Yield Monitoring: the beginning or the end?

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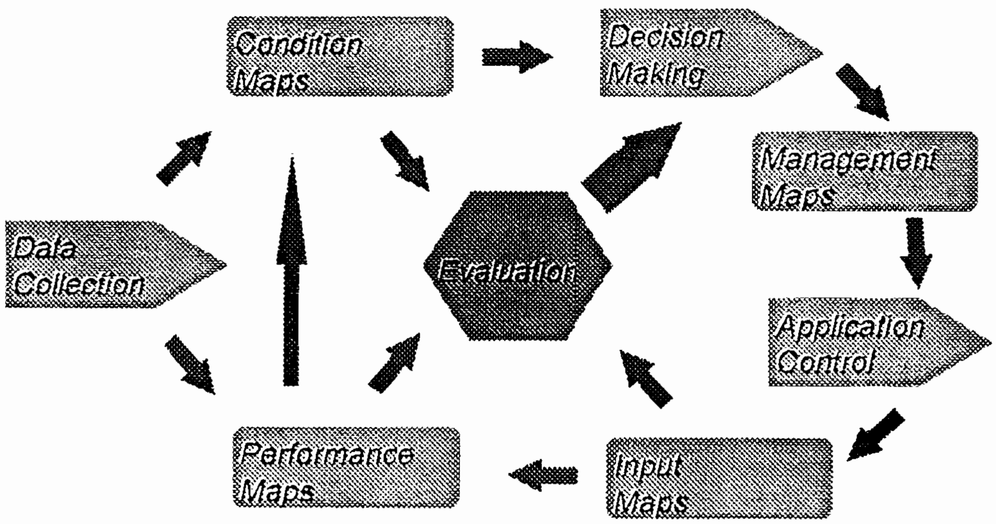
Introduction

As site specific management or precision farming gains acceptance with the agricultural producer, the question remains: "Where do I begin?". As technology creates and makes available new machines for the site specific environment: "How do they fit into the picture?". As the yield monitor has become the most popular and accepted of these technological innovations for the agricultural producer, what role does it play in the site specific management concept? What is site specific management and where does the yield monitor fit in, the beginning or the end?

Site specific management has been defined as "a management concept which recognizes variability within the soil and crop environment and maximizes economic production while minimizing environmental impact for a specific location (Krill 1994)". It is important to point out that site specific management is a management concept, a process, not a piece of technological equipment. The yield monitor does not encompass site specific management but is a technological tool that provides information for site specific management. Site specific management affects the way an agricultural producer makes decisions through the use of information. Agronomic production agriculture will enter the information age through site specific management and the yield monitor will provide a portion of this information. Yield monitor data creates performance maps and enters along with other collected information into the data collection portion of the Site Specific Management Flowchart.

Site Specific Management
Krill 1995



Yield Monitoring Process

Yield monitoring has been defined as "the measurement of the harvested portion of a crop over space and time and the summarization of those measurements in a graphical map form (1994, Pierce)". Is it possible for a combine or any device to measure yield? Not directly, yield is the result of a mathematical calculation using several measurable components. Yield is a calculation based upon the amount of commodity, the area from which the commodity was gathered, and information relative to the commodity. Likewise, yield monitoring is not a simple operation but a complex task requiring mathematical computations and geographical positioning. This task will probably be completed both in the combine during harvest and in the office following importation of harvest data.

At the combine, the machine must complete five specific components: 1)grain flow, 2)grain moisture, 3)grain type, 4)area covered, and 5)location. Grain flow can be measured with paddle wheel, impact, light, magnetic, radiation, or weight type sensors. The impact type sensor is the most popular in the U.S. market and measures the mass of grain being thrown at the sensor located at the top of the clean grain elevator by the clean grain elevator paddles. The result of this sensor is a measurement of mass per unit time (i.e.: lb./sec). Grain moisture is commonly measured as a percentage and is the result of the electrical continuity of the grain as it passes between the negative and positive portions of the sensor. This measurement is generally taken on the clean grain as it passes between the cleaning portion of the combine and the grain tank. The third component, grain information including type and test weight, is critical to the yield computation and even with all the sophistication of the yield monitor is left up to the operator to manually input. Area covered is measured in area per unit time (i.e.: in^2/sec) and is the result of distance traveled, measured through Differential Global Positioning System (DGPS) or the combine's transmission or ground radar systems, and swath width as imputed by the combine operator. The final component is location and it is responsible for putting the puzzle of information bits back together into a field to form a map. This is commonly left up to the DGPS, however it can be done mechanically.

The yield monitoring system at the combine is reasonably effective but it does have some inherent problems. The yield monitor is a sophisticated piece of equipment and is only as good as its installation, calibration, and combine operator. Poor installation can result in improper sensor operation. A wrong calibration table can cause distortion on any mathematical calculation. A major challenge facing the combine operator when operating a grain platform is to accurately determine and maintain a consistent width of cut or swath. Failure to maintain this consistency results in some yield monitor error. The yield monitoring process collects information at various points throughout the combine's activities of gathering, threshing, separating, and cleaning of grain. All of these processes take time, so time lag considerations must be factored into the equations. Secondly, the combine has been designed to be a smoothing machine and attempts to maintain an even continual flow throughout the machine. This smoothing can hide some of the variation that may be occurring in the actual field. The time lag factor and smoothing factor do cause the yield monitor considerable challenges as the combine enters into and exits from the grain harvest as it commonly does during turning at each end of a field. A yield monitor is much more accustom to operating under continual combine load like normally present when traveling through a field harvesting. Finally, a combine may be unable to remove some foreign matter from the clean grain flow that can affect the performance of the sensors. This material can cause false readings because of extra material, different characteristics from the actual grain, or by leaving residues on the sensors. With these inherent problems, it is important to realize that a yield monitor is not perfect and must be used within its capabilities.

The accuracy of yield monitors is an important question. To determine accuracy one must first identify the spacial realm in which to measure. Three common realms are identified as field, strip, and spacial. Field accuracy is what is commonly reported regarding yield monitors. Field accuracy is determined by comparing the total measurements compiled over an entire field for both actual and estimated weights. Actual measurements would commonly be the sum of all net weights from weigh tickets for that field as the grain was taken to market or storage. Estimated weight would be the sum of all calculations performed by the yield monitor for that given field. Advertising claims, field testimonials, and unpublished research indicate that this measurement of accuracy is commonly under 5% and probably in the 2-3% range or less. These claims make no reference to spacial accuracy. The second measurement of accuracy of common concern relates to accuracy for a strip of grain. This is of concern because much of the on-farm research efforts are geared around strip trials. In a poster presentation (Krill 1996), it was indicated that the AgLeader 2000 yield monitor was found to do a respectable job of estimating the quantity of grain harvested in two years of strip trial data. (see appendix for actual results) It was concluded that the yield monitor can be a beneficial tool in strip trial research provided the test was designed within the capabilities of the yield monitor and the yield monitor was properly installed and calibrated. Again, this study made no claims as to spacial accuracy of the monitor. The final book on yield monitoring accuracy has not been written. As stated in Fran Pierce's definition (1994), yield monitoring is the "harvested portion of a crop over space and time". Yet, little if any research is available regarding the spacial accuracy of yield monitors. Spacial accuracy relates to the yield monitors capability to properly calculate the crop yield at a specific point in the field.

Current data only relates to the accuracy of the yield monitor over large areas known as fields, or still relatively large areas known as strips. The accuracy of the yield monitor to a small area or point is still unknown. Additional efforts are needed to better understand this spacial relationship with the yield monitor.

Yield monitoring does not end in the combine but continues back into the office. Data taken from the combine must be recovered, transformed, stored , processed, and placed into a graphical map representation. Because of the quantity of data involved in yield monitoring, all data will be handled electronically through the use of a computer system. Data can be recorded at the combine on either time based or distance based intervals. Accuracy appears to not be greatly compromised as time intervals are increased beyond 1 second to 2 or 3 seconds; however, combined data can never be separated latter for additional analysis. Data will most generally be transposed into some common linear representation (i.e.: ASCII comma delimited). Data collected at the combine are generally transferred to the office through the use of a PCMCIA card. These cards are available in various sizes of both SRAM and ATA types requiring the use of a card reader and drivers to recover the data and enter it into the office computer system. This appears to be a simple procedure but conflicts between PCMCIA cards, card readers, and computer components can exist. It is important to regularly backup data recorded in the combine by transferring it into the office computer system. The office computer should also practice a sound backup procedure to protect the valuable data. It is also important to check the quality of the data collected by the combine so adjustments can be made if discovered necessary. Remember, as an agricultural producer there is only one chance to record harvest and it cannot be redone if a problem exists. Often, the only way possible to examine this data is to transfer it to the office computer. Data are generally recorded in a proprietary format in the combine which must be transformed into a useable format through the use of software provided by the yield monitor provider.

The storage, processing, and map generation portion of yield monitoring is turned over to the Geographical Information System (GIS). This computer based system is simply a filing system where information is filed by geographic position (longitude, latitude) rather than the common alphabetical method. Most systems also provide for the storage of the original raw data from the combine yield monitor. This is important because if for analysis or other purposes a producer would be required to change GIS systems. Often, the data must be imported into the new system in its original format. GIS systems generally do not readily share or transpose data with other systems. The GIS is composed of a database to store numerical or character data and a geographical base to store points, lines, and regions. Together the database and geographical base will store the information and make it available for analysis and map generation. Within the GIS there are potentially many layers of information each filed under a specific geographical position. Within analysis, it is possible to perform calculations across a given layer of information or through layers of information at a given geographic location. The results of any single layer or analysis can then be represented through the creation of a geographically correct map.

Yield monitoring provides information to incorporate into the decision making process. When using information it is important to remember the process through which the data were collected. In interpreting yield maps, the final result of yield monitoring, look for trends in the data and realize that the exact spacial accuracy of the map is unknown. Do not get consumed by absolute positions and remember the inherent problems facing the yield monitor. Make comparisons on areas and stay attentive to trends. Look for lines in the map. Look for pockets of either exceptionally good or poor. Pay attention to patterns appearing in the map that may be attributable to an agronomic practice. Be cautious of visual presentations on the maps. Understand the legend responsible for creating the map. Involve people who know the field and crop experts. Finally, before drawing conclusions, re-examine the data that created the map. Yield monitoring will probable not answer any particular question but it will create more questions as to the crop production environment available for a crop in a given year. Yield monitoring is going to provide the agricultural producer with information, not any direct economic return. The economic return from yield mapping must be found through using the information to make better decisions using the site specific management process. Yield monitoring is nothing more than an information generator for the decision making process.

Summary

Yield monitoring is a popular portion of the emerging agricultural production management system known as site specific management. As individuals become involved in yield monitoring it is important that they remember the place of yield monitoring in the site specific management system. Yield monitoring is merely a data collection device that can produce information. Yield monitoring is neither the beginning or the end of the site specific management process but an important data collection component. The site specific management process is a continual process revolving among data collection, decision making, and application control. Agronomic producers also need to realize that the process of crop growth and development is a complex subject. A subject that is controlled by many variables and the interrelationships between these variables. Yield provides an evaluation of the entire process and in most situations the result is not the symptom of one single event but the compounded effect of many situations throughout the growing season. Some of these situations the agricultural producer may have control over but many of them are purely an act of nature. When implementing new site specific management practices, select situations where the grower can have an effect, and focus on corrective management practices. The concept of site specific management is developing so encourage producers to participate cautiously and realize that much of the book is still being written on site specific management. Be alert to change, and remain committed to the learning process. Only through time, experience, and research will we learn how to maximize the potential of site specific management.

Bibliography:

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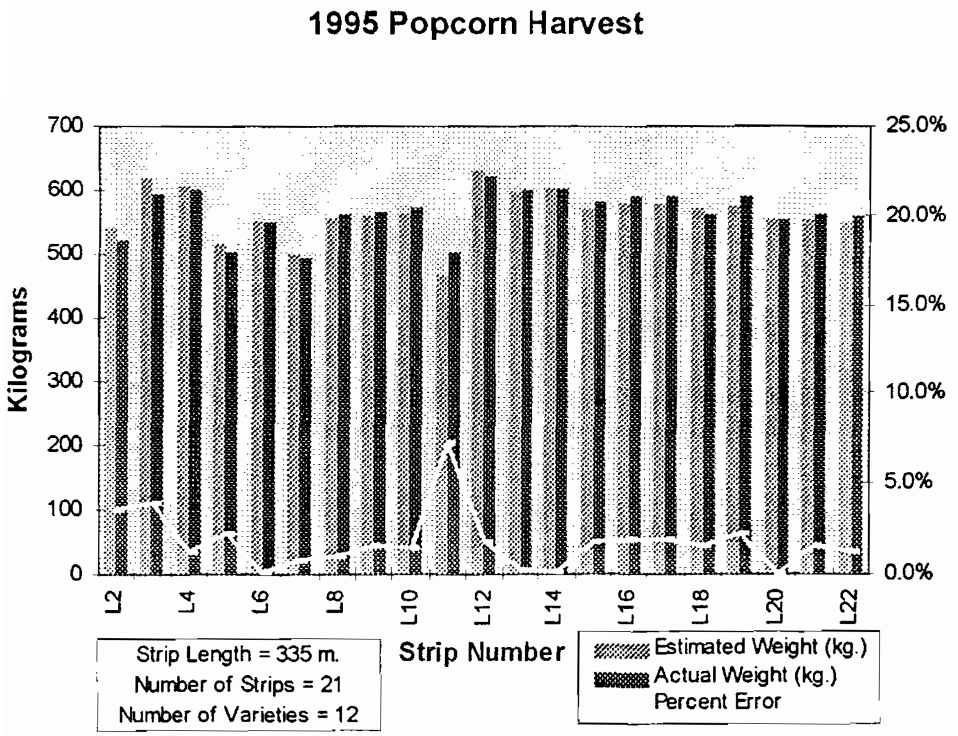
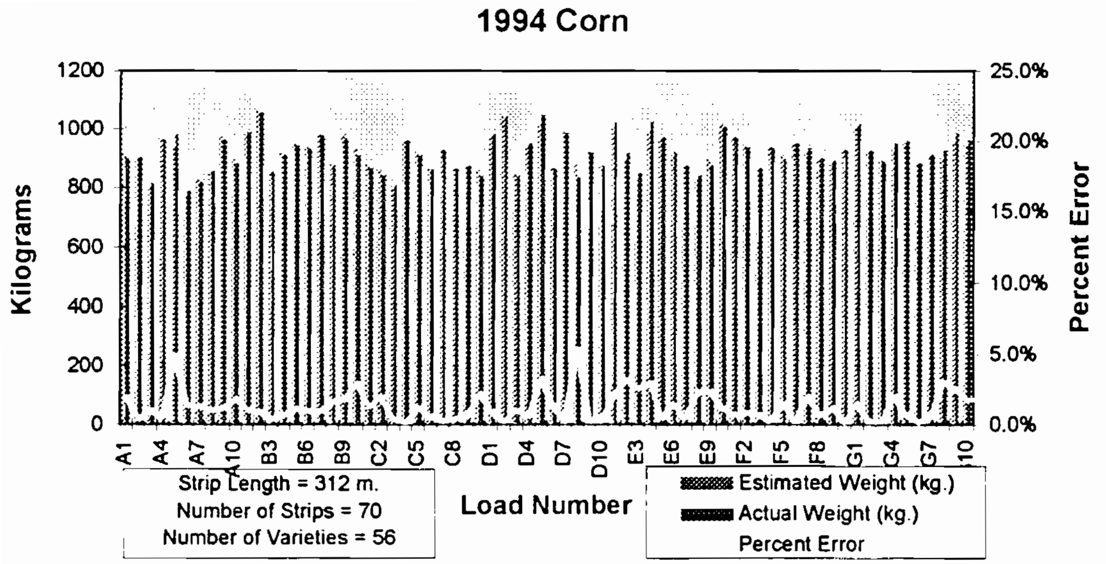
Appendix:

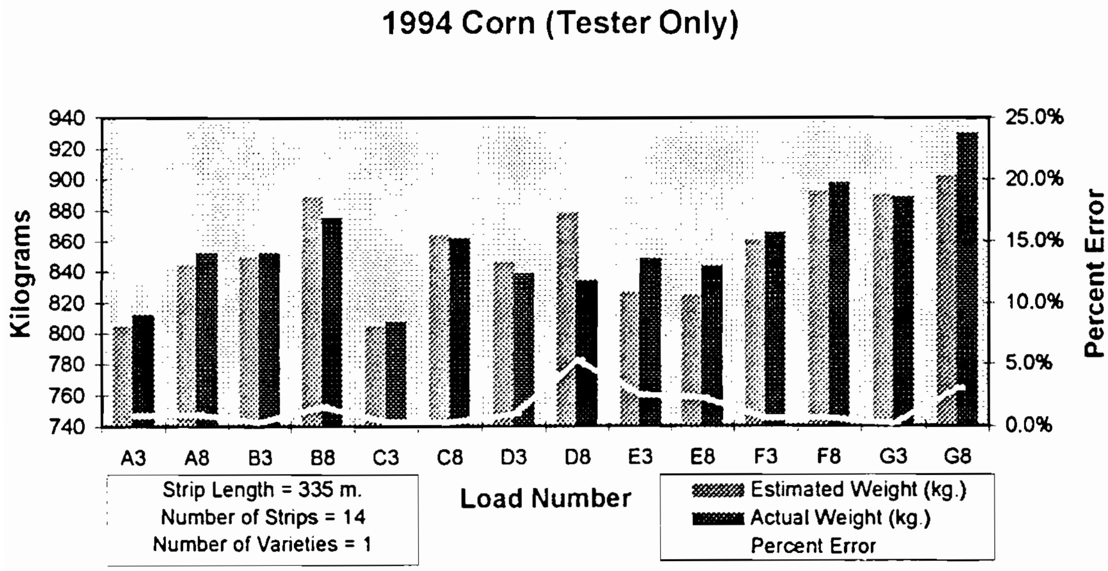
graphics from the poster presentation:

Effectiveness of AgLeader Yield Monitor for Evaluation of Varietal Strip Data

Dr. Thomas L. Krill
3rd International Conference on Precision Agriculture
Bloomington, Minnesota
June 1996




1994 Corn
Kilograms
1200
1000
800
600
400
200
0
Percent Error
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
A1 A4 A7 A10 B3 B6 B9 C2 C5 C8 D1 D4 D7 D10 E3 E6 E9 F2 F5 F8 G1 G4 G7
Load Number
Strip Length = 312 m.
Number of Strips = 70
Number of Varieties = 56
Estimated Weight (kg.)
Actual Weight (kg.)
Percent Error


1994 Corn (Tester Only)
Kilograms
940
920
900
880
860
840
820
800
780
760
740
Percent Error
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
A3 A8 B3 B8 C3 C8 D3 D8 E3 E8 F3 F8 G3 G8
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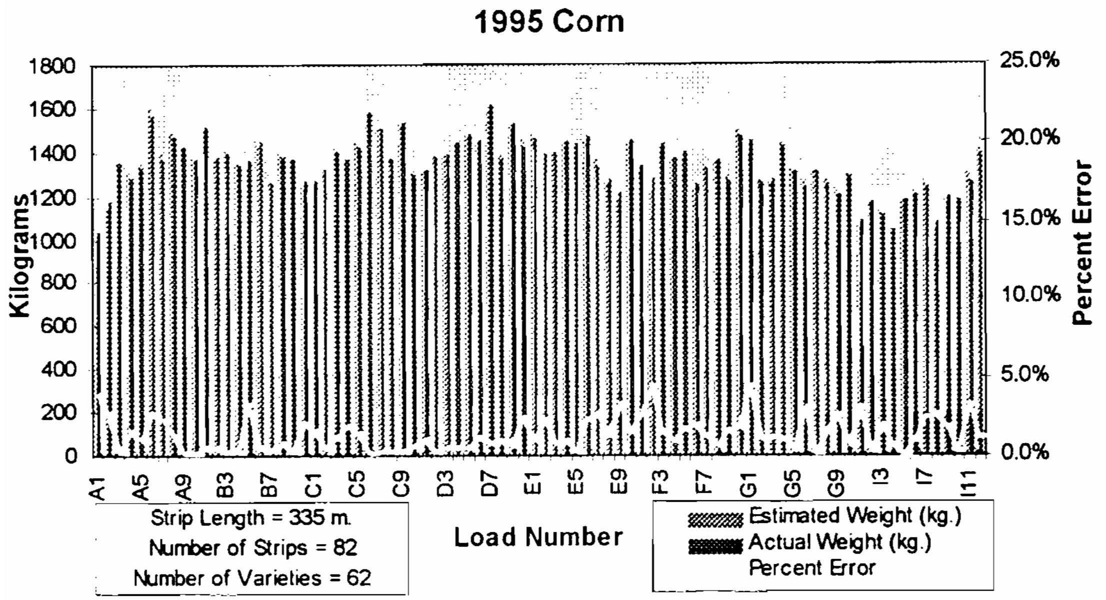
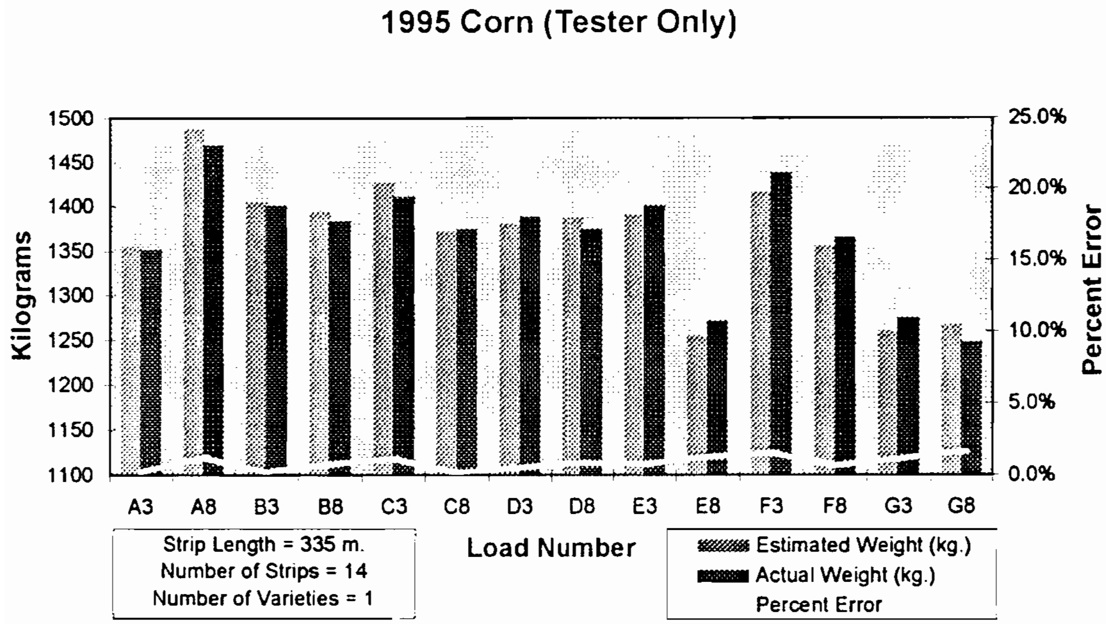
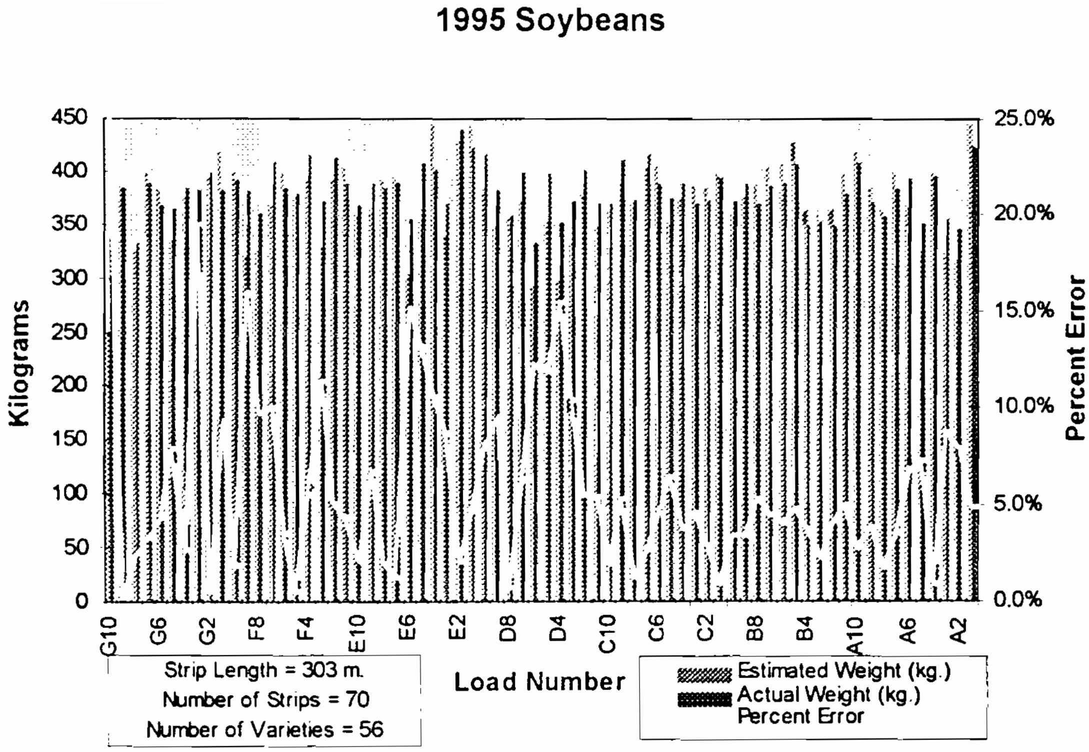
Number of Strips = 14
Number of Varieties = 1
Estimated Weight (kg.)
Actual Weight (kg.)
Percent Error



1995 Corn
Kilograms
Percent Error
Load Number
Strip Length = 335 m.
Number of Strips = 82
Number of Varieties = 62
Estimated Weight (kg.)
Actual Weight (kg.)
Percent Error



1995 Corn (Tester Only)
Kilograms
Percent Error
Load Number
Strip Length = 335 m.
Number of Strips = 14
Number of Varieties = 1
Estimated Weight (kg.)
Actual Weight (kg.)
Percent Error



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Kilograms
Percent Error
Load Number
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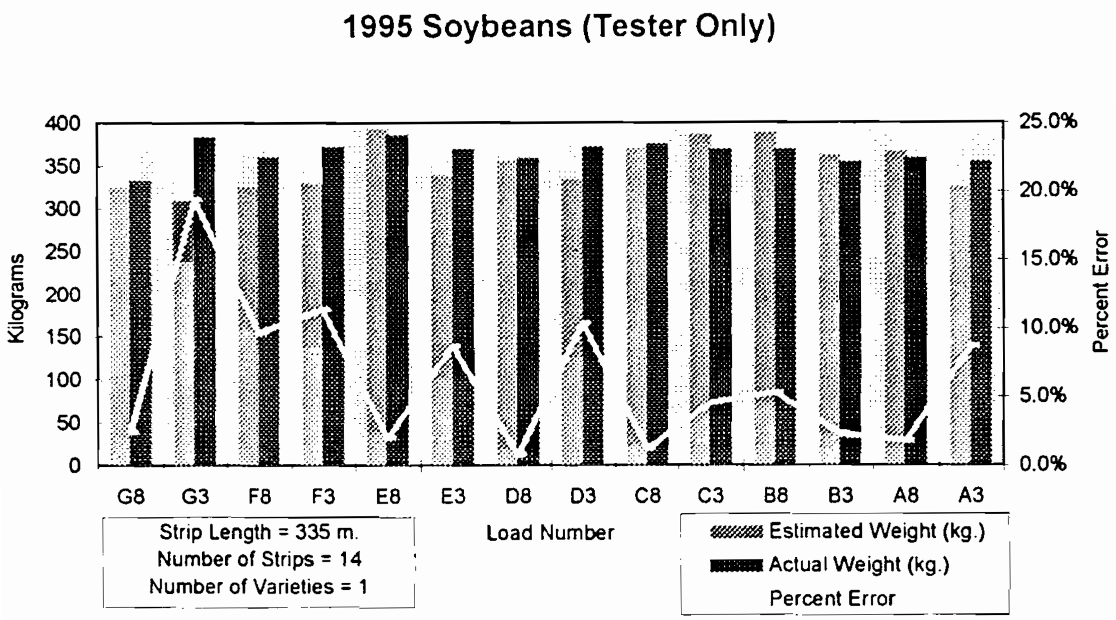
Number of Strips = 70
Number of Varieties = 56
Estimated Weight (kg.)
Actual Weight (kg.)
Percent Error



1995 Soybeans (Tester Only)
Kilograms
Percent Error
Load Number
Strip Length = 335 m.
Number of Strips = 14
Number of Varieties = 1
Estimated Weight (kg.)
Actual Weight (kg.)
Percent Error

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