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Response of hybrid cotton to different plant growth regulators under irrigated conditions

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Abstract
How do plant growth regulators reshape the productivity of hybrid cotton under irrigated systems? This research was carried out during Kharif 2023 at Universidad Agrícola del Bajío, Guanajuato, Mexico, to evaluate hybrid cotton (DCH-32) treated with different PGRs in a randomized block design with seven treatments and three replications. Treatments included GA_3 at 50 and 100 ppm, NAA at 25 and 50 ppm, mepiquat chloride at 750 ppm, cycocel at 1000 ppm, and an untreated control. GA_3 at 100 ppm gave the tallest plants (134.2 cm) and highest boll count (41.3 per plant), while mepiquat chloride shortened stature to 82.4 cm but improved harvest index by 8.7% over control. Seed cotton yield peaked at 2847 kg/ha with GA_3 100 ppm, 31.4% above control. Fiber quality traits didn't differ across PGR treatments. GA_3 at 100 ppm appears most effective for boosting yield in irrigated hybrid cotton, whereas mepiquat chloride suits growers needing compact canopies.

Keywords: Hybrid cotton, plant growth regulators, gibberellic acid, naphthalene acetic acid, mepiquat chloride, irrigated conditions, seed cotton yield, fiber quality, boll retention, growth management

Introduction
Can targeted hormone manipulation unlock the full genetic potential of hybrid cotton in well-watered fields? Cotton (*Gossypium hirsutum* L.) remains a backbone fiber crop across the tropics, with global production near 26 million tonnes of lint per year [1]. Mexico contributes a growing share from irrigated zones in the Bajío region [2]. Hybrid cultivars carry heterosis for yield but often produce excessive vegetative growth that shades lower fruiting branches, encourages boll shedding, and complicates mechanical picking [3].
Plant Growth Regulators (PGRs) can redirect assimilate partitioning from stem elongation toward boll development. GA_3 accelerates internode extension and leaf expansion [4], while NAA strengthens boll peduncle attachment and reduces pre-harvest fruit drop [5]. Anti-gibberellins like mepiquat chloride and cycocel block GA_3 biosynthesis, producing shorter, open canopies that intercept light evenly [6]. Field trials from India and the United States show that PGR choice interacts strongly with genotype, planting density, and irrigation regime [7, 8]. Yet side-by-side comparisons of both growth-promoting and growth-retarding PGRs within a single irrigated trial remain scarce in Mexico [9, 10].
This research measured growth, yield, and fiber quality responses of irrigated hybrid cotton to six PGR treatments. The objectives were:
1) Compare plant height, LAI, and branching across treatments;
2) Quantify seed cotton yield and its components; and
3) Assess whether fiber properties change with PGR application [11].

Research area description
The experiment was carried out at the research farm of Universidad Agrícola del Bajío, near Irapuato, Guanajuato, central Mexico (20.68°N, 101.35°W; 1724 m elevation). Soils were Vertisols with 48.3% clay, 0.71% organic carbon, and pH 7.6. Available N, P, and K were 218, 14.7, and 287 kg/ha. Furrow irrigation was applied at 10-day intervals through a lined canal system [12, 13].

Climatic conditions during the research period
The trial ran from June through December 2023. Mean daily temperature ranged from 18.4°C (November) to 27.9°C (July), with peaks of 33.1°C during the boll-development

window in August. Relative humidity averaged 68.2% across the season. Total rainfall was 547 mm, mainly in July-August. Eight supplementary irrigations of roughly 60 mm each maintained soil moisture near field capacity [14].

Material and Methods

Material

Certified seed of hybrid cotton DCH-32 was sourced from the National Seed Corporation depot in Guanajuato. DCH-32 is a medium-duration (150-165 days) intra-hirsutum hybrid grown across central Mexico for bold boll size and adaptability to irrigation. PGRs used were: GA_3 (90% technical, Sigma-Aldrich), NAA (98% purity, Merck), mepiquat chloride (5% SL, BASF), and cycocel (50% SL, Tata Rallis). Spray solutions were prepared fresh with distilled water plus 0.1% Tween-20. Recommended fertilizers (N 120, P 60, K 40 kg/ha) were applied uniformly. Standard pest management followed the regional IPM calendar [15].

Methods

The experiment followed a randomized block design with seven treatments and three replications (21 plots of 5 m × 4 m). Sowing was on 18 June 2023 at 90 cm × 60 cm spacing. PGR sprays were applied at square formation (45 DAS) and peak flowering (75 DAS) using a knapsack sprayer at 500 L/ha. Five plants per plot were tagged for biometric observations at 30, 60, 90, and 120 DAS. Plant height, LAI (disc method), and branch counts were recorded. Boll number, boll weight, and seed cotton yield were computed from 12 m² net plot area. Fiber samples were tested for 2.5% span length, bundle strength, and micronaire at the Guanajuato fiber testing laboratory. ANOVA and Duncan's Multiple Range Test at P=0.05 were applied [16].

Results

Table 1: Effect of plant growth regulators on growth attributes of hybrid cotton at 90 DAS

Treatment	Plant height (cm)	LAI	Sympodial branches	Monopodial branches	Stem diameter (mm)	Dry matter (g/plant)
Control	98.3	3.14	14.2	1.8	11.3	86.7
GA_3 50 ppm	121.7	4.08	17.6	2.3	12.8	104.3
GA_3 100 ppm	134.2	4.51	19.3	2.6	13.7	118.9
NAA 25 ppm	108.6	3.47	15.8	2.0	11.9	93.1
NAA 50 ppm	115.9	3.82	16.9	2.1	12.4	99.6
Mepiquat Cl.	82.4	2.89	13.1	1.6	10.7	78.2
Cycocel 1000	87.1	2.97	13.6	1.7	10.9	81.4
CD (P=0.05)	6.83	0.29	1.42	NS	0.87	5.61

Growth parameters responded markedly to PGR type (Table 1). GA_3 at 100 ppm produced the tallest plants (134.2 cm), 36.5% above the control. LAI followed a similar trend: 4.51 under GA_3 100 ppm versus 3.14 for the control. Mepiquat chloride reduced height to 82.4 cm, a 16.2% drop. Sympodial branches were most abundant under GA_3 100 ppm (19.3) and fewest under mepiquat chloride (13.1).

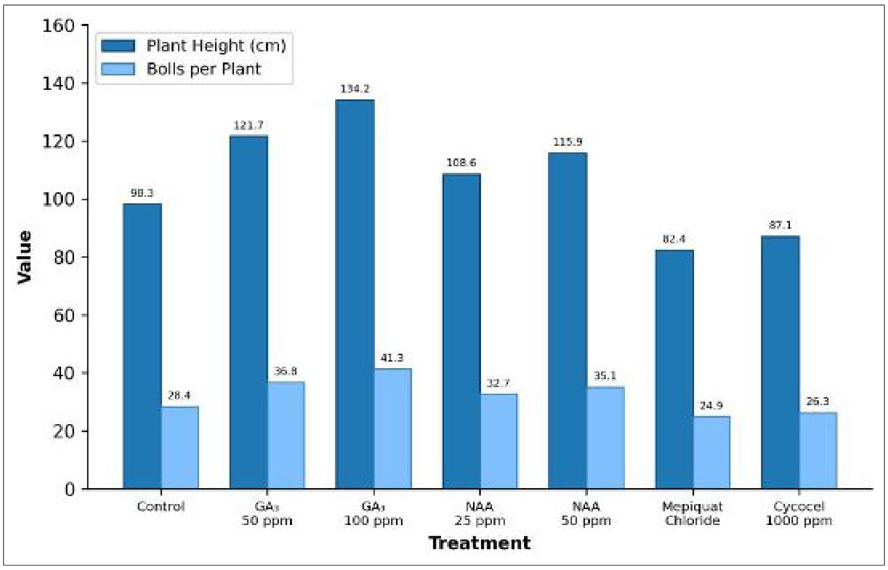

Fig 1: Comparison of plant height and bolls per plant across PGR treatments in hybrid cotton

GA_3 100 ppm maximised both vertical growth and boll number, while growth retardants suppressed both attributes. NAA treatments fell between the two extremes, showing moderate stimulatory effects on boll retention.

Table 2: Yield and fiber quality of hybrid cotton as influenced by PGR treatments

Treatment	Bolls/ plant	Boll Wt. (g)	Seed cotton yield (kg/ha)	Harvest index (%)	2.5% span length (mm)	Bundle strength (g/tex)
Control	28.4	3.92	2167	34.8	28.1	21.3
GA_3 50 ppm	36.8	4.13	2594	36.2	28.4	21.7
GA_3 100 ppm	41.3	4.27	2847	37.1	28.7	22.1
NAA 25 ppm	32.7	4.01	2318	35.6	28.3	21.5
NAA 50 ppm	35.1	4.09	2481	36.0	28.5	21.8
Mepiquat Cl.	24.9	4.31	2103	43.5	28.9	22.4
Cycocel 1000	26.3	4.18	2186	41.2	28.6	22.0
CD (P=0.05)	3.17	NS	187.4	2.94	NS	NS

Seed cotton yield ranged from 2103 kg/ha (mepiquat chloride) to 2847 kg/ha (GA_3 100 ppm), a 31.4% advantage over control (Table 2). The gain was driven by higher boll count rather than boll weight, which didn't differ significantly. Mepiquat chloride achieved the highest harvest index (43.5%), reflecting efficient dry-matter conversion despite lower total biomass. Fiber quality showed no significant differences across treatments.

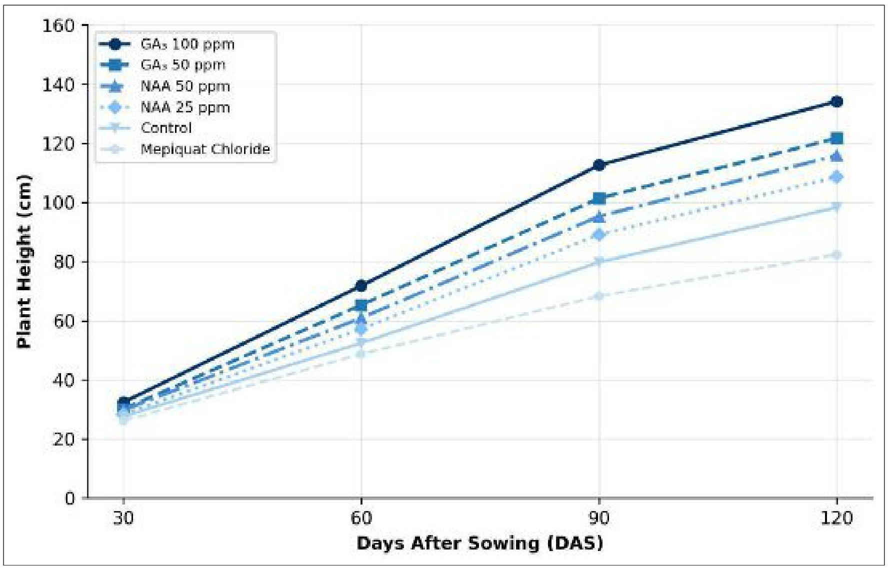

Fig 2: Temporal trends of plant height under selected PGR treatments from 30 to 120 DAS

Height differences widened after 60 DAS, coinciding with the second PGR spray. GA_3 100 ppm gained 40.8 cm between 60 and 90 DAS, whereas mepiquat chloride added only 19.6 cm over the same period.

Comprehensive interpretation

A clear separation emerged between growth-promoting and growth-retarding PGR groups. GA_3 at 100 ppm topped rankings for height, LAI, branching, and yield. Mepiquat chloride gave the best harvest index despite lower absolute yield. NAA at both doses occupied a middle ground with moderate yield gains.

Discussion

The strong positive response to GA_3 aligns with earlier reports from semi-arid cotton in Haryana, where Gill et al. [4] recorded 27-33% height increments with GA_3 between 75 and 125 ppm. The higher response here (36.5%) may reflect sustained moisture supply allowing full cell elongation in response to exogenous gibberellin [7]. Under irrigation, the additional LAI supported greater photosynthetic capacity without crossing the canopy closure threshold that causes light starvation at lower fruiting positions [8]. Mepiquat chloride's internode compression without reducing boll weight echoes US Cotton Belt findings where growth retardants redirect assimilates toward developing seeds [6]. The high harvest index (43.5%) under mepiquat chloride supports this, though the 6.7% yield penalty may be acceptable where mechanical picking is standard [3].

NAA at 50 ppm delivered a balanced outcome: yield rose 14.5% while plant height stayed below 120 cm, manageable for semi-mechanized harvest. Auxin-mediated peduncle strengthening likely reduced pre-harvest drop [5]. Fiber quality remained unchanged across all treatments, consistent with lint properties depending mainly on genotype and post-anthesis temperature rather than exogenous hormones applied during the vegetative-flowering transition [9].

Conclusion

This research demonstrated that PGRs can meaningfully alter growth architecture and yield of irrigated hybrid cotton without compromising fiber quality. GA_3 at 100 ppm produced the highest seed cotton yield of 2847 kg/ha, a 31.4% improvement over the control, driven by greater height, expanded leaf area, and more bolls per plant. Mepiquat chloride at 750 ppm reduced height by 16% and gave the highest harvest index, suiting mechanized systems.

NAA at 50 ppm offered a middle path, raising yield by 14.5% with moderate stature. Fiber quality was unaffected by any PGR treatment. Future work should test these treatments across multiple hybrids and planting densities and explore PGR-irrigation scheduling interactions for water-limited years.

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