console with grain. This limitation may be addressed in future releases of the firmware. The cotton firmware provided the user with bales and pounds rather than bushels and pounds. The console was mounted on the driver's left, above the left window. The console allowed the operator to view harvest variables such as current yield, total load, current ground speed, area harvested, etc., to select Field and Load identifiers, to set system settings, and to perform system diagnostics. The console stored data on a standard Flash (or compact flash with adapter) PCMCIA data card. The AgLeader console had membrane function buttons and a multi-line, back lit LCD display for good "readability".

The AgLeader system provided wiring connections to tap into the 9965's fan speed sensor and ground speed sensor. A power connection tapped into the power point on the front of the picker's control panel. This provided switched power to the console as well as flow sensors. A head height switch was mounted underneath the operator's platform. This switch consisted of a sensor/switch mounted in a bracket, a piece of threaded rod, and a chain/spring combination. The chain/spring was connected to the picker head and then to the end of the threaded rod which was mounted to the sensor/switch such that the sensor/switch was rotated whenever the head moved up or down. Settings in the firmware indicated to the console whenever the head was in the "picking" position.

A Trimble AgGPS 114 DGPS receiver was mounted just above the front light bar on the picker. The AgGPS 114 has both 12 channel GPS and L-band satellite differential in a single package and provides submeter accuracy. The AgGPS 114 provides two separate, programmable, simultaneous outputs via two connectors. Since the FarmScan and the AgLeader systems required different GPS strings, one output was configured for each system. The AgLeader required a special cable to interface the Trimble signal to the PF3000.

The AgLeader flow sensors, shown in Figure 2, consisted of emitter/receiver pairs each with five sensor "eyes". Each sensor housing was attached to a bracket that in turn was mounted to the picker air duct. The sensors attached to the brackets with two thumb screws for easy sensor inspection and/or cleaning after installation.

As mentioned above, the AgLeader system required only two air ducts be instrumented with flow sensor pairs. The Team installed the AgLeader flow sensors on ducts one and three (starting with the air duct on the driver's left as one) so that two adjacent rows would usually not be monitored. Each sensor was installed near the midpoint of the upper section of air duct (Figure 3). Prior to installation, the Team purchased four new air ducts for the 9965 picker. During previous testing (1997 through 1999), the original air ducts had been modified extensively such that they no longer were representative of "standard" picker ducts. The sensor installation required cutting a 8 in by 3.75 in rectangular hole in each side of the air duct. AgLeader provided templates to aid in this installation. Once the hole was cut and smoothed, the sensor mounting bracket was bolted to the air duct over the cut hole.

The AgLeader SMS Basic version 1.00 software was installed to process the yield data. The SMS software provided for mapping, archiving, report generation, etc. Currently, the AgLeader system for a Case picker with two ducts monitored would cost approximately **$5000 US** without GPS and without the SMS software (available at extra cost).

**Agriplan/Zycom**

The Zycom system used in 2000 was nearly identical to systems used in 1998 and 1999 and reported earlier (Durrence et al. (1999)). The company did provide new sensors which were identical in form but apparently had upgraded circuitry.

The Zycom yield monitoring system consisted of an Agriplan 600 user interface console, two pairs of flow sensors, GPS receiver, GPS input, power input, and wiring harness. The console (shown in Figure 4) had three toggle switches and a three window, single line LED display. The console provided limited information during harvest: current yield, total pounds, acres harvested and field identifier. Field identifiers could be changed but the console offered no way to separate loads. The console allowed the user to set various system parameters and provided GPS and sensor diagnostics. The console stored data on a standard 4M linear Flash memory card. The Zycom console was mounted to the operator's right and above the side window. The Zycom system relied on GPS for ground speed thus eliminating the need for a speed sensor. The system used proprietary logic to determine when harvest was occurring (apparently by detecting the presence of cotton passing by the sensors) thereby eliminating the need for a head height switch.

The Zycom system provided an 8 channel GPS receiver but required an RTCM correction signal from another source. The Team mounted the GPS receiver on the front light bar (opposite from the Trimble receiver described above). An Omnistar OS7000 C-band DGPS unit was used to provide the correction signal (via custom wiring and connections) and was mounted on the top front of the picker basket.

The Zycom flow sensors (Figure 5) consisted of emitter/receiver pairs each with three sensor "eyes" in a triangle pattern. Each sensor housing was permanently attached to a bracket that in turn was mounted to the picker air duct. The sensors were attached to the brackets with a hinge such that the sensor housing could be rotated away from the bracket for easy sensor inspection and/or cleaning after installation. The sensor installation required cutting a 3 in by 5 in rectangular hole in each side (front/rear) of air ducts two and four. Once the hole was cut and smoothed, the sensor mounting bracket was attached to the air duct over the cut hole using a lip and bolt.

Agriplan version 2.1.2 software was installed to process and map the yield data. The software was also required to initialize/format the PCMCIA data cards. The cost for an Agriplan/Zycom system varies greatly depending on a number of variables such as "model, number of ducts, and other options". Currently, a system for a picker with two ducts monitored would cost approximately **$7000 US** with Zycom GPS and software but without differential signal.

**Computronics/FarmScan**

The FarmScan system consisted of a Canlink 3000 CYM console (Figure 6), two pairs of flow sensors, GPS input, power input, and wiring harness. The console hardware was unchanged from 1999, but the firmware was much improved - added an option for English/U.S. units, moved or removed several features that were in cumbersome locations in the firmware screens, and added ability to read larger data cards. The console allowed the operator to view harvest variables such as current yield, total load, current ground speed, area harvested, etc., to select Field identifiers (referred to as "trips"), to set system settings, and to perform system diagnostics. Field identifiers could be changed but the console offered no way to separate loads. The console stored data on a standard 2M SRAM PCMCIA data card. The FarmScan console had membrane function buttons and a multi-line, back lit LCD display for good "readability". The console was mounted to the operator's right and above the side window. The FarmScan system can utilize a ground speed sensor, but the Team's system relied on GPS for ground speed thus eliminating the need for a speed sensor. The system also could have accepted an optional head height switch but the Team opted to not use a head switch, instead relying on the "auto hold" feature. However, this feature was not working correctly, therefore, the data was filtered in software later to remove the data values collected when the picker was not actively harvesting crop. However, this was not ideal as the console reported the acres harvested to the user - including the values collected when not harvesting. The Trimble AgGPS 114 (described above) provided NMEA GPS strings to the FarmScan.

The 2000 FarmScan flow sensors were vastly improved over the 1999 models. In 1999, the Team used pre-production models which were prone to malfunctions. The 2000 models (Figure 7) were of much higher quality construction and performed with much fewer malfunctions. The flow sensors contained four emitter/receiver "eyes" housed in a plastic case which was seated in an aluminum bracket. After cutting a 5.67 in by 1.10 in hole in each side (front/rear) of air ducts one and three, the aluminum bracket was placed over the hole and bolted to the air duct. The plastic sensor housing was held in place seated in the aluminum bracket with magnets. A handle mounted to the plastic housing enabled the user to easily remove the sensor for inspection/cleaning.

The Computronics FarmScanDM software was installed to process and map the yield data. The software was also required to initialize/format the PCMCIA data cards. Currently, the Computronics/FarmScan system for a picker with two ducts monitored would cost approximately **$5000 US** without GPS and with software.

## Harvest Sites

To test the yield monitors under a wide variety of conditions, the Team harvested five fields: two fields in Colquitt County, one field in Tift County, and two fields in Coffee County, Georgia. The Colquitt County fields consisted of one irrigated 34 acre field planted in Suregrow 125 "stacked gene" (both Bt and RoundUp ready) variety and a second irrigated field with 15 acres planted in Delta Pearl conventional variety and 9 acres planted in HS12 conventional variety. The fields were harvested over 4 days - November 1st - 3rd and 6th. The Tift County field was non-irrigated 22 acres planted in DP655 "stacked gene" variety. This field was harvested on November 13th and 15th. The Coffee County fields consisted of a 25 acre non-irrigated field planted in DP5690 "RoundUp ready" variety and a 46 acre non-irrigated field planted in Stoneville 4892 "stacked gene" and DP90 "RoundUp ready" varieties. These two fields were harvested December 28th - 30th. Even though it was not planned, the five fields were harvested from highest yield to lowest yield. All the fields except the last were defoliated prior to harvest. Only the part of field 5 with DP90 variety was defoliated. The grower allowed frost to kill the leaves on the rest of the field. However, many leaves remained on the plants which caused much dried plant material to blow around and to accumulate on and around the picker during harvest.

## Harvest Methods

One of the most important steps in yield mapping is yield monitor calibration. Calibration refers to determining the multiplier(s) required to make the sensor reading equal the actual crop weight. An improperly calibrated yield monitor will provide misleading data that will generate invalid yield maps.

In prior years' testing, the Team's goal was to obtain yield maps with the highest possible accuracy. Therefore the Team closely watched the yield monitor weights at each dump of the basket and re-calibrated whenever the yield monitor calibration seemed to be drifting. This effort resulted in accurate yield maps at the expense of a realistic approach to yield mapping - i.e. most operators would not be able to check every load and re-calibrate whenever necessary. For the 2000 harvest, the Team decided to approach the season much like a grower/operator would. This approach would involve a calibration at the beginning of harvest and then using that calibration for the rest of the harvest. All three systems recommended harvesting a minimum of one full picker load for calibration and additional loads to check the calibration. The user could use more than one load for calibration if desired.

Determining actual crop weight in the picker (or combine) usually involves dumping the crop into a wagon and transporting that wagon to a drive-on scale - which may or may not be nearby. This is not a convenient method. The Team wanted a quicker and easier method so a procedure (reported by Durrence et al. (1999)) was developed which involved parking a boll buggy on commercially-available truck scales (Model PT300, Intercomp, Minneapolis , MN ) with 1% accuracy (see Figure 8). Five scales were used to support the four wheels and the tongue of the boll buggy. The boll buggy could be situated stand-alone or next to a trailer or module builder. This setup allowed the picker operator to pull alongside the boll buggy, dump the crop, relay all pertinent yield monitor values (total weight, load weight, acres) to the ground crew, increment any load counters required, and then proceed back to harvest. The ground crew recorded the yield monitor values and recorded the actual weight from the truck scales. The crop could then be dumped into the trailer or module builder. This procedure was used to weigh the crop at every picker dump. For the project results presented in this paper, all crop weights are for seed cotton and not "lint" cotton.

## Results

### Calibration

Prior to beginning harvest in the first grower-owned field, the picker was used to harvest a 3 ac research area. Only the FarmScan and Zycom systems were operational during this harvest. The actual crop weight was determined as described above and this value was used to perform a single-load calibration of both FarmScan and Zycom systems.

Once in the Colquitt County field, the first four loads were harvested and actual weights were compared to yield monitor weights for the three systems. The first four loads were intentionally variable in weight for use in calibration. The AgLeader values differed from the actual values (as expected) as did the FarmScan values (see Table 1) even though a single-load calibration had been done. The AgLeader documentation specified that a single load calibration could be done, but more loads could be used. Having performed calibrations for AgLeader grain yield monitors (where four loads are required), the Team decided to do the same for the AgLeader cotton system and also for the FarmScan system. The Zycom values were inconsistent during these first four loads. This system was monitored and not calibrated until the sixteenth load. The FarmScan was also re-calibrated at the sixteenth load after calculating load values that were consistently below actual crop weight. After these in-field calibrations (once for AgLeader and Zycom, and twice for FarmScan) were performed, no further calibrations were attempted in keeping with the notion of operating much like a grower/operator would.

### Harvest Results

As mentioned above, the Team harvested five grower fields, however, for brevity only results from fields 1, 3, and 4 will be presented.

In the first field (Colquitt County 1 - 34 acres), twenty loads of Suregrow 125 cotton were harvested - 12 on the first day and 8 on the second day. All but one of the loads were weighed with the boll buggy with the one load weight not recorded due to a scale malfunction. Table 2 presents a summary of the Colquitt County 1 harvest. Figures 9 and 10 present the results of the yield monitor comparisons in the first field. The first four loads were used in calibration. From these plots, one can see that the Day 1 Zycom values were quite inconsistent from load to load, as also indicated by the large standard deviation. However, on Day 2 the variation was less but increased during the harvest (following calibration). The Zycom sensors were not cleaned before the Day 2 harvest. On Day 1, the AgLeader system had fairly small errors and over- and under-predicted the actual crop weight. On Day 2, the AgLeader over-predicted the actual weights and the error values began to increase during the harvest. This could be attributed to the sensors becoming dirty and/or scratched as harvest progressed as the AgLeader sensors were not cleaned prior to Day 2 harvest. The FarmScan system was fairly consistent during both days of harvest as indicated by the relatively small standard deviation. The FarmScan system indicated a blocked sensor before Day 2 harvest began so both sets of sensors were wiped clean with a dry cloth.

Figures 11 and 12 illustrate the potential effect of load weight on the measurement error of each system. In both figures, the load weights are sorted and ranked from low (1) to high (20). It appears that load weight had no effect on the error measurement of either of the three systems.

The third field, Tift County 1 (22 acres), was planted with the DP655 variety and yielded nine loads of crop. During this harvest, only the first 5 scale weights were recorded. Table 3 and Figures 13 and 14 indicate the results from the harvest. All three systems' sensors were wiped clean prior to beginning harvest. However, only FarmScan was cleaned before the second day of harvest (system indicated a blocked sensor). The plots reflect consistent readings from all three systems. The FarmScan, though under-predicting the actual crop weight, exhibited the most consistent readings with a standard deviation of less than one for the five loads compared. Both AgLeader and Zycom had low standard deviations (less than 3) for the five loads. Zycom had the most accurate readings for the loads followed by FarmScan. The three systems exhibited similar trends during the second day of harvest even though scale weights were not available. It should be noted that the yield in non-irrigated Tift County 1 was even lower than the previous two fields (approximately 1800 lb/ac). Again, no relationship between load size and error value was apparent in either of the three systems.

The fourth field, referred to as Coffee County 1 (25 ac), yielded 9 loads of cotton for an overall average yield of about 1550 lb/ac. As mentioned earlier, the grower planted DP5690 variety. The results from this harvest are presented in Table 4 and Figures 15 and 16. All sensors were cleaned prior to this harvest. In Figure 16, it appears that the Zycom system errors decreased as harvest proceeded, first under-predicting and then oscillating around the 0% error line. The AgLeader was fairly consistent in its over-prediction of actual weights with the lowest standard deviation of the three systems. FarmScan was similar in its consistency of under-predicting the actual load weights. Once again, no pattern emerged between any of the systems and load weight size.

**Yield Maps**

The load to load comparisons of the three systems are useful for determining monitor performance. However, this analysis does not indicate the spatial yield accuracy of the systems. To investigate the spatial accuracy, yield maps were created from the harvest data by using each yield monitor's respective software package. For brevity in this report, only yield maps of fields 1, 3, and 4 from each system are presented.

Figures 17, 18, and 19 are the yield maps from the AgLeader, FarmScan and Zycom systems of the Colquitt County 1 field. The first thing the reader notices when viewing the 3 images is the shape of the field being different for the FarmScan system. It appears that the FarmScan software is slightly distorting the yield map image. This distortion could be the result of a "bug" in the software code that processes and plots the GPS coordinates but this has not been verified by the company as of this writing. Beyond the image size, the 3 maps reflect the responsiveness of the yield monitors to changing yield levels in the field. Both AgLeader and Zycom were able to detect (and plot) changes as abrupt as the picker crossing a center pivot tire path, but FarmScan did not exhibit quite that much responsiveness.

All three systems exhibited the ability to detect less abrupt yield changes. When the data in Table 2 is considered, it appears that the Zycom system is exhibiting much more "noise" than the other two systems. The table also suggests that the FarmScan yield map should be the most reflective of actual field conditions. However, AgLeader and Zycom were better able to sense a known low yielding region midway between the pivot point and the northern edge of the field. This discrepancy coupled with the low mean load error and low standard deviation for FarmScan suggests that this system may be performing more "averaging" or "smoothing" of the yield data, thus "smoothing" the data in this region. It should be noted that all the yield maps are actual maps created by the individual software packages and each package uses different plotting techniques, pixel sizes, etc. The authors may attempt to extract the raw yield data from these maps and plot the data with the Surfer software to attempt to view the data in a less biased manner.

Figures 20, 21, and 22 are the yield maps from the AgLeader, FarmScan and Zycom systems of the Tift County 1 field. Again, the image size is somewhat distorted with the FarmScan system. All three systems had relatively small load to load standard deviations, with FarmScan's being less than one. Yet, in most of this field, each of the three systems projected different relative yield levels - even though each system had the lowest standard deviations of all five fields. However, those statistics were from the first 5 of the 9 loads harvested.

Figures 23, 24, and 25 are the yield maps from the three systems of the Coffee County 1 field. These three maps showed the most similarity in relative yield levels across the field despite each system having fairly large standard deviations. A visual comparison of the three maps verifies the results in Table 4 - FarmScan under-predicted and AgLeader over-predicted while Zycom had the lowest mean load error.

## Summary

Tables 5 and 6 provide a concise summary of the 2000 harvest results. From these two tables, it appears that the AgLeader system over-predicted actual yields as the average yield levels in a field decreased. FarmScan, conversely, trended toward greater under-predictions as yield decreased but had the smallest standard deviation for each field. The Zycom numbers also suggest a trend toward greater under-predictions as yields decreased in the fields. As described earlier, the three systems were calibrated in field 1 and were not re-calibrated during the season.

The changes in accuracy evident in each of the three systems could be the unique response of each system's sensors to an ever changing environment - ranging from heavy cotton flow with little trash to sparse cotton flow with much trash. The accuracy changes experienced with the FarmScan system were verified by another cooperating grower that used an identical FarmScan system on an identical picker. The grower provided anecdotal evidence that the FarmScan accuracy degraded under "trashy/dusty" conditions - evidence that was born out by resulting yield maps.

These results suggest that all three systems might have benefitted from re-calibration in fields where the cotton crop was substantially different from the crop that was used for initial calibration. These differences could be variety, irrigation, yield levels, defoliation, etc. The results from both the grower's harvest as well as the Team's harvest suggest that the FarmScan sensors need to be able to better handle "trashy" and/or dusty harvest conditions.

The three systems tested in 2000 each have positive and negative aspects. Of the three, the Agriplan/Zycom yield monitor has been on the market the longest (since around 1997). The Zycom had the least "user-friendly" user interface console and its documentation was barely adequate. Jumping through options with up/down and left/right toggle switches can be quite a challenge to master. Quite often a section of the LEDs on the user interface failed to work which required cycling power multiple times to remedy. A few other "negatives" for Zycom include not having a straightforward method of calibration (as AgLeader has), occasional failure of sensor "eyes", lack of a "load" parameter, and having to provide a separate RTCM correction signal for the Zycom GPS unit. The "positives" for Zycom include simple installation; lack of need for fan, ground speed or head height sensors; and use of standard linear Flash memory cards. Nevertheless, Agriplan should consider the following suggestions: improved console/interface, improved documentation, more streamlined calibration procedure, less variability from load to load, and accept external DGPS signal instead of requiring RTCM.

The FarmScan used in 2000 was a second generation system. As mentioned earlier, the FarmScan system was the simplest of the three to install - one console, two pairs of sensors, GPS input, and power. The sensors were much improved over the earlier versions used by the Team in 1999. The "user-friendly" user interface console hardware was the same but the firmware was much improved over 1999. The new firmware allowed for English units (pounds and bales), supported larger (2M) memory cards, and redesigned the screen placement of several key functions that were cumbersome in the 1999 version. The documentation provided was adequate for most users. Nevertheless, the FarmScan system had "negatives" in several areas. Some of these negatives were "small" problems and included lack of an automated calibration procedure (like AgLeader), inconsistent trip/file naming, having to "configure" the sensors, lack of "load" feature, and an annoying "load alarm". Other problems were more important and these included use of small capacity non-mainstream memory cards, sensors reporting blocked or failed eyes, sensors becoming covered with foreign material that clings, and the "auto hold" feature not working properly (causing incorrect acres harvested). In addition, the user's manual was unclear concerning whether crop weight values collected prior to a re-calibration were adjusted after changing the calibration factor. Overall, the FarmScan was more consistent (when in less-trashy cotton) than the previous version, but load to load accuracy and sensor design may need addressing by the manufacturer.

The AgLeader cotton yield monitor came on the market in 2000 after considerable university and private testing. The AgLeader company has been producing grain yield monitors for many years and obviously put their experience behind their cotton product. Many growers favor the concept of having a yield monitor console that will work with both cotton and grain crops.

The AgLeader console and sensors are of a quality that surpasses the Zycom and FarmScan. The console has a logical layout of functions, offers diagnostic functions, and can display many different parameters. Calibration is much more automated than the other two monitors. An important distinction for the AgLeader is the ability to divide a harvest into one or more loads (which ties in with the calibration method) as well as fields. The system stores data on commonly available Flash memory cards which come in many different capacities. The end user documentation is very thorough. The sensors were checked and cleaned at various times throughout the harvest season but never had any significant foreign material build-up. Another important "positive" for the AgLeader is the availability of technical support for the system. Such support is less available for the other two systems.

However, like the other two systems tested, the AgLeader had some "negatives". Installation of the AgLeader system was the most involved of the three. A typical AgLeader system required the console, two pairs of sensors, cable to the picker speed sensor, cable to the picker fan speed sensor, head height sensor, GPS, and power. Both the head height and ground speed sensors required calibration. AgLeader should also modify the firmware so that the PF3000 console could be used for grain or cotton without the need for factory modifications. Another point to consider: FarmScan and Zycom provide mapping software with the yield monitor but AgLeader does not. Finally, AgLeader should proceed with making the cotton yield monitor available for John Deere pickers.

Each of these yield monitoring systems have something to offer the grower interested in creating yield maps. Either system will most likely be able to produce an adequate yield map provided the system is properly calibrated and maintained. In order for a grower to decide which system to use, several attributes should be evaluated: quality of the product, "user-friendliness", ease of installation, availability of a GPS receiver, level of technical support required, skill level of picker operator, and time available for downloading data files.

***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 ones not mentioned.

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Table 1. Calibration values (Percent Errors) for FarmScan and AgLeader - calibrated during first field harvest.

| | Before Calib. | | | After Calib. | | |
|---|---|---|---|---|---|---|
| **Load** | **AgL** | **FarmS** | **Zyc** | **AgL** | **FarmS** | **Zyc** |
| 1 | 42.23 | 37.60 | 16.42 | 0.89 | 1.04 | n/a |
| 2 | 37.89 | 36.22 | 0.30 | -1.86 | 0.03 | n/a |
| 3 | 41.81 | 35.43 | 2.05 | 0.22 | -0.56 | n/a |
| 4 | 40.79 | 34.29 | 10.23 | -0.50 | -1.40 | n/a |

Table 2. Harvest summary statistics for the first harvested field.

| | **Scale** | **AgLeader** | **FarmScan** | **Zycom** |
|---|---|---|---|---|
| Total Yield (lb) | 96080 | 106329 | 95988 | 103232 |
| Area Harvested (ac) | | 34.44 | 41.91 | 35 |
| Mean Yield (lb/ac) | | 3039 | 2632 | 3201 |
| Mean Load Error (%) | | 2.29 | -0.1 | 7.47 |
| Max Load Error (%) | | 11.59 | 5.89 | 24.43 |
| Stand. Dev. (%) | | 4.38 | 2.36 | 7.75 |

Table 3. Harvest summary statistics for the third harvested field.

| | **Scale** | **AgLeader** | **FarmScan** | **Zycom** |
|---|---|---|---|---|
| Total Yield (lb) | 27475 | 29933 | 26604 | 27436 |
| Area Harvested (ac) | | 14.55 | 15.76 | 14.6 |
| Mean Yield (lb/ac) | | 2028 | 1650 | 1875 |
| Mean Load Error (%) | | 9.02 | -3.19 | -0.1 |
| Max Load Error (%) | | 10.94 | -4.29 | 4.27 |
| Stand. Dev. (%) | | 2.03 | 0.95 | 2.92 |

Table 4. Harvest summary statistics for the fourth harvested field.

| | **Scale** | **AgLeader** | **FarmScan** | **Zycom** |
|---|---|---|---|---|
| Total Yield (lb) | 38905 | 43362 | 33460 | 37128 |
| Area Harvested (ac) | | 25.01 | 29.42 | 25 |
| Mean Yield (lb/ac) | | 1703 | 981 | 1487 |
| Mean Load Error (%) | | 11.56 | -14.16 | -4.4 |
| Max Load Error (%) | | 17.25 | -17.61 | -17.95 |
| Stand. Dev. (%) | | 3.79 | 3.81 | 6.59 |

Table 5. Summary statistics for all fields harvested.

| | | Mean Yield (lb/ac) | | |
|---|---|---|---|---|
| **Field** | **Overall Field Avg** | **AgL** | **F** | **Zyc** |
| 1 | 3013 | 3039 | 2632 | 3201 |
| 2 | 2339 | 2326 | 1606 | 2332 |
| 3 | 1800 | 2028 | 1650 | 1875 |
| 4 | 1550 | 1703 | 981 | 1487 |
| 5 | 1023 | 1148 | 642 | 978 |

Table 6. Summary statistics for all fields harvested.

| | Mean Load Error (%) / Stand. Dev. | | |
|---|---|---|---|
| Field | AgL | F | Zyc |
| 1 | 2.29 / 4.38 | -0.10 / 2.36 | 7.47 / 7.75 |
| 2 | 12.31 / 4.28 | -7.25 / 3.06 | 14.47 / 9.93 |
| 3 | 9.02 / 2.03 | -3.19 / 0.95 | -0.10 / 2.92 |
| 4 | 11.56 / 3.79 | -14.16 / 3.81 | -4.40 / 6.59 |
| 5 | 14.34 / 6.34 | -24.78 / 4.50 | -4.24 / 9.62 |
| Season | 9.90 / 9.51 | 8.62 / 7.87 | 9.39 / 6.01 |


Figure 1. AgLeader user interface console.

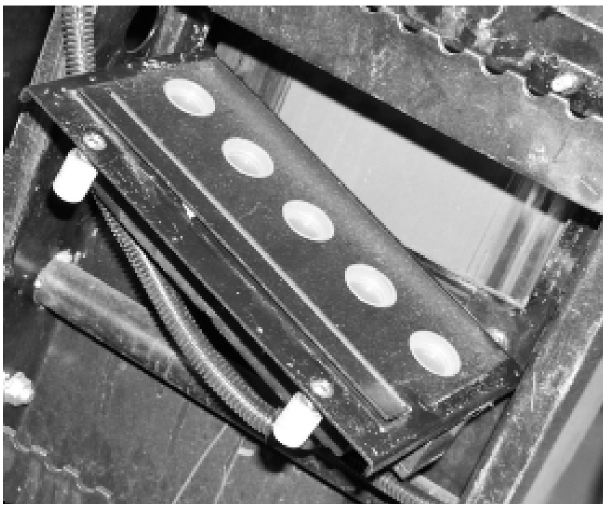

Figure 2. AgLeader sensor detached from duct.

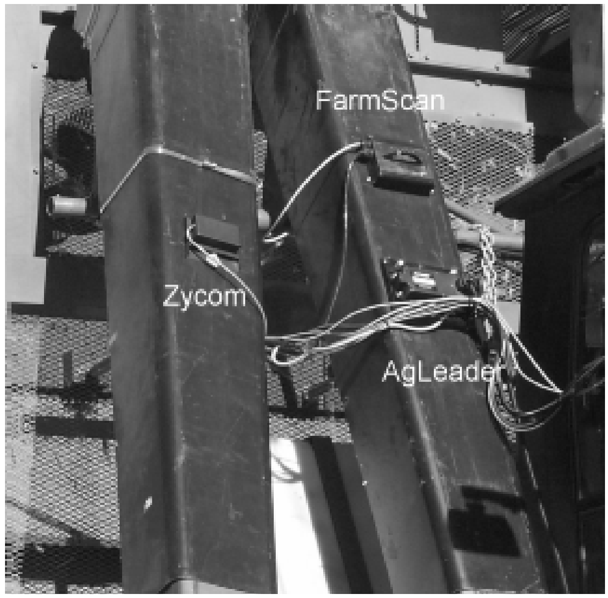


Figure 3. View of all 3 sensors mounted on ducts 3 and 4.


Figure 4. Zycom user interface console.

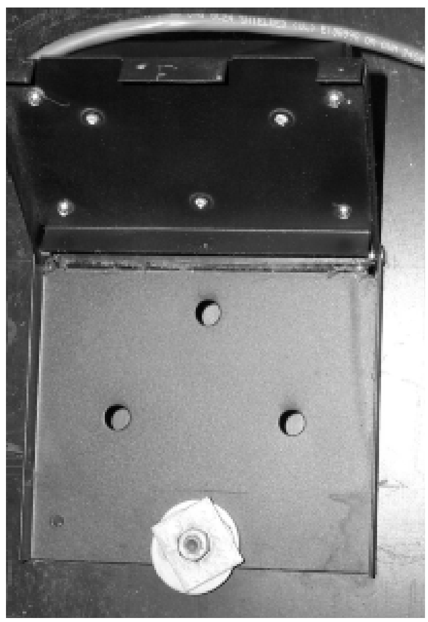

Figure 5. Zycom sensor (raised to show “eyes”).


Figure 6. FarmScan user interface console.

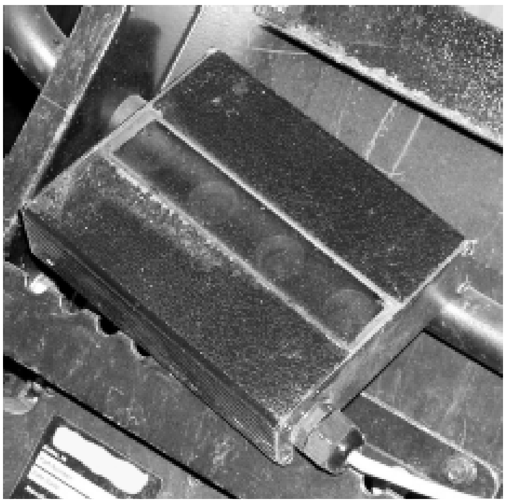

Figure 7. FarmScan flow sensor detached from duct.

Figure 8. Boll buggy resting on truck scales for weighing crop.

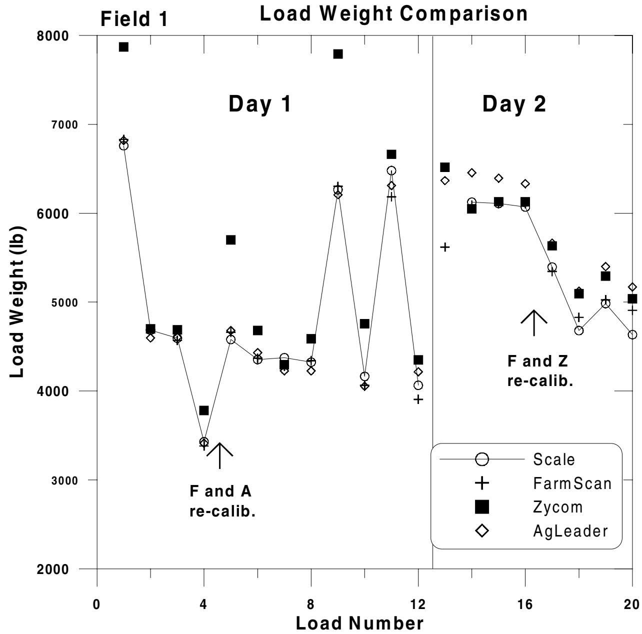


Figure 9. Load by load comparisons from the first field harvested.

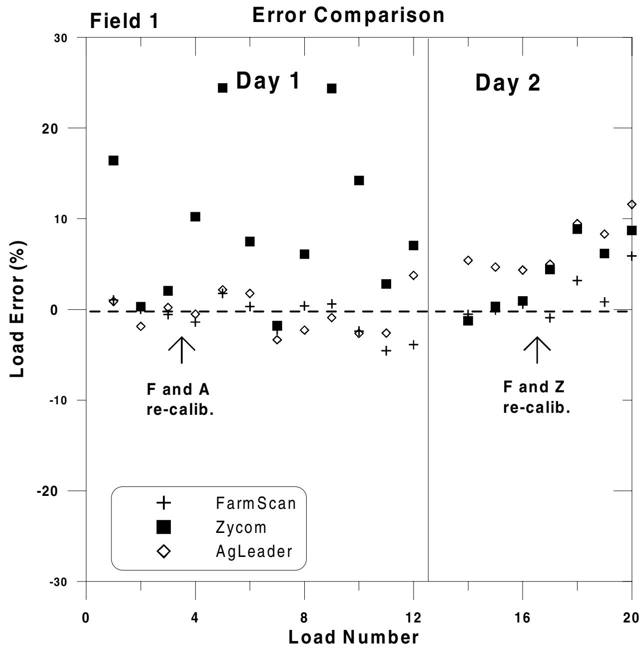


Figure 10. Percent errors from each load compared in the first field harvested.

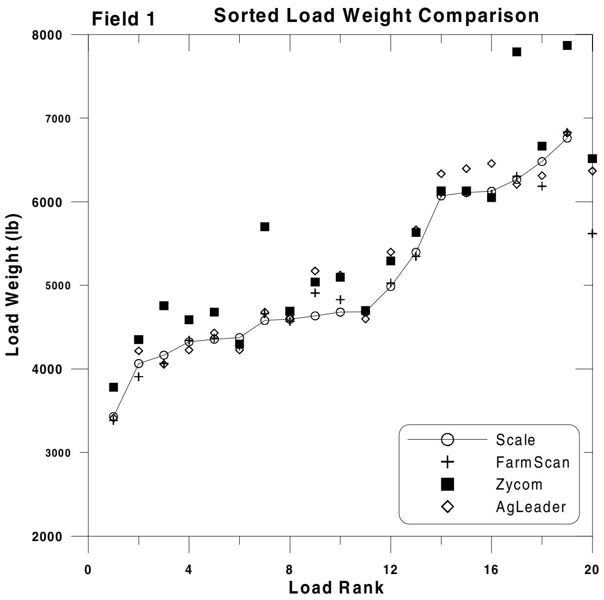


Figure 11. Sorted (ascending) load comparisons for first field.

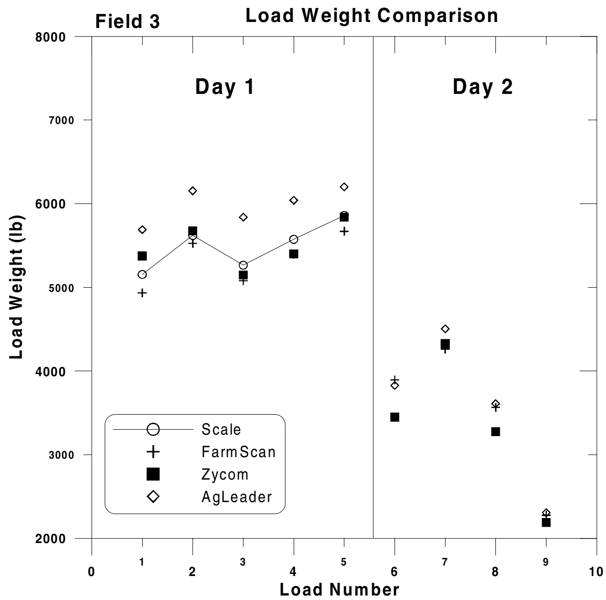


Figure 13. Load-by-load comparisons from the third field harvested.

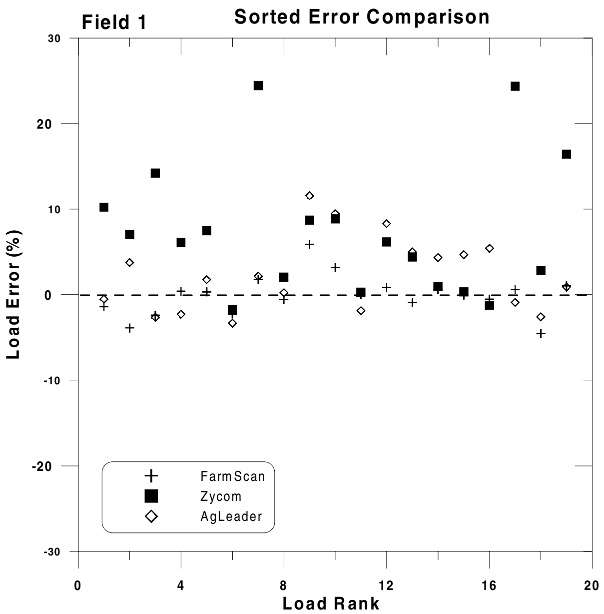


Figure 12. Percent errors of the sorted loads compared in the first field.

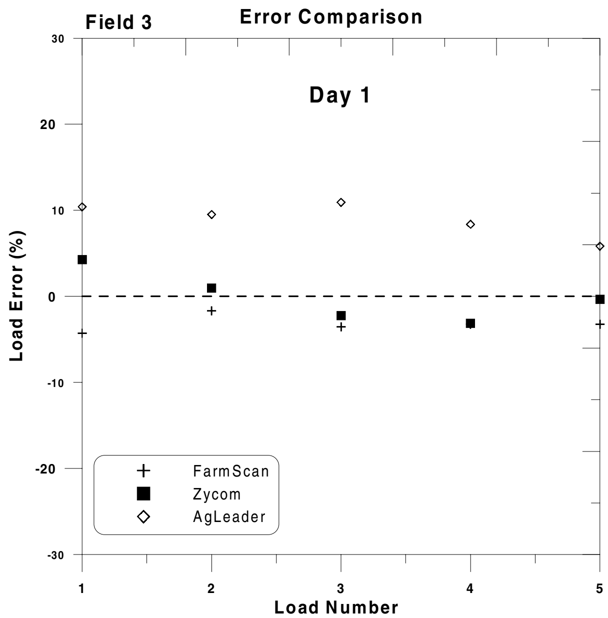


Figure 14. Percent errors from the loads compared for the third field.

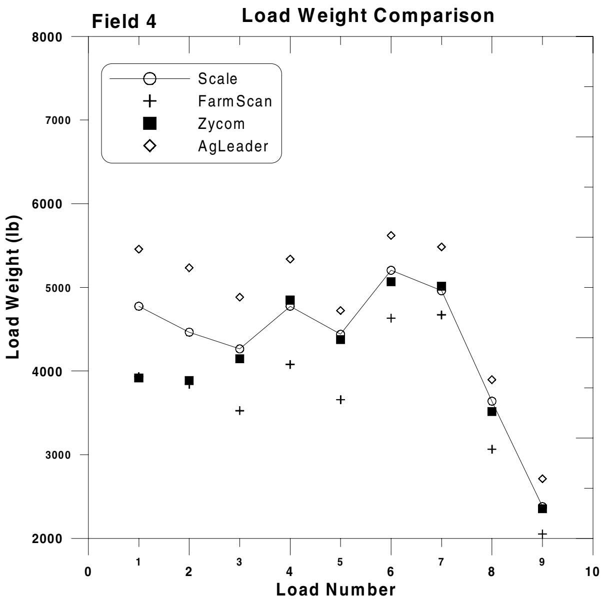


Figure 15. Load-by-load comparisons for the fourth field harvested.

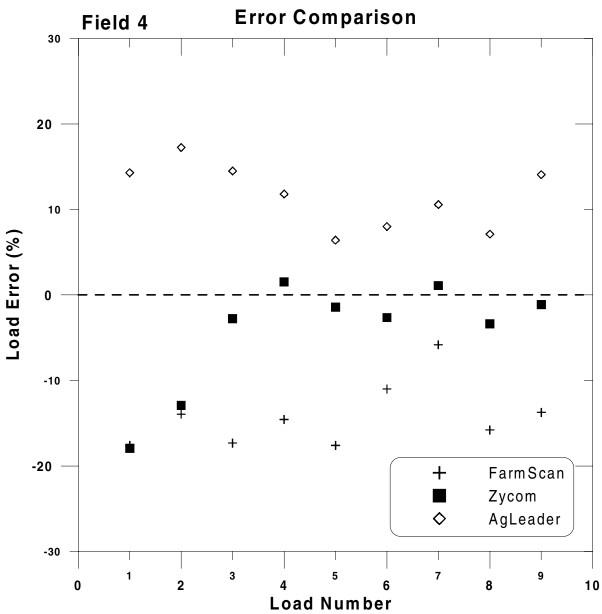


Figure 16. Percent errors for the loads compared in the fourth field.

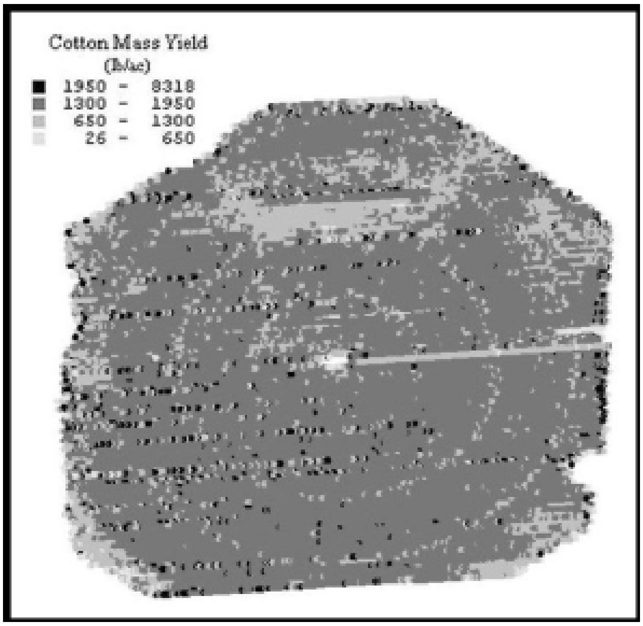


Figure 17. AgLeader yield map from the first field harvested.

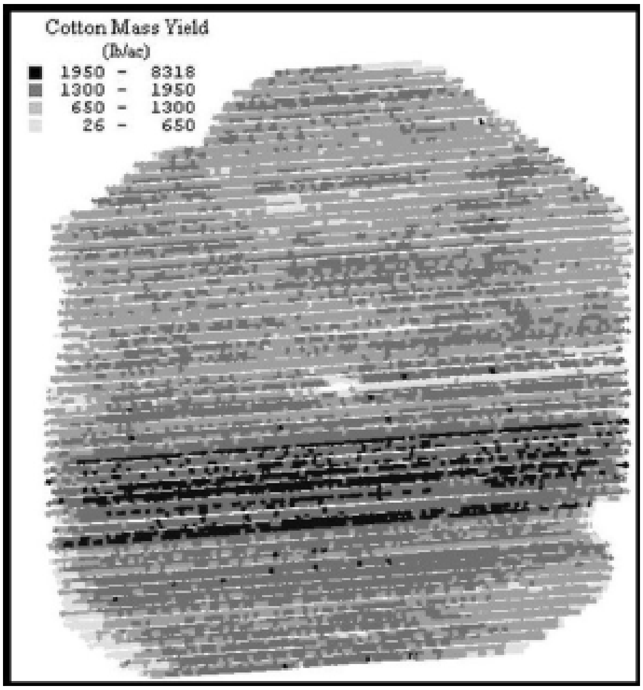


Figure 18. FarmScan yield map from the first field harvested.

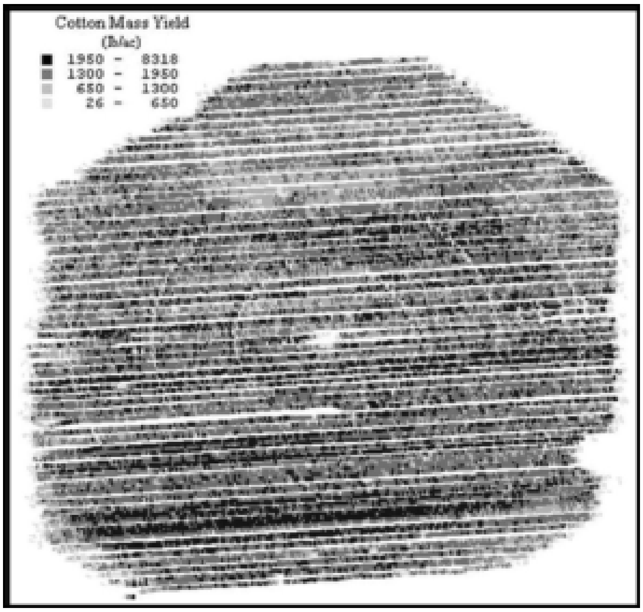


Figure 19. Zycom yield map from the first field harvested.

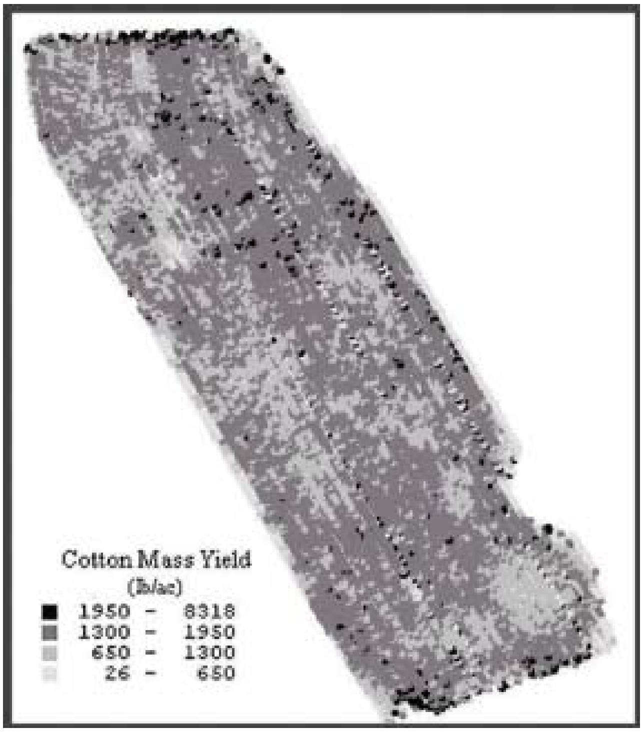


Figure 20. AgLeader yield map from the third field harvested.


Figure 21. FarmScan yield map from the third field harvested.

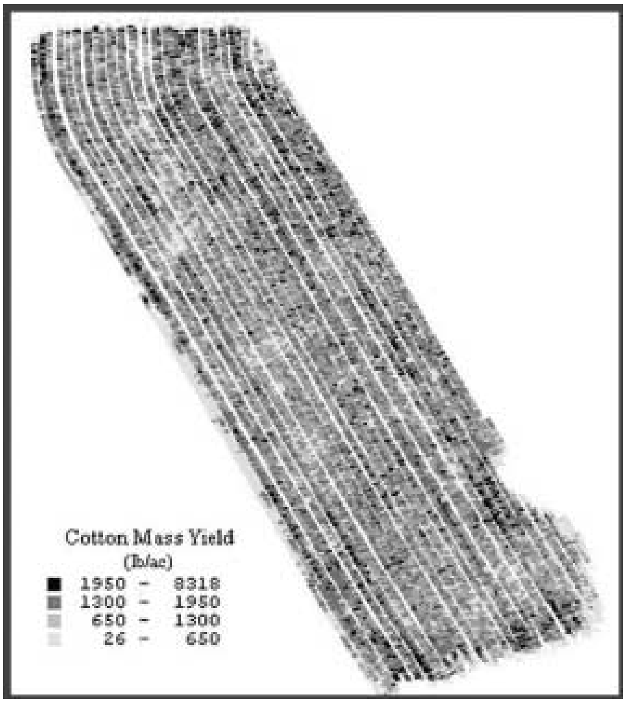


Figure 22. Zycom yield map from the third field harvested.

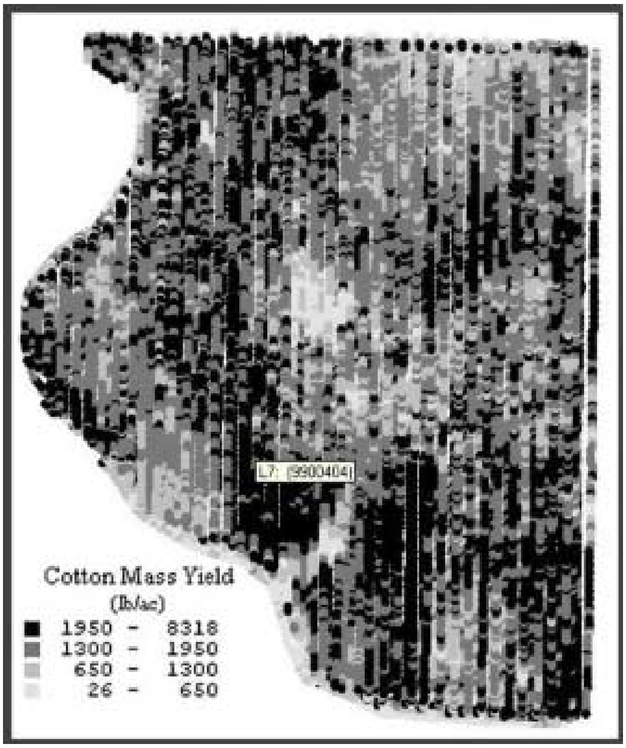


Figure 23. AgLeader yield map from the fourth field harvested.

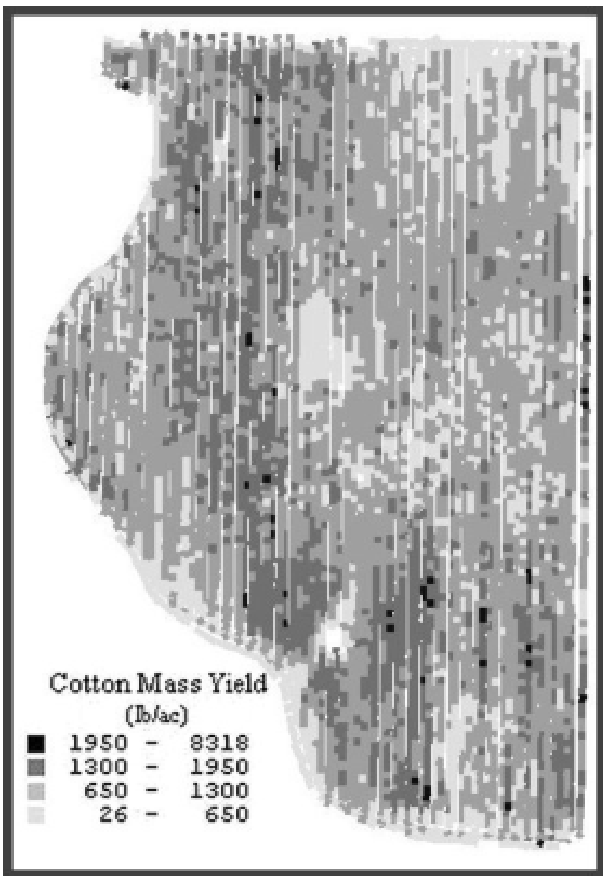


Figure 24. FarmScan yield map from the fourth field harvested.

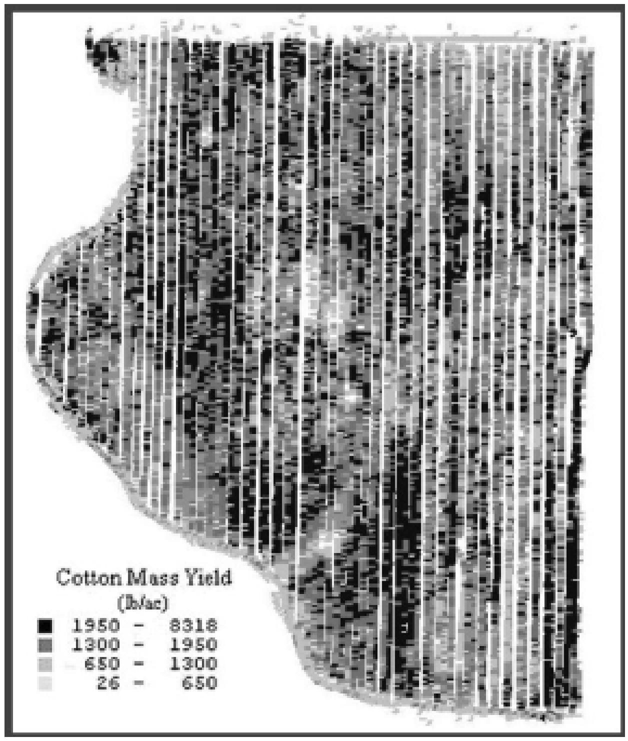


Figure 25. Zycom yield map from fourth field harvested.