# Sugarcane Yield Monitor Update

By

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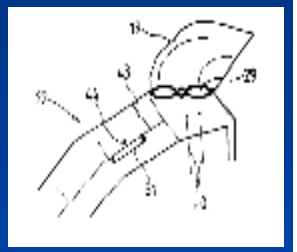
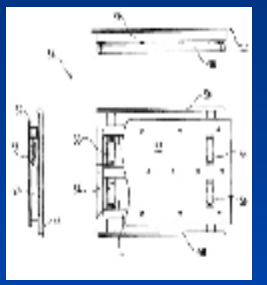
# Syllabus:

- Current systems available and being tested world wide
- Louisiana needs
- Systems we are currently working on
- Where we are at today

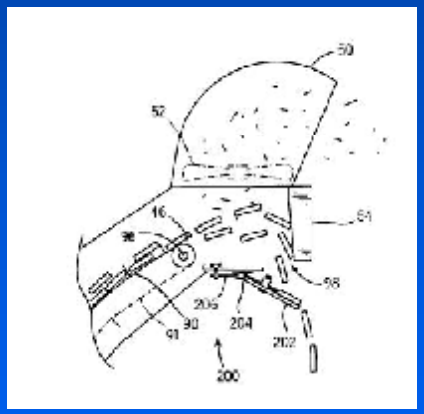
# Previous Yield Monitors:

- Elevator load cell and weight plates
  - 10% on mapping size units, 4% on truck load out weight
  - Problems: Silting in of plate, Lot of sensors needed (tilt, Butterworth filers, etc.), adaptation to harvesters in the field





- Torsion impact plate
  - Wendt et al. (2001) – Case IH
  - Outlet of elevator
  - Patented system also used base cutter pressure sensor
  - Accuracies not stated, but hasn't been produced



- Harvestmaster
  - Overhead looking system
  - Not patented
  - 5 Ultrasonic sensors arranged across width of conveyor
  - Not researched, but thought to have 1% accuracy over short time periods
  - Problems: Wouldn't hold calibration over ½ day periods
  - Not very good instruction how to use or mount unit

rrp1

# Yield Monitors Tested in Australia (2010):

- TechAgro:
  - Senses feed train roller opening and end of feed train before chopper unit
- MTData Unit:
  - Measuring change in hydraulic pressure across the chopper and roller motors
- AgGuide Unit:
  - Measuring change in pressure across the elevator motor.

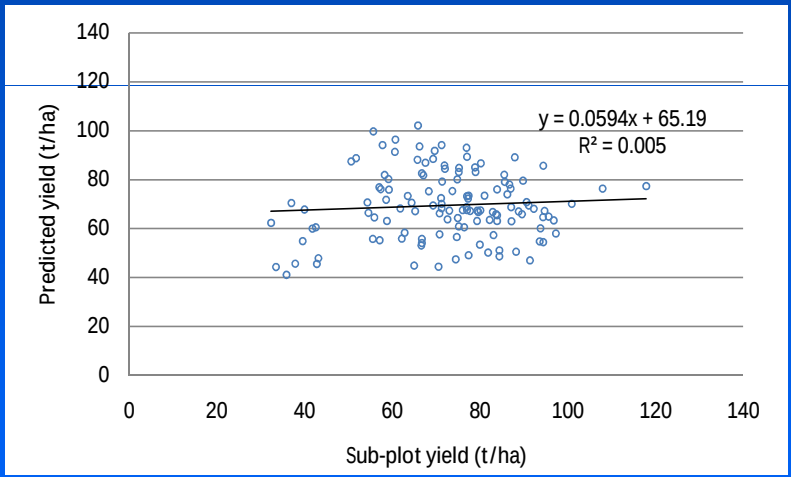
TechAgro Unit

**Slide 4**

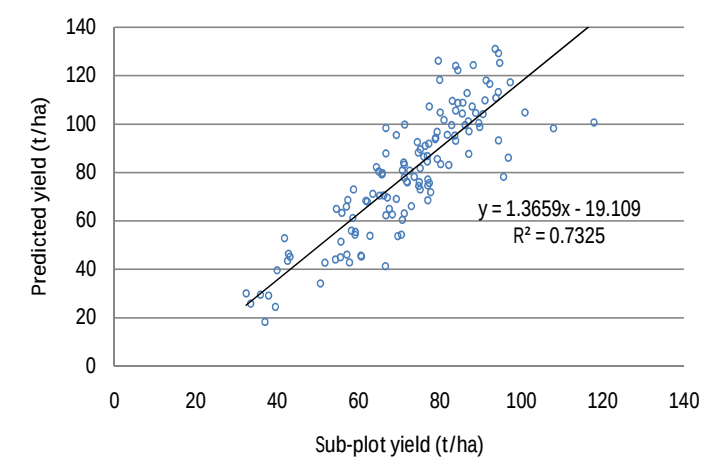
**rrp1** - these actually sold in Australia and Available for Purchase
-It should be noted that the primary function of the MTData unit is for vehicle tracking. As an add-on, Mackay Sugar has fitted pressure transducers to selected harvesters to investigate work-rate as a coarse indication of yield variation. This has allowed the MTData unit to be used out of context, as a yield monitor.
Randy R. Price, 5/21/2010

# Results of Australian Units:

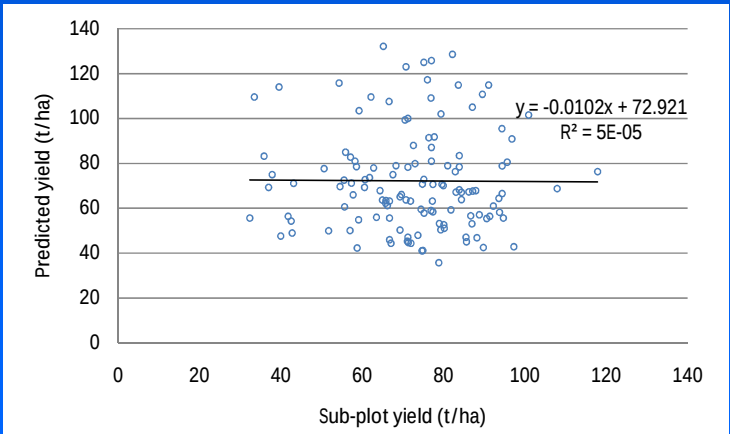
- Jensen, T (2010) “Assessment of Sugarcane Yield Monitoring Technology for Precision Agriculture”)
- Tested Mappings Units Only: 60 meter lengths




AgGuide: change in pressure across the elevator motor



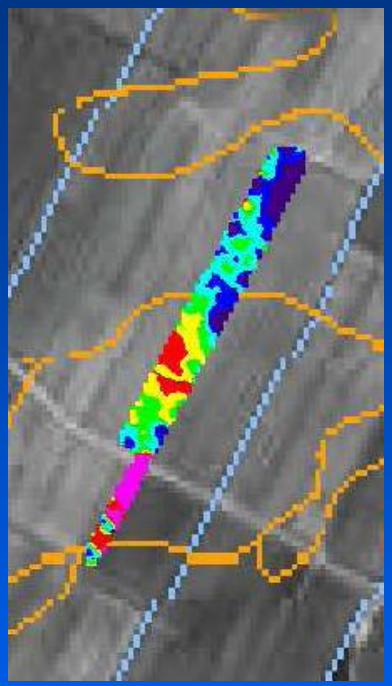

TechAgro: feed train roller opening



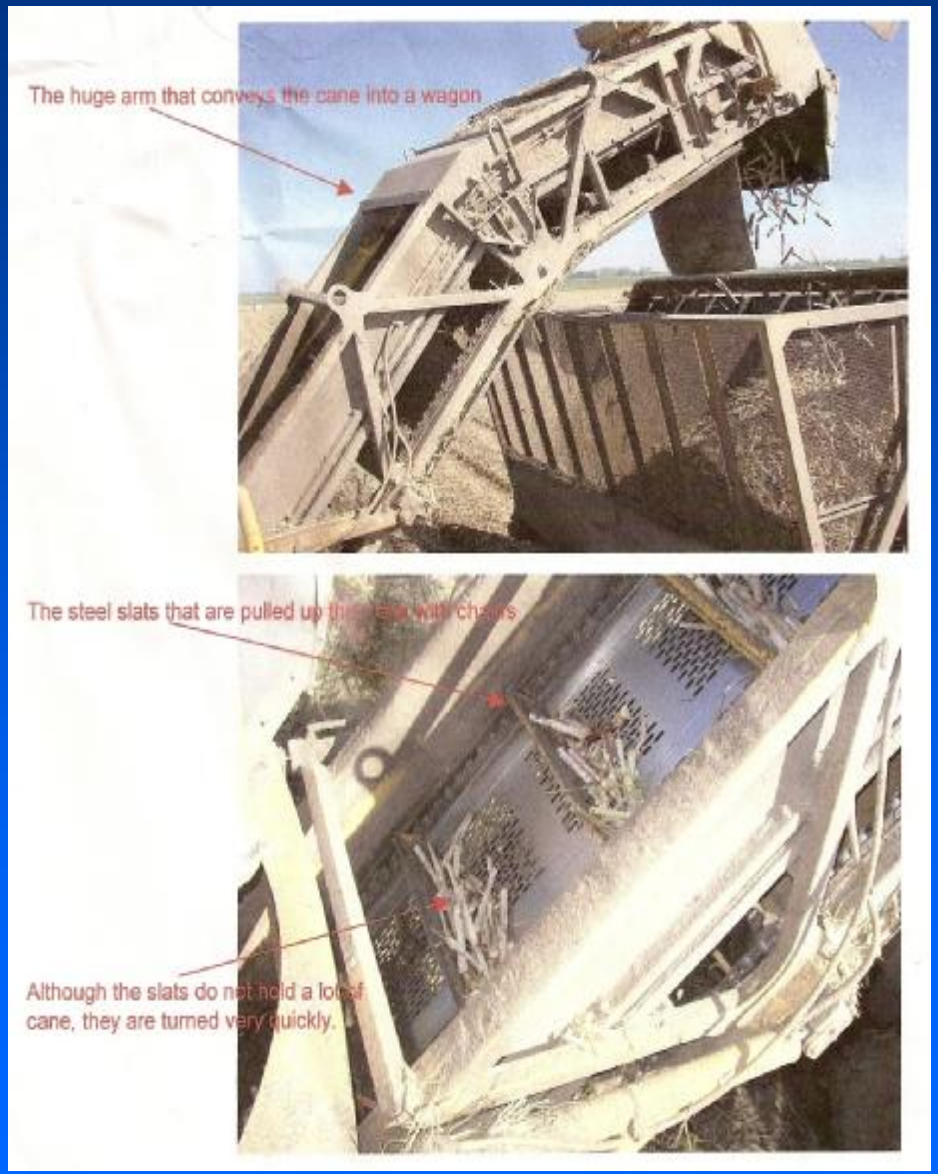

Macky Sugar MTD Unit: Monitors change in hydraulic pressure across the chopper and roller motors

# Yield Monitors for Louisiana Sugarcane Industry:

- Two Uses:
  - Mapping
    - Allows construction of a prescription maps
  - Load Out Weight of Trucks
    - i.e.- one farmer could save 3 truck loads per day
    - 90 truck loads over a 3 month season

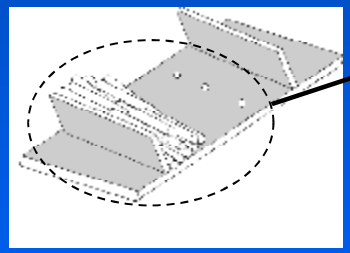


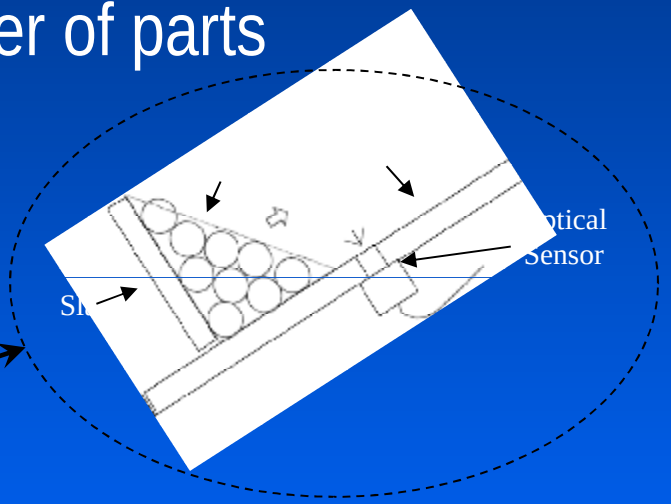
# Under-conveyor Approach:



# Under-Conveyor Approach:

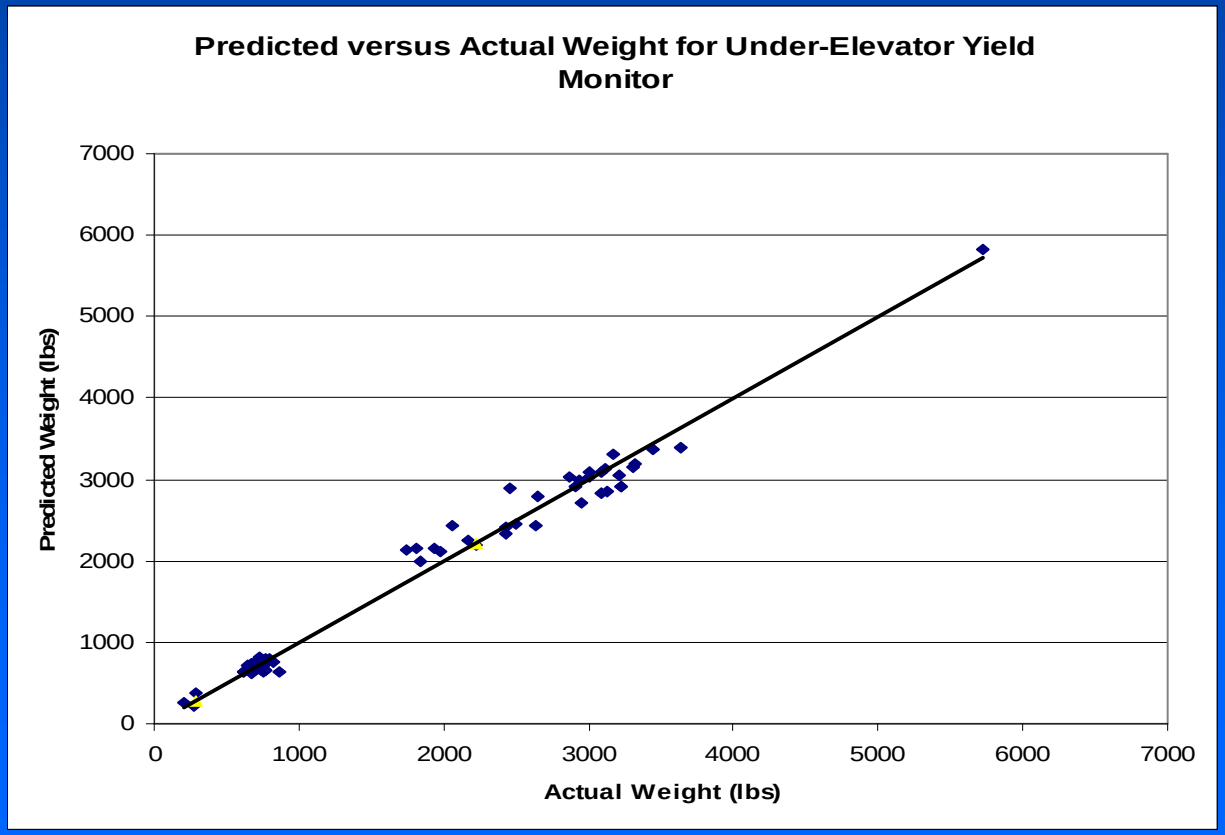
- Three fiber optic sensors mounted underneath the conveyer
  - Advantages: self-cleaning, low number of parts
  - Easy to install



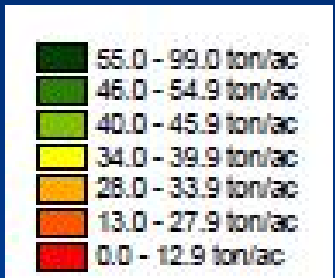


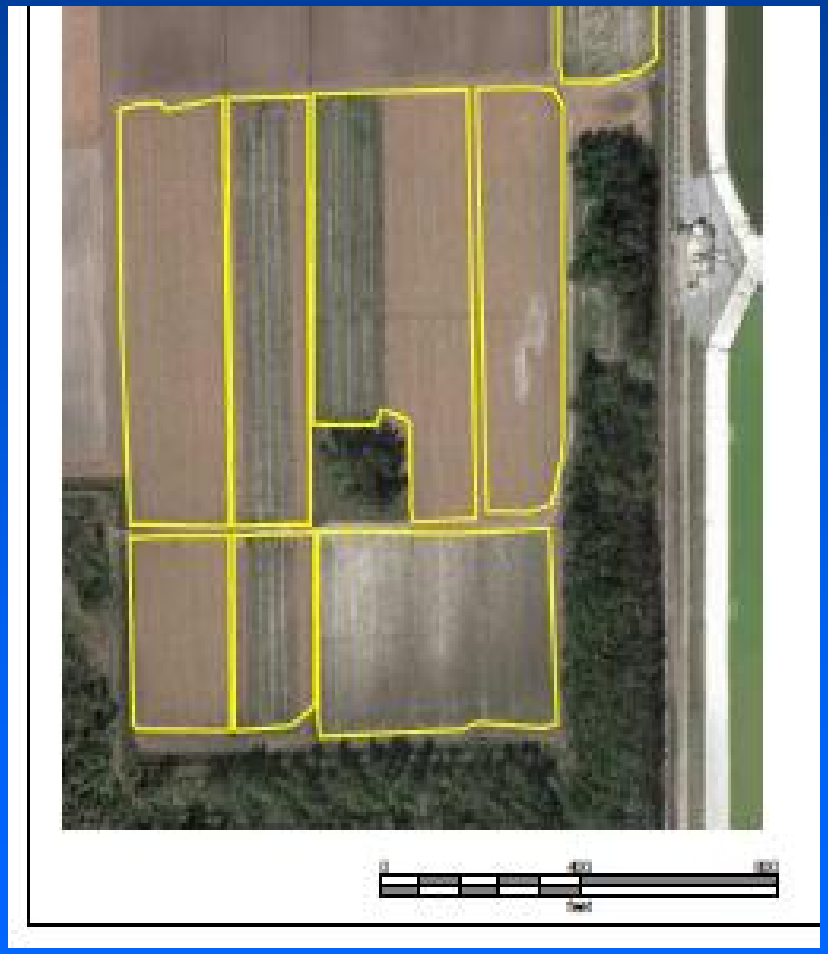

# Results for Under-conveyor:

- Linear Output
- Good R-square – 0.94



# Louisiana Maps 2011
# Agronomic Consultant



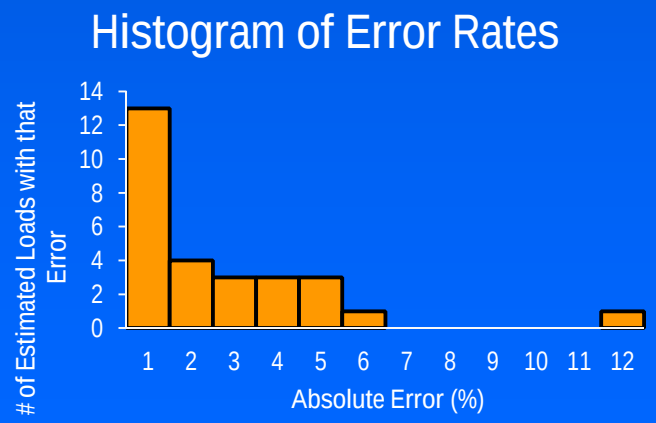
# Truck Load Out Weight Estimates (Short Period: 2-3 hours after calibration):

- 46,000 lb Truck Load Estimates
- One day, November 9, 2009, New Iberia, Louisiana:
- Weight = 0.10219 * Raw Sensor Reading

| Raw Sensor Reading | Actual Weight | Estimated Weight | Error (%) |
|---|---|---|---|
| 411000 | 43200 | 42000.09 | 2.78 |
| 460000 | 46222 | 47007.4 | 1.70 |
| 437000 | 45420 | 44657.03 | 1.68 |
| 475000 | 47560 | 48540.25 | 2.06 |
| | | Average Error | 2.05 |
| | | Standard Deviation | 0.51 |

# Truck Weights Over 1 Week Period:

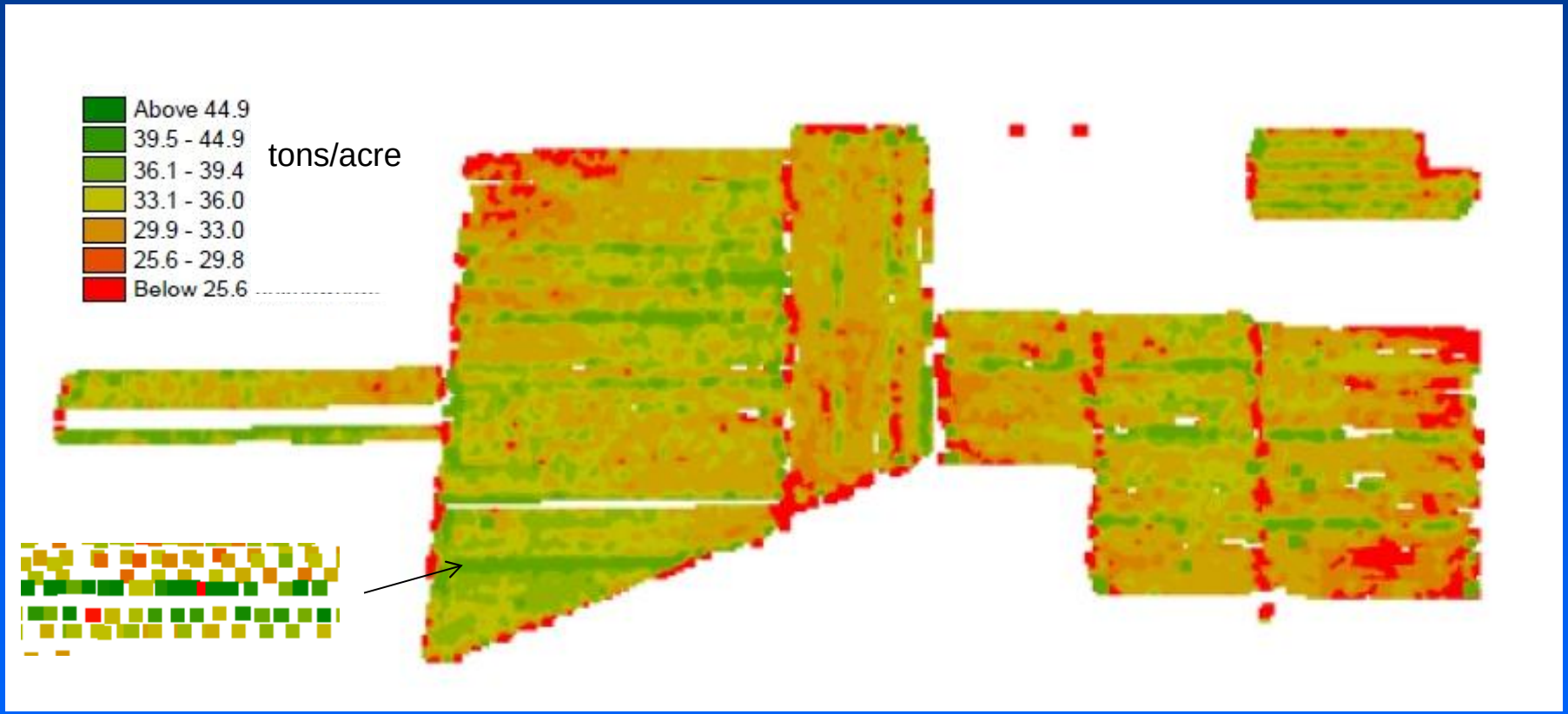
- 28 truck load weights in the 44,000 to 50,000 lb range
- Average Error: 2.53%
  - Stdev: 2.55%
  - 95% of errors below 5%




| Date | Actual Weight | Estimated Weight | Error (%) |
|---|---|---|---|
| 11/9/2009 | 44380 | 45756.67 | 3.10 |
| 11/9/2009 | 46980 | 45394.72 | 3.37 |
| 11/9/2009 | 45840 | 48119.58 | 4.97 |
| 11/9/2009 | 49300 | 43175.13 | 12.42 |
| 11/10/2009 | 49080 | 48819.5 | 0.53 |
| 11/10/2009 | 46100 | 44392.45 | 3.70 |
| 11/10/2009 | 46900 | 46748.94 | 0.32 |
| 11/10/2009 | 46420 | 45578.87 | 1.81 |
| 11/10/2009 | 46480 | 46850.31 | 0.80 |
| 11/10/2009 | 45100 | 44559.46 | 1.20 |
| 11/10/2009 | 48040 | 50727.44 | 5.59 |
| 11/10/2009 | 47960 | 45719.53 | 4.67 |
| 11/10/2009 | 50020 | 49127.42 | 1.78 |
| 11/10/2009 | 44300 | 42580.2 | 3.88 |
| 11/10/2009 | 46900 | 49215.67 | 4.94 |
| 11/11/2009 | 47000 | 47499.8 | 1.06 |
| 11/11/2009 | 44860 | 45616.29 | 1.69 |
| 11/11/2009 | 44380 | 44283.93 | 0.22 |
| 11/11/2009 | 45080 | 43707.78 | 3.04 |
| 11/11/2009 | 46420 | 47269.5 | 1.83 |
| 11/11/2009 | 49220 | 51283 | 4.19 |
| 11/11/2009 | 51200 | 51842.86 | 1.26 |
| 11/11/2009 | 51084 | 51578.6 | 0.97 |
| 11/11/2009 | 45260 | 45000.90 | 0.57 |
| 11/11/2009 | 45380 | 45658.79 | 0.61 |
| 11/13/2009 | 44660 | 45242.46 | 1.30 |
| 11/13/2009 | 46320 | 46532.50 | 0.46 |
| 11/15/2009 | 46140 | 45929.4 | 0.46 |
| | | Average: | 2.53 |
| | | Stdev | 2.55 |

# Yield Map - New Iberia, LA:

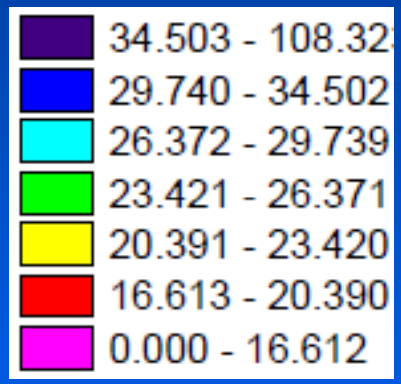
- One week of cutting - 1 harvester (3510)

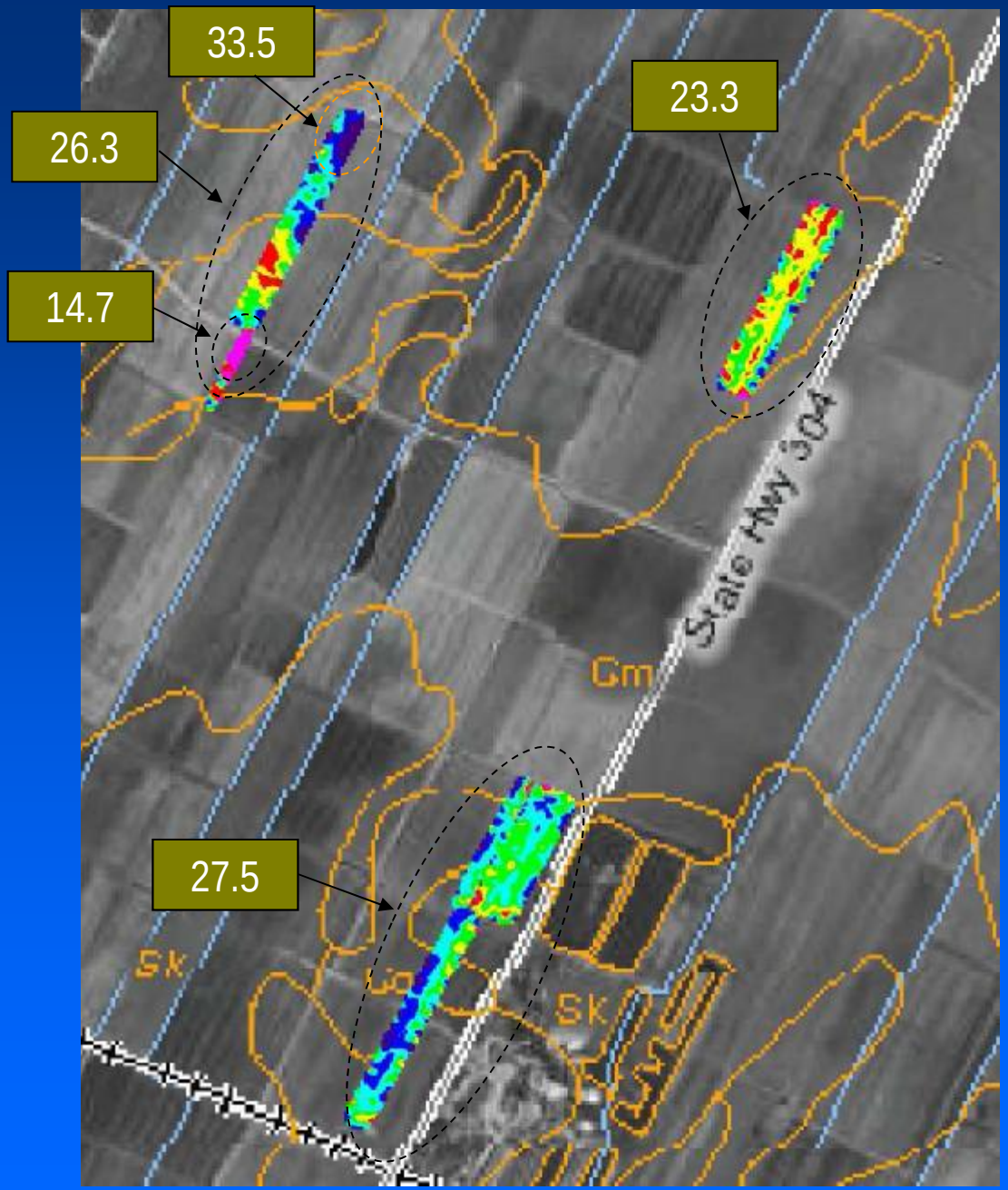



Data shows high yield rows where material was broke out with a whole stalk harvester (two rows thrown into one)

# Yield Map for 2010 in Louisiana:

- tons/acre

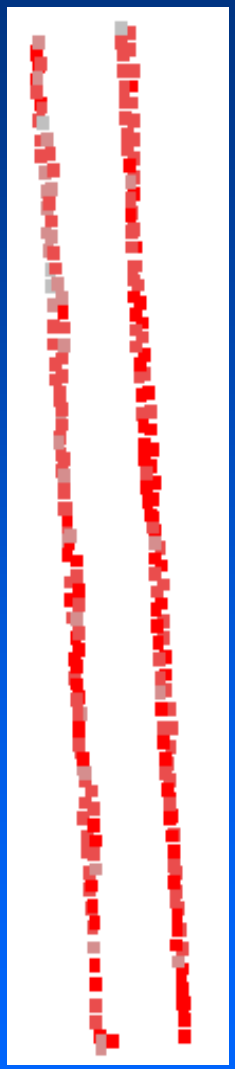


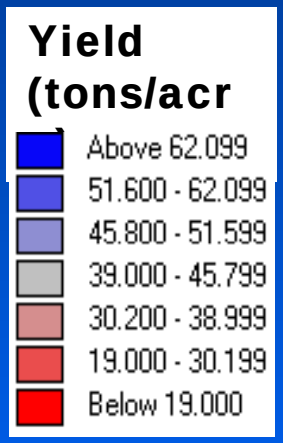



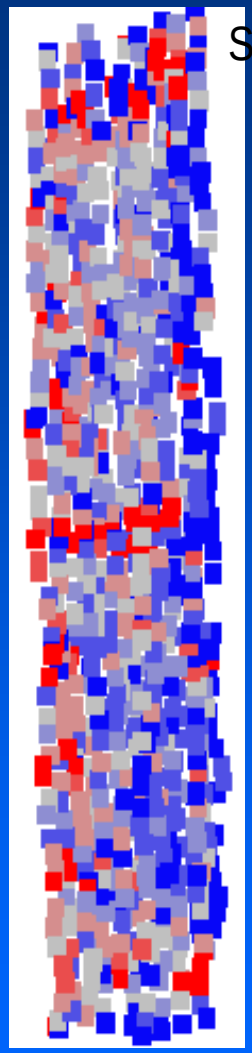
# Test Variety Plots at USDA Houma:

Field 1

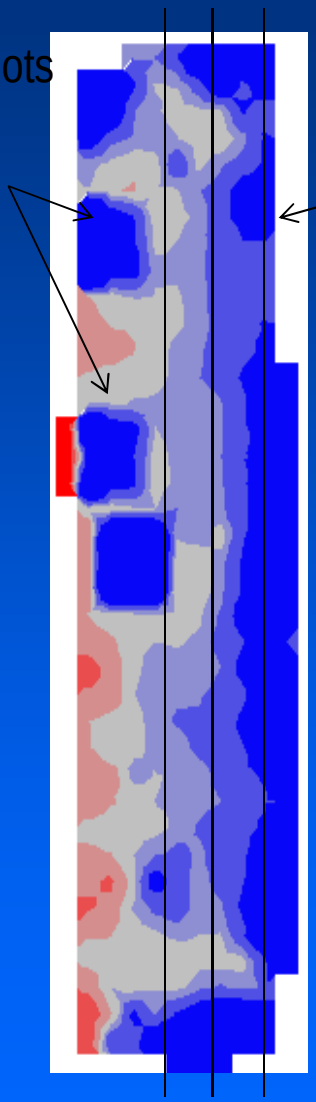
Field 2





Square Plots



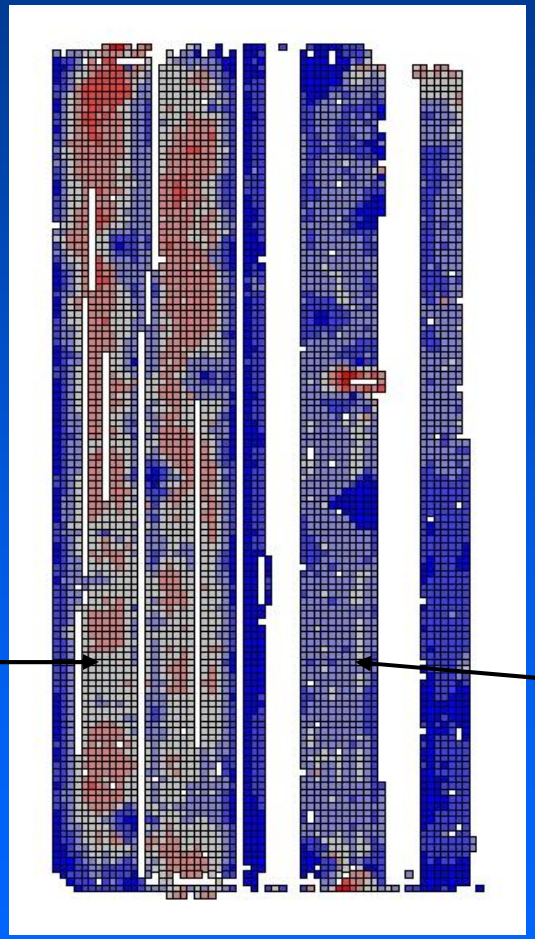
Straight Rows of different Yielding Varieties

Pure Variety Seedlings

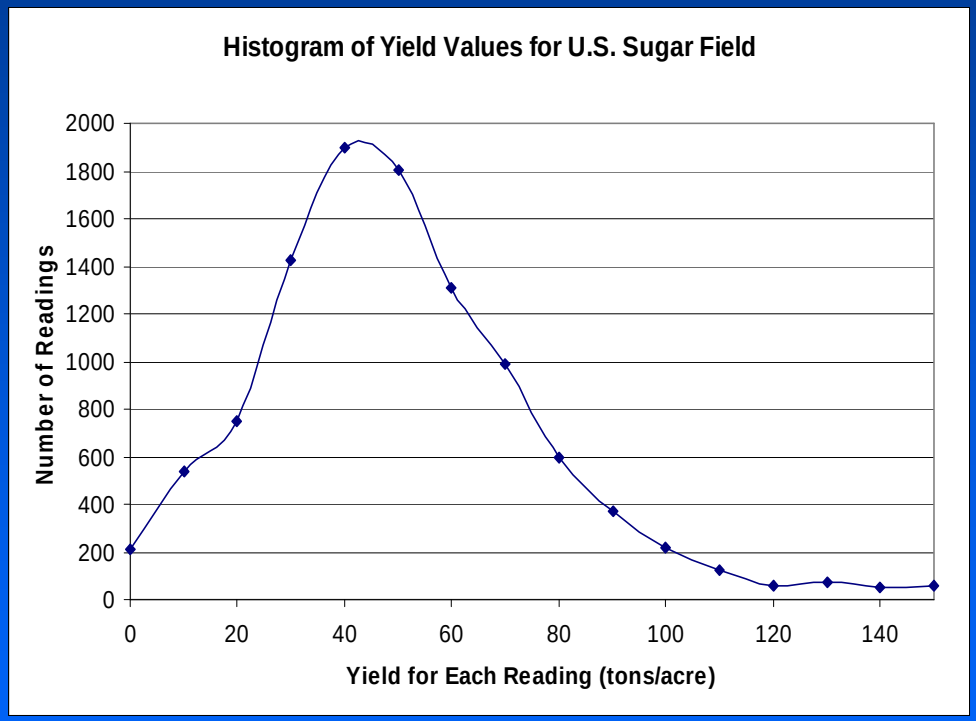
Raw Data

Smooth Data (15 ft. Blocks)

# U.S. Sugar Field – Agronomic Check:



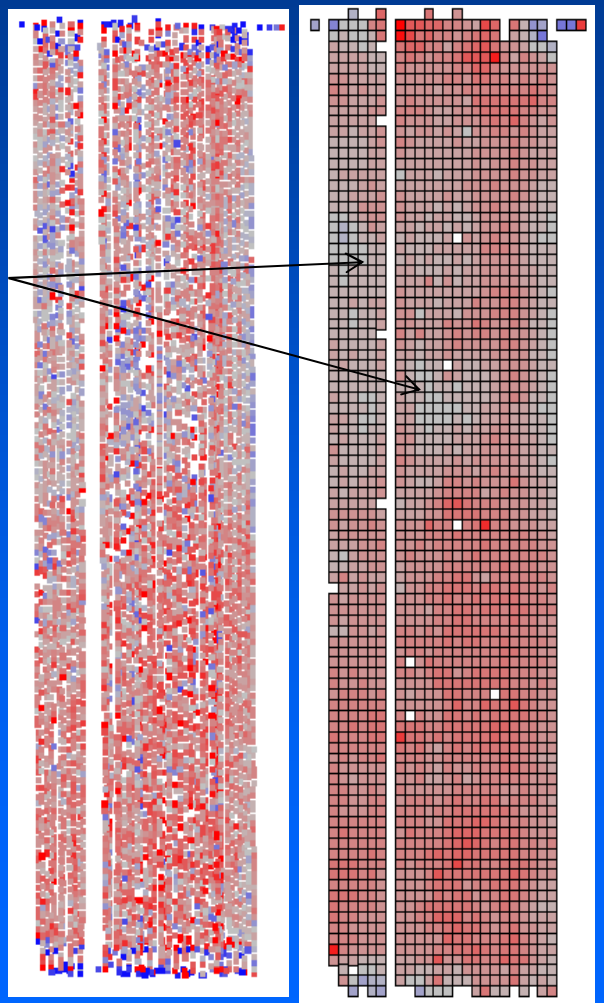
# Histogram of U.S. Sugar Field



# Louisiana Field (Alexandria):

-Yield variances in sugarcane fields > 10 tons/acre
- Monitor can show that easily

Lower Yield Areas



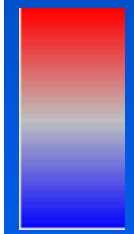
Raw Data

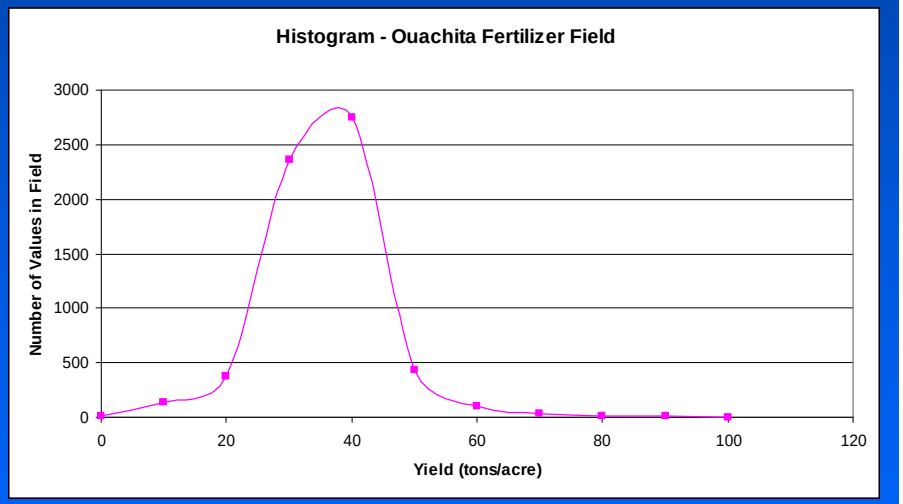


Smoothed Data

Yield

(Tons/acre)



# Honduras Central America - 2011

- Yield map compared to stand density
- 2 Calibration loads
  - 4.2% Error
- Near Azimuth Mill (owned and operated by Coca Cola)

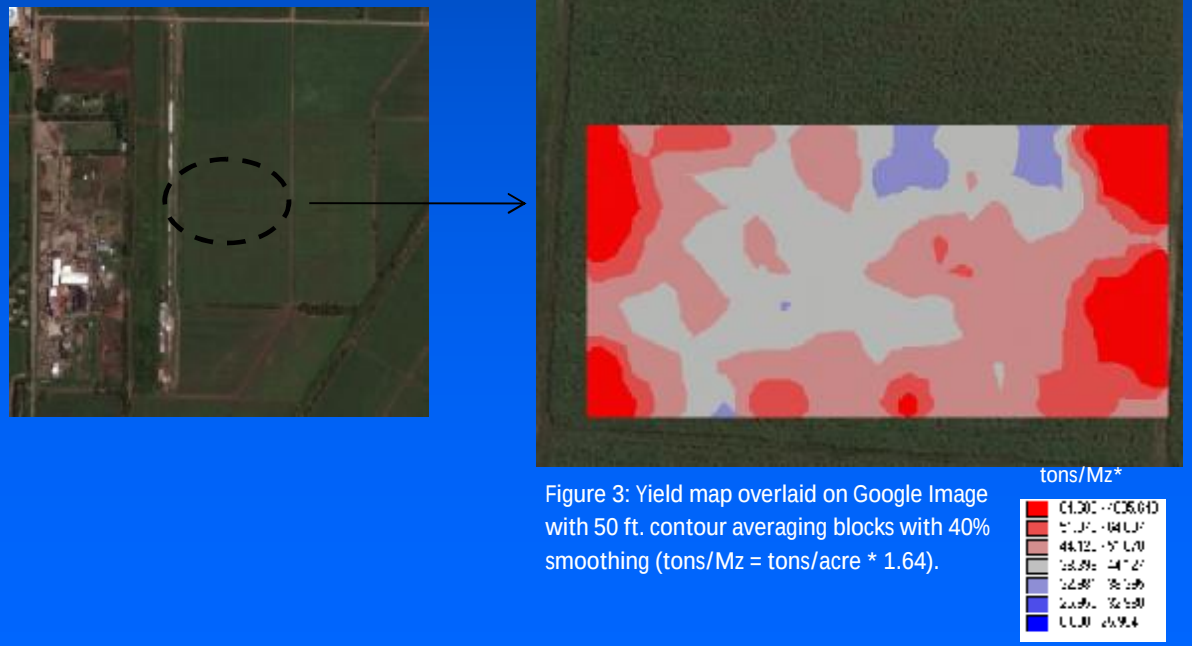



Figure 3: Yield map overlaid on Google Image with 50 ft. contour averaging blocks with 40% smoothing (tons/Mz = tons/acre * 1.64).

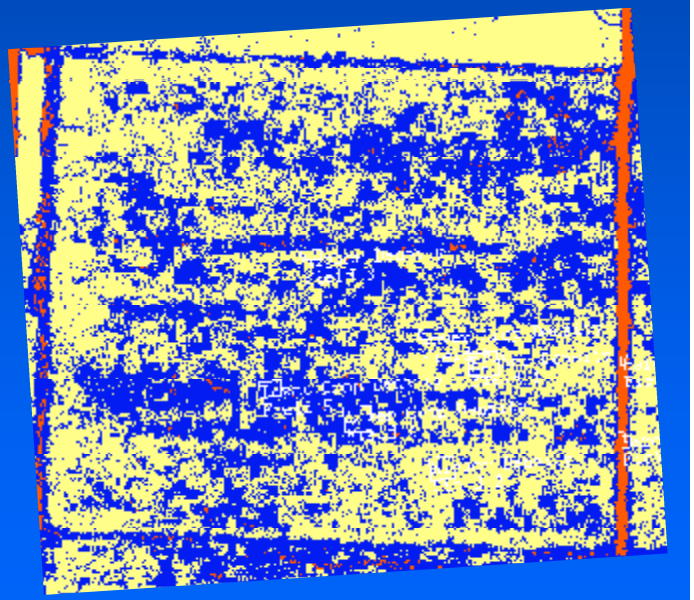
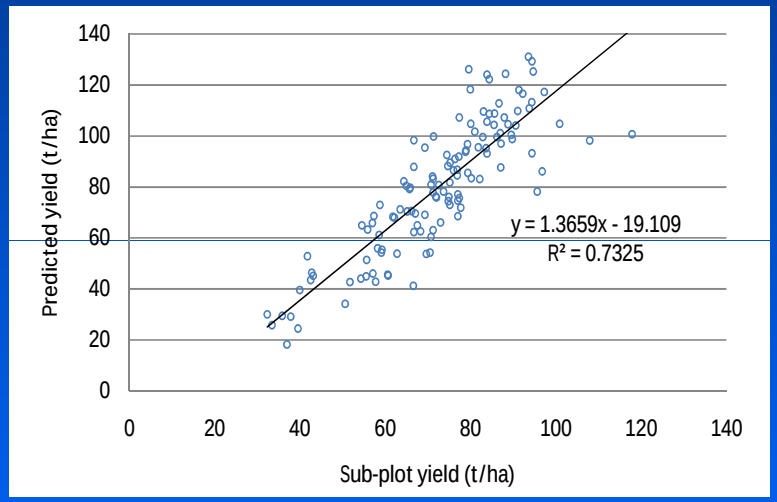


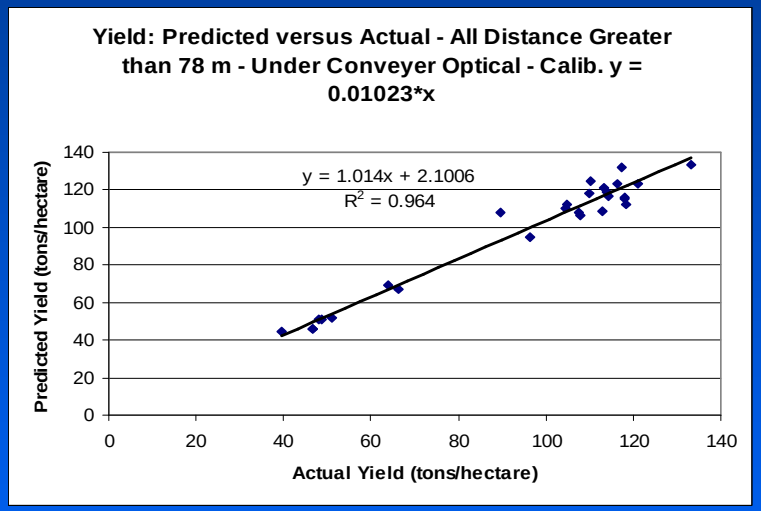
Figure 4: Image classified into two main areas: 1) Higher, denser foliage – light yellow; and 2) Lower foliage – Blue.

# Comparison to TechAgro Unit:

- Compare only 60 meter long run data:

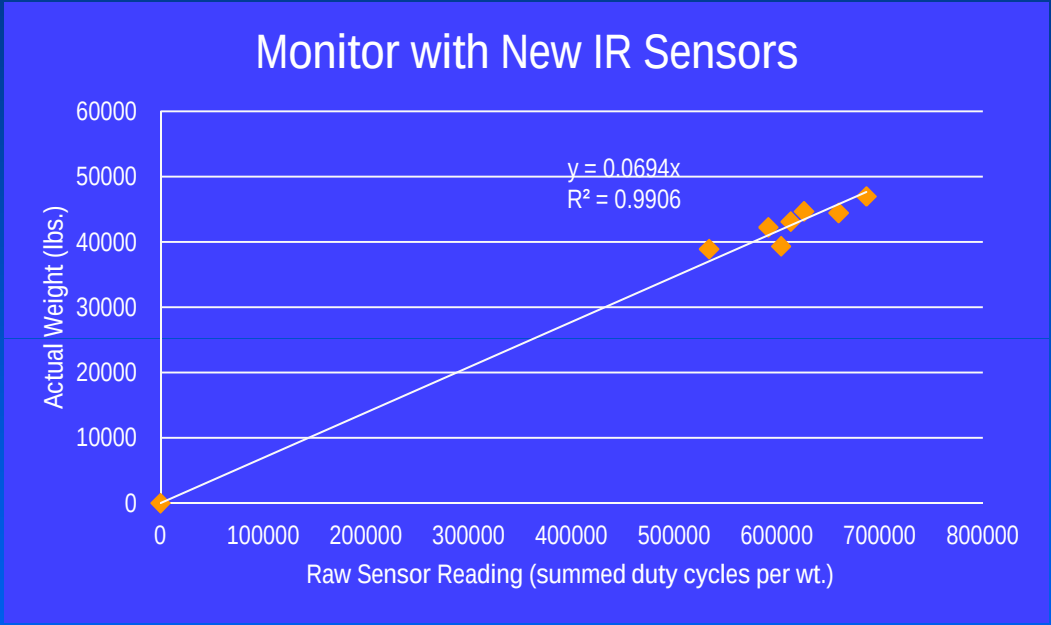



TechAgro: feed train roller opening




Under-conveyer Optical

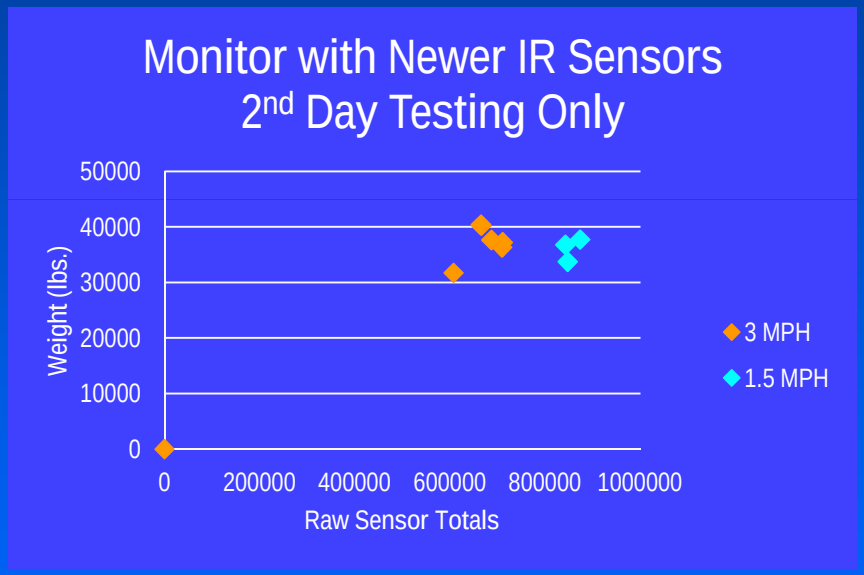
# Testing in Burnt Cane with Trimble:

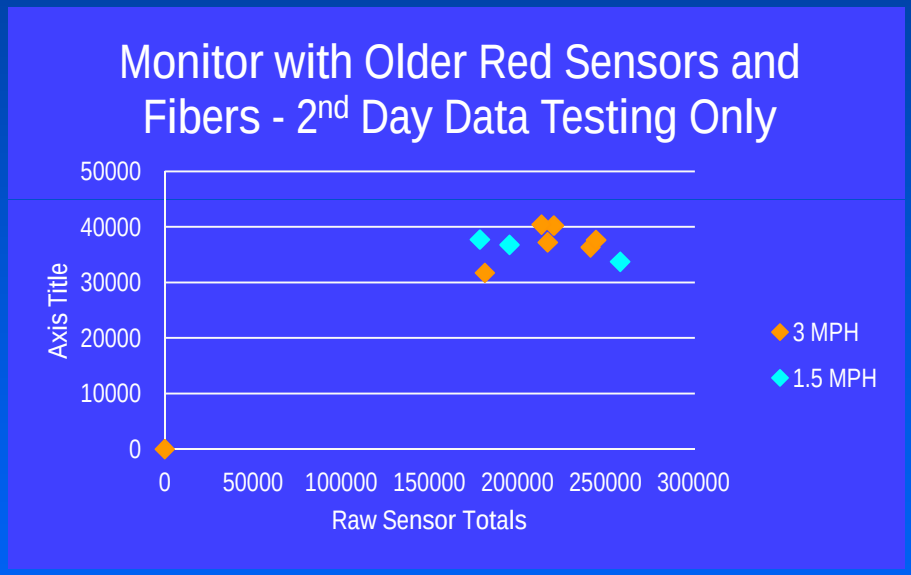



| Estimated Weight (lbs.) | Actual Weight (lbs.) | Abs Error (%) |
|---|---|---|
| 41037 | 42240 | 2.8 |
| 42544 | 43110 | 1.3 |
| 41897 | 39340 | 6.5 |
| 45003 | 43040 | 3.6 |
| 45777 | 44450 | 3.0 |
| 37034 | 38900 | 4.8 |
| 47659 | 46980 | 1.4 |
| 43443 | 44680 | 2.8 |

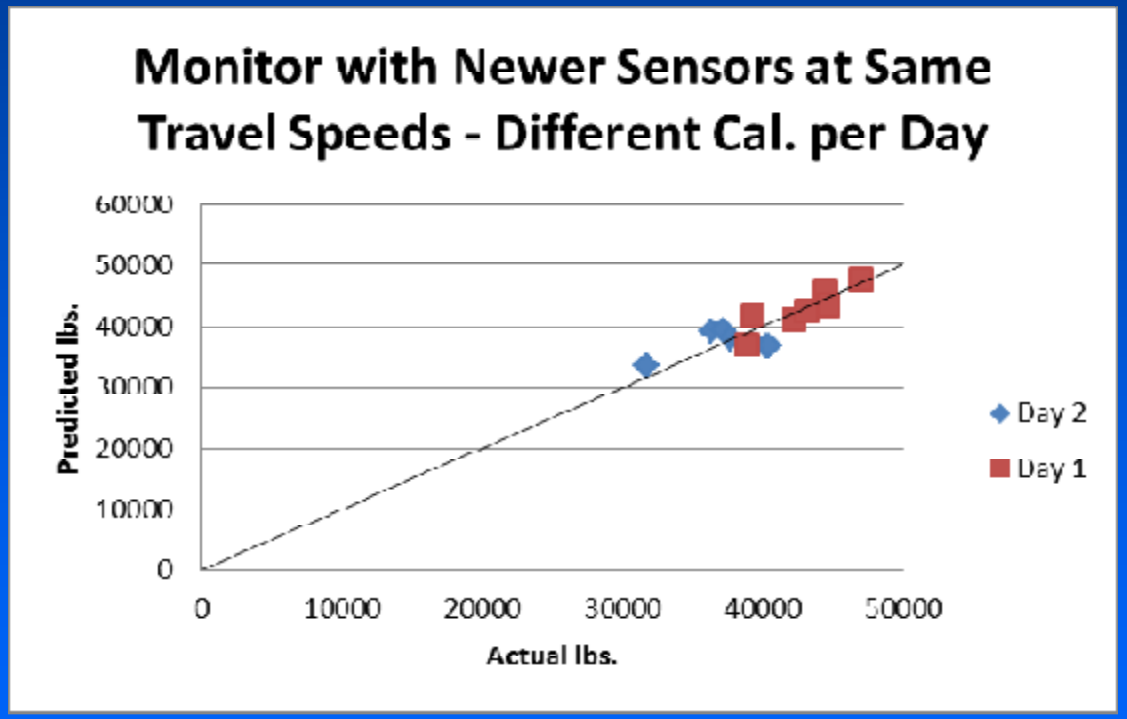
Aver. Error: 3.4 %

# Next Day in ½ Burnt Trashy Cane:



# Data Graphed with Calibration per Day:

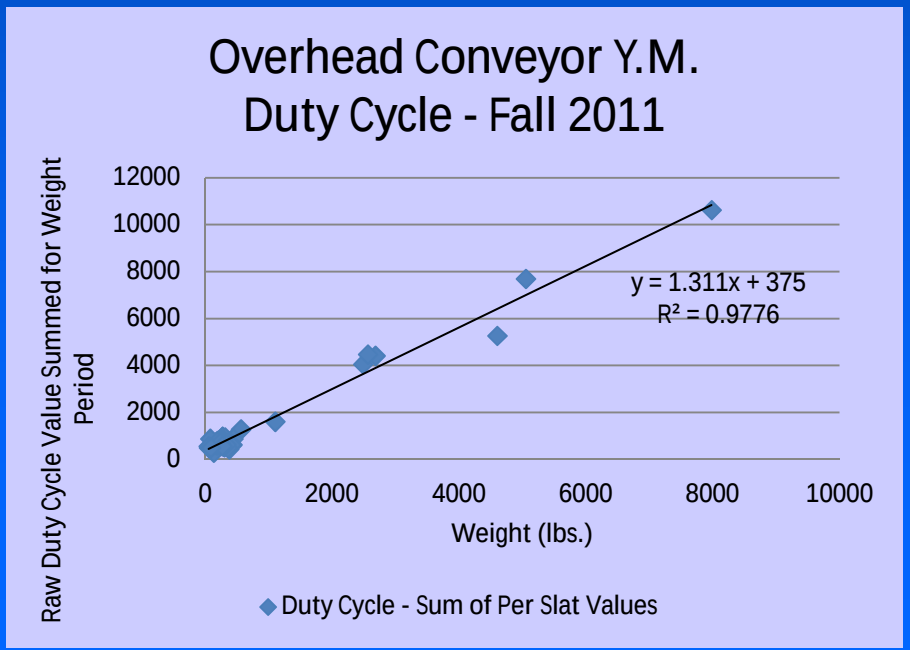


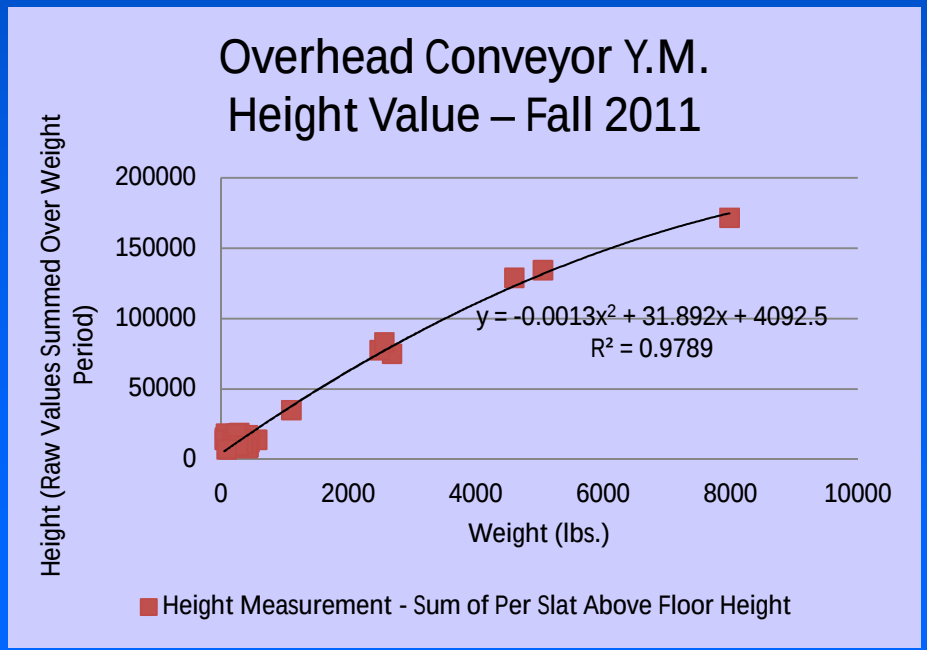
# Overhead Yield Monitor:

- Mounted on top of conveyor
- Measures volume and depth of billets on slats

# Results:

- Nearly Linear Lines
  - Good Curve Fits
- Problems:
  - Jump in calibration during test
  - Errors may actual be similar to previous year's versions



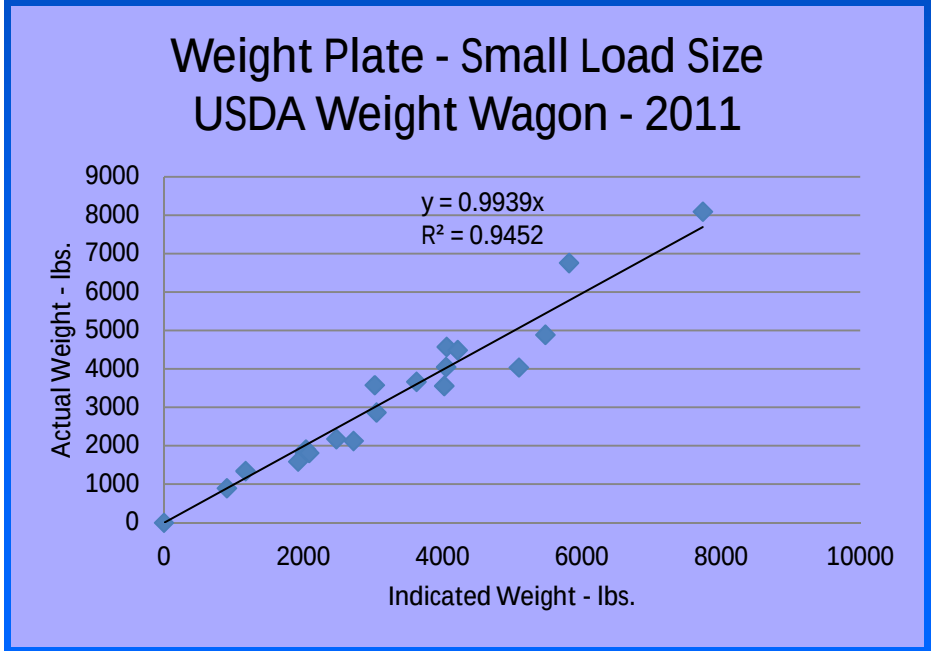



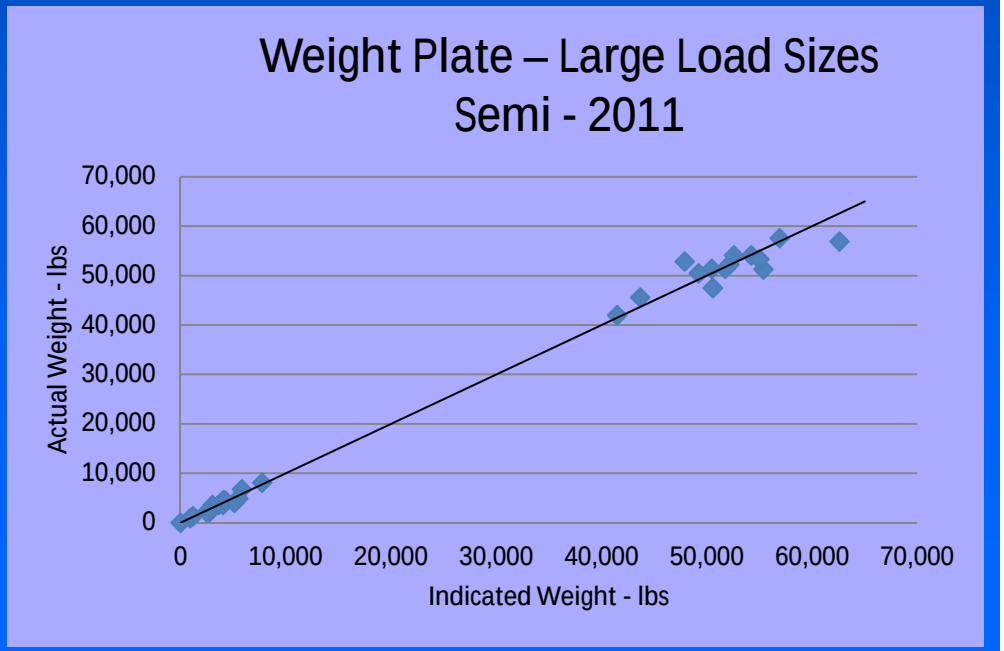
# Weight Plate:

- Trying to build system that estimates the load out weights of trucks and wagons very accurately (< 1%) and requires little or no calibration

# Calibrated Results:

- Actual versus predicted weight using a proportional calibration factor (linear):
  - Error:
    - Mapping Size Loads: 10-11%
    - Truck Size Loads with frequent re-calibration: 3.4%
    - No calibration: 10%



# Wagon and Truck Load Out Weight Errors:

| Estimated Weight from Monitor | Actual Weight | Percent Error (%) | Absolute Error (%) |
|---|---|---|---|
| 4050 | 4050 | 0 | 0 |
| 4059 | 4575 | -11.27869 | 11.27869 |
| 3625 | 3670 | -1.226158 | 1.226158 |
| 4024 | 3560 | 13.0337 | 13.03371 |
| 902 | 900 | 0.22222 | 0.222222 |
| 1171 | 1345 | -12.9368 | 12.9368 |
| 5817 | 6760 | -13.9497 | 13.9497 |
| 7738 | 8095 | -4.41013 | 4.41013 |
| 3026 | 3580 | -15.47486 | 15.47486 |
| 4217 | 4490 | -6.080178 | 6.080178 |
| 3052 | 2870 | 6.34146 | 6.341463 |
| 5476 | 4890 | 11.9836 | 11.98364 |
| 5096 | 4040 | 26.1386 | 26.13861 |
| 2722 | 2130 | 27.7934 | 27.79343 |
| 2475 | 2180 | 13.5321 | 13.53211 |
| | | Average | 10.96011 |
| | | Stdev | 8.354911 |

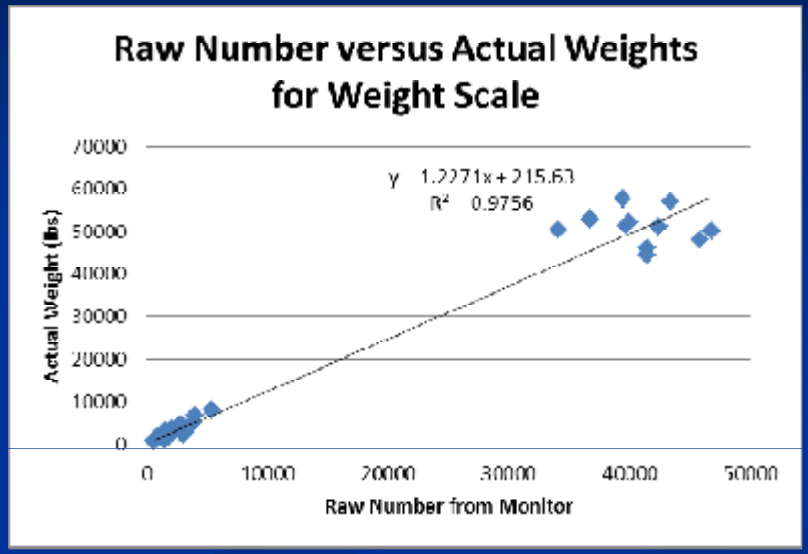
Small Loads (< 8000 lb)

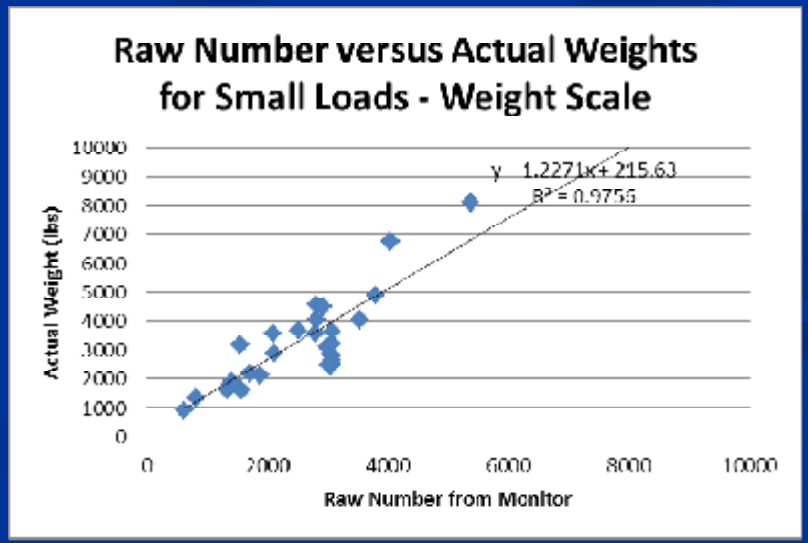
| Estimated Weight from Monitor | Actual weight | Percent Error (%) | Absolute Error (%) |
|---|---|---|---|
| 43659.37 | 45600 | -4.444927 | 4.444927 |
| 41464.14 | 42000 | -1.29234 | 1.29234 |
| 50566 | 47500 | 6.06336 | 6.063357 |
| 50456.99 | 51400 | -1.868931 | 1.868931 |
| 47880.43 | 52860 | -10.4 | 10.40002 |
| 55357.98 | 51280 | 7.366562 | 7.366562 |
| 51734.36 | 51380 | 0.684954 | 0.684954 |
| 52158.35 | 52280 | 0.23324 | 0.233241 |
| 54201.8 | 54133 | 0.12709 | 0.127094 |
| 52552.18 | 54130 | -2.914872 | 2.914872 |
| 54975 | 53340 | 2.974079 | 2.974079 |
| 49210 | 50500 | -2.554455 | 2.554455 |
| 62583 | 56920 | 9.94905 | 9.949051 |
| 56900 | 57600 | -1.215278 | 1.215278 |
| | | Average | 3.720654 |
| | | Stdev. | 3.454904 |

Truck Size Loads (50,000 lb)

# Un-calibrated Results:

- 10% error
- Clogging problems on sides
- Small drift problem



# Where We Are at Today:

- Still, no yield monitors being manufactured for sugarcane:
  - Need 3% error rate or lower
- Current research units have:
  - 7% to 10% error rates on mapping units
  - 2.5% to 6% error on truck load estimates
- Variances quite large in fields (> 10 tons/acre or more)
  - 7% to 10% good enough for this mapping
- Systems being researched:
  - Combine multiple readings (cane property with volume, etc.)
  - Other types of yield monitors: Wagon, etc.
  - Continue to work on weight scale method

# Added Wireless Capabilities:

- AT&T or Verizon, 12 VDC or 110 VAC
- Static I.P.
- Approx. $200 per year wireless fee and $600 in initial equipment fee
- Plugs into bottom of box
- IEEE Ethernet Plug
- Serves HTML Pages

# Special Thanks to:

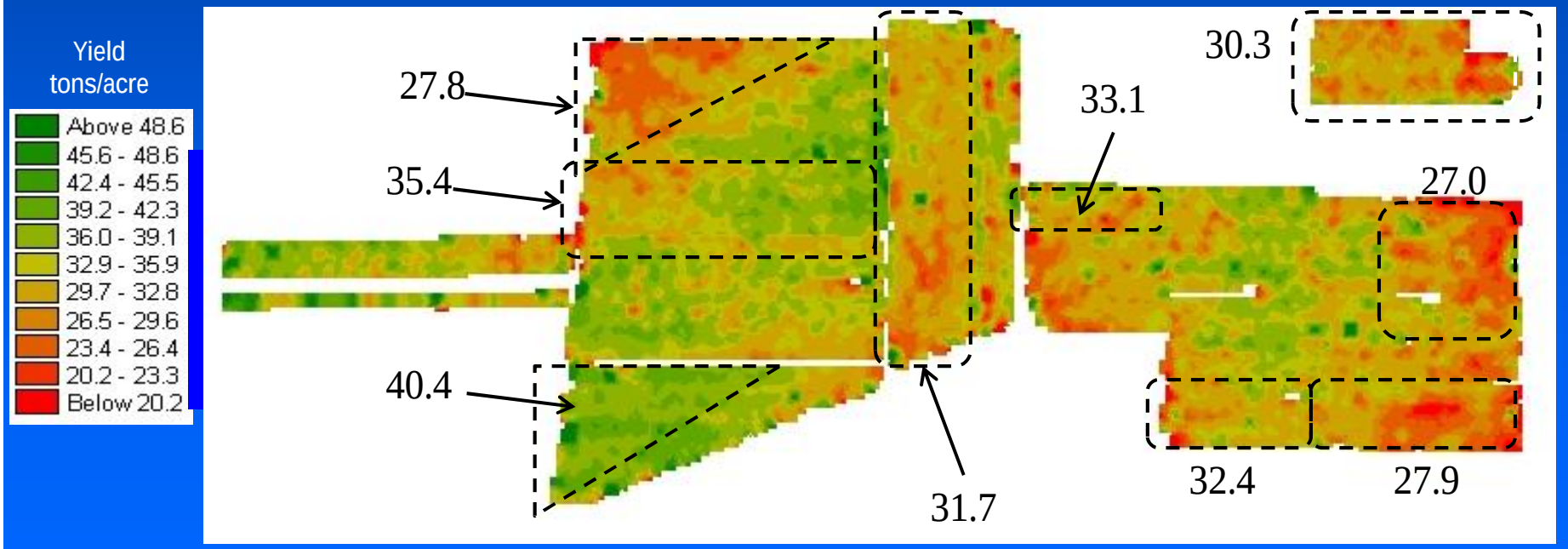
- American Sugarcane League
- USDA-ARS Houma
- Various producers, operators, and consultants around the state



# The End

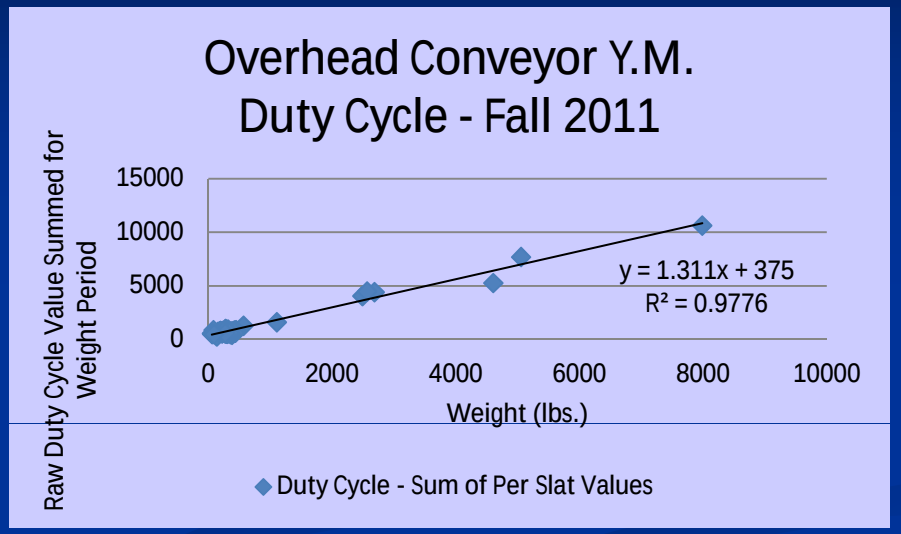
# Yield Differences in Field:

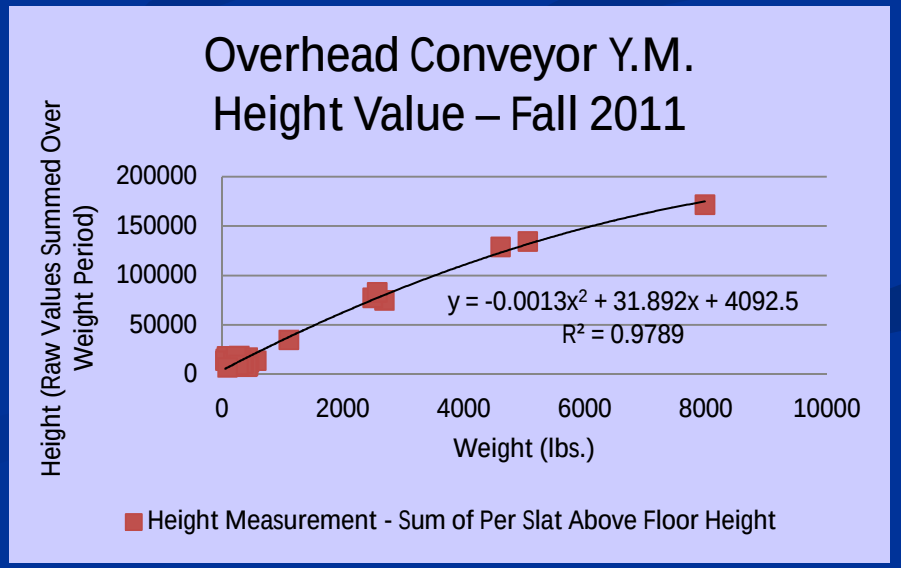
- Map shows different yield areas of field
- Louisiana averages about 30 tons/acre



# Overhead Yield Monitor:

- Some promising results but still needs more testing



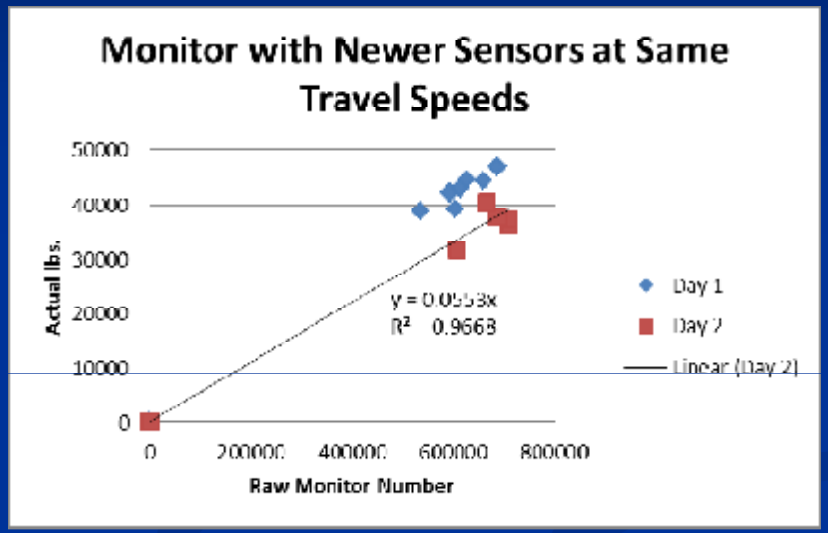
# Truck Load Estimates => 4% on Average

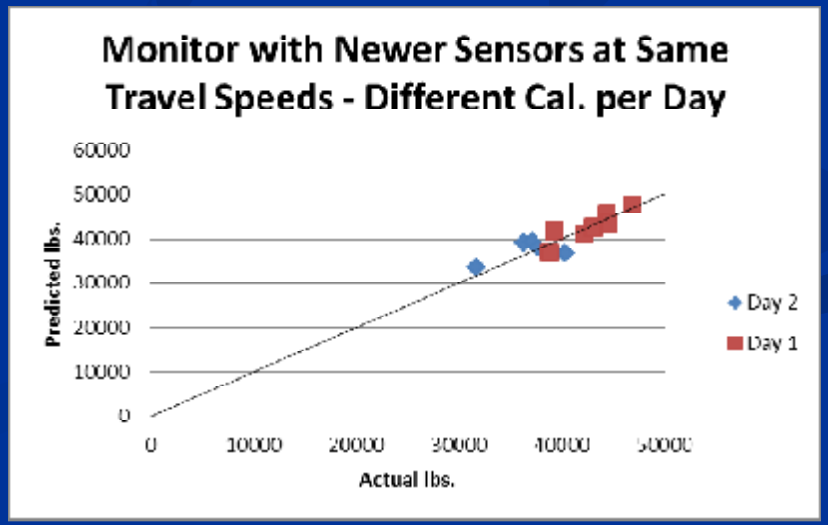
| Location | Year Tested | Calibration Method | Error (%) | Known Problems with Monitor |
|---|---|---|---|---|
| U.S. Sugar, Clewiston, FL | 2003-04 | Weight wagons - approx. 7 | Not Enough Data for Truck Loads | None |
| Bunkie, LA | 2006 | One calibration point | ? | None |
| USDA ARS Houma. LA | 2008 | Two Truck loads using more than 50 loads ranging from 500 to 3500 lbs | 4.1% | None |
| New Iberia | 2009 | Continuous Calibration Every Truck Load - IR | 2.5% | None |
| USDA-ARS | 2010 | Weight wagons 15-20 Slat Sensor Tripping - IR | 3.6% | Slat Sensor Monitor Zeros Not Added |
| John Deere, Thibodaux, LA | 2010 | 3 truck loads – Low Power Red | 6%? | |
| Honduras, C.A. | 2011 | 2 Truck loads – High Power Red | 4.2% | None |
| Florida | 2012 | 7 truck loads – well burned cane – newer optical eyes - | 3.2% | None |
| Florida | 2012 | 8 truck loads –a lot of trash – newer optical eye | 6% | Really trash laden cane |

# Newer Weight Plates:

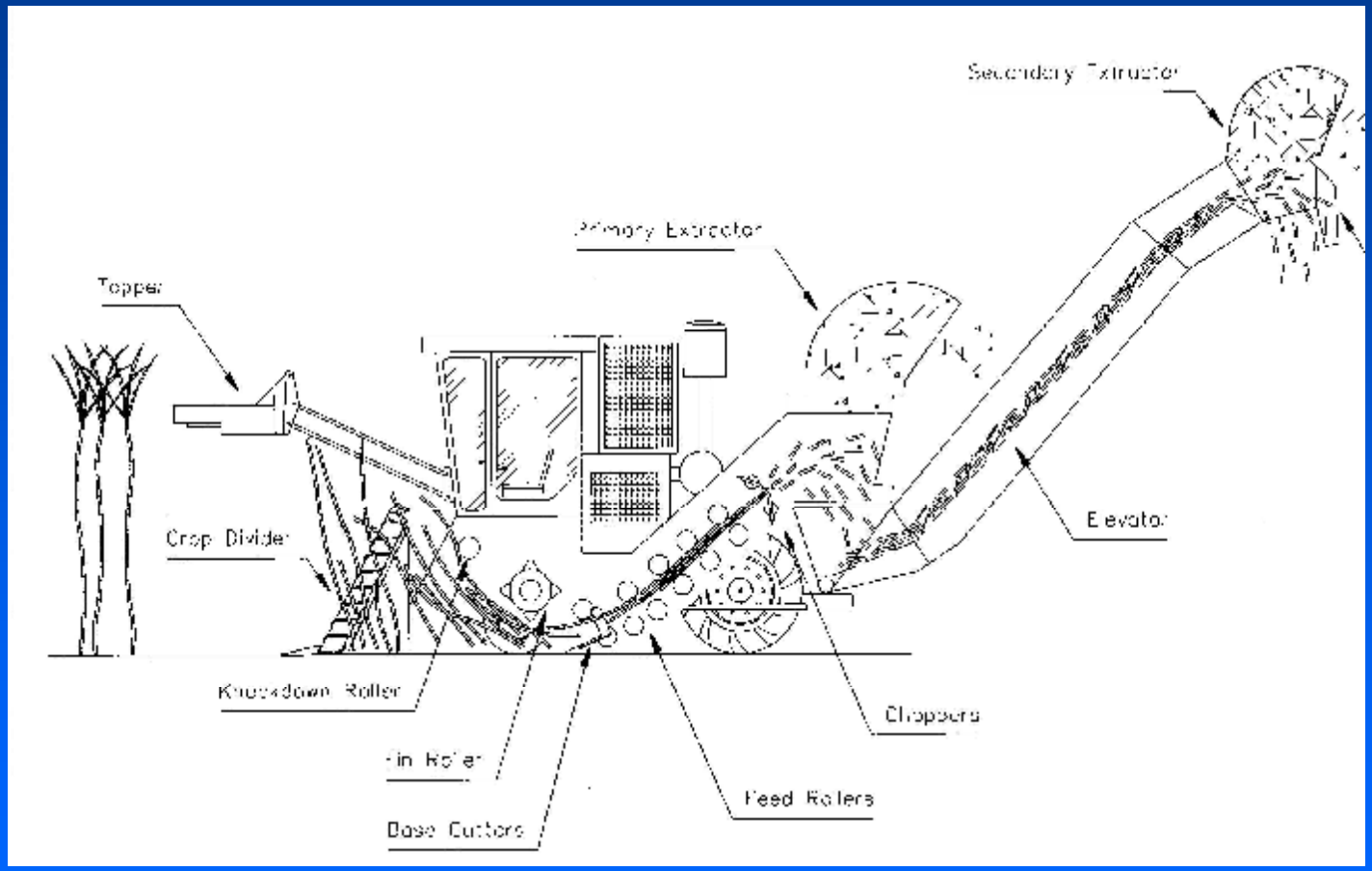
# Newer Test of Under-conveyor with Newer Optical Eyes

- Not durable enough for long term use
  - Optical Eyes Destroyed after about two weeks

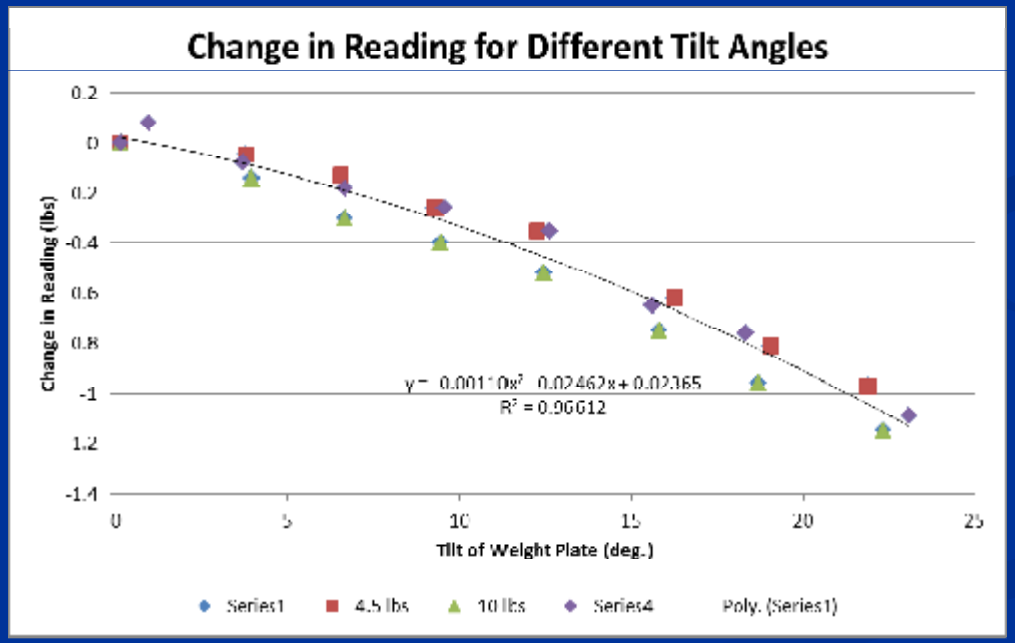



# Diagram of Harvester:



# Change in Weight Caused by Tilt:

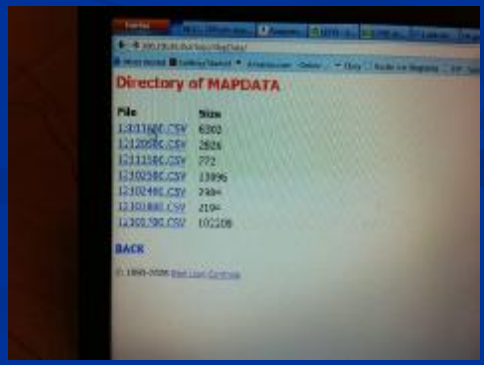
- Load cells not really meant for tilted use
- Something causing a 2.2% error in readings




| Temp (F) | Low lbs | High lbs |
|---|---|---|
| 76 | 9.91 | 10.02 |
| 99.1 | 9.67 | 9.87 |

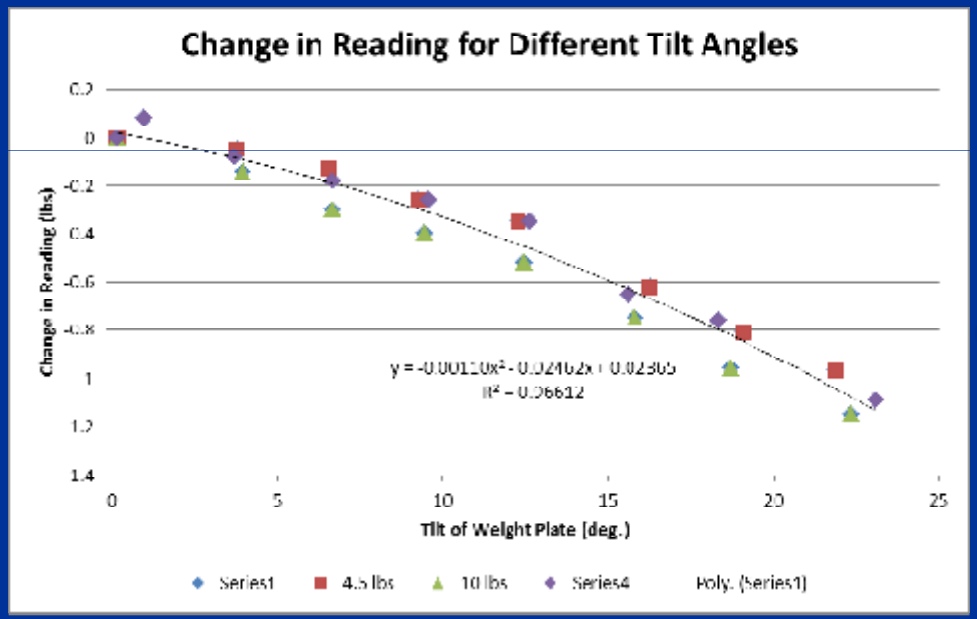
# Example of Wireless System:

- Serves 3 different types of HTML pages:
  - Exact Screen Display
  - Yield and GPS Variables
  - Data Files and Access

# Change in Reading per Slat

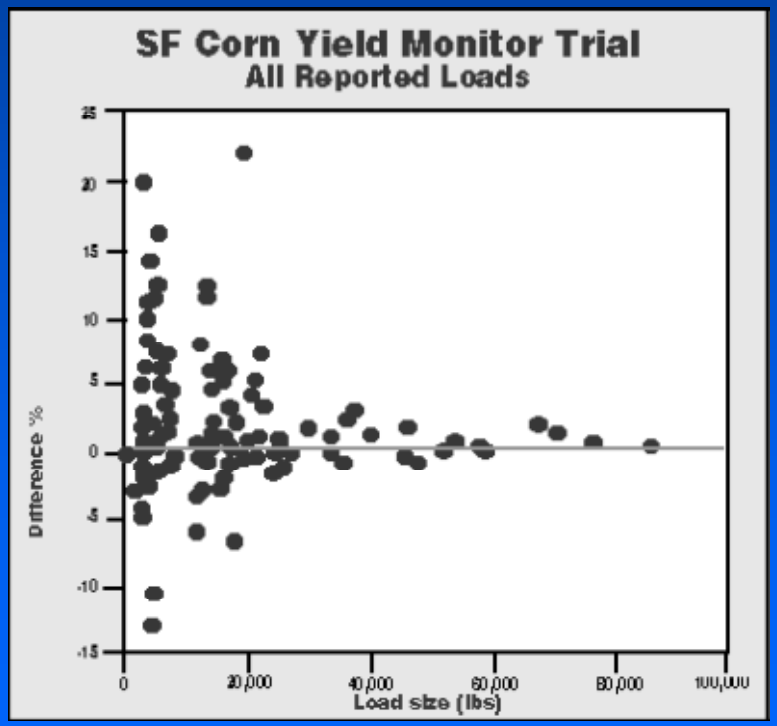
- Each reading up to 0.2 lbs off
- Possible cause of drift error



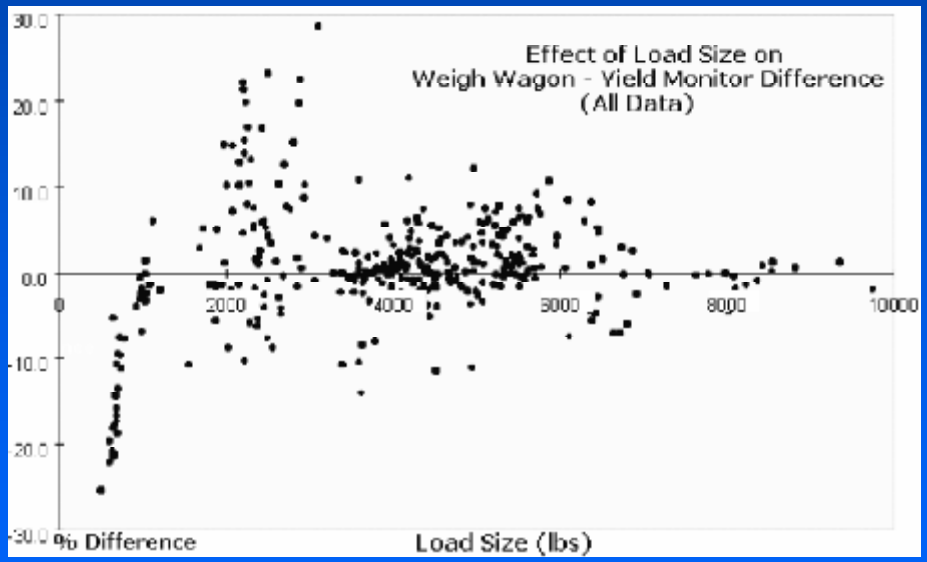

| Estimated Weight from Monitor | Actual Weight | Percent Error (%) |
|---|---|---|
| 4050 | 4050 | 0 |
| 4059 | 4575 | -11.3 |
| 3625 | 3670 | -1.2 |
| 4024 | 3560 | -13.0 |
| 902 | 900 | 0.2 |
| 1171 | 1345 | -12.9 |
| 5817 | 6760 | -13.9 |
| 7738 | 8095 | -4.4 |
| 3026 | 3580 | -15.5 |
| 4217 | 4490 | -6.1 |
| 3052 | 2870 | 6.3 |
| 5476 | 4890 | 12.0 |
| 5096 | 4040 | 26.1 |
| 2722 | 2130 | 27.8 |
| 2475 | 2180 | 13.5 |
| | Average | 11.0 |
| | Stdev | 8.4 |

# Typical Yield Monitor Errors in Other Industries:

- Beginning grain yield monitors also exhibited a reduction in error with increased weight totaling:




Wilcox (1998) – Corn Yield Monitor




Doerge (1997) – 192 grain yield monitors