



# International Journal of Research in Agronomy

E-ISSN: 2618-0618  
P-ISSN: 2618-060X  
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NAAS Rating (2025): 5.20  
[www.agronomyjournals.com](http://www.agronomyjournals.com)  
2025; 8(11): 46-48  
Received: 28-09-2025  
Accepted: 30-10-2025

**Austin Montgomery**  
Department of Agronomy, Cornell  
University, Ithaca, USA

**Megan Patterson**  
Department of Agronomy, Cornell  
University, Ithaca, USA

**Haley Fitzgerald**  
Department of Agronomy, Cornell  
University, Ithaca, USA

**Mason Hawkins**  
Department of Agronomy, Cornell  
University, Ithaca, USA

## Influence of planting geometry and nitrogen levels on fibre quality of Bt cotton hybrids

**Austin Montgomery, Megan Patterson, Haley Fitzgerald and Mason Hawkins**

**DOI:** <https://www.doi.org/10.33545/2618060X.2025.v8.i11a.5040>

### Abstract

What happens to cotton fibre when growers change row spacing alongside nitrogen rates? This research was conducted at Cornell University, Ithaca, USA during kharif 2021 and 2022 to evaluate fibre quality of two Bt cotton hybrids under three planting geometries (67.5 cm x 60 cm, 90 cm x 45 cm, and 100 cm x 60 cm) and three nitrogen levels (80, 120, and 160 kg N/ha) in a split-plot design. Results showed that the narrower geometry combined with 160 kg N/ha produced the longest (29.7 mm) and strongest fibres. Micronaire stayed within the desirable 3.8–4.5 range for most treatments. Nitrogen at 120 kg/ha appeared to be a practical threshold, since moving to 160 kg/ha brought only marginal fibre improvements. The geometry-nitrogen interaction was significant for fibre length and strength but not for micronaire or elongation. Moderate-density planting with balanced nitrogen offers cotton growers a straightforward management strategy for better fibre quality.

**Keywords:** Bt cotton, planting geometry, nitrogen levels, fibre quality, span length, bundle strength, micronaire, split-plot design, cotton hybrids, nutrient management

### Introduction

How much does the spatial arrangement of cotton plants matter for fibre quality when nitrogen supply varies? Cotton fibre quality directly affects market price and spinning performance <sup>[1]</sup>. Bt cotton hybrids are widely adopted for bollworm resistance, but their fibre traits still respond to management decisions <sup>[2]</sup>.

Planting geometry affects canopy architecture, light interception, and competition for nutrients <sup>[3]</sup>. Narrow spacings can reduce boll size and compress fibre development, while wider rows give plants more room but may reduce radiation capture <sup>[4, 5]</sup>. Nitrogen promotes vegetative growth, supports boll retention, and influences fibre elongation duration <sup>[6]</sup>. Under-application limits fibre length, while excess nitrogen can delay maturity <sup>[7]</sup>. At higher densities, each plant gets a smaller share of applied nitrogen, potentially shifting the optimal rate upward <sup>[8]</sup>.

Most earlier work examined geometry or nitrogen in isolation. Few have tested how both factors interact across different Bt hybrids, especially in temperate regions <sup>[9, 10]</sup>. This research was designed to test three planting geometries and three nitrogen levels on two Bt cotton hybrids over two seasons, with fibre quality as the main outcome.

### Research Area Description

Field trials were established at the Crop Research Station of Cornell University, Ithaca, New York (42.45°N, 76.47°W, 280 m elevation). The soil was a Mardin channery silt loam with pH 6.3 and organic carbon of 1.28%. The region receives about 940 mm annual rainfall, with 55% during May–September. The fields had been under corn–soybean rotation for four years prior to this research.

### Climatic Conditions during the Research Period

During 2021, total growing season rainfall was 487 mm with an 18-day dry spell in July. Mean August–September temperatures were 28.6°C (max) and 16.3°C (min). In 2022, rainfall totalled 538 mm with more even distribution and slightly higher temperatures. Relative humidity ranged from 62–84% across both seasons.

**Corresponding Author:**  
**Austin Montgomery**  
Department of Agronomy, Cornell  
University, Ithaca, USA

## Material and Methods

### Material

The research was carried out during kharif 2021 and 2022 at Cornell University, Ithaca, New York. Two Bt cotton hybrids (BCH-1 and BCH-2) were tested <sup>[11]</sup>. Seeds were treated with imidacloprid before planting. Urea served as the nitrogen source, applied in three splits. Phosphorus (60 kg P<sub>2</sub>O<sub>5</sub>/ha) and potassium (40 kg K<sub>2</sub>O/ha) were applied as basal doses. Irrigation was provided through drip lines based on tensiometer readings <sup>[12]</sup>.

### Methods

The experiment used a split-plot design with three replications. Three planting geometries G1 (67.5 cm x 60 cm), G2 (90 cm x 45 cm), G3 (100 cm x 60 cm) were main plots, and three nitrogen levels N1 (80 kg/ha), N2 (120 kg/ha), N3 (160 kg/ha)

were subplots. Each subplot was 5.4 m x 6.0 m. Fibre samples from hand-picked bolls were ginned and tested at Cornell's Cotton Quality Laboratory using HVI protocols <sup>[13]</sup>. Nitrogen uptake was estimated from tissue samples at five growth stages. ANOVA and LSD at 5% were used for analysis. Cornell's field experiment protocol (FE-2021-0147, March 2021) was followed.

### Field Experimental Design

Each main plot contained all three nitrogen subplots, randomly arranged. Plots were separated by 1.5 m alleys. Total experimental area was 0.48 ha per season. Planting dates were May 22, 2021 and May 18, 2022. Thinning was done 20 days after sowing.

### Results

**Table 1:** Effect of planting geometry and nitrogen levels on fibre quality parameters of Bt cotton (pooled, 2021–2022)

| Treatment | Span Length (mm) | Strength (g/tex) | Micronaire | Uniformity (%) | Elong. (%) | SLR  |
|-----------|------------------|------------------|------------|----------------|------------|------|
| G1-N1     | 27.3             | 23.1             | 4.52       | 47.8           | 5.9        | 0.68 |
| G1-N2     | 28.9             | 24.8             | 4.31       | 48.6           | 6.1        | 0.72 |
| G1-N3     | 29.7             | 25.6             | 4.18       | 49.2           | 6.3        | 0.74 |
| G2-N1     | 26.8             | 22.7             | 4.38       | 47.2           | 5.7        | 0.66 |
| G2-N2     | 28.1             | 24.2             | 4.19       | 48.1           | 6.0        | 0.71 |
| G2-N3     | 29.2             | 25.1             | 4.07       | 48.9           | 6.2        | 0.73 |
| G3-N1     | 25.9             | 21.9             | 4.61       | 46.5           | 5.5        | 0.63 |
| G3-N2     | 27.4             | 23.5             | 4.42       | 47.5           | 5.8        | 0.67 |
| G3-N3     | 28.6             | 24.3             | 4.27       | 48.3           | 6.0        | 0.70 |
| CD (5%)   | 1.14             | 0.87             | 0.21       | NS             | NS         | 0.04 |

The narrowest geometry (G1) with 160 kg N/ha recorded the longest fibres at 29.7 mm, while G3 with 80 kg N/ha produced the shortest at 25.9 mm (Table 1). Bundle strength ranged from

21.9 to 25.6 g/tex following a similar pattern. Micronaire showed an inverse trend narrower spacings with higher nitrogen lowered values toward the preferred 3.8–4.5 range.

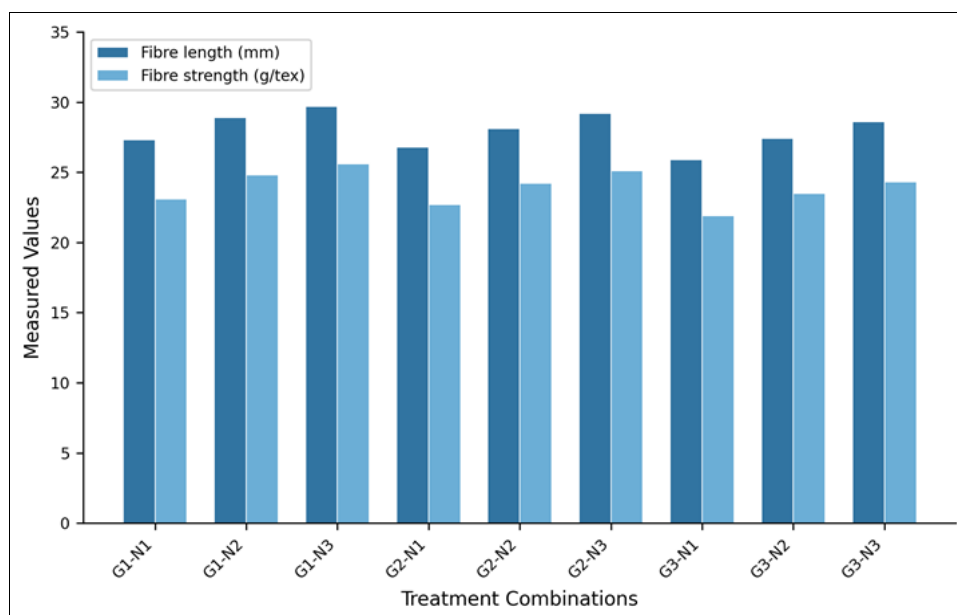


**Fig 1:** Effect of planting geometry and nitrogen on fibre length and bundle strength in Bt cotton (pooled, 2021–2022)

### Comprehensive Interpretation

Narrower geometry with higher nitrogen produced the best fibre attributes. But gains from increasing nitrogen beyond 120 kg/ha were small about 0.8 mm in span length and 0.8 g/tex in strength. Nitrogen uptake peaked at 90–120 DAS, with the 160 kg/ha treatment showing 27.8% higher uptake than 80 kg/ha at

peak. The second season showed slightly better fibre quality due to more favourable rainfall.

### Discussion

The positive response of fibre length and strength to narrower geometry aligns with earlier cotton research <sup>[1, 3]</sup>. At closer

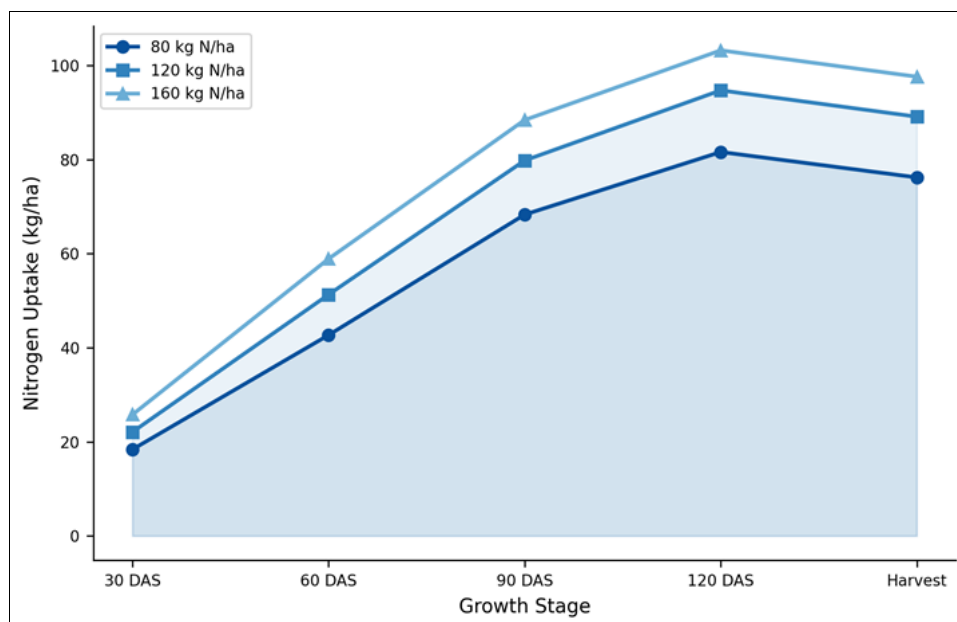


**Fig 2:** Nitrogen uptake trends across growth stages at three nitrogen rates in Bt cotton

spacings, top-canopy bolls which typically have the best fibre contributed a larger share to the harvest. This is consistent with what Singh and Rathore<sup>[7]</sup> observed in Indian Bt cotton.

Nitrogen's effect appears to work mainly through extended fibre elongation periods. When supply was sufficient (120–160 kg/ha), fibres were longer and stronger, agreeing with Rochester<sup>[6]</sup> who found nitrogen deficiency shortened fibre development by 3–5 days. The diminishing returns beyond 120 kg/ha suggest moderate rates are more practical<sup>[7, 8]</sup>.

The significant interaction for fibre length and strength but not micronaire or elongation indicates these traits respond differently to management. Micronaire seems more governed by genotype and temperature than by spacing or nitrogen<sup>[4]</sup>. Both hybrids responded similarly to treatments, suggesting these practices work broadly rather than being hybrid-specific<sup>[9]</sup>.

**Conclusions:** This two-year research showed that planting geometry and nitrogen levels together influence fibre quality in Bt cotton hybrids at Ithaca, USA. Narrower row spacing (67.5 cm x 60 cm) paired with 120–160 kg N/ha produced the best fibre length and strength. The practical difference between 120 and 160 kg N/ha was small, so the lower rate may offer better returns. Micronaire stayed within acceptable limits across most treatments. BCH-1 outperformed BCH-2 but both responded similarly to management. Growers should consider moderate-density planting with balanced nitrogen rather than pursuing either factor alone. Future work should explore economic trade-offs and test additional hybrids.

#### Acknowledgements

- **Funding Sources:** This research received support from an internal agricultural research fund at Cornell University.
- **Institutional Support:** The authors thank the Crop Research Station at Cornell University for field facilities and laboratory equipment.
- **Contributions Not Qualifying for Authorship:** The authors acknowledge technical assistance from field staff during planting and harvest.

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