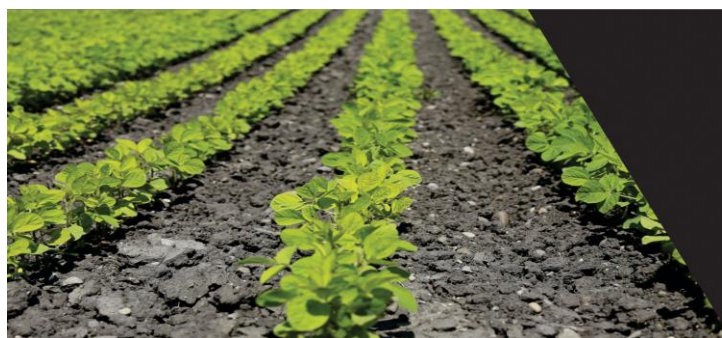




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## Effect of spacing and liquid organic growth hormones on growth, yield and economics of Chia (*Salvia hispanica* L.)

**Sunita Yadav, Lalit Kumar Sanodiya, Amita, Aviral Singh Yadav and Nidhi Patel**

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### Abstract

A field experiment was conducted during the Rabi season of 2025–26 at the Agricultural Research Farm, Department of Agronomy, Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj, to study the effect of three plant spacings (30×10, 45×15 and 60×20 cm) and three liquid organic growth hormones (Panchgavya 5%, Jeeva Amrut 5% and Dashparni Ark 5%) on the growth, yield and economics of chia. The experiment was laid out in a Randomized Block Design with ten treatments replicated thrice. Results revealed that wider spacing of 60×20 cm combined with foliar application of Jeeva Amrut 5% (T<sub>8</sub>) recorded the maximum plant height (79.83 cm), number of branches per plant (19.75), dry matter accumulation (90.50 g plant<sup>-1</sup>), crop growth rate (9.20 g m<sup>-2</sup> day<sup>-1</sup>), number of spikes per plant (29.20), spike length (18.76 cm) and spike weight (3.25 g) at harvest. The same treatment also produced the highest seed yield (11.70 q ha<sup>-1</sup>), biological yield (38.20 t ha<sup>-1</sup>) and harvest index (30.63%). Economic analysis showed that T<sub>8</sub> gave the maximum gross return (₹1,79,630 ha<sup>-1</sup>), net return (₹1,27,129 ha<sup>-1</sup>) and benefit–cost ratio (3.02), as against the lowest values under the control (T<sub>10</sub>). It is concluded that adoption of 60×20 cm spacing with foliar spray of Jeeva Amrut 5% is the most effective and profitable practice for chia cultivation under the agro-climatic conditions of Prayagraj.

**Keywords:** Chia, *Salvia hispanica*, spacing, jeeva amrut, panchgavya, Dashparni ark, biostimulants, seed yield, benefit–cost ratio

### 1. Introduction

Chia (*Salvia hispanica* L.), an emerging oilseed crop of the family Lamiaceae, has gained worldwide attention as a “superfood” owing to its rich content of omega-3 fatty acids, high-quality protein, dietary fibre, antioxidants, vitamins and essential minerals.  $\alpha$ -Linolenic acid (ALA), an omega-3 fatty acid essential for human health, constitutes about 30–35% of the seed oil. The crop is well suited to tropical and subtropical environments, tolerates drought and requires minimal inputs, making it a promising option for sustainable and organic farming systems.

Plant spacing, or crop geometry, is a crucial agronomic factor that governs plant population and influences light interception, nutrient use efficiency and ultimately yield. Wider spacing favours better development of individual plants, whereas closer spacing raises plant population per unit area. Liquid organic growth hormones (biostimulants) such as Panchgavya, Jeeva Amrut and Dashparni Ark contain beneficial microorganisms, enzymes, vitamins and growth-promoting substances that enhance nutrient uptake, microbial activity and physiological efficiency. However, information on the combined effect of spacing and liquid organic formulations on chia under Indian conditions, particularly the Prayagraj region, is limited.

Keeping this in view, the present investigation was undertaken with the following objectives: (i) to study the effect of spacing and organic growth hormones on growth of chia; (ii) to study their effect on yield of chia; and (iii) to work out the economics of the different treatment combinations.

### 2. Materials and Methods

The field experiment was conducted during the Rabi season of 2025–26 at the Agricultural Research Farm, Department of Agronomy, Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj (24°47' N, 81°19' E; 98 m above mean sea level). The region has a tropical, semi-arid climate. The crop variety used was Chia Ampion W-83. The experiment was laid out in a

Randomized Block Design (RBD) with ten treatments and three replications, giving a total of 30 plots of 3 m × 3 m (9 m<sup>2</sup>) each. Three spacings (30×10, 45×15 and 60×20 cm) were combined factorially with three liquid organic formulations (Panchgavya 5%, Jeeva Amrut 5% and Dashparni Ark 5%), along with a control (farmer practice). The treatment combinations are presented in Table 1.

**Table 1:** Treatment combinations

| Treatment       | Spacing (cm) | Organic growth hormone |
|-----------------|--------------|------------------------|
| T <sub>1</sub>  | 30 × 10      | Panchgavya 5%          |
| T <sub>2</sub>  | 30 × 10      | Jeeva Amrut 5%         |
| T <sub>3</sub>  | 30 × 10      | Dashparni Ark 5%       |
| T <sub>4</sub>  | 45 × 15      | Panchgavya 5%          |
| T <sub>5</sub>  | 45 × 15      | Jeeva Amrut 5%         |
| T <sub>6</sub>  | 45 × 15      | Dashparni Ark 5%       |
| T <sub>7</sub>  | 60 × 20      | Panchgavya 5%          |
| T <sub>8</sub>  | 60 × 20      | Jeeva Amrut 5%         |
| T <sub>9</sub>  | 60 × 20      | Dashparni Ark 5%       |
| T <sub>10</sub> | Control      | Farmer practices       |

Observations on growth parameters (plant height, number of

branches per plant, plant dry weight, crop growth rate and relative growth rate) were recorded at 30, 60, 90 DAS and at harvest. Yield attributes (number of spikes per plant, spike length, spike weight and test weight), yield (seed, straw and biological yield, harvest index) and economics (cost of cultivation, gross return, net return and benefit–cost ratio) were recorded at harvest. Data were analysed by ANOVA for RBD following Panse and Sukhatme (1967) [8]; treatment differences were tested by the critical difference (CD) at the 5% level of significance.

### 3. Results and Discussion

#### 3.1 Growth parameters

**Plant height:** Plant height increased progressively with crop age under all treatments (Fig. 1, Table 2). At harvest, the maximum plant height (79.83 cm) was recorded under T<sub>8</sub> (60×20 cm + Jeeva Amrut 5%), followed by T<sub>9</sub> (78.63 cm) and T<sub>7</sub> (77.63 cm), while the minimum (59.80 cm) was recorded under the control (T<sub>10</sub>). Wider spacing consistently produced taller plants than closer spacing, owing to reduced inter-plant competition and better availability of light, moisture and nutrients; Jeeva Amrut further enhanced height through its growth-promoting microflora and readily available nutrients.

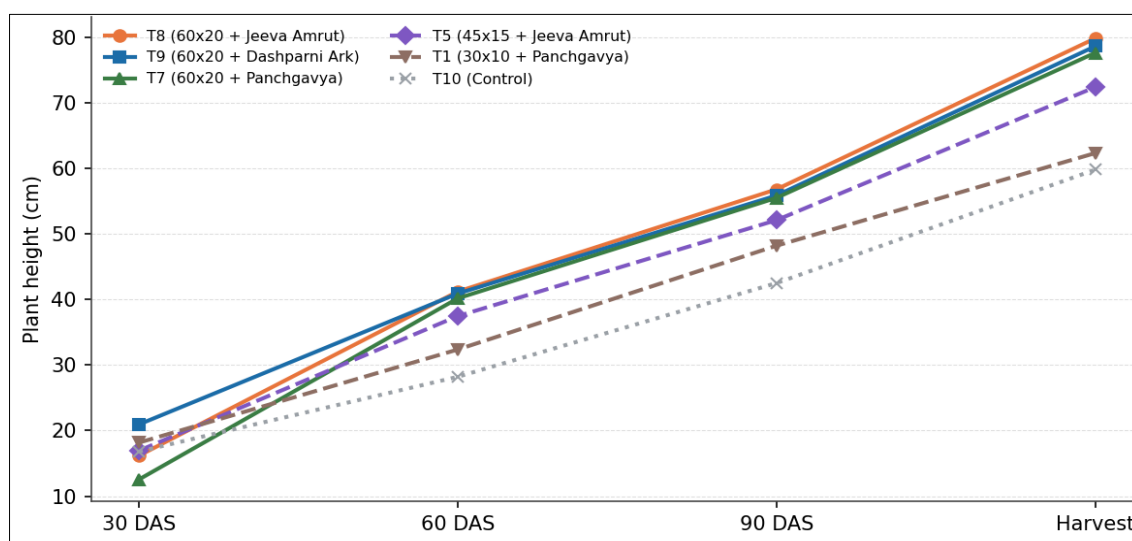


**Fig 1:** Plant height of chia at different growth stages.

**Table 2:** Effect of spacing and organic growth hormones on plant height (cm)

| Treatment       | 30 DAS | 60 DAS | 90 DAS | At harvest |
|-----------------|--------|--------|--------|------------|
| T <sub>1</sub>  | 18.16  | 32.36  | 48.20  | 62.33      |
| T <sub>2</sub>  | 17.56  | 31.56  | 48.10  | 61.10      |
| T <sub>3</sub>  | 18.83  | 33.56  | 47.75  | 64.56      |
| T <sub>4</sub>  | 17.23  | 36.70  | 50.45  | 70.20      |
| T <sub>5</sub>  | 16.93  | 37.46  | 52.10  | 72.40      |
| T <sub>6</sub>  | 13.76  | 37.26  | 54.35  | 71.83      |
| T <sub>7</sub>  | 12.53  | 40.16  | 55.50  | 77.63      |
| T <sub>8</sub>  | 16.16  | 41.20  | 56.80  | 79.83      |
| T <sub>9</sub>  | 20.93  | 40.90  | 55.86  | 78.63      |
| T <sub>10</sub> | 16.80  | 28.20  | 42.50  | 59.80      |

SEm(±): 0.34 (30 DAS), 2.14 (60), 2.33 (90), 4.54 (harvest); CD (5%): NS, 6.87, 6.95, 13.56 respectively.

**Number of branches and dry matter.** The number of branches per plant and dry matter accumulation followed the same trend (Fig. 2, Table 3). At harvest, T<sub>8</sub> recorded the highest number of branches (19.75, statistically at par with T<sub>7</sub>) and the maximum dry weight (90.50 g plant<sup>-1</sup>), whereas the control gave the lowest

values (17.00 branches; 78.00 g plant<sup>-1</sup>). Wider spacing improved canopy development and root proliferation, while the organic formulations enhanced axillary bud development and photosynthetic assimilate production.

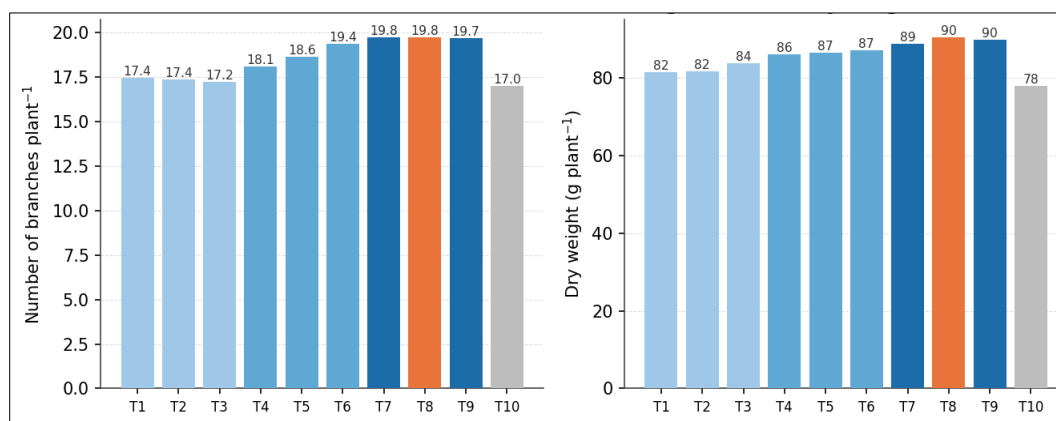


Fig 2: Number of branches per plant (a) and plant dry weight (b) at harvest.

Table 3: Number of branches plant<sup>-1</sup> and plant dry weight (g plant<sup>-1</sup>)

| Treatment       | Branch 90DAS | Branch harvest | DW 60DAS | DW 90DAS | DW harvest |
|-----------------|--------------|----------------|----------|----------|------------|
| T <sub>1</sub>  | 6.30         | 17.45          | 8.45     | 32.79    | 81.50      |
| T <sub>2</sub>  | 6.13         | 17.40          | 8.13     | 33.23    | 81.81      |
| T <sub>3</sub>  | 6.70         | 17.25          | 8.07     | 33.52    | 83.80      |
| T <sub>4</sub>  | 7.80         | 18.10          | 10.50    | 34.40    | 86.20      |
| T <sub>5</sub>  | 8.10         | 18.65          | 10.80    | 30.30    | 86.60      |
| T <sub>6</sub>  | 7.97         | 19.40          | 10.60    | 30.50    | 87.20      |
| T <sub>7</sub>  | 9.00         | 19.75          | 12.27    | 33.10    | 88.80      |
| T <sub>8</sub>  | 9.40         | 19.75          | 12.70    | 40.23    | 90.50      |
| T <sub>9</sub>  | 9.23         | 19.70          | 12.57    | 34.84    | 89.80      |
| T <sub>10</sub> | 5.90         | 17.00          | 7.80     | 31.57    | 78.00      |

**Crop growth rate and relative growth rate:** Both CGR and RGR increased with crop age and were highest under wider spacing with Jeeva Amrut (Fig. 3). At 90 DAS, T<sub>8</sub> recorded the maximum CGR (9.20 g m<sup>-2</sup> day<sup>-1</sup>) and the highest RGR (40.76

mg g<sup>-1</sup> day<sup>-1</sup>), against 5.30 and 21.50 respectively under the control. Improved aeration, light interception and microbial-mediated nutrient availability under T<sub>8</sub> raised photosynthetic efficiency and biomass accumulation.

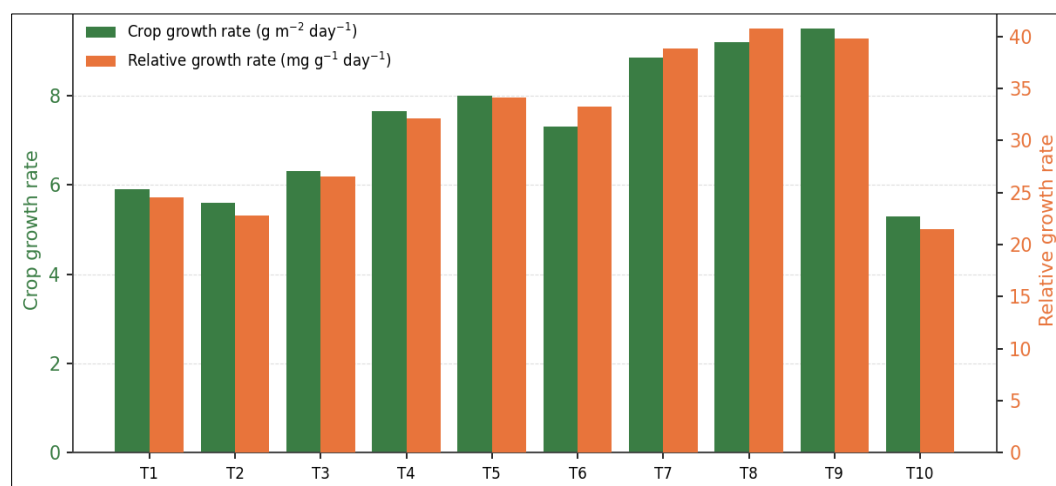


Fig 3: Crop growth rate and relative growth rate at 90 DAS.

Table 4: Crop growth rate (g m<sup>-2</sup> day<sup>-1</sup>) and relative growth rate (mg g<sup>-1</sup> day<sup>-1</sup>)

| Treatment       | CGR 30 | CGR 60 | CGR 90 | RGR 60 | RGR 90 |
|-----------------|--------|--------|--------|--------|--------|
| T <sub>1</sub>  | 1.52   | 4.85   | 5.91   | 29.83  | 24.56  |
| T <sub>2</sub>  | 1.27   | 4.63   | 5.60   | 27.83  | 22.83  |
| T <sub>3</sub>  | 1.83   | 5.12   | 6.30   | 31.83  | 26.50  |
| T <sub>4</sub>  | 1.65   | 6.23   | 7.65   | 38.50  | 32.16  |
| T <sub>5</sub>  | 1.97   | 6.56   | 8.00   | 40.76  | 34.16  |
| T <sub>6</sub>  | 1.23   | 6.46   | 7.30   | 39.76  | 33.23  |
| T <sub>7</sub>  | 1.57   | 7.45   | 8.85   | 46.16  | 38.83  |
| T <sub>8</sub>  | 1.82   | 7.82   | 9.20   | 48.23  | 40.76  |
| T <sub>9</sub>  | 1.70   | 7.65   | 9.50   | 47.23  | 39.76  |
| T <sub>10</sub> | 1.00   | 4.30   | 5.30   | 25.80  | 21.50  |

### 3.2 Yield attributes

Yield-contributing characters were significantly improved by wider spacing combined with organic formulations (Fig. 4, Table 5). The maximum number of spikes per plant (29.20), spike length (18.76 cm) and spike weight (3.25 g) were recorded under T<sub>8</sub>,

followed by T<sub>9</sub> and T<sub>7</sub>, while the control recorded the lowest values. Better interception of sunlight, improved nutrient translocation and enhanced spike development under wider spacing accounted for the superiority of T<sub>8</sub>.

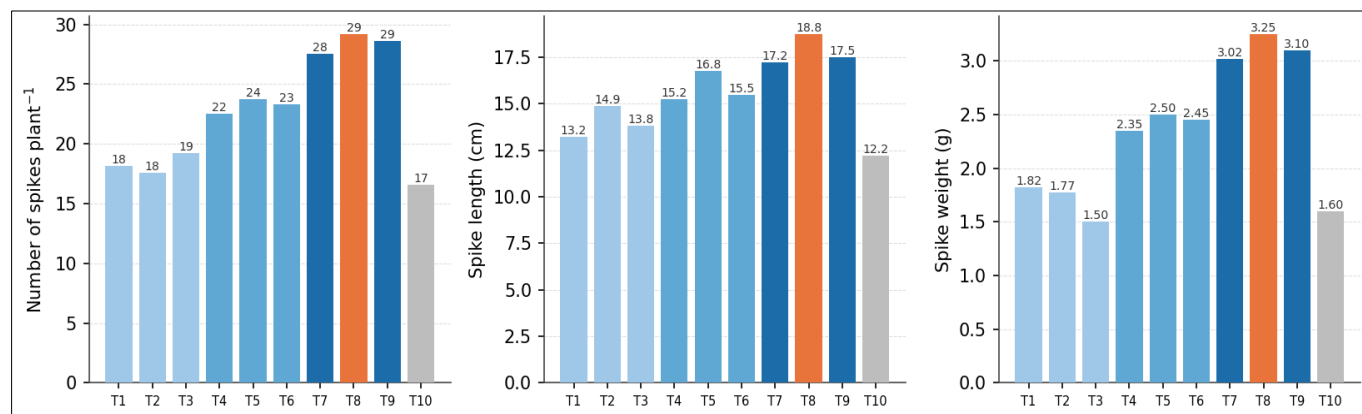


Fig 4: Number of spikes per plant (a), spike length (b) and spike weight (c)

Table 5: Yield attributes of chia

| Treatment       | Spikes plant <sup>-1</sup> | Spike length (cm) | Spike weight (g) | Test weight (g) |
|-----------------|----------------------------|-------------------|------------------|-----------------|
| T <sub>1</sub>  | 18.16                      | 13.23             | 1.82             | 1.37            |
| T <sub>2</sub>  | 17.57                      | 14.86             | 1.77             | 1.21            |
| T <sub>3</sub>  | 19.20                      | 13.80             | 1.50             | 1.24            |
| T <sub>4</sub>  | 22.50                      | 15.23             | 2.35             | 1.41            |
| T <sub>5</sub>  | 23.73                      | 16.76             | 2.50             | 1.44            |
| T <sub>6</sub>  | 23.27                      | 15.50             | 2.45             | 1.45            |
| T <sub>7</sub>  | 27.50                      | 17.23             | 3.02             | 1.36            |
| T <sub>8</sub>  | 29.20                      | 18.76             | 3.25             | 1.29            |
| T <sub>9</sub>  | 28.57                      | 17.50             | 3.10             | 1.50            |
| T <sub>10</sub> | 16.54                      | 12.20             | 1.60             | 1.32            |

CD (5%): spikes 0.92; spike length 3.69; spike weight 0.08; test weight NS.

### 3.3 Seed, straw and biological yield

Seed yield, straw yield and biological yield differed significantly among treatments (Fig. 5 and 6, Table 6). The highest seed yield (11.70 q ha<sup>-1</sup>) was obtained under T<sub>8</sub>, followed by T<sub>9</sub> (10.00 q ha<sup>-1</sup>) and T<sub>7</sub> (9.56 q ha<sup>-1</sup>); the lowest (7.90 q ha<sup>-1</sup>) was under the

control. T<sub>8</sub> also recorded the maximum biological yield (38.20 t ha<sup>-1</sup>) and harvest index (30.63%). The higher yields under wider spacing with Jeeva Amrut resulted from improved growth, dry matter accumulation and superior yield attributes.

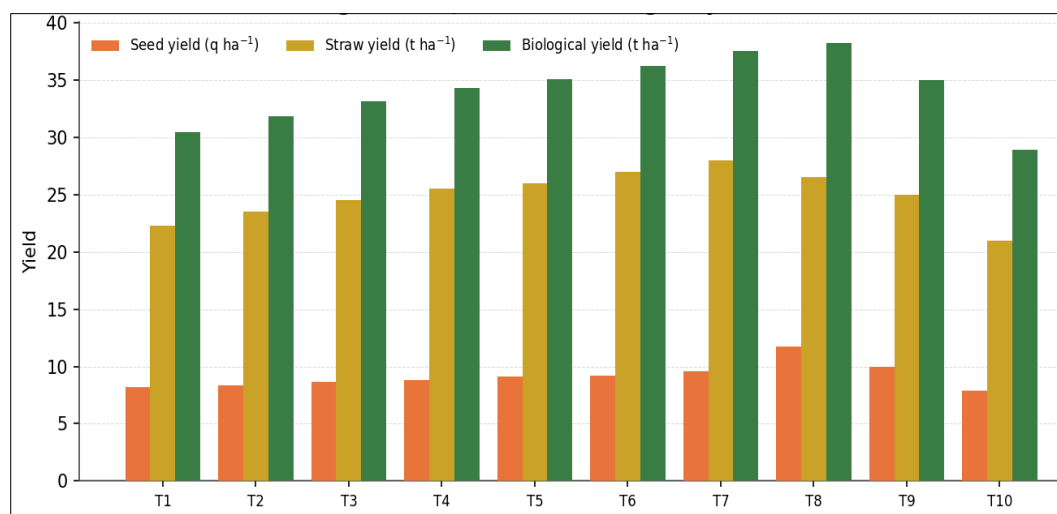


Fig 5: Seed, straw and biological yield of chia.

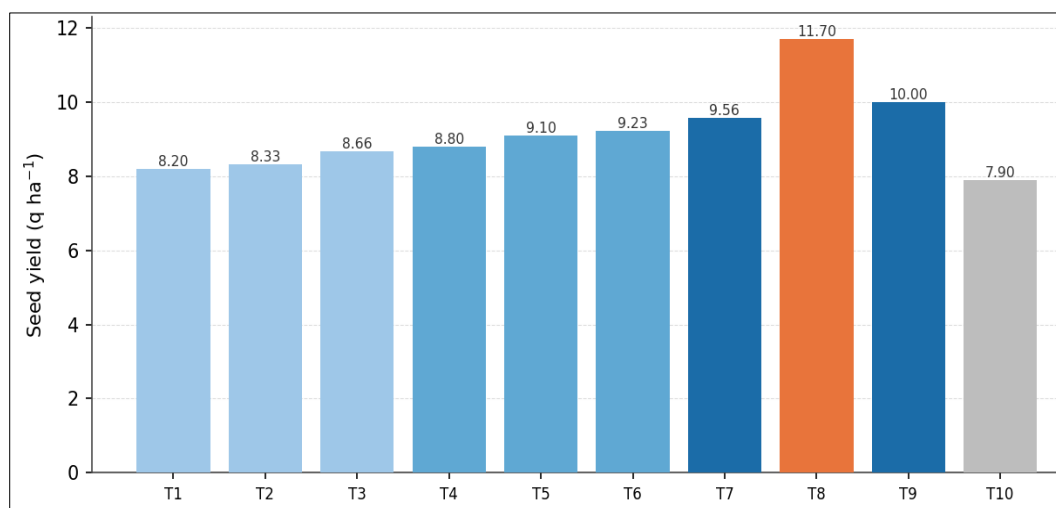


**Fig 6:** Seed yield as influenced by treatments.

**Table 6:** Seed, straw, biological yield and harvest index

| Treatment       | Seed yield (q ha <sup>-1</sup> ) | Straw yield (t ha <sup>-1</sup> ) | Biological yield (t ha <sup>-1</sup> ) | Harvest index (%) |
|-----------------|----------------------------------|-----------------------------------|----------------------------------------|-------------------|
| T <sub>1</sub>  | 8.20                             | 22.25                             | 30.45                                  | 26.93             |
| T <sub>2</sub>  | 8.33                             | 23.50                             | 31.83                                  | 26.17             |
| T <sub>3</sub>  | 8.66                             | 24.50                             | 33.16                                  | 26.12             |
| T <sub>4</sub>  | 8.80                             | 25.50                             | 34.30                                  | 25.66             |
| T <sub>5</sub>  | 9.10                             | 26.00                             | 35.10                                  | 25.93             |
| T <sub>6</sub>  | 9.23                             | 27.00                             | 36.23                                  | 25.48             |
| T <sub>7</sub>  | 9.56                             | 28.00                             | 37.56                                  | 25.45             |
| T <sub>8</sub>  | 11.70                            | 26.50                             | 38.20                                  | 30.63             |
| T <sub>9</sub>  | 10.00                            | 25.00                             | 35.00                                  | 28.57             |
| T <sub>10</sub> | 7.90                             | 21.00                             | 28.90                                  | 27.34             |

CD (5%): seed yield 1.89; straw yield 6.81; biological yield 7.28; harvest index NS.

### 3.4 Economics

Economic analysis (Fig. 7 and 8, Table 7) showed marked variation among treatments. T<sub>8</sub> (60×20 cm + Jeeva Amrut 5%) recorded the maximum gross return (₹1,79,630 ha<sup>-1</sup>), net return (₹1,27,129 ha<sup>-1</sup>) and the highest benefit–cost ratio (3.02), owing

to its superior seed yield. This was followed by T<sub>9</sub> (B:C 2.83) and T<sub>7</sub> (B:C 2.38). The control recorded the lowest B:C ratio (1.14). Thus, wider spacing combined with Jeeva Amrut not only improved productivity but also maximised profitability.

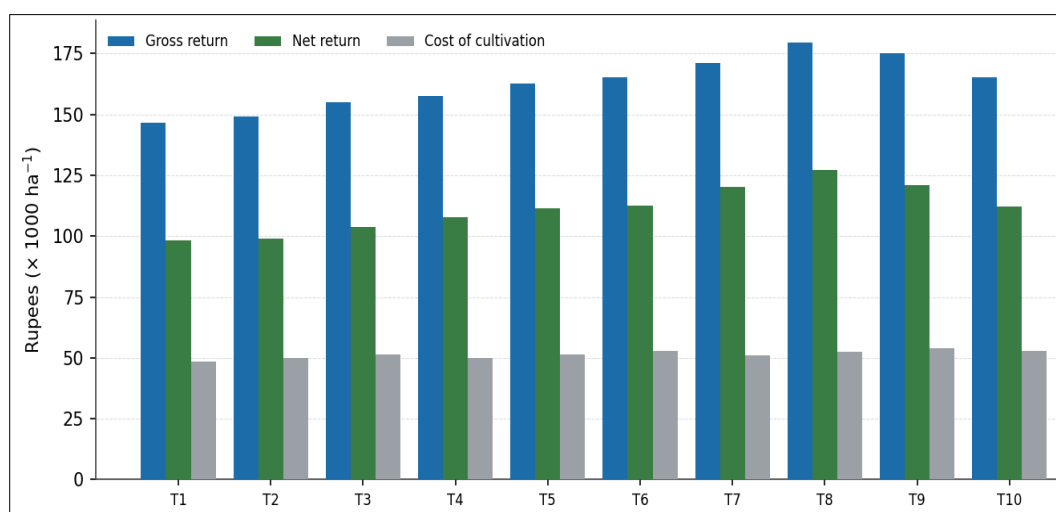


**Fig 7:** Gross return, net return and cost of cultivation (₹ × 1000 ha<sup>-1</sup>)

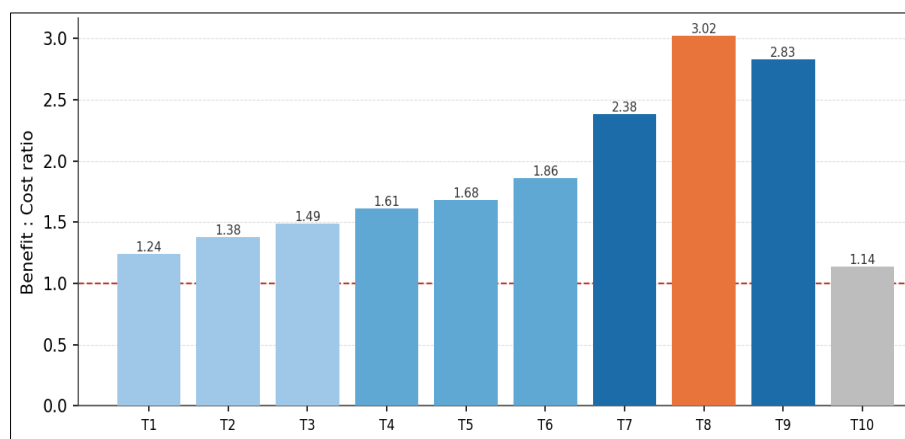


**Fig 8:** Benefit–cost ratio of different treatments.

**Table 7:** Economics of chia cultivation

| Treatment       | Cost of cult.<br>(₹ ha <sup>-1</sup> ) | Gross return<br>(₹ ha <sup>-1</sup> ) | Net return<br>(₹ ha <sup>-1</sup> ) | B:C<br>ratio |
|-----------------|----------------------------------------|---------------------------------------|-------------------------------------|--------------|
| T <sub>1</sub>  | 48,501                                 | 1,46,780                              | 98,279                              | 1.24         |
| T <sub>2</sub>  | 50,000                                 | 1,49,107                              | 99,107                              | 1.38         |
| T <sub>3</sub>  | 51,501                                 | 1,55,193                              | 1,03,692                            | 1.49         |
| T <sub>4</sub>  | 49,800                                 | 1,57,520                              | 1,07,720                            | 1.61         |
| T <sub>5</sub>  | 51,300                                 | 1,62,890                              | 1,11,590                            | 1.68         |
| T <sub>6</sub>  | 52,800                                 | 1,65,217                              | 1,12,417                            | 1.86         |
| T <sub>7</sub>  | 51,001                                 | 1,71,303                              | 1,20,302                            | 2.38         |
| T <sub>8</sub>  | 52,501                                 | 1,79,630                              | 1,27,129                            | 3.02         |
| T <sub>9</sub>  | 54,000                                 | 1,75,000                              | 1,20,999                            | 2.83         |
| T <sub>10</sub> | 53,001                                 | 1,65,217                              | 1,12,216                            | 1.14         |

#### 4. Conclusion

Among all the treatment combinations, T<sub>8</sub> — 60×20 cm spacing with foliar application of Jeeva Amrut 5% — proved the most effective and profitable for chia cultivation. It recorded the maximum plant height (79.83 cm), branches per plant (19.75), dry matter (90.50 g plant<sup>-1</sup>), spikes per plant (29.20), seed yield (11.70 q ha<sup>-1</sup>), net return (₹1,27,129 ha<sup>-1</sup>) and benefit–cost ratio (3.02). Wider spacing improved resource use efficiency and photosynthetic activity, while Jeeva Amrut enhanced microbial activity and nutrient availability. Therefore, under the agro-climatic conditions of Prayagraj, farmers may be advised to adopt 60×20 cm spacing with foliar spray of Jeeva Amrut 5% for achieving higher seed yield, greater profitability and sustainable chia production.

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