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## Effect of fertilizer level and growth regulator on the growth and yield of safflower (*Carthamus tinctorius* L.) in Prayagraj District.

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### Abstract

The study was carried out in irrigated conditions during the Rabi season of 2025-2026 to determine the effect of fertilizer levels and growth regulators on growth and yield of Safflower (*Carthamus tinctorius*) in the Prayagraj district. The experiment was set up as a randomized block design in 10 Treatment and 3 replications at the Faculty of Agriculture in Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj. The treatment combination are as follows (T<sub>1</sub>) RDF @ 50% + GA<sub>3</sub> 100 PPM, (T<sub>2</sub>) RDF @ 50% + Seaweed Sap 200 PPM, (T<sub>3</sub>) RDF @ 50% + Humic Acid 150 PPM, (T<sub>4</sub>) RDF @ 75% + GA<sub>3</sub> 100 PPM, (T<sub>5</sub>) RDF @ 75% + Seaweed Sap 200 PPM, (T<sub>6</sub>) RDF @ 75% + Humic Acid 150 PPM, (T<sub>7</sub>) RDF @ 100% + GA<sub>3</sub> 100 PPM, (T<sub>8</sub>) RDF @ 100% + Seaweed Sap 200PPM, (T<sub>9</sub>) RDF @ 100% + Humic Acid 150PPM, (T<sub>10</sub>)Control (Farmer Practices), the foliar application of PGR(GA<sub>3</sub>, Humic acid, seaweed sap) is done at 30 DAS and 60 DAS. The result showed the significant change in the growth parameter like Plant height(92.84 cm at 100DAS), no. of branches(28.11 at 100 DAS), plant dry weight(34.80 g at 100 DAS)) and also in the Yield attribute like capitula plant<sup>-1</sup>(16.99), seeds capitula<sup>-1</sup>(21.33), test weight(59.11 g), seed yield ha<sup>-1</sup>(14.58 q/ha), stover yield ha<sup>-1</sup>(47.65 q/ha) in all the parameter under all treatment combination T<sub>9</sub>(100%RDF +Humic acid 150 ppm) shows the superiority followed by T<sub>8</sub>(100%RDF + 200ppm Seaweed sap) and lowest data shows the T<sub>10</sub> control.

**Keywords:** *Carthamus tinctorius* L, RDF, Humic Acid, GA<sub>3</sub>, Seaweed Sap, Fertilizer Level

### Introduction

Safflower (*Carthamus tinctorius* L.) belongs to the family Asteraceae family. The cultivated species, *Carthamus tinctorius* L, has a chromosomal number of 2n = 24. Safflower is native to semi-arid Mediterranean. It is an annual herb with prickly leaves and bracts that mimic thistles. Additionally, it contains a number of branches, each of which terminates in a spherical flower head that may be yellow, orange, or red. Safflower is a crop that may be grown in a variety of climates and soil types. Based on available data, safflower is cultivated at elevations below 900 meters above sea level. Temperature significantly affects the rate of germination, which occurs three to eight days after sowing. Charles Mazereku.*et al.* (2014) [2] Its flowers and seeds are processed to vegetable oil, food coloring, flavoring agent, and textile dye. When compared to soybean, sunflower, cottonseed, corn, rapeseed, and palm oil, safflower seeds are the most commonly used (Weiss, 2002; Ogut *et al*, 2012) [3]. It's oil is rich in saturated and unsaturated fatty acids, including oleic and linoleic acids, as well as a class of flavonoids and phenolic compounds known as antioxidants (Al-Doori, 2025) [4]. Safflower with a high seed oil content (35-40%) of excellent quality has been widely used in the food sector as well as industrial use in biofuel pro-duction and the manufacture of paints (Rahman Kılıç *et al*, 2024) and varnishes the residue left over after oil extraction includes up to 25% crude protein, it can also be used as animal feed. Nutrient deficiencies, unavailability, or toxicity have been shown to cause unusual plant growth and dramatically reduce crop plant yields globally, the interactions between nutrients in plants have a major impact on the yield of annual crops. The antagonistic or synergistic effects of these interactions may affect the efficiency of nutrient use. (Kursat Korkmaz.*et al*, 2024) [7]. One of the key tactics for enhancing plant growth and raising crop plant production and quality in agricultural Settings seems to be appropriate and balanced fertilization.

The introduction of plant growth regulators (PGR) has added a new dimension to the possibility of improving the growth and yield of crop. Foliar applications of plant growth regulators, both natural and synthetic, have known to positively influence and improve crop growth and achieving higher yield. Humic acid's availability of nutrients encourages plant growth and productivity regardless of any chemical or physical constraints in the soil. Unlike ground fertilization, which takes longer for seeds to fill, humic acid foliar spray accelerates the buildup of dry matter in plants. (Malan, 2015; Keshavarz *et al*, 2016) <sup>[5, 6]</sup> Research on many plants has demonstrated that Humic Acid improves their growth both directly and indirectly, with different plant kinds experiencing varied benefits (Hemati *et al*. 2022) <sup>[9]</sup>. By enhancing soil characteristics such soil compaction, water-holding capacity, soil microbial activity, and micro/macro element availability, Humic Acid indirectly promotes plant growth. Additionally, it directly enhances plant growth by boosting plant biomass in terms of Humic Acid material absorption and transportation to plant tissues (Amoozad & Zahedi, 2024) <sup>[8]</sup>.

In field crops, GA<sub>3</sub> is also said to enhance the efficient portioning and translocation of photosynthates from source to sink (Senthil *et al*, 2003) (Haifaa *et al*, 2022) <sup>[10, 11]</sup> conducted a study on the production of rice seeds and found that applying GA<sub>3</sub> increased plant height, encouraged panicle and spikelet exertion, improved stigma exertion and longevity, and increased seed set rate and grain yield in rice—a crucial aspect of rice cultivation. They stated that a higher concentration of gibberellins promotes plant growth by promoting cell elongation and a rise in intermodal length in the stem, leaves, and other aerial parts. It revealed that gibberellic acid is a phytohormone that is required in small amounts at low concentrations to improve plant growth and development in order to boost dry weight and yield in safflower (Mahmood and Muhammad. 2022) <sup>[12]</sup>. Gibberellic acid is one of the growth regulators that helps plants by increasing dry weight, plant production, and vegetative development. (Burhan Arslan and Emrullah Culpan, 2017) <sup>[13]</sup>

seaweed contains a variety of substances that stimulate plant growth, including macronutrient and microelement nutrients, growth hormones, amino acids, vitamins, betaines, cytokinins, and sterols, it can be added as a bio-stimulant to improve plant growth and as an amendment to increase crop yield. (Vafa & Sohrabi *et al*, 2021) <sup>[14]</sup>. Seaweed extracts increase plant growth and nutrient uptake by altering physiological and biochemical processes. They raise agricultural output, promote early seed germination, boost root growth, boost leaf chlorophyll, and strengthen tolerance to biotic and abiotic stress. Furthermore,

seaweed extracts enhance the soil's biological, chemical, and physical characteristics. This experiment aimed to study the impacts of fertilizer and of biostimulants, (seaweed sap, GA<sub>3</sub>, humic acid) on the vegetative growth and seed yield of safflower.

## Material and Methods:

### Experimental Site

The experiment was conducted at research farm of Department of Agronomy at Prof. Rajendra Singh (Rajju Bhaiyya) University Naini, Prayagraj. The experiment site falls in a subtropical climate situated at 25°13'28" N latitude and 81°46'25" E longitude and 98 m above mean sea level.

### Climatic condition

Agro-climatically, Prayagraj District represents the subtropical belt of the South East of Uttar Pradesh, and is endowed with extremely hot summer and fairly cold winter. The maximum temperature of the location ranges between 46°C - 48°C and seldom falls below 40°C-50°C. The relative humidity ranges between 20-94%. The average rainfall of this area is around 1100 mm annually.

### Treatment Combination

The experiment is to be done in a randomized block design (RBD) which composed of 10 treatments in 3 replications. The data for growth and yield attributes of Indian Safflower was recorded using five random chosen plants from each treatment after seed sowing. Treatments comprised of T<sub>1</sub>-RDF @ 50% + GA<sub>3</sub> 100 ppm, T<sub>2</sub>- RDF @ 50% + Seaweed Sap 200 ppm, T<sub>3</sub>- RDF @ 50% + Humic Acid 150 ppm, T<sub>4</sub>-RDF @ 75% + GA<sub>3</sub> 100 ppm, T<sub>5</sub>-RDF @ 75% + Seaweed Sap 200 ppm, T<sub>6</sub>- RDF @ 75% + Humic Acid 150 ppm, T<sub>7</sub>-RDF @ 100% + GA<sub>3</sub> 100 ppm, T<sub>8</sub>- RDF @ 100% + Seaweed Sap 200 ppm, T<sub>9</sub>-RDF @ 100% + Humic Acid 150 ppm, T<sub>10</sub>-Control (Farmer Practices). Two foliar sprays of humic acid, GA<sub>3</sub> and seaweed sap were given at 30 DAS and 60 DAS.

## Result and Discussion:

### Growth parameter:

#### Plant height:

Results demonstrated that, across a range of treatment combinations, the application of T<sub>9</sub> 100% RDF +humic acid 150m ppm showed significantly heighest in plant height, followed by T<sub>8</sub> 100%RDF + Seaweed sap 200 ppm when compared to T<sub>10</sub>(control).

Thakur *et al*, (2013) reported that Combined application of RDF + humic acid granules @ 12.5 kg ha<sup>-1</sup>(as basal) significantly influenced the growth parameters.

**Table 1:** Effect of different levels of RDF and plant growth regulators on plant height (cm) at different growth stages

|                 | Treatments                        |       |        |        |        |         |            |
|-----------------|-----------------------------------|-------|--------|--------|--------|---------|------------|
|                 |                                   |       | 40 DAS | 60 DAS | 80 DAS | 100 DAS | At harvest |
| T <sub>1</sub>  | RDF @ 50% + GA3 (100 PPM)         |       | 19.12  | 48.25  | 64.30  | 80.85   | 79.57      |
| T <sub>2</sub>  | RDF @ 50% + Seaweed Sap (200 PPM) |       | 19.70  | 49.57  | 66.66  | 83.22   | 81.93      |
| T <sub>3</sub>  | RDF @ 50% + Humic Acid (150 PPM)  |       | 20.41  | 50.99  | 67.85  | 84.40   | 83.12      |
| T <sub>4</sub>  | RDF @ 75% + GA3 (100 PPM)         |       | 21.08  | 52.44  | 69.69  | 86.25   | 84.96      |
| T <sub>5</sub>  | RDF @ 75% + Seaweed Sap (200 PPM) |       | 21.85  | 54.09  | 71.07  | 87.63   | 86.34      |
| T <sub>6</sub>  | RDF @ 75% + Humic Acid (150 PPM)  |       | 22.77  | 56.04  | 72.33  | 88.88   | 87.60      |
| T <sub>7</sub>  | RDF @ 100% + GA3 (100 PPM)        |       | 23.80  | 57.30  | 73.43  | 89.98   | 88.70      |
| T <sub>8</sub>  | RDF @ 100% + Seaweed Sap (200PPM) | 12.22 | 24.78  | 58.21  | 74.90  | 91.45   | 90.17      |
| T <sub>9</sub>  | RDF @ 100% + Humic Acid (150PPM)  | 12.59 | 26.16  | 58.91  | 76.28  | 92.84   | 91.55      |
| T <sub>10</sub> | Control (Farmer Practices)        | 10.43 | 18.52  | 43.79  | 60.68  | 77.24   | 75.95      |
|                 | S.Em. (±)                         | 0.544 | 1.12   | 1.63   | 2.06   | 2.18    | 2.06       |
|                 | C.D. at 0.5%                      | -     | 3.34   | 4.87   | 6.15   | 6.39    | 6.16       |

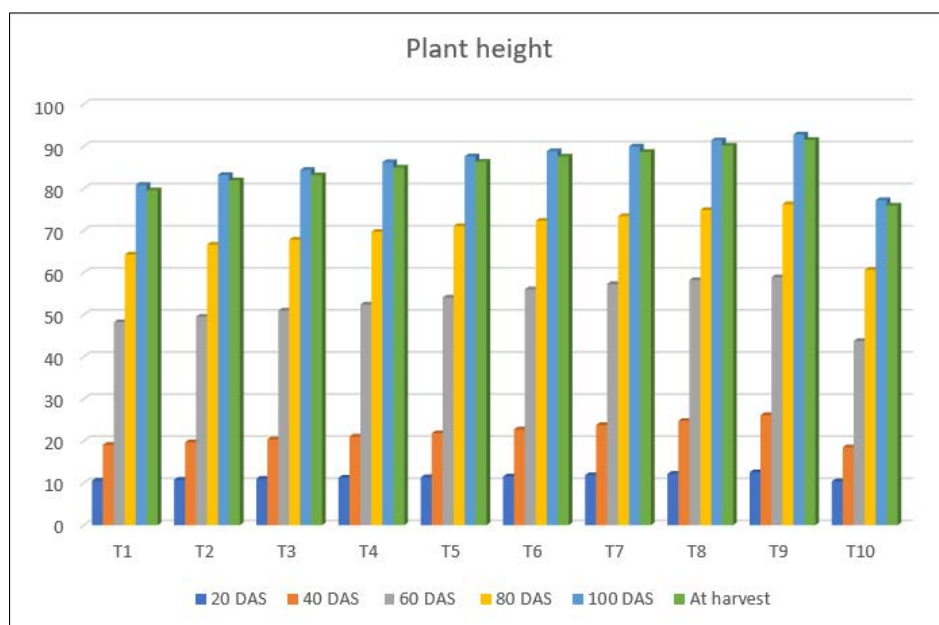


**Fig 1:** Effect of different RDF levels and plant growth regulators on plant height at different growth stages

### No. of Branches:

Leaves, flowers, and capitula form on branches. As a result, they are closely connected to plant yield and photosynthetic activity. The data showed that at 40 DAS branches non-significant under different treatment combination and 60 DAS, 80 DAS, 100 DAS and at harvest the data shows significant variation in the no. of

branches, T<sub>9</sub> (100%RDF+ humic acid 150 ppm) shows the highest no. of branches under all the treatment combination in compare to T<sub>10</sub>. Hivare *et al*, 2019<sup>[17]</sup> also represent that the treatment combination of humic acid + NAA shows the highest no. of branches.

**Table 2:** Effect of different levels of RDF and plant growth regulators on number of branches per plant at different growth stages

| Treatments      |                                   | No. of branches |        |        |         |            |
|-----------------|-----------------------------------|-----------------|--------|--------|---------|------------|
|                 |                                   | 40 DAS          | 60 DAS | 80 DAS | 100 DAS | At harvest |
| T <sub>1</sub>  | RDF @ 50% + GA3 (100 PPM)         | 5.63            | 11.60  | 16.37  | 18.69   | 16.88      |
| T <sub>2</sub>  | RDF @ 50% + Seaweed Sap (200 PPM) | 5.77            | 12.18  | 16.78  | 20.28   | 18.47      |
| T <sub>3</sub>  | RDF @ 50% + Humic Acid (150 PPM)  | 5.94            | 12.89  | 17.22  | 22.18   | 20.37      |
| T <sub>4</sub>  | RDF @ 75% + GA3 (100 PPM)         | 6.10            | 13.56  | 17.62  | 23.57   | 21.76      |
| T <sub>5</sub>  | RDF @ 75% + Seaweed Sap (200 PPM) | 6.22            | 14.33  | 18.00  | 24.49   | 22.68      |
| T <sub>6</sub>  | RDF @ 75% + Humic Acid (150 PPM)  | 6.29            | 15.25  | 18.46  | 25.35   | 23.54      |
| T <sub>7</sub>  | RDF @ 100% + GA3 (100 PPM)        | 6.38            | 16.28  | 19.15  | 26.06   | 24.25      |
| T <sub>8</sub>  | RDF @ 100% + Seaweed Sap (200PPM) | 6.42            | 17.26  | 19.69  | 27.23   | 25.42      |
| T <sub>9</sub>  | RDF @ 100% + Humic Acid (150PPM)  | 6.52            | 18.64  | 20.25  | 28.11   | 26.30      |
| T <sub>10</sub> | Control (Farmer Practices)        | 5.45            | 9.04   | 13.28  | 14.48   | 12.67      |
| S.Em. (±)       |                                   | 0.188           | 1.19   | 2.70   | 2.64    | 2.26       |
| C.D. at 5%      |                                   | -               | 3.55   | 8.18   | 7.85    | 6.68       |

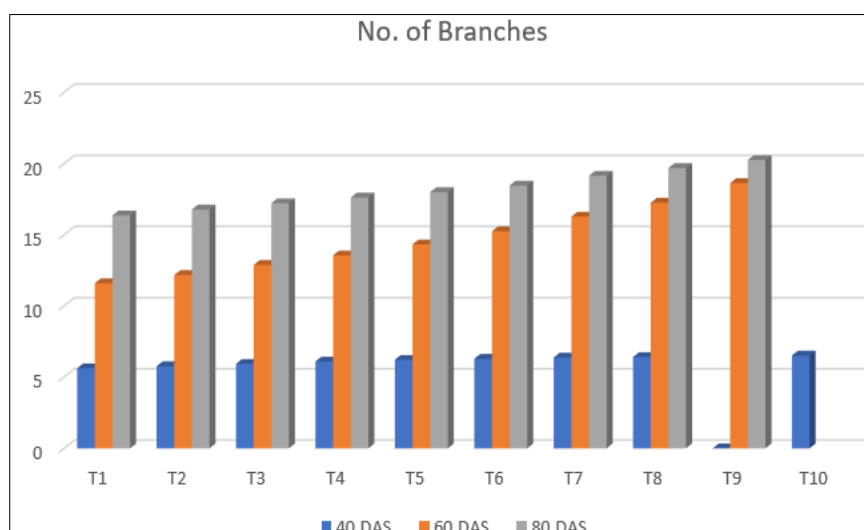


**Fig 2:** Effect of different levels of RDF and plant growth regulators on number of branches at different growth stages

**Plant dry weight:**

The application of growth regulators greatly increased the accumulation of total dry matter, which may have been caused by increased cell division and other physiological processes. As leaf area increased, more photosynthates were produced, which raised the plant's total dry matter. Data represent that at 20 DAS all the treatment shows non-significant but at 40DAS, 60 DAS, 80 DAS, and at harvest data reflect the significant variation in plant dry

accumulation and among all the treatment combination T<sub>9</sub> (100% RDF + Humic acid 150 ppm) perform best and shows highest dry matter accumulation, lowest data represent by T<sub>10</sub> (farmer practices).

Nahid Amoozad and Morteza Zahedi.2024 shows in his research that the application of humic acid increase root weight and shoot weight.

**Table 3:** Effect of different levels of RDF and plant growth regulators on plant dry weight (g) at different growth stages

| Treatments      |                                   | Plant dry weight (g) |        |        |        |         |            |
|-----------------|-----------------------------------|----------------------|--------|--------|--------|---------|------------|
|                 |                                   | 20 DAS               | 40 DAS | 60 DAS | 80 DAS | 100 DAS | At harvest |
| T <sub>1</sub>  | RDF @ 50% + GA3 (100 PPM)         | 0.46                 | 2.49   | 11.06  | 28.01  | 31.07   | 32.22      |
| T <sub>2</sub>  | RDF @ 50% + Seaweed Sap (200 PPM) | 0.48                 | 2.53   | 11.17  | 28.34  | 31.40   | 33.81      |
| T <sub>3</sub>  | RDF @ 50% + Humic Acid (150 PPM)  | 0.52                 | 2.55   | 11.33  | 28.61  | 31.67   | 35.71      |
| T <sub>4</sub>  | RDF @ 75% + GA3 (100 PPM)         | 0.55                 | 2.58   | 11.59  | 28.91  | 31.97   | 37.10      |
| T <sub>5</sub>  | RDF @ 75% + Seaweed Sap(200 PPM)  | 0.58                 | 2.64   | 11.92  | 29.37  | 32.43   | 38.02      |
| T <sub>6</sub>  | RDF @ 75% + Humic Acid (150 PPM)  | 0.60                 | 2.71   | 12.21  | 30.04  | 33.10   | 38.88      |
| T <sub>7</sub>  | RDF @ 100% + GA3 (100 PPM)        | 0.62                 | 2.78   | 12.39  | 30.84  | 33.90   | 39.59      |
| T <sub>8</sub>  | RDF @ 100% + Seaweed Sap (200PPM) | 0.65                 | 2.84   | 12.53  | 31.47  | 34.53   | 40.76      |
| T <sub>9</sub>  | RDF @ 100% + Humic Acid (150PPM)  | 0.67                 | 2.89   | 12.93  | 31.74  | 34.80   | 41.64      |
| T <sub>10</sub> | Control (Farmer Practices)        | 0.41                 | 2.46   | 10.95  | 27.76  | 30.82   | 31.17      |
| S.Em. (±)       |                                   | 0.055                | 0.07   | 0.256  | 0.39   | 1.393   | 2.25       |
| C.D. at 0.5%    |                                   | -                    | 0.21   | 0.760  | 1.16   | 3.96    | 6.77       |

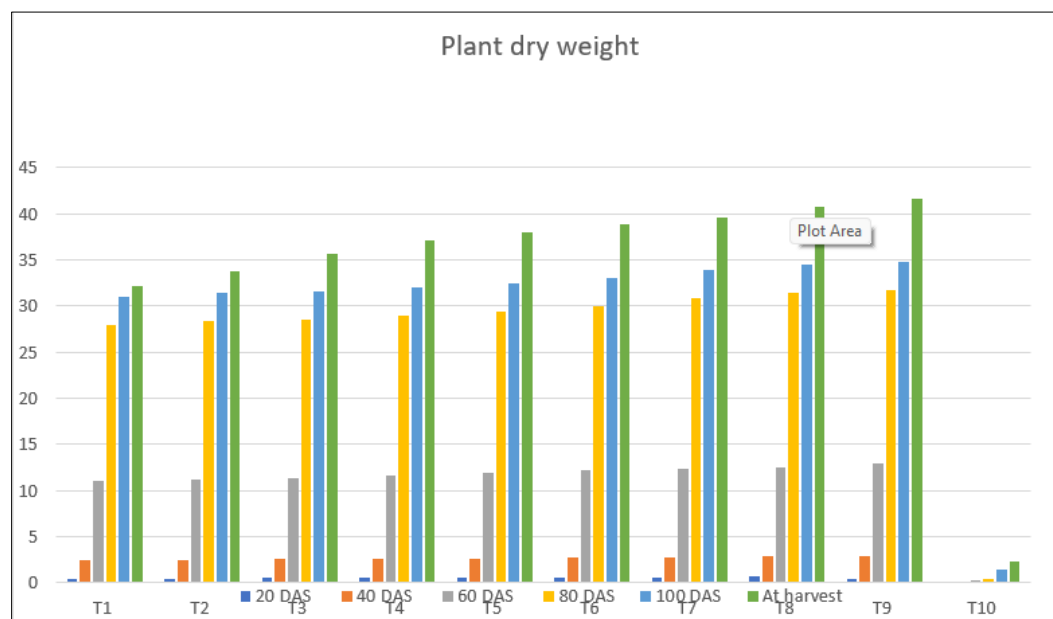


**Fig 3:** Effect of different levels of RDF and plant growth regulators on plant dry weight at different growth stages

**Yield attribute:**

No. of capitula per plant:

Significantly highest number of capitula /plant was obtained in treatment T<sub>9</sub> (100%RDF+ 150 ppm humic acid) followed by treatments T<sub>8</sub> (100%RDF+seaweed sap 200 ppm) when compared with T<sub>10</sub> control.

Deotale *et al.*2020 shows in his research that the application of humic acid and NAA increase the no. of capitula per plant.

Seeds per capitula:

The highest no. of seeds per capitula was obtained in the treatment T<sub>9</sub> (100%RDF + 150 ppm humic acid) followed by treatment T<sub>8</sub> (100%RDF+ seaweed sap 200ppm) when compared with T<sub>10</sub> control.

Metre.2013 <sup>[19]</sup> also shows that the application of humic acid at 100ppm 200ppm results the increase in the no. of seeds per pod.

**Test weight:**

1000 seed weight was significantly maximum in treatment T<sub>9</sub> (100%RDF +150 ppm humic acid) followed by treatments T<sub>8</sub> (100%RDF + 200 seaweed sap), when compared with T<sub>10</sub> (control).deotel *et al.*2020 also shows that application of humic acid and NAA increase Test weight.

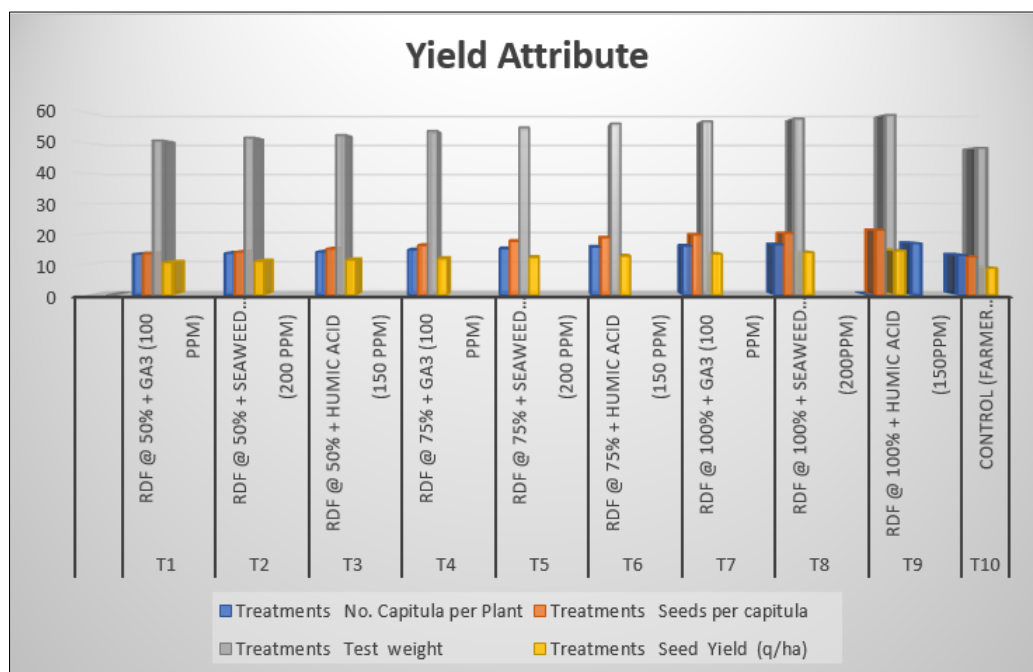
**Seed yield and strover yield:**

The data shows the response of different levels of fertilizer and growth regulators on yield of Safflower. The maximum Seed Yield 14.58q/ha, Stover yield 47.65 q/ha of Safflower was recorded in T<sub>9</sub> [RDF @ 100% + Humic Acid (150PPM)] and the minimum Seed Yield 8.91 q/ha, Stover yield 34.02 q/ha found in T<sub>10</sub> (control).

Malac C.2015. Also present that the application of humic acid and fulvic acid significantly increase the seed yield and strover yield.

**Table 4:** Effect of different levels of RDF and plant growth regulators on yield attributes, seed yield, and stover yield

| Treatment       |                                   | No. Capitula per Plant | Seeds per capitula | Test weight (g) | Seed Yield (q/ha) | Stover yield (q/ha) |
|-----------------|-----------------------------------|------------------------|--------------------|-----------------|-------------------|---------------------|
| T <sub>1</sub>  | RDF @ 50% + GA3 (100 PPM)         | 13.47                  | 13.60              | 50.73           | 10.70             | 38.23               |
| T <sub>2</sub>  | RDF @ 50% + Seaweed Sap (200 PPM) | 13.78                  | 14.16              | 51.68           | 11.11             | 39.82               |
| T <sub>3</sub>  | RDF @ 50% + Humic Acid (150 PPM)  | 14.18                  | 15.18              | 52.54           | 11.55             | 41.73               |
| T <sub>4</sub>  | RDF @ 75% + GA3 (100 PPM)         | 14.83                  | 16.34              | 53.89           | 11.95             | 43.11               |
| T <sub>5</sub>  | RDF @ 75% + Seaweed Sap (200 PPM) | 15.21                  | 17.72              | 55.02           | 12.33             | 44.04               |
| T <sub>6</sub>  | RDF @ 75% + Humic Acid (150 PPM)  | 15.78                  | 18.87              | 56.28           | 12.79             | 44.89               |
| T <sub>7</sub>  | RDF @ 100% + GA3 (100 PPM)        | 16.10                  | 19.79              | 57.02           | 13.48             | 45.60               |
| T <sub>8</sub>  | RDF @ 100% + Seaweed Sap (200PPM) | 16.52                  | 20.30              | 57.92           | 14.02             | 46.78               |
| T <sub>9</sub>  | RDF @ 100% + Humic Acid (150PPM)  | 16.99                  | 21.33              | 59.11           | 14.58             | 47.65               |
| T <sub>10</sub> | Control (Farmer Practices)        | 13.09                  | 12.58              | 48.32           | 8.91              | 34.02               |
| S.Em. (±)       |                                   | 0.36                   | 1.11               | 1.87            | 1.78              | 1.64                |
| C.D. at 0.5%    |                                   | 1.07                   | 3.29               | 5.55            | 5.23              | 4.89                |

**Fig 4:** Effect of different levels of RDF and plant growth regulators on yield attributes and seed yield

## Conclusion

The present study on safflower (*Carthamus tinctorius* L.) clearly showed that fertilizer dose and growth regulators together had a strong influence on plant growth and yield under Prayagraj conditions. T<sub>9</sub> (RDF @ 100% + Humic Acid 150 ppm) produced the best overall results out of the ten treatments. Compared to all other treatments, the plants in this treatment grew taller, developed more branches, and gained more dry weight. This demonstrates how humic acid improves root and shoot development and helps the crop absorb nutrients more effectively when applied in conjunction with the full recommended dosage of fertilizer. T<sub>8</sub> (RDF @ 100% + Seaweed Sap 200 ppm) performed the best, indicating that seaweed sap functions well with full RDF as well, but marginally less so than humic acid. The yield parameters also showed the similar pattern. In the end, T<sub>9</sub> had the largest seed yield and stover yield (q/ha), as well as the greatest number of capitula per plant, more seeds per capitula, and superior test weight. Once more, T<sub>8</sub> was the second-best treatment for all of these yield characteristics. However, for every growth and yield metric measured in the study, T<sub>10</sub>, the control plot based on standard farmer practice, produced the lowest values. This suggests that farmers who solely use traditional methods without managing growth regulators and nutrients properly are probably missing out on a significant portion of the possible output. Overall, it can be said that the best combination for improving

safflower growth and yield in this area is to apply RDF @ 100% and Humic Acid @ 150 ppm (T<sub>9</sub>). RDF @ 100% with Seaweed Sap @ 200 ppm (T<sub>8</sub>) is a good substitute in situations when humic acid is not readily available. To increase the profits from safflower farming, farmers are encouraged to switch from traditional methods to an enhanced nutrient management strategy.

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