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# Influence of plant growth regulators on growth, flowering and yield of fenugreek (*Trigonella foenum-graecum* L.)

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**Abstract**
An investigation entitled "Influence of plant growth regulators on growth, yield and quality of fenugreek (*Trigonella foenum-graecum* L.)" was conducted during the *rabi* season of 2024-2025 at the Research Block, Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, Bagalkot, University of Horticultural Sciences, Karnataka. The experiment was laid out in a Randomized Block Design (RBD) with eleven treatments replicated thrice, comprising foliar application of $GA_3$ and NAA at 25 and 50 ppm applied at 30 and 50 DAS and observations were recorded on growth, flowering and yield of fenugreek. Significant variations were observed among the treatments for all vegetative, flowering, yield parameters. The combined application of $GA_3$ @ 50 ppm + NAA @ 50 ppm at 30 and 50 DAS was found superior, recording maximum plant height (60.06 cm), plant spread (342.40 $cm^2$) and number of branches per plant (14.06). This treatment also resulted in the earliest 50% flowering (42.57 days) and seed maturity (104.54 days). Yield attributes such as number of pods per plant (45.37), pod length (14.44 cm), pod weight (11.29 g), number of seeds per pod (16.53), seed yield per plant (8.74 g), seed yield per plot (0.460 kg) and seed yield per hectare (14.58 q) were also markedly higher under this treatment. The results clearly indicate that combined application of $GA_3$ and NAA significantly enhanced the growth, earliness in flowering and yield of fenugreek compared to other treatments.

**Keywords:** Fenugreek, growth regulator, $GA_3$, NAA, yield, growth, flowering

## 1. Introduction
Fenugreek (*Trigonella foenum-graecum* L.), commonly known as methi, bird's foot or Greek clover, is a versatile leguminous crop grown as a leafy vegetable, spice, fodder and green manure. Believed to have originated in the Mediterranean region, it is widely cultivated in India particularly in Rajasthan, Gujarat and Madhya Pradesh (Meena *et al.*, 2014) [8]. The plant grows 30-90 cm tall, with trifoliate aromatic leaves, whitish to yellow flowers and curved pods containing 10-20 seeds (Snehalatha and Payal, 2012) [20]. Fenugreek is valued for its nutritional richness, being a good source of protein, vitamin C, minerals and essential oils (Khan *et al.*, 2005; Chhibba *et al.*, 2007) [6, 3]. Its seeds contain trigonelline, which imparts a slightly bitter taste and contributes to its medicinal value. They are widely used in traditional medicine for managing diabetes, cholesterol and digestive disorders due to their hypoglycaemic, antilipidemic and therapeutic properties (Meghwal and Goswami, 2012) [9]. Owing to its adaptability and health benefits, fenugreek holds great economic and medicinal importance.

For achieving higher productivity in fenugreek, improving both crop growth and seed yield is essential, which can be further enhanced through the use of plant growth regulators (PGRs). These organic compounds, even at very low concentrations, significantly influence physiological processes and regulate plant growth and development. Their effectiveness depends on factors such as species, dosage, timing and method of application. PGRs improve the source-sink relationship and enhance translocation of photo-assimilates, thereby promoting flowering, fruit set and seed development. Naphthalene Acetic Acid (NAA), a synthetic auxin, regulates cell elongation, root initiation, abscission and fruit setting, thereby improving yield attributes in fenugreek.

Similarly, gibberellic acid ($GA_3$) is a key growth stimulator that enhances stem elongation, vegetative growth, flowering, fruit enlargement and early maturity, contributing significantly to fenugreek growth and productivity.

## 2. Materials and Methods

The current study was undertaken during the *Rabi* season, from October 2025 to June 2025 was conducted at Research Block, Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, Bagalkot, University of Horticultural Sciences, Karnataka. The experiment was laid out in a Randomized Block Design (RBD) with eleven treatments replicated thrice, comprising foliar application of $GA_3$ and NAA at 25 and 50 ppm applied at 30 and 50 DAS. The experimental material consists of a variety DFC-21 (Krishna Prabha Devimenthi-1) seeds are sown in a line with a spacing of 30 cm x 10 cm. Plant growth regulator treatments comprising of $T_1$ (GA3 @ 50 ppm at 30 DAS), $T_2$ (GA3 @ 50 ppm at 30 DAS and 50 DAS), $T_3$ (NAA @ 25 ppm at 30 DAS), $T_4$ (NAA @ 25 ppm at 30 DAS and 50 DAS), $T_5$ (NAA @ 50 ppm at 30 DAS), $T_6$ (NAA @ 50 ppm at 30 DAS and 50 DAS), $T_7$ (GA3 @ 50 ppm + NAA @ 25 ppm at 30 DAS), $T_8$ (GA3 @ 50 ppm + NAA @ 25 ppm at 30 DAS and 50 DAS), $T_9$ (GA3 @ 50 ppm + NAA @ 50 ppm at 30 DAS), $T_{10}$ (GA3 @ 50 ppm + NAA @ 50 ppm at 30 DAS and 50 DAS), $T_{11}$ (Control). Data on growth, flowering and yield performance were recorded and statistically analysed.

## 3. Results and Discussion

### 3.1 Growth parameters

Application of GA3 @ 50 ppm + NAA @ 50 ppm at 30 DAS and 50 DAS proved more effective in significantly enhancing the growth attributes of fenugreek compared to other application levels. The greatest plant height of 60.06 cm at harvest was achieved when $GA_3$ at 50 ppm and NAA at 50 ppm were applied via foliar spray at 30 and 50 days after sowing this increase in height is attributed to the combined action of $GA_3$ and NAA in promoting cell elongation, division and diminishing apical dominance, thus encouraging robust stem development. $GA_3$ enhances internodal elongation by stimulating cell division and expansion, while NAA supports vegetative growth by promoting cell enlargement and maintaining hormonal equilibrium; when used together, these regulators significantly amplify plant height compared to untreated plants or those given a single growth promoter, as evidenced in studies of Singh *et al.* (2012) [19] in coriander, Rohamare *et al.* (2013) [13] in ajwain, Talab *et al.* (2014) [22] and Siddik *et al.* (2015) [18] in fenugreek.

**Table 1:** Effect of $GA_3$ and NAA plant growth regulators on growth parameters at harvest in fenugreek

| Treatments | Plant height (cm) | Plant spread (E-W × N-S) ($cm^2$) | Number of branches |
|---|---|---|---|
| $T_1$ | 48.45 | 244.64 | 8.83 |
| $T_2$ | 57.09 | 292.06 | 12.43 |
| $T_3$ | 47.52 | 228.01 | 8.42 |
| $T_4$ | 49.26 | 245.38 | 9.80 |
| $T_5$ | 47.17 | 247.52 | 8.73 |
| $T_6$ | 49.42 | 260.27 | 10.27 |
| $T_7$ | 54.86 | 269.65 | 10.82 |
| $T_8$ | 57.68 | 302.41 | 12.67 |
| $T_9$ | 54.77 | 279.09 | 11.46 |
| $T_{10}$ | 60.06 | 342.40 | 14.06 |
| $T_{11}$ | 40.92 | 195.62 | 5.80 |
| Mean | 51.54 | 263.82 | 10.29 |
| S. Em ± | 0.65 | 3.00 | 0.11 |
| CD @ 5% | 1.91 | 8.87 | 0.34 |

DAS: Days after sowing
$T_1$: Application of $GA_3$ @ 50 ppm at 30 DAS
$T_2$: Application of $GA_3$ @ 50 ppm at 30 DAS and 50 DAS
$T_3$: Application of NAA @ 25 ppm at 30 DAS
$T_4$: Application of NAA @ 25 ppm at 30 DAS and 50 DAS
$T_5$: Application of NAA @ 50 ppm at 30 DAS
$T_6$: Application of NAA @ 50 ppm at 30 DAS and 50 DAS
$T_7$: Application of $GA_3$ @ 50 ppm + NAA @ 25 ppm at 30 DAS
$T_8$: Application of $GA_3$ @ 50 ppm + NAA @ 25 ppm at 30 DAS and 50 DAS
$T_9$: Application of $GA_3$ @ 50 ppm + NAA @ 50 ppm at 30 DAS
$T_{10}$: Application of $GA_3$ @ 50 ppm + NAA @ 50 ppm at 30 DAS and 50 DAS
$T_{11}$: Control

**Table 2:** Effect of $GA_3$ and NAA plant growth regulators on flowering parameters in fenugreek

| Treatment | Days to first flowering | Days to 50 % flowering | Days to seed maturity |
|---|---|---|---|
| $T_1$ | 31.23 | 46.58 | 107.27 |
| $T_2$ | 34.03 | 44.46 | 105.72 |
| $T_3$ | 30.66 | 51.17 | 112.74 |
| $T_4$ | 33.70 | 48.91 | 110.20 |
| $T_5$ | 31.32 | 49.54 | 110.57 |
| $T_6$ | 34.02 | 47.98 | 110.47 |
| $T_7$ | 35.33 | 47.13 | 106.93 |
| $T_8$ | 31.48 | 43.59 | 105.09 |
| $T_9$ | 32.78 | 47.10 | 109.22 |
| $T_{10}$ | 32.48 | 42.57 | 104.54 |
| $T_{11}$ | 32.28 | 53.57 | 112.78 |
| Mean | 32.66 | 47.51 | 108.68 |
| S. Em ± | 0.32 | 0.29 | 1.43 |
| CD @ 5% | 0.94 | 0.84 | 4.21 |

DAS: Days after sowing
$T_1$: Application of $GA_3$ @ 50 ppm at 30 DAS
$T_2$: Application of $GA_3$ @ 50 ppm at 30 DAS and 50 DAS
$T_3$: Application of NAA @ 25 ppm at 30 DAS
$T_4$: Application of NAA @ 25 ppm at 30 DAS and 50 DAS
$T_5$: Application of NAA @ 50 ppm at 30 DAS
$T_6$: Application of NAA @ 50 ppm at 30 DAS and 50 DAS
$T_7$: Application of $GA_3$ @ 50 ppm + NAA @ 25 ppm at 30 DAS
$T_8$: Application of $GA_3$ @ 50 ppm + NAA @ 25 ppm at 30 DAS and 50 DAS
$T_9$: Application of $GA_3$ @ 50 ppm + NAA @ 50 ppm at 30 DAS
$T_{10}$: Application of $GA_3$ @ 50 ppm + NAA @ 50 ppm at 30 DAS and 50 DAS
$T_{11}$: Control

**Table 3:** Effect of $GA_3$ and NAA plant growth regulators on yield attributing parameters in fenugreek

| Treatment | Number of pods per plant | Pod length (cm) | Pod weight per plant (g) | Number of seeds per pod | Seed yield per plant (g) | Seed yield per plot (kg) | Seed yield Per hectare (q) |
|---|---|---|---|---|---|---|---|
| $T_1$ | 27.60 | 9.81 | 7.49 | 12.49 | 4.66 | 0.406 | 12.90 |
| $T_2$ | 38.44 | 13.21 | 9.47 | 14.87 | 7.21 | 0.438 | 13.92 |
| $T_3$ | 26.37 | 8.37 | 6.44 | 10.76 | 4.21 | 0.389 | 12.35 |
| $T_4$ | 30.17 | 10.53 | 7.34 | 11.83 | 5.21 | 0.425 | 13.43 |
| $T_5$ | 27.13 | 8.43 | 5.79 | 10.01 | 3.50 | 0.404 | 12.76 |
| $T_6$ | 34.05 | 11.56 | 7.33 | 12.67 | 5.71 | 0.426 | 13.57 |
| $T_7$ | 36.73 | 11.81 | 8.53 | 13.82 | 6.27 | 0.429 | 13.61 |
| $T_8$ | 40.73 | 13.67 | 9.68 | 15.45 | 7.66 | 0.452 | 14.34 |
| $T_9$ | 37.17 | 12.58 | 8.34 | 14.35 | 6.74 | 0.436 | 13.84 |
| $T_{10}$ | 45.37 | 14.44 | 11.29 | 16.53 | 8.74 | 0.460 | 14.58 |
| $T_{11}$ | 20.29 | 7.20 | 5.40 | 8.76 | 3.41 | 0.283 | 9.03 |
| Mean | 33.09 | 11.06 | 7.92 | 12.87 | 5.76 | 0.413 | 13.12 |
| S. Em ± | 0.89 | 0.25 | 0.24 | 0.23 | 0.14 | 0.006 | 0.17 |
| CD @ 5% | 2.61 | 0.75 | 0.70 | 0.69 | 0.41 | 0.016 | 0.50 |

DAS: Days after sowing
$T_1$: Application of $GA_3$ @ 50 ppm at 30 DAS
$T_2$: Application of $GA_3$ @ 50 ppm at 30 DAS and 50 DAS
$T_3$: Application of NAA @ 25 ppm at 30 DAS
$T_4$: Application of NAA @ 25 ppm at 30 DAS and 50 DAS
$T_5$: Application of NAA @ 50 ppm at 30 DAS
$T_6$: Application of NAA @ 50 ppm at 30 DAS and 50 DAS
$T_7$: Application of $GA_3$ @ 50 ppm + NAA @ 25 ppm at 30 DAS
$T_8$: Application of $GA_3$ @ 50 ppm + NAA @ 25 ppm at 30 DAS and 50 DAS
$T_9$: Application of $GA_3$ @ 50 ppm + NAA @ 50 ppm at 30 DAS
$T_{10}$: Application of $GA_3$ @ 50 ppm + NAA @ 50 ppm at 30 DAS and 50 DAS
$T_{11}$: Control

The increased plant spread (342.40 $cm^2$ at harvest) and number of branches (14.06 harvest) observed in fenugreek with the combined foliar application of GA3 and NAA at 50 ppm at 30 and 50 days after sowing (Table 1). This may be due to application of GA3 reduces apical dominance by inhibiting terminal bud growth, facilitating nutrient movement to axillary buds and fostering lateral branching and greater plant spread. Concurrently, NAA, functioning as an auxin, stimulates cell division, elongation and nutrient uptake. Together, these hormones enhance photosynthesis, nutrient absorption and the plant's hormonal balance, boosting vegetative growth and branch formation. Similar findings have been reported in fenugreek by Vasudevan *et al.* (2008) [24], Krishnaveni *et al.* (2014) [7] and Sowmya *et al.* (2017) [21], as well as in chickpea by Baloch and Zubair (2010) [2].

### 3.2 Flowering parameters

The application of a 50-ppm mixture of $GA_3$ and NAA at 30 and 50 days after sowing resulted in the earliest 50 % flowering (42.57 days) and the shortest time to seed maturity (104.54 days) in fenugreek (Table 2). This is due to $GA_3$ plays a crucial role in boosting photosynthetic activity and nutrient transport, which accelerates the initiation of flowering. At the same time, NAA promotes cell division and tissue differentiation, enhancing nutrient movement from source to sink tissues, thereby advancing seed development and reducing the maturity period. Similar trends have been observed in previous studies by Shah *et al.* (2006) [15] and Pavankumar *et al.* (2018) [11] in black cumin, Panda *et al.* (2007) [10] and Sahu (2021) [14] in coriander, Gangaram (2011) [4] along with Reddy and Hore (2020) [12] in fenugreek.

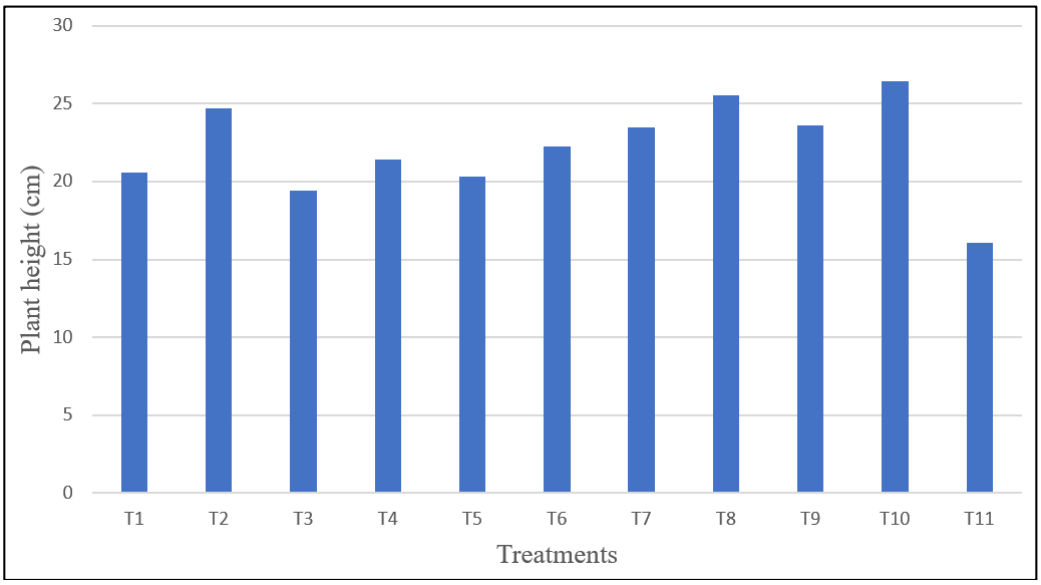
### 3.3 Yield parameters

Data on yield attributes such as pods per plant, pod length, pod weight per plant, seeds per pod, seed yield per plant, seed yield per plot, seed yield per hectare were systematically recorded and are presented here (Table 3). Application of $GA_3$ @ 50 ppm + NAA @ 50 ppm applied at 30 and 50 DAS recorded maximum number of pods per plant (45.37), pod length (14.44 cm), pod weight per plant (11.29 g), number of seeds per pod (16.53), maximum seed yield per plant (8.74 g), maximum seed yield per plot (0.460 kg), maximum seed yield per hectare (14.58 q/ha).

The significant increase in the number of pods per plant may be due to $GA_3$ and NAA application leads to increases branching, boost flowering, enhancing fruit retention and minimizing flower and pod shedding. This is achieved through stimulation of cell division, cell elongation, and maintaining hormonal equilibrium in the plant. Consequently, the greater pod count results in increase in the total pod weight per plant. These results are supported by previous studies of Shah *et al.* (2006) [15] in black cumin, Panda *et al.* (2007) [10], Shivran and Jat (2013) [16] and Andrabi *et al.* (2019) [1] in coriander, Rohamare *et al.* (2013) [13] in ajwain.

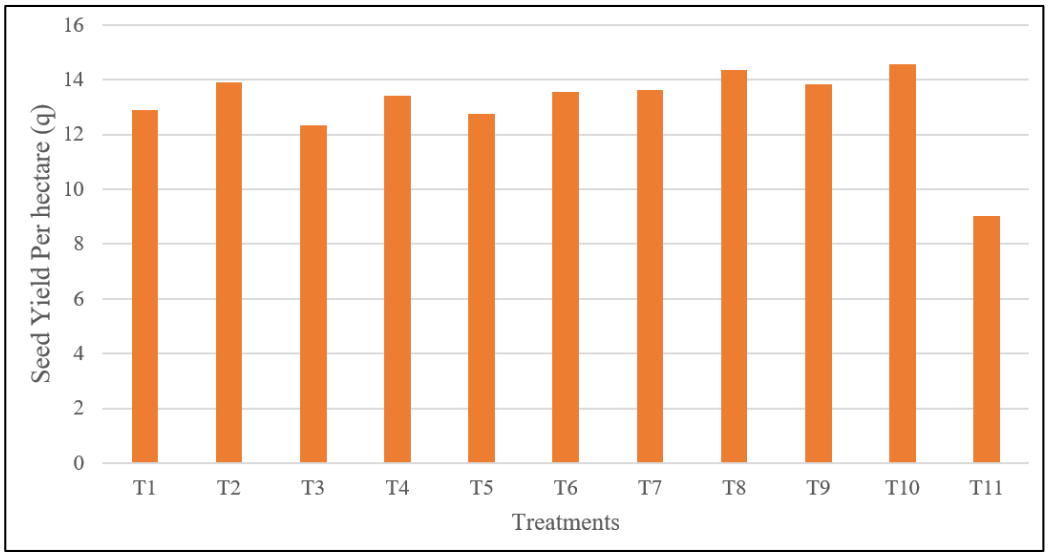
The greatest pod length might be a result of $GA_3$ and NAA stimulating rapid cell division and elongation, which promotes the expansion of individual cells in the developing pod. This leads to noticeably longer pods compared to untreated plants. As the pods grow longer, these growth regulators also contribute to a higher seed count within each pod. These results are similar with the findings of Yadav *et al.* (2025) [25] in fenugreek and Haokip *et al.* (2016) [5] in coriander.

The highest seed yield per plant, seed yield per plot and seed yield per hectare was observed in fenugreek plants treated with $T_{10}$ ($GA_3$ @ 50 ppm + NAA @ 50 ppm at 30 DAS and 50 DAS). This is due to overall increase in yield parameters like pods per plant, pod length and seeds per pod. Tufail *et al.* (2020) [23], Shivran *et al.* (2016) [17] and Yadav *et al.* (2025) [25] in fenugreek.




$T_1$: $GA_3$ @ 50 ppm at 30 DAS
$T_2$: $GA_3$ @ 50 ppm at 30 DAS and 50 DAS
$T_3$: NAA @ 25 ppm at 30 DAS
$T_4$: NAA @ 25 ppm at 30 DAS and 50 DAS
$T_5$: NAA @ 50 ppm at 30 DAS
$T_6$: NAA @ 50 ppm at 30 DAS and 50 DAS
$T_7$: $GA_3$ @ 50 ppm + NAA @ 25 ppm at 30 DAS
$T_8$: $GA_3$ @ 50 ppm + NAA @ 25 ppm at 30 DAS and 50 DAS
$T_9$: $GA_3$ @ 50 ppm + NAA @ 50 ppm at 30 DAS
$T_{10}$: $GA_3$ @ 50 ppm + NAA @ 50 ppm at 30 DAS and 50 DAS
$T_{11}$: Control

**Fig 1:** Effect of $GA_3$ and NAA plant growth regulators on plant height (cm) in fenugreek




$T_1$: $GA_3$ @ 50 ppm at 30 DAS
$T_2$: $GA_3$ @ 50 ppm at 30 DAS and 50 DAS
$T_3$: NAA @ 25 ppm at 30 DAS
$T_4$: NAA @ 25 ppm at 30 DAS and 50 DAS
$T_5$: NAA @ 50 ppm at 30 DAS
$T_6$: NAA @ 50 ppm at 30 DAS and 50 DAS
$T_7$: $GA_3$ @ 50 ppm + NAA @ 25 ppm at 30 DAS
$T_8$: $GA_3$ @ 50 ppm + NAA @ 25 ppm at 30 DAS and 50 DAS
$T_9$: $GA_3$ @ 50 ppm + NAA @ 50 ppm at 30 DAS
$T_{10}$: $GA_3$ @ 50 ppm + NAA @ 50 ppm at 30 DAS and 50 DAS
$T_{11}$: Control

**Fig 2:** Effect of $GA_3$ and NAA plant growth regulators on seed yield in fenugreek

## 4. Conclusion

The results of the study indicated that among the various concentrations and application timings of $GA_3$ and NAA, the combined application of $GA_3$ and NAA at 50 ppm applied at 30 and 50 DAS ($T_{10}$) proved significantly superior in promoting vegetative growth, enhancing flowering traits and achieving the highest seed yield (14.58 q/ha).

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