

OPERATION OF YIELD MONITORS IN CENTRAL ARIZONA: GRAINS AND COTTON

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Introduction

There is a wealth of information that can be extracted from yield monitor data. Yield maps can be an important management tool to quantify the impact of management practices including water, fertility, pest control, variety selection, etc. (Andrade-Sanchez and Heun, 2013). Yield monitoring technology provides farm managers with information to improve input utilization, therefore many guidelines for their use are available online, including university cooperative extension bulletins for grain crops (Grisso et al, 2009, Adamchuk et al. 2004), and cotton (Vellidis et al. 2013 a-b). Since most of these resources were generated for the US Midwest and South-East regions, there is a need to develop up-to-date materials that apply directly to the irrigated Southwest conditions. Production of cotton and small grains in semi-arid conditions of Arizona are characterized by long growing seasons and high yields. Therefore high volumes of vegetative material are handled by harvesting machines creating particular needs for frequent, effective calibration.

New combine machines and cotton pickers are available with integrated yield monitors and older machines can easily be retrofitted with systems. Harvest machines fitted with yield monitoring electronics can provide high-resolution field data to a grower. Although yield data from an uncalibrated machine may be useful for looking at the general variability within a field, a properly calibrated system can allow us to quantify those differences and even help us make real-time business or operational decisions without waiting for gin/elevator weigh values.

Here, we will discuss what is needed to perform calibrations on instrumented grain combines and cotton pickers, an evaluation of how well these systems performed in various crops harvested in central Arizona, and tips for successful data collection from these systems.

Calibration of the System

When harvesting for the first time (harvest season) be sure to set-up the display for the current field and operate the machine in the field before attempting to calibrate it. Make the necessary mechanical adjustments to optimize

machine performance. It is important for the machine to be performing satisfactorily before attempting to calibrate the electronic system.

Once the system is set-up, the sensors must be calibrated. Accuracy and precision can be obtained with a proper calibration. This is critical when more than one machine will be monitoring yields in the same field and absolute measurements can then be directly compared.

Start off by calibrating the header sensor height. Follow the procedure as described in your operator's manual. This will allow the machine to know that it is in a harvestable area versus the end of the field. The system will keep track of harvested area automatically, based on whether the header is up or down. The header height should be set just above the upper level which they will be used during harvest. You will raise the header above this height to turn the machine around at the end of the field.

Tools Required for Calibration

Grains-

- Scale-instrumented grain cart with unloading auger (see Figure 1, right)
- Hand-held or bench-top grain moisture tester
- Digital thermometer

Cotton-

- Scale-instrumented boll buggy (see Figure 1, left)

There are several sensors to calibrate on grain combines and each system manufacture is different. Typically, the temperature sensor, header height sensor, header dimensions, vehicle dimensions, and offsets (in reference to the GPS antenna location) should be set before the harvesting season begins. The system will apply the offsets to the GPS antenna position to correctly map the location of harvested product. Be sure to correctly set the width dimension or row spacing for the header. Improper settings will throw off the computed harvested area calculations. Figure 1 shows mobile scales at the University of Arizona used for standard calibration of grains and cotton yield monitoring systems.



Figure 1. Examples of mobile scales used for load calibration of cotton (left) and grains (right) yield monitoring systems. Close up images in the bottom-right corners show weigh-bars load sensors installed in the 4 corners of the frame (cotton boll buggy) and at the wheels of the axle (grain cart).

Grain Combines

When the machine is ready to operate, harvest a few loads to verify and fine tune operation of the combine. If it is the first time running the machine for the season, there will be areas in the grain tank and inside the combine devoid of grain. Avoid using the first load as a calibration load because those areas will fill with some grain and won't be counted when dumping the tank into a scale. The first load to be used for calibration will need to be defined as such. When using an AgLeader Insight monitor, switch the region and mark as a calibration load. In AFS Pro 600/700, simply define a new task, with John Deere GreenStar systems, follow the instructions on the calibration menu. Most systems recommend harvesting a load between 3000 to 6000 lbs. and this is the same load that is used to calibrate the on-board moisture sensor.

Using the grain moisture tester, take several moisture readings and determine the average to adjust the moisture reading for the load. Dump the clean grain into the scale system. Input the scale weight into the yield monitor. In most cases, it will be necessary to repeat the process a minimum of 3 times and usually 4 in order to mathematically fit the sensor based measurements as close as possible to the real amounts. Each load should be kept track of separately by changing the region or task in the display after dumping the previous load and before harvesting the next.

The best calibration will include a wide range of scale weights (such as 3000, 4000, 5000, 6000 lbs.) and a range of speeds (normal, normal + 1 mph, normal - 1 mph, normal - 2 mph) that are no slower than 1 mph. When weighing loads with an instrumented grain cart, try to place the scale in as flat of a surface as possible and keep the scale in that same position/location when weighing all loads. This will prevent measurement errors due to changes in roll/pitch angles of the axle scale cart from load to load. When calibrating, select the loads that have the smallest errors when compared to the scale weights. To minimize errors during calibration, select a

portion of the field with uniform plant size, good stand, and free of weeds; these conditions often lead to larger inaccuracies in the performance of the yield monitoring system.

Cotton Pickers – Optical type Yield Sensors

When ready to calibrate, move the machine to the edge of the cotton field and line it up to pick. For the Insight display, change the 'region' and check the box under the region name to enable this region as a calibration load. In AFS Pro 600/700 displays, change the 'task' to 'new task'. Begin picking and harvest a load. It may be convenient to run once up and down the field depending on field length and scale capacity. When the first load is done being harvested, lift the headers and shut down the blower. This will help prevent any sensor drift from accumulating yield between the field and the scale. Dump the load into the scale and weigh. Record the weight. Repeat this process at least two more times to have a total of 3 to 4 loads for calibration. Enter the weights in the calibration screen and select the loads that will be used for calibration. The display will calculate a linear fit for the scale weights. Run the machine again, changing the region (mark for a calibration load) or task and weigh the load on the scale to check system performance. This allows the operator to enter the scale weight on this load if it is closer than one of the previous loads. Successful calibration will lead to errors within 2%, then the system is ready.

John Deere Pickers and GreenStar

The John Deere GreenStar (GS2 & GS3) calibration process is a little different. It is a single point calibration process. In the display's calibration screen, the operator starts and stops yield measurements before and after harvesting a load for calibration. The load is dumped into the scale and weighed. The weight is entered into the display. A new calibration factor is calculated based on the scale weight and the previous

Table 1. Performance of yield monitoring systems in Arizona. System accuracy expressed as the percent difference between the estimated yield and the scale load measurement. Numbers in parenthesis are the range of errors observed during the harvest season and reflect accuracy fluctuations due to variety, crop stand, defoliation state (in cotton), grain moisture, and other sources of error.

Yield Monitoring System	Crop	System Accuracy - % error -	
		Field Calibration ¹	Whole Field ²
John Deere 6-row picker – 6 rows instrumented w/ MW sensors	Cotton	1.91	-2.60 (13.19)
Case IH 6-row picker – 2 rows instrumented w/ optical sensors	Cotton	3.24	3.92 (12.65)
John Deere Combine 35 ft header – Single force plate sensor	Barley	0.02	-3.08 (6.80)
John Deere Combine 35 ft header – Single force plate sensor	Sorghum	-0.13	2.13 (n/a)
Case IH Combine 20 ft header – Single force plate sensor	Durum wheat	0.37	1.08 (3.19)

¹ Field calibration was performed at the beginning of harvest season with boll buggy (cotton) and grain cart (grains) instrumented with load scales.

² Whole field errors were determined on a by-field basis accounting for multiple fields

calibration factor. Follow the calibration procedures suggested in the GreenStar user’s manual. Auger-shaft or blower fan speed sensor

Performance: Platforms and Crops

Several hundred acres were yield mapped in central Arizona between 2010 and 2012 in partnership with growers and contractors using grain and cotton harvest machinery equipped with electronic yield monitors. In Table 1, a report on yield monitor accuracy amongst several machines and yield monitoring systems are summarized.

Harvest Tips

- Data organization - Be consistent when naming fields and keep them separated such as: Grower, Farm, Field, Task (or Event). This will provide consistency when moving data into a GIS desktop software.
- Use a GPS unit with differential correction (accuracy of ~1m or better). GPS units usually start with DGPS (WAAS) accuracy at no extra cost.
- Grain combines – adjust the value used for grain density (lbs. per bushel) to accurately reflect the true density harvested.
- Cotton pickers – adjust the gin turn-out value and weight of a bale to more accurately reflect the percent of mass made up by the lint. This will improve the bales per acre values calculated by the system.
- Make sure the header sensor is set to a height level that is reasonable so the headers don’t have to be raised all the way up to stop the area tracking. At the same time, make sure the header is raised above that set height so area that is not harvested (ends of the field) is not counted as part of the production area. This will reduce yields on a per-acre basis in the system. If this is not possible, manually turning the area tracking on and off will preserve the bales / acre accuracy in the system.
- Manually turn off header sections that overlap into rows harvested by another machine. This will help preserve accuracy on area harvested.
- When buying a boll buggy or grain cart, a system with a self-powered hydraulic system works best. It can be pulled behind a pick-up truck instead of a tractor.
- If harvest is contracted out, ask the contractor if they can provide yield maps for you. New harvest machinery comes with integrated yield monitoring equipment. They may be able to accommodate your request.

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