COTTON YIELD MONITOR EVALUATION, SOUTH CAROLINA – YEAR 2

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Abstract

Initial field testing finds commercially available cotton yield monitors to be a promising technology. However, widespread adaptation is limited because of problems maintaining sensor cleanliness and calibration in the real world cotton-harvesting environment. This paper presents the results of two years testing of Zycom and Micro-Trak yield monitoring systems in South Carolina. A Clemson University patent-pending mounting system to help keep sensors clean and in calibration is also evaluated.

Introduction

A key element of precision agriculture involves the analysis of georeferenced yield maps. In order to develop cotton yield maps, a commercial cotton yield monitor must be available. The cotton yield monitor must be accurate, economical, reliable, easy to use, and stand up to the harsh conditions found in the cotton- harvesting environment.

Wilkerson et al. (1994) reported on the development of a sensor to measure flow rates of cotton in the discharge chutes of a cotton picker in real time by using a non-intrusive technique. The sensor consisted of a linear plane of light sources and a photo detector array. Thomasson et al. (1997) constructed and tested two electronic devices to measure the flow of pneumatically conveyed cotton. Both devices worked on the principle of optical manipulation and consisted of a light sensing bar, a light source, and a data acquisition system. Searcy et al. (1997) reported development of a weighing type cotton yield mapping system based on the concept of weighing the mass of cotton in the basket using load cells as it was harvested.

During 1997, Zycom Corporation and Micro-Trak Systems, Inc. introduced commercially available cotton yield mapping systems. Gvili (1998) reported a test of the Zycom cotton yield monitor. In the field tests, errors of 1.7% or better on module size loads were obtained. Wallace and Willcut (1998) evaluated a Zycom yield monitor on small plots with a good correlation between measured and predicted weight. Searcy and Roades (1998) evaluated the Zycom yield monitor in field conditions comparing the accuracy of yield estimates at points within the field rather than accumulated mass measurements. Durrence et al. (1998) tested both the Zycom and Micro-Trak yield monitors in field and plot conditions. Generally good correlation between actual weights and yield monitor predicted weights were found when the yield monitors were clean and calibrated. Most authors found that dirt, trash, and lint often interfered with the yield monitor's operation resulting in significant error.

During 1997, both the Micro-Trak and Zycom cotton yield monitors were evaluated in South Carolina. The major problem encountered was keeping the sensing units clean and calibrated. Both companies introduced new sensor mounting technologies in 1998 to address the problem of dirt, trash, and lint interfering with sensor operation. After testing of the 1998 redesigned mounting technologies of Zycom and Micro-Trak, it was decided to design and test additional mounting technology. A new system of keeping the sensors clean in order to reduce errors was developed at Clemson University. The device was evaluated for both the Micro-Trak and Zycom yield sensors.

Overview of Micro-Trak and Zycom Cotton Yield Monitors

The Micro-Trak and Zycom cotton yield monitoring systems are similar in design but exhibit some differences. Both systems utilize an infrared sensor method to measure cotton flow. Infrared is used rather than visible light in the flow sensors to eliminate the negative effects of sunlight and shading. By combining cotton flow with picker width and ground speed, the instantaneous cotton yield can be determined and recorded throughout the field.

Both systems record and store yield data on PCMCIA cards. The Micro-Trak system incorporates a magnetic ground speed sensor and a run/hold unit tied to the header control. The run/hold unit controls the writing of data to the PC card. The Zycom system does not use a speed sensor or run/hold switch. It determines speed from the DGPS (differentially corrected global positioning system) signal and records whenever there is cotton passing the flow sensors.

The calibration procedure is almost identical for both systems. A full basket of cotton is harvested, then weighed. The weight value is then input to the system's display located in the cab. The Zycom yield monitor back calculates the stored calibration data. This allows the cotton yield data collected during calibration to be an accurate part of the yield record after the calibration process is completed. The Micro-Trak yield monitor does not back calculate calibration data. Thus the yield map data collected by the Micro-Trak system during calibration retains its original calibration values.

Description of South Carolina Test

A Micro-Trak yield monitor was installed on a Case-IH 4-row picker model # 2055 owned and operated by Bozard

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Farms in Cameron, South Carolina. Sensing units were installed on two chutes of the picker. The yield monitor was installed and calibrated as per the printed instructions. Calibration weights were obtained with a commercial truck scale and cotton wagons in 1997 and by utilizing boll buggy in 1998. During both years, the yield monitor was cleaned and calibrated at the beginning of the test. Subsequent weight measurements were determined with the boll buggy or truck scales during the day to compare with the recorded yield monitor readings.

A John Deere model 9900 2-row picker was utilized for testing at the Edisto Research and Education Center, Blackville, South Carolina. During 1997, the picker was equipped with a Zycom yield monitoring system with sensors placed on each picker chute. The picker was configured as a plot harvester with weights obtained utilizing portable scales for the bagged cotton.

A Micro-Trak yield monitoring system was added to the John Deere picker in 1998. Each picker chute was equipped with both Zycom and Micro-Trak sensors. During 1998, the picker was calibrated as a conventional picker with weights obtained via a boll buggy.

During the first year of cotton yield monitor availability, both companies experimented with different sensor mounting techniques. The mounting technique used in 1997 South Carolina tests incorporated an air gap between the sensing unit and the picker chute. Both Zycom and Micro-Trak introduced new mounting technology for their sensors in 1998. The mounting technique sealed the sensor on three sides against the chute. The fourth side incorporated an air gap.

The air gap is designed to draw air across the electronic eyes in an attempt to keep them clean. Initial testing of the 1998 sensor mounting designs showed minimal improvement over 1997 performance. Because the airflow may be erratic and also prone to drawing in contaminated air or lint, a positive air pressure mounting technique was developed by Agricultural and Biological Engineering at Clemson University.

The patent-pending AirBox device completely encloses the existing sensor effectively sealing it from environmental contamination. The AirBox is pressurized by the picker fan which forces air across the sensor eyes. As tested in South Carolina, the Micro-Trak and Zycom sensors are mounted as normal on the picker chute. Figure 1 shows both the Micro-Trak and Zycom sensors installed within the AirBox. Figure 2 shows the AirBox installation on the picker chute with air supply tubes running from the picker fan.

Results

1997 Harvest

Field test results at the Bozard Farm for 1997 are shown in Figure 3. The Micro-Trak unit was successful in producing a yield map, which exhibited cotton yield variations across the field. However, the recorded data did not match field observations of cotton yield. The Micro-Trak yield monitor recorded constantly increasing cotton yield as harvesting progressed across the field. Visual observation indicated more uniformity across the field than recorded by the yield monitor.

The Micro-Trak sensor units were cleaned and calibrated at the beginning of the data collection in Figure 3. Without cleaning and re-calibration of the unit during harvest, it recorded constantly increasing yields over time as the infrared sensing unit became progressively contaminated. The field data of Figure 3 was recorded to the PC card in six separate records, which are defined as loads. Figure 4 shows the six chronologically collected loads, which make up the data depicted in the cotton yield map of Figure 3. It can be seen that the estimated yield became progressively higher as each load was harvested.

Results of the 1997 Zycom unit testing at the Edisto Station are presented in Table 1. The Zycom sensors were cleaned at the beginning of data collection for each load. Errors were in the 2 to 7 percent range when the sensor units were clean throughout the test. When the sensing units became obstructed, error increased dramatically.

1998 Harvest

During 1998, redesigned Micro-Trak sensor mountings were evaluated on the Bozard Farm, Table 2. The trial began with a cleaning and calibration of the yield monitor. Four loads of cotton were monitored. Load #1 exhibited a very accurate estimate. Loads #2 and #3 overestimated cotton weight, as the sensing units became dirty. After load #3, the infrared units were cleaned but the system was not recalibrated. This cleaning returned the units to an “average cleanliness” level greater than during the calibration, which caused the underestimation of yield.

The 1998 redesigned sensor-mounting configuration of the Micro-Trak and Zycom units were evaluated on the Edisto Research and Education Center as presented in Table 3. The sensors were cleaned before each of the seven harvested loads in Table 3. During load 2, the Micro-Trak sensor became obstructed. Load 4 includes cotton contaminated with a large amount of leaves due to poor defoliation. The Zycom sensor was blocked in load 6 by a piece of grass lodged in the fabricated chute. This blockage was the result of chute design and not a reflection of the Zycom sensor mounting. Even with cleaning before each load, errors greater than 5% are evident in Table 3 data.

The 1998 results obtained after installation of the AirBox are presented in Table 4. The yield monitors were cleaned and calibrated prior to data collection for load A1. In addition the sensors were cleaned but not calibrated after load B5. The data shows only one error reading in excess of 5% (load C4), which can be blamed upon sensor blockage. The Micro-Trak sensors were left in the open position during trial A1and A2 and no data was obtained. This condition was concealed from view since the units were enclosed in the AirBox. During test A4, improper defoliation left a large amount of leaves on the plant. During test B1, a piece of grass lodged in the cotton chute was obstructing the Zycom unit but not the Micro-Trak unit. This was a function of chute fabrication and not a reflection upon the sensor abilities.

Discussion and Summary

Field trials in 1997 and 1998 show the Micro-Trak and Zycom units will accurately predict cotton weight when they remain clean and free from obstruction. Two years of results on the Bozard Farm show sensors to become dirty and obstructed very quickly under normal field harvesting conditions. Testing at the Edisto Research and Education Center in 1997 and 1998 show sensors becoming dirty and obstructed enough to affect accuracy even when cleaned at the beginning of each harvested load.

Initial results of the Clemson designed AirBox mounting technology are very promising. The positive air pressure and isolation from dirt, dust, and lint contamination appear to keep the sensing units clean over several harvested loads. A filter and/or screen will be installed in the AirBox supply line to improve supplied air quality even further for future testing.

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Table 1. 1997 Zycom Trial, Edisto Research and Education Center, Blackville, SC.

Load #	Actual (lbs.)	Measured (lbs.)	% Error	Sensor Cond.[1]
1	49.6	50.8	2.4	clean
2	78.8	81.0	2.8	clean
3	86.4	89.7	3.8	clean
4	101.2	129.4	27.8	1 of 6
5	160.2	164.8	2.8	clean
6	234.1	343.6	46.8	2 of 6
7	520.4	485.4	6.7	clean

Two Zycom units were employed for a total of 6 "electronic-eyes". This column indicates the number of electronic-eyes, which were obstructed by dirt, dust, trash, or lint during test.

Table 2. 1998 Micro-Trak Trial, Bozard Farms, Cameron, SC.

Load #	Actual	Measured	% Error
1	2520	2506	-0.1
2	2670	3130	17.2
3	1990	4130	107.5
4	1975	1522	-22.9

Table 3. Yield monitor Trials, Edisto Research and Education Center, Blackville, SC, 1998.

Date	Load	Actual Weight (lbs).	Zycom (lbs.)	Micro-Trak (lbs.)	% Error Zycom	% Error Micro-Trak
08.29.98	1[1]	1940	-	1955	-	0.77
08.30.98	2[2]	2154	2176	2643	1.02	22.70
	3[3]	580	613	571	5.69	-1.55
	4[4]	849	818	772	-3.65	-9.07
	5	1035	1050	1060	1.45	2.42
	6[5]	409	500	393	22.25	-3.91
	7[6]	1035	1072	1100	3.57	6.28

Note: Infrared units were cleaned before each load was harvested.
Explanation:
[1] Zycom was inadvertently turned off
[2] Micro-Trak: 3 holes were blocked
[3] Dirt build-up on Zycom
[4] Dry leaves still on the plant due to poor defoliation
[5] Zycom had a piece of grass interfering with sensors. This problem was due to chute fabrication and not a function of the Zycom sensor itself.
[6] Dirt build-up on Micro-Trak

Table 4. Yield Monitor Trials after Addition of AirBox Technology Edisto Research and Education Center, 1998.

Date	Load	Actual Weight (lbs.)	Zycom (lbs)	Micro-Trak (lbs.)	% Error Zycom	% Error Micro-Trak
11.05.98	A1[1]	424	425	-	0.24	-
	A2[2]	454	464	-	2.20	-
	A3	357	358	366	0.28	2.52
	A4[3]	247	253	268	2.43	8.50
11.13.98	B1	845	1004	822	18.82	-2.72
	B2	1070	1065	1026	-0.47	-4.11
	B3	1194	1198	1193	0.34	-0.08
	B4	786	796	779	1.27	-0.89
	B5	924	938	934	1.52	1.08
11.24.98	C1	1463	1488	1471	1.71	0.55
	C2	1375	1405	1387	2.18	0.87
	C3	1486	1465	1548	-1.41	4.17
	C4	1440	1405	1532	-2.43	6.39
11.25.98	D5	1390	1417	1393	1.94	0.22
	D6	1336	1363	1386	2.02	3.74

Note: Yield monitors were cleaned and calibrated before load A1. In addition, sensors were cleaned only prior to load C1.

Explanation:

[1, 2] Micro-Trak sensors open, while hidden from view inside air box

[3] Dry leaves still on the plant due to poor defoliation

[4] Zycom had a piece of grass interfering with sensors. This problem was due to chute fabrication and not a function of the Zycom sensor itself.

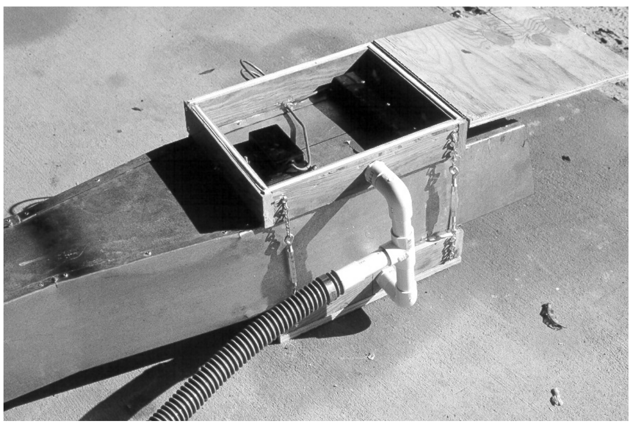

Figure 1. AirBox enclosure surrounding Micro-Trak and Zycom sensors. Note air supply tubes and the sealing of sensors from environment when plywood lid is closed.

Figure 2. AirBox enclosure mounted on picker. Note air supply lines from fan to AirBox.

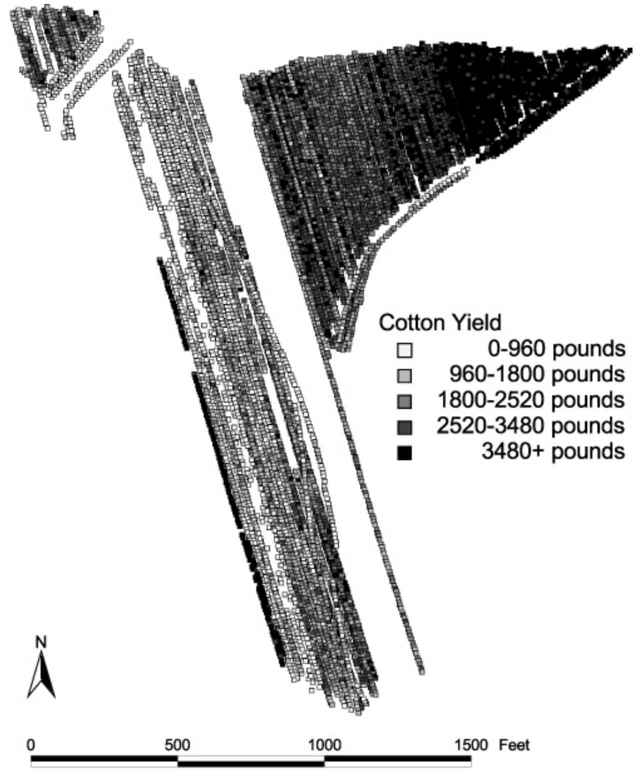

Figure 3. Cotton yield map data generated by Micro-Trak yield monitor. Bozard Farm. 1997.

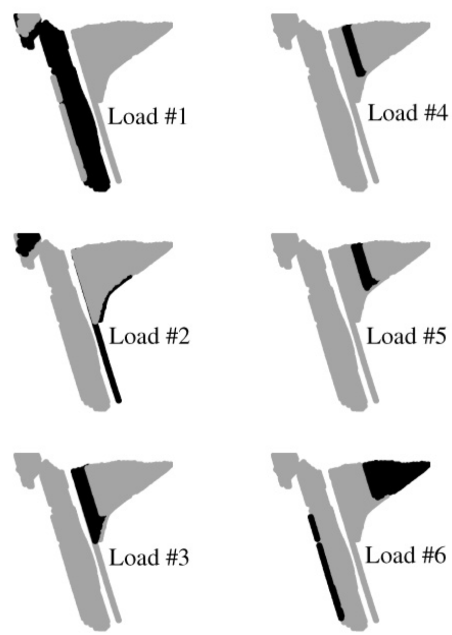

Figure 4 . Six chronologically harvested loads, which comprise the yield map data of Figure 3. (Note increase in recorded weight over time). Bozard Farm. 1997