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USDA LTAR Common Experiment measurement: Collection of grain yield data using a yield monitor

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Abstract

This protocol provides detailed methods for in-field collection of grain yield data using a combine harvester equipped with a yield monitor. Proper in-field procedures are key to the collection of high-quality continuous grain yield data. Well-functioning harvest equipment including the combine, yield monitor, and sensors are necessary to produce high-quality data. These data are exported via USB or cloud transfer and a yield map can be developed. Yield maps are highly valuable for farmers and scientists as we work towards increased production and yield stability.

To reduce error and provide high-quality continuous grain yield data we recommend the following steps: harvester setup and calibration, field overview, machine operation (yield monitor setup, calibration, set export parameters), and applying calibration. These will be discussed in detailed sections below. A separate protocol (*USDA LTAR Common Experiment measurement: Post-processing of spatial grain yield data*) addresses the post-processing steps required to convert yield data into accurate yield maps.

Across the LTAR Cropland Experiments to-date, there are four sites that utilize John Deere Greenstar yield monitors while eight utilize Ag Leader Integra yield monitors (based on a survey in 2022). In this protocol, we focus primarily on Ag Leader Integra procedures and recommendations due to its prevalence among the sites but also provide information regarding the John Deere Greenstar system.

We suggest utilizing the Ag Leader monitoring system to obtain research-grade data when possible. We understand the cost and familiarity issues associated with moving to a new system. However, after 2012, the John Deere Greenstar system was replaced by Greenstar ActiveYield. Using ActiveYield can create more difficulty during the post-processing phase. This is due to the calibration adjustments which occur automatically when using ActiveYield, which may result in many different calibration curves within a single field. Application of these calibration curves occurs only for the section of the field that has just been calibrated, essentially creating multiple data sets for a single field. Therefore, if using the post-2012 Greenstar system we recommend disabling ActiveYield and using the manual, multi-point calibration procedure to make post-processing more repeatable and clearer.

Attachments

USDA ARS_Yield_Edito...

799KB

Materials

This protocol was developed using the following equipment and software:

- Harvester: Gleaner R42 Combine
- In-field grain yield monitor: Ag Leader Integra

Although the protocol was developed using this specific equipment, the goal is to make it applicable across multiple combine yield monitoring systems.

Before start

Two items to note:

1. The '<>' notation found throughout the protocol denotes headings found in manuals and other documents.
2. We recommend users also have manuals for equipment and software on hand. Links to electronic resources are provided in the References section. The Yield Editor manual is also attached as a PDF to this protocol.

Harvester Setup and Calibration

1 Before harvesting, update any monitor software to the newest version available and review your combine manual to ensure the combine is serviced and working properly. Details about maintenance, setup, calibration, and operation can be found there.

> **Note**
>
> Yearly checks of harvesting machinery, sensors, and yield monitors are essential to avoid problems such as unresponsive sensors and general combine breakdowns which can be a result of poor pre-harvest inspection.

2 It is also important to check the version of the yield monitor operating software and install the newest version. See Figure 1 for a diagram showing the general location of sensors in a typical combine yield monitoring system.

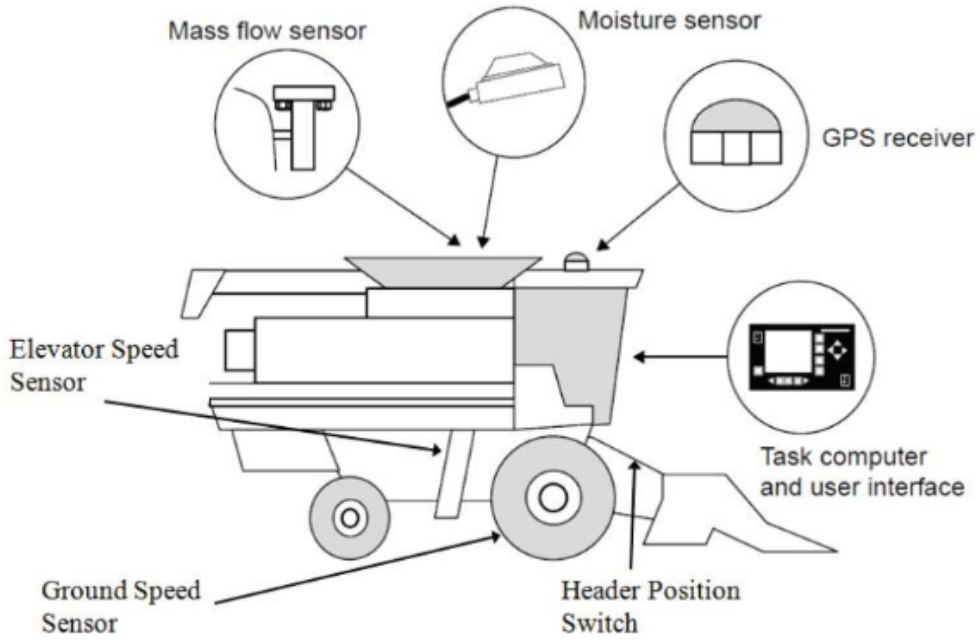

Figure 1

3 First, a visual inspection of the combine and its components should be performed to ensure there is no damage and the machine is in good working condition.

3.1 In particular, ensure the elevator chain is tight and the paddles are not extremely worn.

4 Inspect the sensors and wiring based on the following steps.

4.1 Check for damage to the mass flow, grain moisture, elevator speed, and header position sensors.

> **Note**
>
> In most yield monitoring systems, the mass flow sensor is an impact plate against which grain is thrown from the top of the clean grain elevator.

4.2 Be sure your sensors have not shifted in position and are firmly attached.

4.3 Check your impact plate for debris and damage such as holes, divots, and cracks.

4.4 Also check the area behind the plate for material buildup and make sure the clearance between the impact plate and elevator paddles is within specification.

> **Note**
>
> If using an Ag Leader Integra yield monitor, the manual states that clearance between the elevator paddles and the plate should be between 3/8 and 5/8 inch.

4.5 The combine may require sensor calibration especially if it is new or has new parts such as a new head or impact plate flow sensor.

5 Once again, consult the brand-specific manual for the harvester and yield monitor to set up and calibrate your combine properly.

6 In addition, perform a test harvest on a small section of the field or nearby “bulk” area to verify the system is running properly. A detailed section on completing a test harvest is below.

Field overview

7 Before harvesting a field, make yourself aware of possible impediments to harvesting such as in-field features (ditch, terracing), obstacles (old well, rocks), and crop damage (weak stalks due to insect feeding).

> **Note**
>
> By having this knowledge, potential damage to the combine is avoided, there is time to ask questions before entering the field, and a mental plan can be developed for how to best harvest the field to account for obstacles.

8 Also investigate potential challenges that may affect your harvest plan, such as severely lodged corn which may require harvesting in only one direction to allow the combine head to pick up the stalks.

Start-up procedures - Yield monitor installation

9 A yield monitor is required for collection of yield data during harvest. Place the monitor so you have easy access to the screen for viewing and adjustments while driving the combine.

10 Avoid placing the monitor where it hinders access to machine controls, or your view.

11 All wiring should be placed in a manner such that it does not cause a tripping hazard.

12 Before installing the yield monitor, check the wires for damage.

> **Note**
>
> For more specifics, see the instructions in your installation and mounting kit and brand-specific yield monitor manual.

Start-up procedures - Yield monitor setup

13 When using the yield monitor for the first time, you will need to specify the required settings when prompted during setup.

14 Systems may allow choice of metric (SI) or conventional (or Imperial) units. Imperial units will often be preferred as that is most familiar to the majority of combine operators.

15 In addition, the operator should check that appropriate field metadata are chosen or entered in the monitor before starting the field of interest.

> **Note**
>
> Metadata includes farm and field names, crop type, hybrid or variety, and other identifying information.

16 It is important to enter proper machine measurements, which will ensure accurate offset values.

16.1 In the *Ag Leader Integra Manual*, most information regarding offset setup can be found in the <Vehicle Offsets> section.

> **Note**
>
> Offset values are used when the header is not mounted on the center of the combine and to determine the relative location of the GPS receiver.

16.2 With incorrect machine measurements and offsets, swath width, location, and flow delay will be inaccurate.

17 Once the initial setup is complete, the yield monitor information is saved, and you will not need to add it again.

> **Note**
>
> If changes are made that would alter your information such as different offsets, remember to change the setup values.

18 After completion of the initial setup, input harvest settings.

Note

For Ag Leader Integra monitors, information about these topics can be found on page 23 in the <Grain Harvest Settings> section.

19 Check the available memory of your yield monitor.

19.1 Depending on storage availability, you may want to perform a data cleanup or simply remove data from your monitor and place it in a storage device such as a USB.

19.2 Also, back up data from previous years to reduce the possibility of data loss.

Note

For information on data cleanup and creating a backup file, see page 75 of the *Ag Leader Integra Manual* under the subsections <Manage Files> and <Advanced Options>.

Calibration

20 When preparing for harvest each year, be sure to calibrate each sensor and follow instructions specific to your monitor.

Note

Calibration details are outlined first for Ag Leader Integra followed by John Deere, including both the standard calibration procedure and the S-Series Combine (ActiveYield) procedure.

Ag Leader and John Deere calibrations compared

21 It is **IMPORTANT** to understand how calibration works for your yield monitor. Ag Leader monitors apply calibration to all fields of the same year and crop type which makes data uniform. John Deere calibration is not applied backward to previously harvested data for that crop type and year. As indicated in weight calibration above, this means a new data set will essentially be created within the field each time a new calibration is performed in the field. For

all yield monitors, the best practice is to collect data to develop an accurate calibration before harvesting any fields or plots where yield data will be used for research purposes.

Ag Leader Integra calibration steps

22 The *Ag Leader Integra Manual* states the calibrations to perform and the order they are to be performed in.
Pay particular attention to the following list of calibrations.

Note

- This list can be found in the Harvest section of the manual under the section <Configuration Setup>, subsection <Calibration Sequence> on pages 341 and 342.
- There are also detailed explanations on each calibration which can be found on pages 342-345.
- Other important settings include Auto Swath Sensitivity and Delay found on pages 346 and 347, respectively.
- Auto swath will be discussed further in Other Features while delay will be discussed in Export Parameters.

Ag Leader calibration - Distance

23 Even when using GPS to determine ground speed, this calibration is recommended prior to harvest as it can take the place of GPS if signal loss occurs.

23.1 Check your calibration by driving over a known distance. For example, if your plots are known to be 100 feet long, perform a distance calibration parallel to a plot.

Ag Leader calibration - Header sensor

24 Perform this calibration for each different crop type as the header height will vary between crops. This allows the sensor to determine when crops are being harvested, signaling the recording of data.

24.1 Offset entry is only required when the header is not mounted on the center of the combine (this is uncommon). As noted above, offset measurements are crucial to gaining high-quality yield data.

Ag Leader calibration - Vibration

25 Be sure to have the proper head for the specific crop type on the combine. Repeat this calibration for each different header and crop type.

25.1 The threshing system and feeder house should be engaged.

25.2 Inability to successfully complete the vibration calibration may indicate that your impact plate flow sensor needs to be replaced.

> **Note**
>
> Additional details are available for the Ag Leader Integra **vibration calibration**. Consult your Ag Leader dealer for assistance in troubleshooting.

Ag Leader calibration - Temperature

26 Perform once per season. If midday, park the combine in a shady spot and leave it for a couple of hours or calibrate in the morning. The combine should be free of grain. This calibration ensures air and combine temperatures are equivalent.

Ag Leader calibration - Moisture

27 Perform moisture calibrations once per crop per season. New calibrations will only affect data harvested after the change.

27.1 Collect four to six samples of grain from the hopper and determine moisture content using a moisture tester (with a stated accuracy of 0.5% or better) or by bringing to a local elevator.

27.2 Adjust the moisture value on the yield monitor to match the known moisture.

27.3 Moisture can also be set manually. This feature should be used when there is a specific area of the field in which you suspect the moisture monitor may give inaccurate results. An example is harvesting green soybean.

Note

- The sap from the stems will coat the moisture sensor which will result in the sensor reading the moisture of the sap instead of the grain.
- Using the manual moisture setting to alter moisture does not affect all previous data, it only applies to the area being adjusted.

Ag Leader calibration - Grain weight (calibration of the mass flow sensor)

28 Be sure to perform this calibration four to six times to achieve accurate weight values.

29 Ideally, the calibration loads will vary in yields to give a more robust calibration. One way to obtain this variation is to harvest some of the calibration loads with less than a full swath. The recommended load weights are three to six thousand pounds (i.e., 50-100 bushels).

Note

- When weighing, use the same vehicle and scale.
- Ag Leader recommends to not use semi-trucks because of their large capacity.

30 Calibrate the display for grain weight to an average error between 1% and 3%.

31 If the average does not fall within the range, remove the load containing the largest error and recalibrate. Recalibration will be applied to all grains of that type harvested during that season.

32 If fields vary substantially in grain moisture, treat wet (20-30% moisture) and dry corn as separate crops. They will have unique weight calibrations and setup values in your monitor.

John Deere (original GreenStar system) calibration - Mass flow sensor

33

Note

John Deere GreenStar Yield Monitor Calibration Quick Guide – High and Low Flow Calibration provides further information for general calibration procedures and flow procedures. The information below is condensed from that document.

This calibration should be performed for each different crop harvested. Accurate mass flow sensors allow you to obtain accurate grain weights. Additional accuracy may be obtained by using Low Flow Compensation procedures when the grain flow rate is highly variable.

34 The Flow Comp Number Screen is where the Low Flow Compensation procedure will be performed. This will be discussed following the standard calibration procedures.

John Deere (original GreenStar system) calibration - Yield (standard calibration procedure)

35 Prior to performing the calibration, machines used to collect and haul grain (combine and auger tube, wagon, truck) should be empty to achieve the most accurate results. The test should be performed at harvest speed for the specific crop type and conditions.

36 Select Calibration Mode to begin the yield calibration and harvest a known amount of grain (wagon load, grain tank full, etc.).

37 Stop the calibration, empty the combine, and weigh the harvested grain.

Note

Be sure the grain tank is completely empty prior to weighing the grain.

38 Upon obtaining the scale ticket, enter the weight value. The calibration factor will change according to the new grain weight.

Note

Standard calibration procedure does not apply backward to data already saved. Once changes are made by inputting a weight value as shown in the Yield Calibration section above, harvest information from that point forward will reflect the changes.

John Deere (original GreenStar system) - Low flow compensation procedure

39 Do not manually adjust the calibration factor if using Low Flow Compensation procedure.

40 Perform after the Yield Calibration procedure outlined above for the same crop type and conditions.

41 Set the ground speed to 1/2 to 2/3 of the speed used in the standard calibration procedure.

42 The Calibration Mode screen will indicate whether Low Flow Comp should be performed.

43 Select Low Flow Comp Mode to start.

> **Note**
>
> For additional information on yield calibration with the original GreenStar system, see *John Deere GreenStar Yield Monitor Calibration Quick Guide - Single Point Calibration.*

John Deere ActiveYield (S-Series and later combines) calibration - Temperature

44

> **Note**
>
> *John Deere GreenStar S-Series Yield Monitor Calibration Quick Guide* is the source for the following steps.

Perform once per season. If midday, park the combine in a shady spot and leave it for a couple of hours, otherwise calibrate in the morning. The combine should be free of grain. This calibration ensures are and combine temperatures are equivalent.

John Deere ActiveYield (S-Series and later combines) calibration - Mass flow vibration

45 Be sure to have the proper head for the specific crop type on the combine. Repeat this calibration for each different header and crop type. The head should be in an operational position. The combine should be stationary with the threshing system and feeder house engaged.

John Deere ActiveYield (S-Series and later combines) calibration - Moisture sensor

46 This calibration should be completed once per crop per season. Prior to this calibration, perform temperature calibration and check the moisture box to ensure the plates are clean.

47 Collect four to six samples of grain from the hopper and determine moisture content using a moisture tester (assuming 0.5% accuracy) or bringing it to a local elevator.

48 Enter the offset between the measured value and displayed value (can be positive or negative number).

Note

If inconsistencies develop in moisture readings with the harvest of 'wet' or high moisture grain, cleaning the moisture sensor is a potential troubleshooting tool.

John Deere ActiveYield (S-Series and later combines) calibration - Weight

49 Perform once per season per crop. Perform temperature and moisture sensor calibration prior. It is recommended to use uniform loads over 3,000 lbs. Five to seven loads, with each harvested at a different grain flow rate, provide the most accurate results.

50 Keep the grain flow rate constant within a single load. This can be accomplished by harvesting loads at different ground speeds but keeping the speed constant within a load. Do NOT dump on the go during calibration.

Note

- Note that recalibration will not alter previous harvest data which means if you perform a recalibration in the middle of a field, there will be two sections in the field. This will make post processing of the data difficult.
- Treat wet and dry corn as separate crops. This means they will have unique weight calibrations and setup values in your monitor.

Harvest data collection - Performing a test harvest

51 After performing the calibrations listed above, choose an area to perform a test harvest (a "bulk" area or a location where research data collection is not required).

52 While performing this test, look at the yield monitor screen to familiarize yourself with the monitor. Familiarity with how real-time information is displayed will allow you to see problems when they develop.

53 When using the Ag Leader Integra system, things to note on the monitor include harvest path, GPS status indicators (to check for loss of GPS accuracy), and how yield and moisture data are displayed.

54 In addition, explore the harvest diagnostics. Select the <Harvest Diagnostic> button, located on the bottom right-hand corner of the <Harvest Map> screen. This will provide you with information about flow rate, moisture, header sensor, elevator mount sensor, etc.

> **Note**
>
> The information can be used to diagnose a problem that occurred during calibration or harvest.

55 This would be accomplished by recognizing values that are inconsistent with the combine and crop type.

> **Note**
>
> For a John Deere system, diagnostic assistance can be found through a search for quick reference guides on the John Deere website. In addition, there are diagnostic pages in the manuals for the equipment.

Harvest data collection - Yield mapping operations

56 A general harvest suggestion for producing high quality data is the creation of good harvest patterns which avoid operational errors. Taking time to make a plan ahead of harvest will improve harvest efficiency and the quality of data obtained. Examples of operational errors include narrow swaths, multiple point rows, improper raising and lowering of the header, and excessive number of cleanup swaths.

57 Rapid velocity changes increase the likelihood for erroneous high or low yield data points. Maintain velocity within the range used to perform calibrations and avoid abrupt changes in velocity.

58 Lifting the head at the end of the pass results in a yield map which is easier to clean because the passes are clearly defined, and each pass can be isolated in a yield cleaning program such as USDA ARS Yield Editor 2.0.7.

59 In general, pay attention to your machine. Problems will often present through odd noises, sensors showing warning signs, or the combine beeping to indicate an issue.

60 In addition, periodically check the yield monitor to ensure it is not displaying error symbols as explained in the section above, Performing a Test Harvest.

61 Yield monitor data will likely be collected from areas in which discrete measurements were previously obtained such as aboveground biomass. The highest quality yield data from the yield monitor are likely desired at/near those same locations.

61.1 Ensure the combine is taking in a full swath of grain in that area.

61.2 Swath width is a key component when calculating grain yield values. A poorly recorded width value (incorrect value, width is changing frequently) will alter the yield value for that area.

Harvest data collection - Addressing in-field issues

62 For Ag Leader Integra systems, information can be found via the <Harvest Diagnostic> button discussed above in the section Performing a Test Harvest.

> **Note**
>
> Use information found in <Grain Harvest Diagnostics> to identify the problem.

63 For John Deere systems, select the diagnostics button, (denoted by a wrench laying in a book) and follow the directions.

64 If available, ask another operator/knowledgeable resource to ride along to help with identification and response to problems.

65 If the problem is calibration or sensor related, understand how the calibrations will be applied to the grain yield data collected for your specific yield monitor. This is addressed in the Yield Monitor Calibration section beneath the numbered list of calibration steps.

Note

- No matter the yield monitor brand, it is undesirable to create different data sets within the field by having different calibrations applied to different parts of the field.
- These data would be extremely difficult to work with when attempting to clean using the procedures defined in the *USDA LTAR Common Experiment measurement: Post-processing of spatial grain yield data* protocol.
- It is best for part of the field to be out of calibration and then attempt to edit and reconcile using the post-processing techniques.

Harvest data collection - Other considerations

66 Ag Leader has an Auto Swath Sensitivity setting which automatically alters the swath width when the harvester crosses an already-harvested area or field boundary.

Note

This setting is important because unknown or incorrect swath width is a common source of error in yield maps.

67 There are five sensitivity levels with Sensitivity 3 being the default. This is helpful so the operator does not have to manually adjust swath width. (This may be a task they are unwilling or unable to do.)

68 However, auto swath relies on GPS accuracy. If your GPS has a stated error greater than 20 centimeters (8 inches) a best practice would be to turn off the auto swath and manually adjust swath width during harvest.

69 Incorrect values for swath width result in inaccurate yield information as swath width is one of the variables used to calculate yield.

Data export from yield monitor software

70 Check that your USB has enough storage to hold new data.

71 Avoid deleting and replacing data when moving it to USB for storage. See pages 73-76 of the *Ag Leader Integra Manual* for instructions regarding file export and management.

Export parameters

72 Proper choice of the data export parameters in yield monitor software will allow best results when post-processing the data.

73 The parameters should be set to minimize the number of points deleted during export (data deleted during the export cannot be recovered in yield editing software such as USDA ARS Yield Editor 2.0.7).

74 More exported points allow those cleaning yield maps to determine which points are relevant and which are not.

75 Suggestions for export parameter values are provided in the bullets below.

- Grain flow delay should be within five seconds of the correct value (plus or minus). The *USDA ARS Yield Editor Manual* states that 12 seconds would be an adequate value for most setups.
- Start and stop delays (start and end pass) should be set to zero.
- Minimum and maximum yield filters should be disabled.
- In some cases, it may be useful to keep positional flyers and points where the header is raised.

Summary and overview of key points

76 To minimize errors with a grain yield monitor collection system, the following steps are recommended. The following is a checklist from Chapter 5 of the *Precision Agriculture Basics* textbook included in the references. This checklist also summarizes steps discussed throughout the protocol.

76.1 Inspect your clean grain elevator chain for wear and make sure the mass flow sensor and associated impact plate are in good shape and clean.

76.2 Inspect all wiring harnesses for any wear or damage. If needed, securely attach any loose wiring to prevent damage.

76.3 Clean and inspect the moisture sensor.

76.4 Check the yield monitor display for any errors and wires for rodent damage. Check the data card and preload field names and hybrids.

76.5 Check for any firmware updates for various components including the in-cab display.

76.6 Review the owner's manual as a refresh on operation and calibration.

76.7 Calibrate the sensors.

Calculations

77 To calculate **yield using harvest moisture**, in bushels/acre:

$$Y = \frac{m_{harvest} \times t_{sample}}{d \times w \times \rho_{grain}} \times \frac{144\ in^2}{1 ft^2} \times \frac{43{,}560 ft^2}{1 acre}$$

Equation 1.

- $m_{harvest}$ harvest mass flow rate (not adjusted to market moisture, based on harvest moisture)
- t_{sample} data logging interval (seconds)
- d distance traveled (inches)
- w width of combine header (inches)
- ρ_{grain} mass grain density (pounds per bushel)

Note

In Equation 1, the variable ($m_{harvest}$) can be replaced with m_{market} when m_{market} is calculated as shown in Equation 2.

77.1 Convert the above mass flow rate from **pounds per second** to **kilograms per second.**

1 pound = 0.453592 kilograms

78 To calculate **yield using market moisture**, in bushels/acre:

Convert wet mass flow rate to market flow rate using Equation 2. The new flow rate will be in pounds per second. Use this flow rate in place of *mharvest* in the yield calculation above.

$$m_{market} = \frac{100\% - MC_{harvest}}{100\% - MC_{market}} \times m_{harvest}$$

Equation 2.

- m_{market} corrected mass flow rate (pounds per second)
- $m_{harvest}$ mass flow rate of moist grain
- $MC_{harvest}$ moisture content of the moist grain
- MC_{market} moisture content basis (15.5% for corn, 13.0% for soybean)

79 Common conversions (Iowa State University, 2022):

1. Corn/Grain Sorghum
   - 1 bu/acre = 62.77 kg/ha
   - 1 kg/ha = 0.0159 bu/acre

2. Soybean/Wheat
   - 1 bu/acre = 67.25 kg/ha
   - 1 kg/ha = 0.0149 bu/acre

Summary and overview of key points - Quality assessment and quality control

80 Record calibration weights from the combine along with the associated scale weight, as well as any other loads for which a scale weight has been obtained. You should indicate what loads in the yield monitor are associated with each respective weight.

Archiving

81 The operator should make sure the appropriate field metadata are chosen or entered in the monitor before starting the field of interest. This could include enterprise, farm and field names, crop type, variety, and other identifying information.

Protocol references

AgLeader

Ag Leader Integra Manual. **https://portal.agleader.com/community/s/contentdocument/069f400000DTJ2QAAX?language=en_US**

John Deere

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Yield Editor

USDA ARS Yield Editor Manual. Attached as a PDF to this protocol and also available as part of the software download package at: https://agdatacommons.nal.usda.gov/articles/model/Yield_Editor_2_0_7/24664038

General

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