FIELD TESTING OF COTTON YIELD MONITORS

G.F. Sassenrath-Cole, S.J. Thomson and J. R. Williford
USDA-ARS-APTRU
Stoneville, MS
K.B. Hood
Hood Farm and Gins
Gunnison, MS
J. A. Thomasson
Ag. and Bio. Engineering Dept
Mississippi State University, MS
J. Williams and D. Woodard
Global Positioning Solutions, Inc.
Inverness, MS

Abstract

Two commercially available yield monitors and one developmental model were field tested in Mississippi. This study was a component of an on-going research effort exploring within-field variability in crop yield and quality. The main objective of this study was to measure the accuracy and reliability of yield monitors for on-farm use. Yield monitor accuracy was reduced by dust build-up on the sensor face. Strands of cotton caught on imperfections in the picker chute also contributed to sensor inaccuracies. The continual drift observed in sensor accuracy together with the inability to distinguish between trash and lint limit the utility of currently available monitors in a production setting.

Introduction

Cotton production can deliver a healthy profit at the end of the season. However, the costs of production are higher for cotton than for other crops such as corn and soybeans. In order to optimize profit, a cotton producer must put significantly greater resources at risk than in a grain production system. Within-field variability of a cotton crop can result in an economic differential ranging from a net loss of more than $200 per acre in parts of the field to a net profit in excess of $200 per acre in other areas of the same field (Sassenrath-Cole et al., 1998). The potential of precision agriculture will be realized when we are able to locally manage each of these disparate regions in order to optimize the profit margin. Given the high input costs and sensitivity to soil and environment, cotton production could benefit substantially from site-specific management. A first step in developing site-specific management scenarios is to determine the extent of within-field variability. Accurate information on final yield is an essential component needed to identify potential areas of low productivity. Advances in adaptation of precision agriculture technologies have been hampered in cotton production due to the lack of an accurate, reliable yield monitor.

This study was undertaken to test the accuracy and reliability of commercially available cotton yield monitors, and one monitor under development. The consistency and accuracy of individual measurements was determined in small-scale research plots, and the utility and reliability of the units was tested in a production setting.

Materials and Methods

Two commercial cotton yield monitors (Vision System, using a MicroTrak sensor; and Zycom) and one developmental model were field tested in production fields and experimental plots in 1997 and 1998. Sample sizes ranged from near 100 pounds to more than 2000 pounds of seed cotton. All yield monitors employed optical measurement of flow through the picker chute as determined by interruption of the light beam between transmitting and receiving units. Yield monitor output was compared to actual harvested weight for large samples using a weigh wagon, that is, a modified boll buggy with load cells on the axles. Smaller samples were weighed on a small scale in the field.

Description of prototype cotton yield monitor

The prototype cotton yield monitor consists of a frame with orthogonally placed diode arrays situated across from their respective light source banks. A device based on the same concept had already been used successfully to measure mass flow of seed cotton in the unloading duct of a cotton gin (Thomasson et al., 1999). The device was sandwiched between two mounting plates in one of the discharge ducts, above the first bend of the duct at the front of the machine. The sensor was placed flush in the duct so as not to disturb flow.

Data Acquisition

Zycom and Vision Systems

The Zycom system was evaluated in the 1997 field study. The system has since been upgraded by integrating the data storage/control unit with the display unit. The device used for this study stored data in a proprietary data module that used a parallel port interface. The Vision System was completely integrated. Data from the MicroTrak sensors and a GPS were stored in memory after processing. Data could be downloaded and analyzed later. Details of the 1997 Zycom and MicroTrak systems can be found in Durrence et al. (1998).

Prototype Yield Monitor

A proprietary software algorithm is used to properly interpret readings from orthogonally placed diode sensors and is an integral part of the sensing system. The algorithm in its original form was written in QBASIC and was set to output mass flow to the screen and disk (Thomasson et al. 1999). Programmed parameters were modified slightly so the sensor could be used on the harvester, and the programming code was further modified to extract time codes and positioning data (simultaneously with mass flow data) from GPS output strings. A Starlink Invicta 210A GPS (Starlink, Inc., Austin, TX) was used to provide these data, and was set up to operate in parallel with the GPS already integrated with the MicroTrak system.

Diode arrays were interfaced directly with a ComputerBoards PCM-D24C3 PCMCIA digital input card attached to a notebook computer mounted on the floor of the cab. LED's were wired into each channel and mounted on a prototyping board. These LED's could indicate if a sensor was blocked and were useful for calibration and troubleshooting.

Results

All units were able to generate yield maps of the harvested areas. However, significant post-processing of the yield measurements was required to remove the errors introduced in the measurement systems. The two principal components contributing to errors in the yield measurement were strands of cotton caught on imperfections in the picker chute (stringers) and foreign matter build-up on the face of the sensors. For a representative field test, foreign matter build-up indicated a more than 50% reduction in transmissivity of the sensor face after only a few hours of cotton flow through the picker chute (Figure 1). Chemical treatment to retard adhesion to the surface was able to maintain a greater transmissivity, although a significant decline was still obvious.

Between runs, sensors were not cleaned so that the effect of dust accumulation on sensor calibration could be measured. Figure 2 illustrates the effect of dust build-up on sensor calibration over time for the prototype yield monitor. To judge the integrity of data from the prototype sensor as the harvester was being run, one person was situated in the cab to continually observe mass flow as values were updated every second. In this way, anomalies could be noted and documented, and the harvester could be stopped if data indicated severe blockage or other malfunctions. Dust accumulated steadily from runs 1 to 12, resulting in a steady reduction in the calibration value over time. At run 13, a substantial change in sensor calibration was noticed, and the harvester was stopped in the middle of run 16 because of consistently high mass flow readings towards the end of the run. The duct was separated, and stringers were noticed in the duct. Stringers were removed, sensors and light sources were completely cleaned of dust, and run 16 was resumed. After this cleaning, there was a marked change in the calibration, which decreased more rapidly as dust re-accumulated, settling to a more consistent value. Similar tests with the commercial models yielded similar results (data not shown).

In addition to the two problems contributing to measurement error, none of the systems was able to distinguish between lint and trash content. Overestimation of cotton yield would occur under conditions of higher trash content in the harvested cotton. Efforts are being directed to incorporate modifications in the prototype monitor to overcome shortcomings of current technology.

Conclusions

It is possible to obtain a measure of yield within a cotton production field by careful attention to cleaning of sensor heads and post-processing to remove introduced errors. However, the continual cleaning and re-calibration required to maintain confidence in the measured values are not amenable to the rigors of harvest in a production setting.

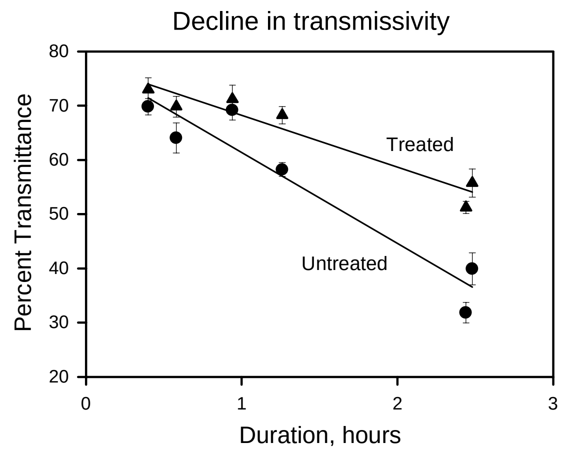

Figure 1. Decline in transmissivity of surfaces inside picker chute with dust accumulation.

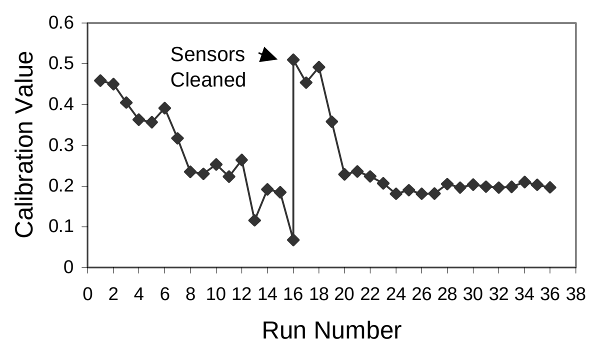

Figure 2. Calibration value vs. run number for prototype yield monitor.

Disclaimer

Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the U.S. Department of Agriculture or Mississippi State University and does not imply approval of the product to the exclusion of others that may be available.

References

Durrence, J.S., C.D. Perry, G. Vellidis, D.L. Thomas, and C.K. Kvien. 1998. Evaluation of commercially available cotton yield monitoring systems in Georgia field conditions. ASAE Paper No. 98-3106. St Joseph, MI:ASAE.

Sassenrath-Cole, G.F, K.B. Hood, V.J. Alarcon, R. Olson, L. Tarpley, J. Varco, and M. Seal. 1998. Remote sensing of crop physiological function: applications for development of variable rate inputs. Proceedings of the First Int'l Conference on Geospatial Information in Agriculture and Forestry, June 1-3. Pp II 604-608.

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 Agriculture. 15(1): 11-17.