Fiber Quality and Minimizing Plastic Contamination

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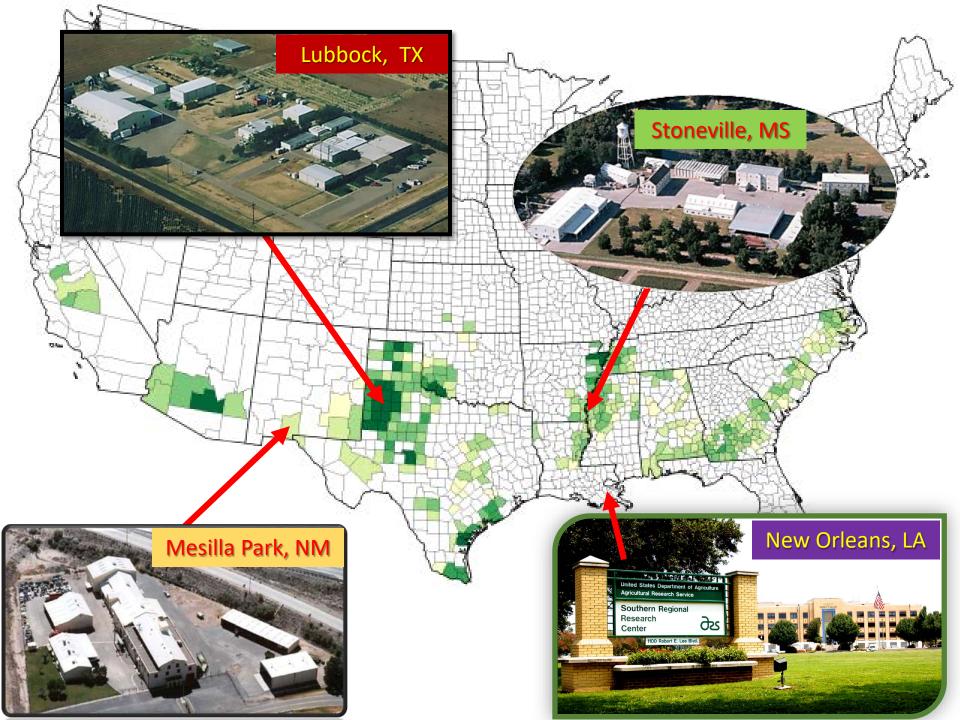
Great Plains Cotton Conference
February 26, 2020

- USDA Ginning and Fiber Quality Labs

- Fiber Quality
  - What is Fiber Quality?
  - How is it Measured?
  - How is Fiber Quality Influenced by Harvesting and Ginning?

- Minimizing Plastic Contamination

Lubbock, TX

Stoneville, MS
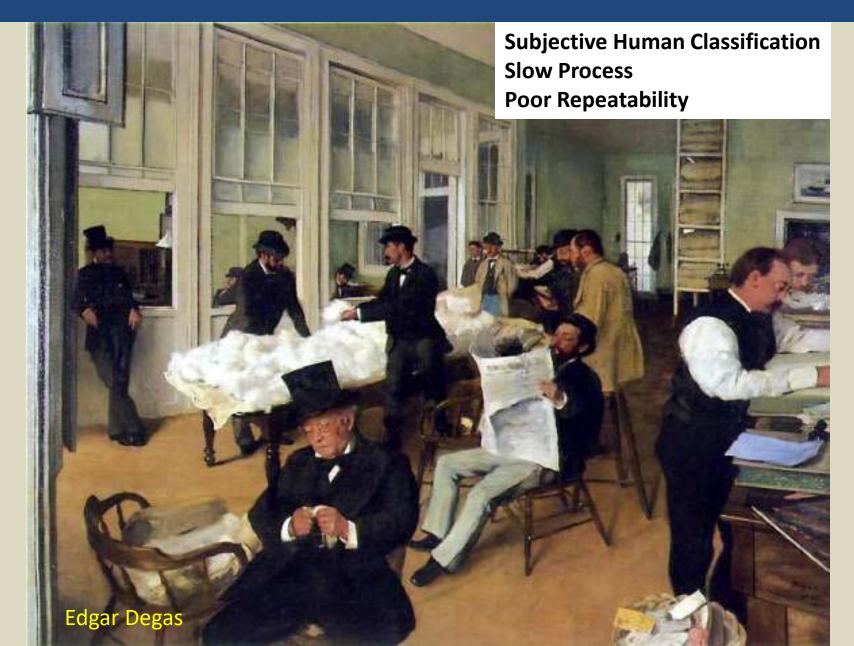
Mesilla Park, NM

New Orleans, LA

What is Fiber Quality?

- Physical characteristics of fiber that indicate its economic value to the manufacturer
  - Strength
  - Length
  - Color
  - Foreign Matter Content
  - Dyeability

How is Cotton Fiber Quality Determined?

Subjective Human Classification
Slow Process
Poor Repeatability

Edgar Degas

How is Cotton Fiber Quality Determined?

Objective Classification
700-800 samples per shift
Accurate and Repeatable

Image: H. Ghorashi, USTER

HVI Fiber Measurements

Image: H. Ghorashi, USTER

HVI Fiber Measurements
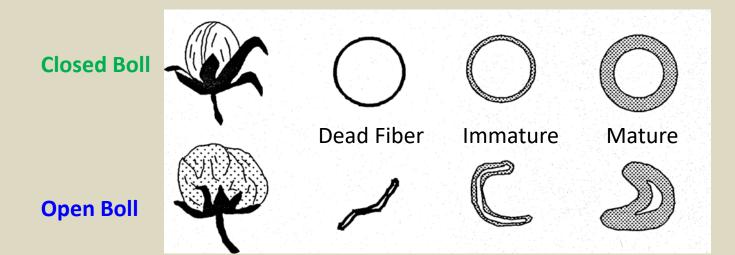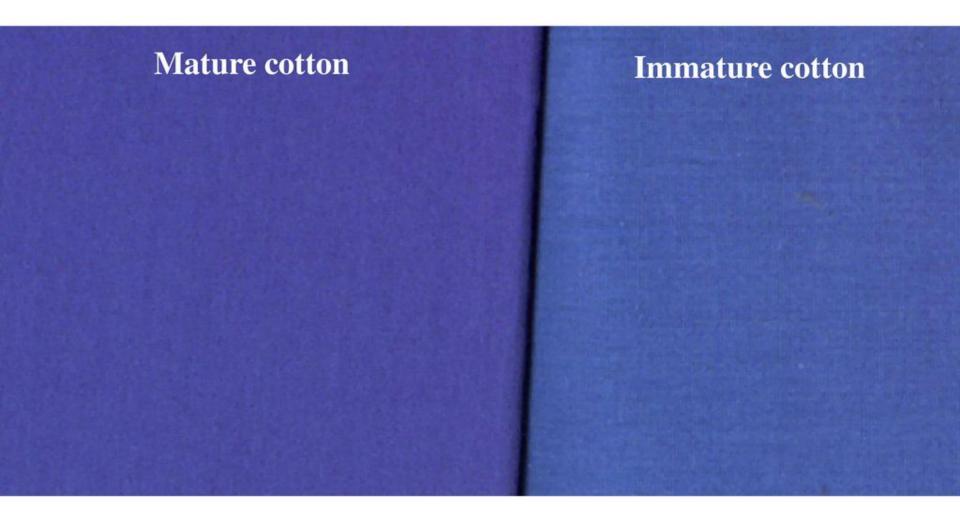
Micronaire (MIC) – air flow measurement through a plug of cotton that is related to fiber maturity and fineness.

- Maturity – cellulose deposition in secondary cell wall
  - Dyeability and single fiber strength
- Fineness – fiber diameter expressed in terms of linear density
  - How many fibers can we get in the yarn cross section
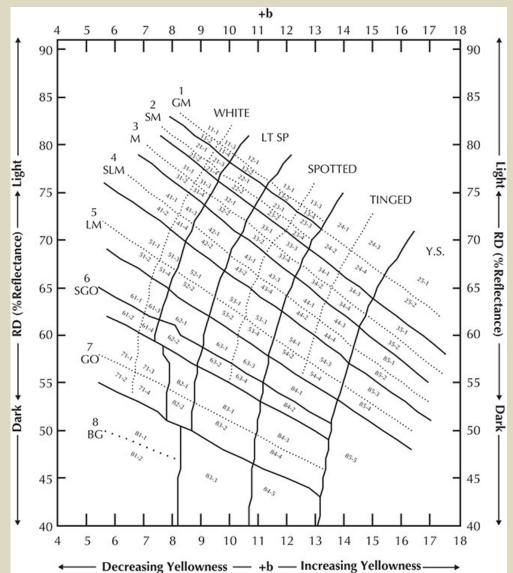 - Influences yarn appearance, uniformity, and strength

Closed Boll

Open Boll

Dead Fiber   Immature   Mature

100% cotton fabric (same variety, same field)

Mature cotton

Immature cotton

Hequet and Abidi, TTU-FBRI

- Measurements on a Beard of Combed Fiber
- Fibrograph method – light attenuation vs length
  - Length (UHML) – Average length of the longest 50% of fibers in the beard
    - Yarn strength and spinning efficiency
  - Length Uniformity – ratio of mean length to UHML
    - Yarn strength and uniformity, spinning efficiency
- Strength – force to break the fiber beard expressed as g/tex
    - 1/8" gauge length
    - Yarn and fabric strength, and spinning efficiency

- Fiber Color Grade
  - Rd – reflectance, brightness of fiber
  - Plus B – yellowness
  - Nickerson-Hunter graph:
  - Rd & +B → Color Grade

HVI Fiber Measurements

- Leaf Grade
  - Human Classer determined Leaf Grade until 2012
  - Instrument Leaf Grade
    - Trash - % Area
    - Trash – Particle Count
  - Indication of waste in spinning, spinning efficiency
- Extraneous Matter
  - Only parameter called by human
  - Preparation, Bark, Grass, Seed Coat Fragments, Oil, Spindle Twist, Plastic, and "Other"
  - Waste and spinning efficiency

How is Fiber Quality Influenced by Harvest?

Moisture Content <12%

Safe in-field storage MC level

- ## Harvest Aid Timing and Efficacy
  - Defoliation, Boll Opening, and Desiccation

- ## Machine Settings
  - Strippers:
    - Row Unit Brush-Bat Sequencing
    - Stripper Roll Spacing
    - Lower/Upper Cotton Duct Settings
    - Field Cleaner Setup/Maintenance
    - Harvest Ground Speed
  - Pickers:
    - Row Unit Setup/Maintenance
      - Sharp spindle barbs
      - Doffer to spindle clearance
      - Moisture pad condition and adjustment
      - Solution pressure
      - Scrapping Plates
    - Row Unit/Ground Speed Sync.
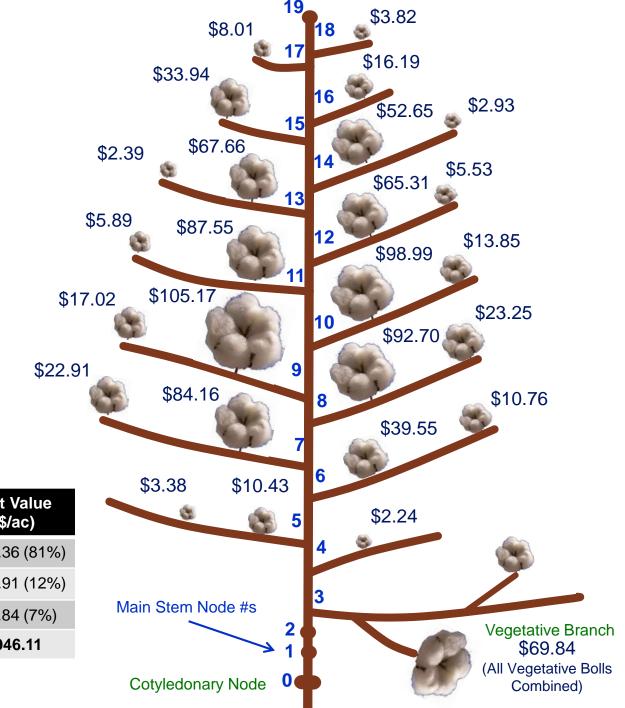   - Synchronized or gathering/lagging

Pickers vs. Strippers

- If it's all the same cotton – why is there a difference?

- It Depends!
  - Condition of the crop at harvest
    - Crop maturity: bigger differences with poorer maturity
    - Boll opening: poor boll exertion = poorer picking efficiency
    - Boll type: storm proof vs. "picker-type" bolls
  - Harvest Efficiency
    - Pickers ~ 90 - 95%
    - Strippers ~ 95 - 99%

"Storm-proof" – Boll Type

Loose – Picker Boll Type

Contribution to Lint Value by Fruiting Position ($/ac)

2nd Harvest Event 100% Open Bolls FM 9180 B2F

Boll Location	Lint Yield (lb/ac)	Lint Value ($/ac)
1st Position	1343 (81%)	$768.36 (81%)
2nd Position	188 (12%)	$107.91 (12%)
Vegetative	121 (7%)	$69.84 (7%)
Total	1652	$946.11

$3.82
$8.01
$16.19
$33.94
$52.65
$2.93
$67.66
$2.39
$65.31
$5.53
$87.55
$5.89
$98.99
$13.85
$105.17
$17.02
$92.70
$23.25
$22.91
$84.16
$39.55
$10.76
$3.38 $10.43
$2.24

Main Stem Node #s

Vegetative Branch
$69.84
(All Vegetative Bolls Combined)

Cotyledonary Node

19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0

Average Foreign Matter Content

	Picked (lbs/bale)	Stripped w/FC (lbs/bale)	Stripped – NFC (lbs/bale)	Cleaner Efficiency
Burrs	34	160	450	64%
Sticks	9	50	115	57%
Fines	56	100	135	26%
Total	99	310	700	56%
Turnout (%)	35-40	30-35	25-30	

Ginning is a Process

1. **Seed-cotton Unloading System**
   - Remove cotton from post-harvest storage, begin the seed-cotton drying process, and feed cotton at a uniform rate into the SC cleaning system

2. **Seed-cotton Cleaning System**
   - Dry, open, and remove foreign material from seed cotton prior to ginning

3. **Ginning**
   - Removal of fiber from the seed

4. **Lint Cleaning System**
   - Removal of lint contaminants

5. **Lint Packaging**
   - Formation of lint into marketable units for shipment

Unloading Systems

Minimal Influence on Fiber Quality
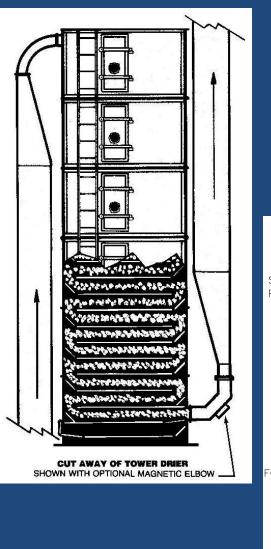Can Introduce Significant Plastic Contamination

Image Courtesy of Lummus Corp.

Seed Cotton Cleaning Systems

- Components
  - Drying System
    - 3 – 5% SC Moisture Content is Ideal for Cleaning
  - Cylinder Cleaners
  - Extractor Cleaners
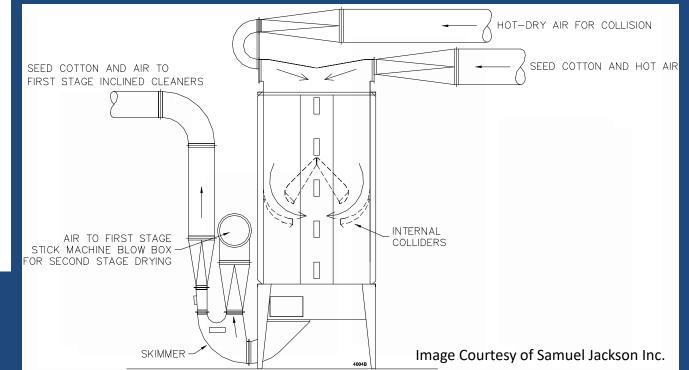 - Main influence on fiber quality is to reduce trash - Leaf

Image Courtesy of Lummus Corp.

Drying Systems

CUT AWAY OF TOWER DRIER
SHOWN WITH OPTIONAL MAGNETIC ELBOW

- 4 Critical Factors in Drying System Design
  - Air Temperature, Air Volume, Exposure Time, Turbulence
- Over-drying can reduce strength and decrease length and uniformity
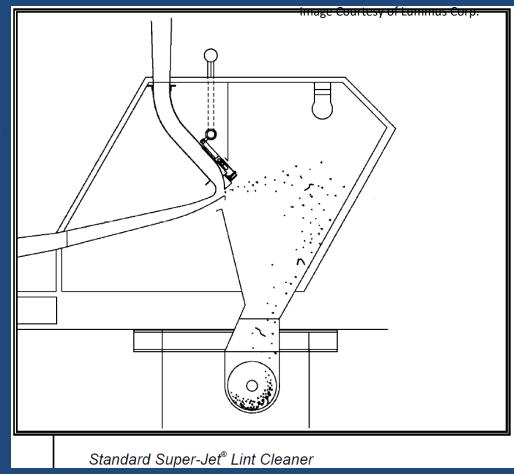- Under drying can increase trash and Leaf

HOT–DRY AIR FOR COLLISION

SEED COTTON AND HOT AIR

SEED COTTON AND AIR TO
FIRST STAGE INCLINED CLEANERS

AIR TO FIRST STAGE
STICK MACHINE BLOW BOX
FOR SECOND STAGE DRYING

INTERNAL
COLLIDERS

SKIMMER

4004B

Image Courtesy of Samuel Jackson Inc.

Saw Gin Stand

Ideal Moisture: 6 – 8%
Low MC cotton breaks more and produces shorter fiber length and lower uniformity
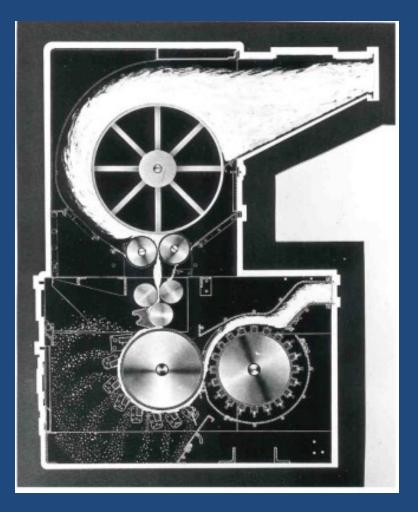
Lint Cleaning Systems

- Air Type
  - Trash is ejected by centrifugal force as lint turns past nozzle opening
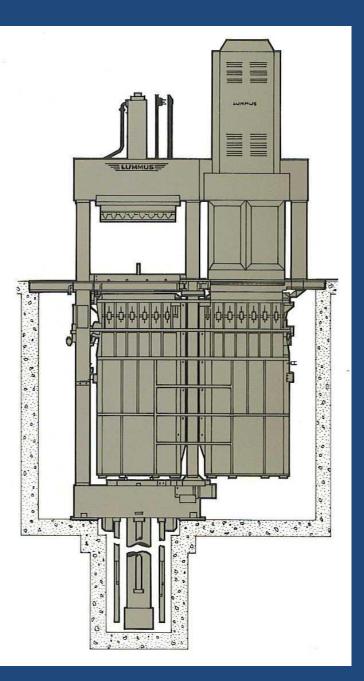 - Air velocity ~10,000 – 12,000 ft/min
  - No fiber damage

Image Courtesy of Lummus Corp.

Standard Super-Jet® Lint Cleaner

Lint Cleaning Systems

- Saw Type
  - Trash is removed from a batt of fiber by centrifugal force, scrubbing of the fiber against grid bars, and an air wash.
  - Combing of the fibers by the saw removes prep and improves color/appearance
  - Typically causes more fiber damage than all other machines in the gin.

Lint Packaging System

- Bale press forms ~500 lb bales for market
  - Gin Universal Density = 28 lb/ft^3
  - Maximum lint moisture <7.5%
    - >7.5% can lead to color change
  - Extraneous Matter Calls for Oil if not maintained properly

Minimizing Plastic Contamination

USDA-ARS, Lubbock, TX - Cotton Production & Processing Research Unit

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USDA-ARS, Stoneville, MS – Cotton Ginning Research Unit

Chris Delhom, Cody Blake

Cotton Incorporated

ars Agricultural Research Service

Contamination

- ## What is Contamination?
  - ### Anything that is not Cotton…
    - Black plastic – plastic mulch, ditch liners, etc.
    - Shopping bags, twine, misc. fabric
    - Plastic from module tarps and module wrap
    - Non-washable module marking paint
    - Grease/oil from harvesting units or gin machinery

- ## Efforts must be taken during all phases of harvesting, transportation, and ginning to prevent contamination

- ## Preventing contamination is critical to maintaining the reputation of US cotton in the world fiber market.

Contamination Costs

Common for mills to share collections of what they find in their cotton

Decrease in premium for US cotton
    Premium for US relative to the rest of world has eroded

For 20.5 million bale crop 2019-2020
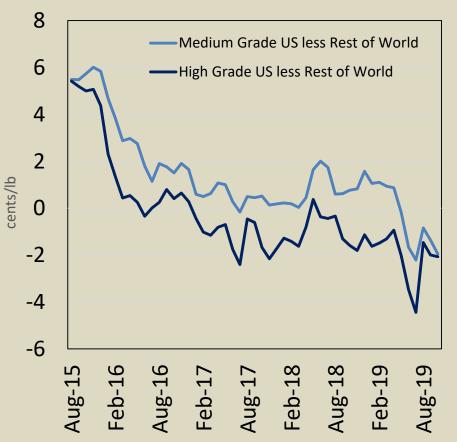   This is $750 million lost revenue to US growers. ($100 million per cent/lb)

Loan Chart Plastic Discounts:
    71 – 510 points
    72 – 775 points

Spot Quote Discount – 4000 points
    If you can find a buyer!
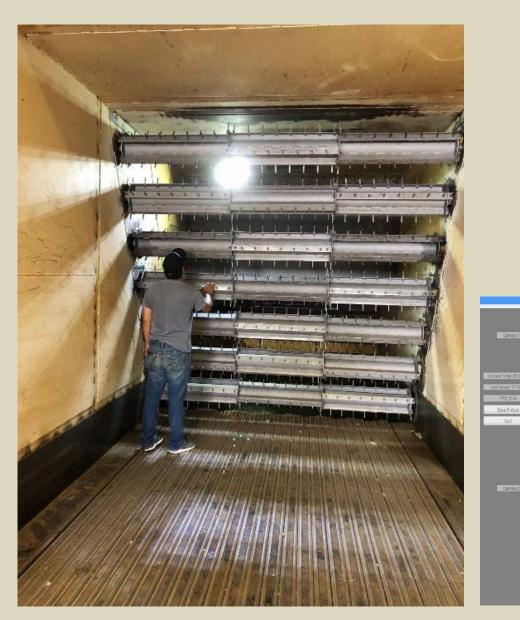
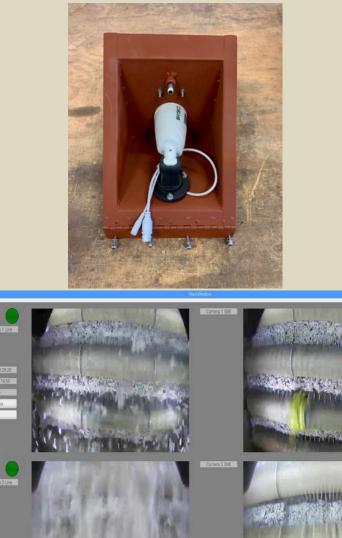### Difference between U.S. Quotes and the Average from Other Exporters

Legend:
- Medium Grade US less Rest of World
- High Grade US less Rest of World

y-axis: cents/lb (8 to -6)
x-axis: Aug-15, Feb-16, Aug-16, Feb-17, Aug-17, Feb-18, Aug-18, Feb-19, Aug-19

Jon Devine; Senior Economist, Cotton Inc.

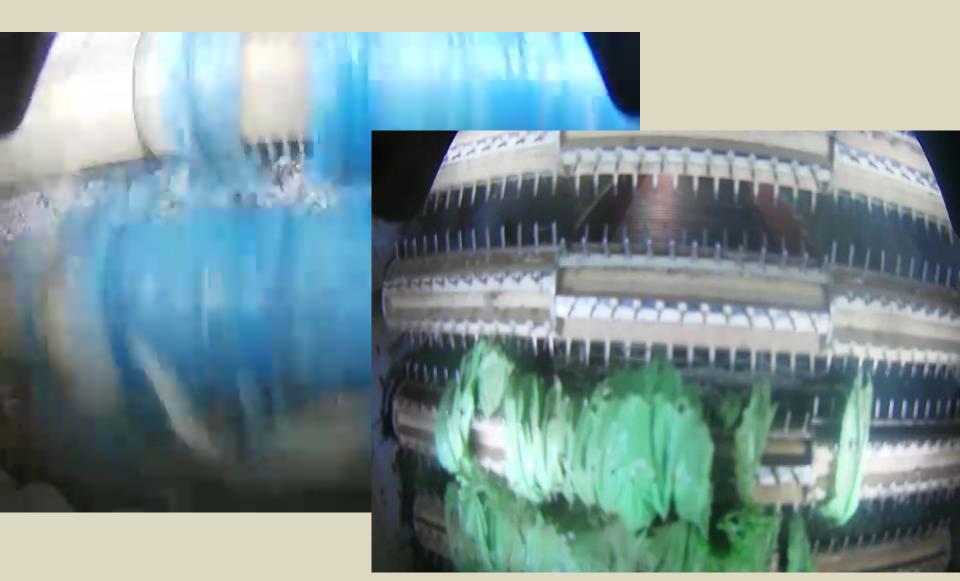# So What Are We Doing About Contamination?

- Module Feeder Detection
  - Identify potential "contamination events"
  - Document what may be causing events
    - Worker Education/Training
- Gin Feeder Apron Detection and Removal
  - Digital Color Image Processing
  - Pneumatic Sorting Technology
- Golden Lion Machine
- Thermal processing system
- UAV mapping of trash in fields
- Harvester systems to prevent contamination

Module Feeder Detection System

Plastic Module Wrap Can Cause it to Rain Plastic at Gin-Stand Feeder (Commercial Gin)

Video Recording of Module Feeder for Diagnostics
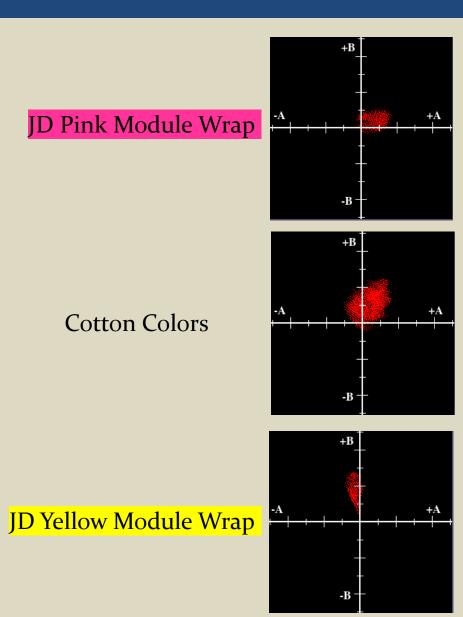
Video Recording of Module Feeder for Diagnostics

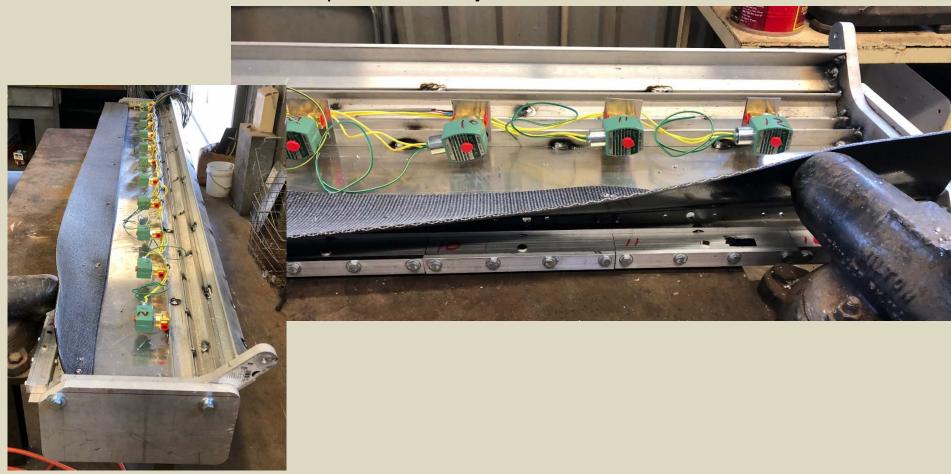# Gin Stand Feeder Apron provides Optimal location for detection-removal station in Cotton-Gins

Low Cost – Color Digital Image Based Detection

Design Challenges

- Color Space Issues
  - Yellow and Pink module wrap overlap natural seed cotton color space

- Wrap material
  - Single layer non-tacky opaque
    - Common in fiber samples
  - Tacky multi-layer
    - Thicker material tends to come out easier in seed cotton cleaners

- Camera speed
  - Faster the better!

JD Pink Module Wrap

Cotton Colors

JD Yellow Module Wrap

Feeder Apron Tail with Ejection Solenoids

Rapid System Trouble-shooting

Contaminants Removed – Commercial Gins

Commercial VIPR™ System

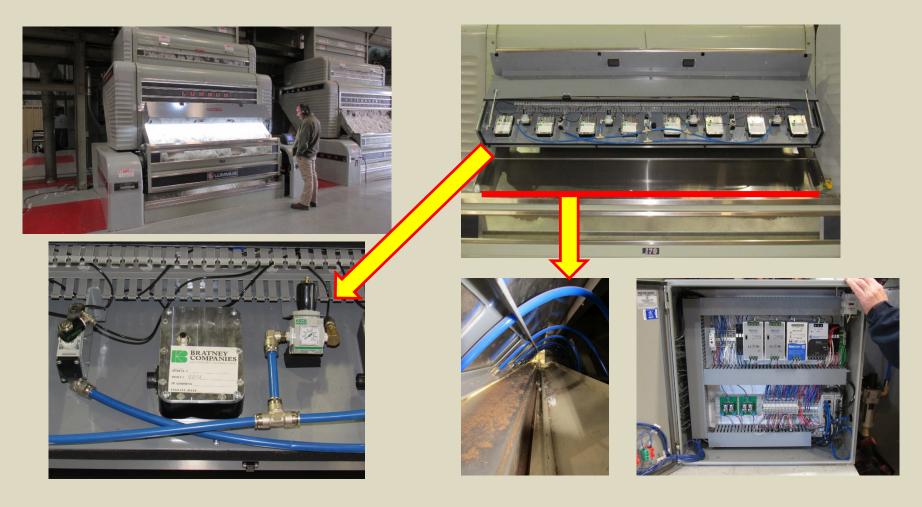# Commercial Testing

Testing Conducted by Lummus of Bratney's version of USDA-ARS Plastic-Contamination Detection-Ejection System (VIPER)

Witnessed by USDA-ARS Researchers

Testing Protocol (75 Test Runs Total):

         Set of 5 Test Runs (5 colors); Replicated 3 Times

Module Wrap Plastic, 2" squares (selected as typical size found at Gin-Stand Feeder). Each piece, crumpled before insertion into cotton flow ahead of VIPER Detection-Ejection System
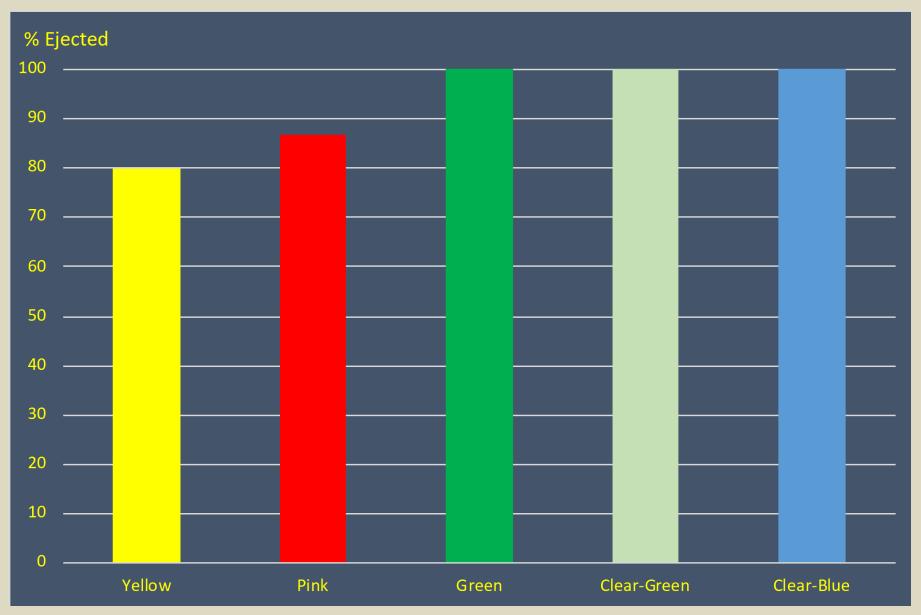
Colors Tested:

- Yellow (Opaque, [main wrap])
- Pink (Opaque, [main wrap])
- Green (Opaque, [main wrap])
- Green (Translucent, [Tacky-Outer Leader])
- Blue (Translucent, [main wrap])

Commercial Testing

Acknowledgements