Investigating the Impact of Seed Size Across the Cotton Supply Chain

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Cotton seed size is shrinking

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BREEDING, GENETICS, AND GENOMICS

Cotton Seed Size – What is the "Fuzz" all About?

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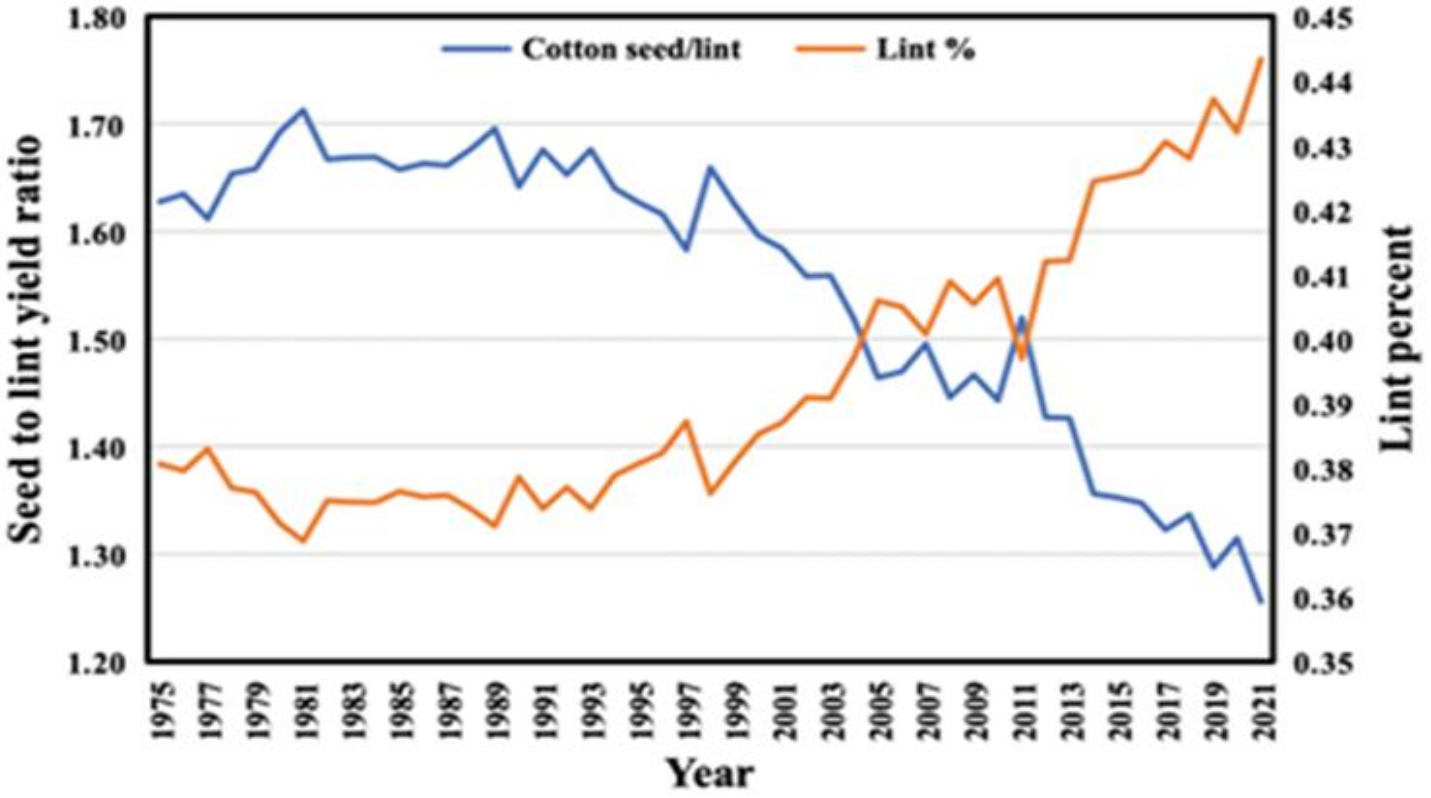


Figure 1. Historic seed to lint ratio (cotton seed to lint yield) from 1975 to 2021 (in blue, left Y axis) and lint percent (in orange, right Y axis).

- Commercial cotton seed sizes are reducing, and lint percent is increasing.
- Seed to lint ratio has reduced from 1.70 to 1.30 from 1975 to 2021.
- Seed size is a **quantitative trait** and impacted by many factors.
- Size itself has been one of the least impactful traits when considering a variety release- we prefer fiber yield.

What leads to smaller seed?

Trait is Environmentally Dependent:

- Heat
- Drought
- Plant spacing has been known to impact seed size- nutrient and water availability.
- Maturity– immature seeds are smaller.

Breeding Impact:

- Shifting focus to higher lint yields- Lint is estimated to account for 85-87% of the year end profit (Albers, 2019).
- Breeder goals are driven by marketability.
- Varieties are chosen that more efficiently partition cells to fiber over seed.

Seed vs Fiber Development:
Cell Partitioning

0-25 DPA
- Zygote undergoes cell division and embryo begins to form and grow. Seed coat forms.
- Fiber cells begin to develop on seed coat.

25-45 DPA
- Embryo maturation – Increase in size and weight, accumulation of oil, protein, other nutrients.
- Secondary fiber cell wall develops.
  - Fiber maturity.

45+ DPA
- Embryo reaches its maximum dry weight begins to separate from the plant.
- Fiber reaches maturation.

Sectors Impacted by Smaller Seed:

Ginning and Spinning

Emergence and Vigor

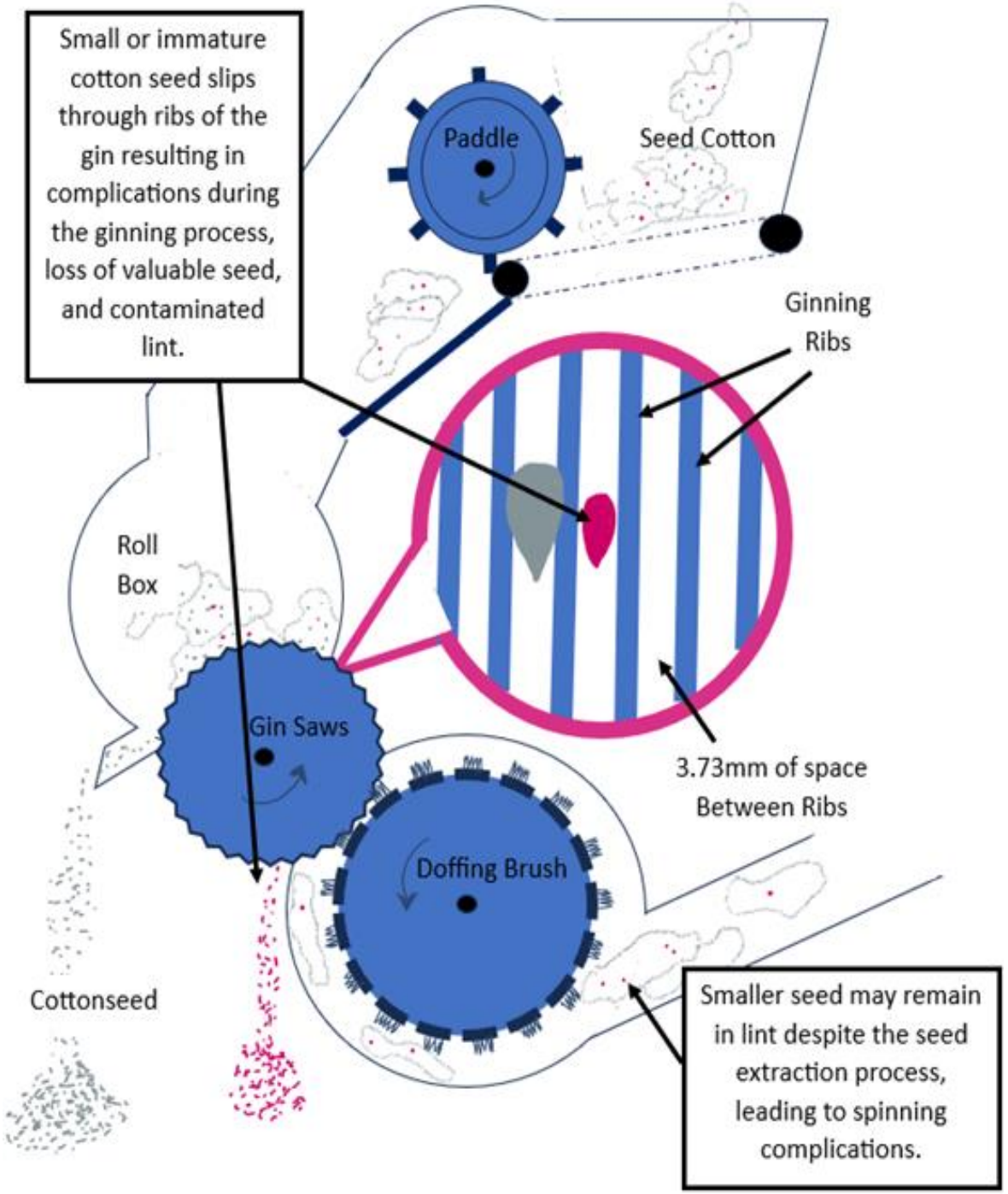
Cattle Feeding

Oil Production and Protein

Emergence and Vigor?

Does seed size impact seedling emergence and vigor?

- In other crops, size is a limiting factor for emergence.
- Seedling uses energy stored in endosperm for germination.
- What role does variety play into emergence?



Ginning and Spinning:

- The loss of smaller seeds slipping between ribs results in loss in producer revenue.
- The cottonseed revenue was used to pay for the ginning fees.
- Now, the profit from the improved fiber production will help cover the cost of ginning, no longer covered by the revenue of cottonseed.
  - Other factors involved: Inflation

Oil Production and Content

- Ginned seed is used as animal feed, or processed into meal, hull, short linters and oil.
- Cotton is the 5th largest oil crop in the world.
  - Production of smaller seed can change that.
- Cottonseed oil is produced during the embryo maturation phase.
- Storage of other nutrients important to oil content occurs at the same stage.
  - It is believed these nutrients have a high impact on planting seed quality.

Crushing and Feeding

- Cottonseed products for cattle feeding:
  - Whole cottonseed
  - Cottonseed meal
  - Cottonseed hulls
- More that 50% of cotton seed produced in the United States is fed to dairy cattle.
  - Cotton seed offers high protein, energy, and fiber into feed rations.
- Changes in cottonseed size or content impact the quantity and quality of feed.

Our Goal: Creating A Genetic Resource

Increase the understanding of the size characteristic in cottonseed and its implications on downstream sectors of the cotton industry.

1

Develop a genetic resource for cottonseed size related research by establishing functional populations that vary only in cottonseed size.

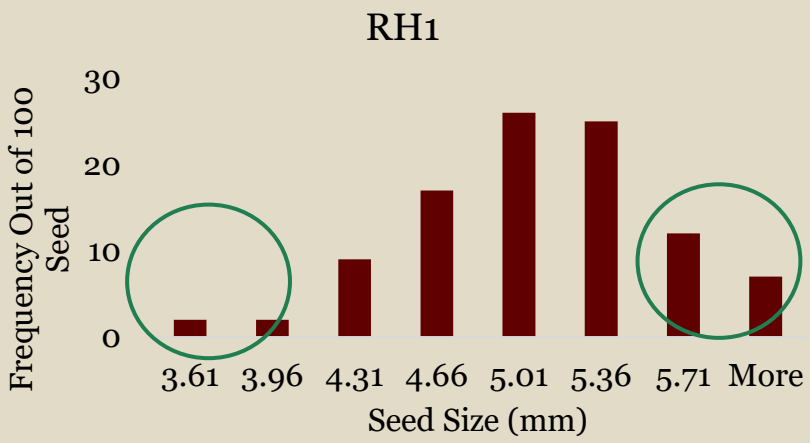
2

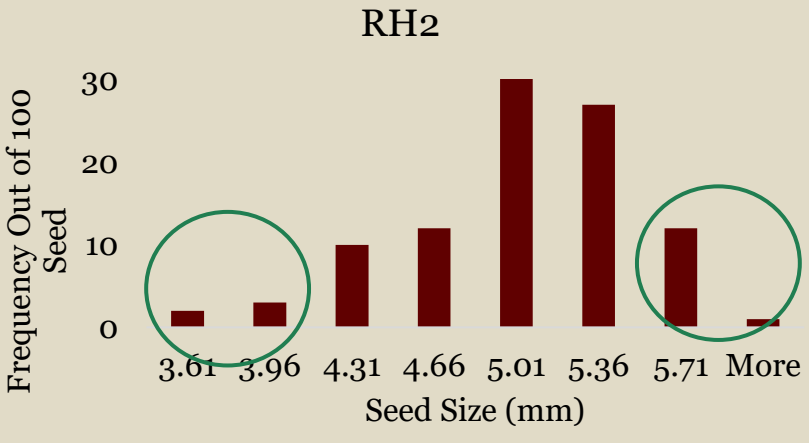
Evaluate the heritability components of the seed size characteristic for a better understanding of how the trait develops with the breeding process.

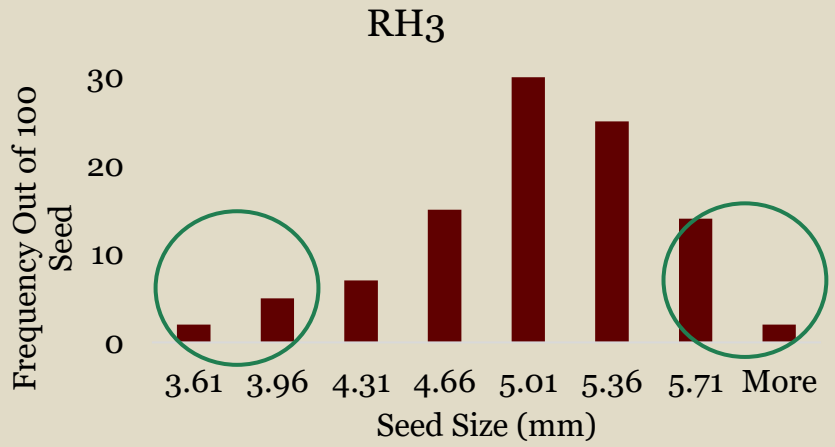
3

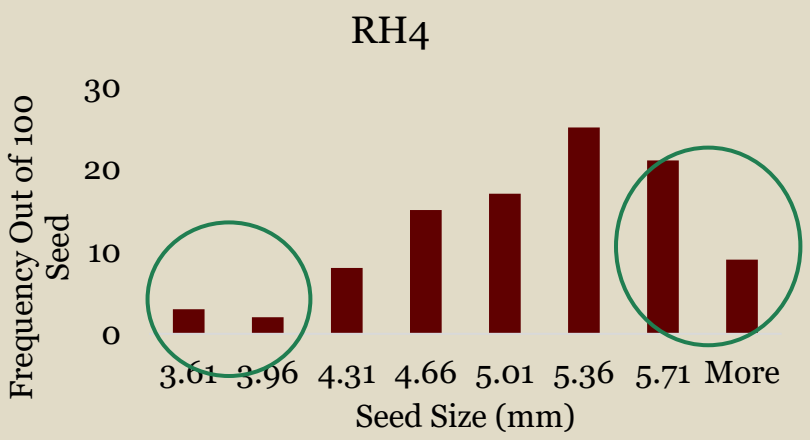
Evaluate the potential impacts shrinking cottonseed can have on the downstream sectors of the cotton industry.

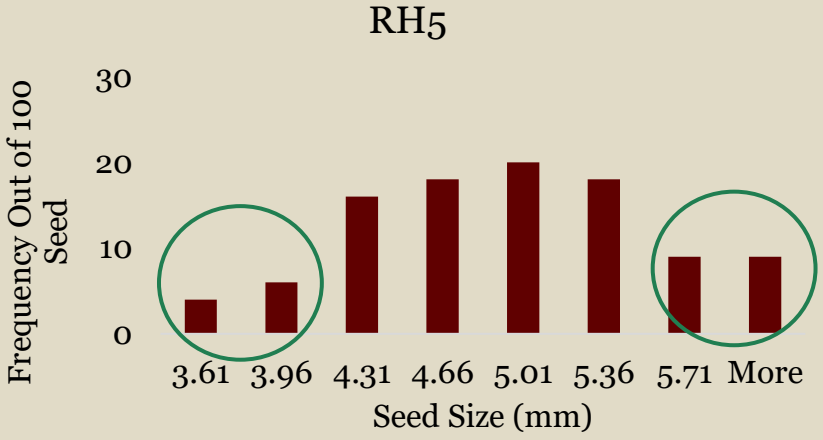
F2 Seed Measured:

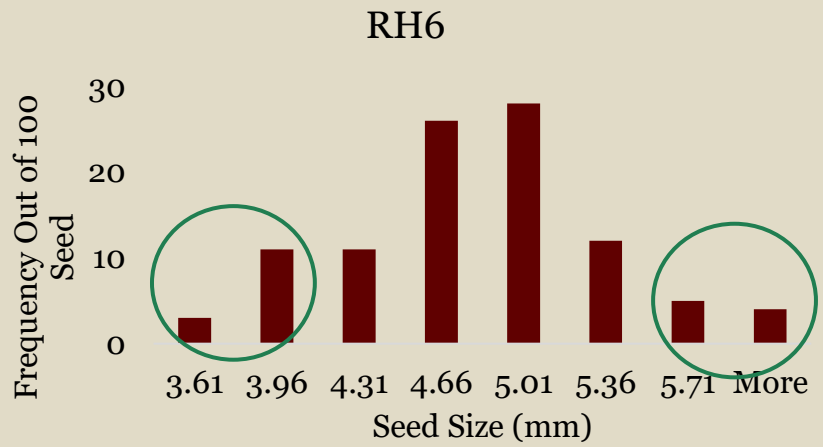












Goal: *To create populations from the genetic potential indicated above, within each pedigree.*

Size analysis of selected individuals within each pedigree

	Nursery A			Nursery B		
Family	High Mean (g)	Low Mean (g)	Significant Difference?	High Mean (g)	Low Mean (g)	Significant Difference?
RH1	12.7	9.4	***	11.1	9.1	**
RH2	11.7	9.5	***	10.9	8.2	***
RH3	12.0	9.1	***	10.5	8.5	***
RH4	12.5	9.0	**	10.5	7.9	***
RH5	11.1	8.3	***	10.4	8.0	***
RH6	11.7	8.3	***	10.7	7.4	***

Independent Student's T-Test analysis between the high and low seed index selections for each population. Analysis performed with JMP.
*** significance indicated at the 0.001 level
** significance indicated at the 0.01 level

G x E Analysis- Boll Samples

Do these lines maintain their rank across environments despite the environmental impact on seed size?

Source	df	MS	Significance?
Genotype	8	4.04	***
Environment	1	18.38	***
G X E	8	0.15	NS
Error	36	0.22	

Analysis of Variance Mean Squares for the seed index characteristic.
*** Significance indicated at the 0.001 level.
Analysis performed using JMP. **R- Squared= 0.867**

No GxE interaction suggests that cottonseed size remains small or large relative to its environment.

Current Conclusions

1. There is a measurable difference in seed size between the selected "high and low" representatives of each family. By utilizing the independent culling and divergent selection strategies, it is possible to impact cottonseed size through breeding.

2. Small seeded germplasm will remain smaller and large seeded germplasm will remain larger relative to the growing environment.

Availability of Material and Project Timeline:

- 2024- F3 Individual Plant Selections
- 2025- F4 Whole Row Selections; Seed Increase
- 2026- F5 Selections and Seed Increase; Multi-Location Heritability trial; Investigation Into Impacts on Downstream Sectors.
- 2027/2028- Release of Divergent Material

Sources

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Thank you!!!

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