MULTI-VARIETAL TRIAL ON SESAMUM

(*Sesamum indicum L.*)
under Organic Management in the Gangetic Plains of West Bengal

SwitchON Foundation

Founded in 2008, the Environment Conservation Society (ECS), also known as SwitchON Foundation, is a nonprofit organization dedicated to fostering equitable and sustainable development in India. Our vision is to build a sustainable and equitable India, focusing on Clean Energy, Clean Air, Sustainable Mobility, Climate Smart Agriculture, Conservation and Integrated Management of Natural Resources, Just Transition, Skilling, and Sustainable Cities. Our mission is to promote sustainable livelihoods and address environmental challenges through innovative business models and technologies, aiming to create opportunities for 10 million people at the bottom of the pyramid by 2030.

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Executive Summary

Introduction

India, poised to become the world's most populous country, faces significant food security challenges despite its vast agricultural resources. With a 16.3% prevalence of undernutrition and a heavy reliance on edible oil imports, the country's agricultural sector, which supports 70% of the population, is under pressure. The per capita consumption of oilseeds is projected to reach 102.3 million tonnes by 2030, yet India imports 60-65% of its edible oil. Efforts to boost local production, like the Yellow Revolution and the National Mission on Edible Oil–Oil Palm, are crucial. This study focuses on multi-varietal trials of organic sesame in West Bengal to enhance yields and sustainability.

Aims & Objectives

This study aims to identify and select high-yielding sesame lines to boost commercial cultivation interest among farmers in the New Alluvial Zone of West Bengal. It focuses on finding sesame varieties with high market potential suited for the Indo-Gangetic plains, evaluating the impact of organic farming practices on the growth and yield of white and black-seeded cultivars, and analyzing the economic viability of different varieties under organic management. The goal is to enhance profitability and support sustainable farming practices.

Materials & Methods:

- **Location:** Gopalpur, Nadia district, West Bengal.
- **Soil Characteristics:** Sandy loam to clayey, well-drained, fertile; pH near neutral; EC < 2 dS/m.
- **Management:** Conducted by landholder Madan Mondal.
- **Varieties Tested:** GT-2, GT-3, GT-4, GT-6, GT-10, JLT-5, Savitri, Smarak, Suprava.
- **Soil Analysis:** Regular monitoring for pH, moisture, nutrients (N, P, K), and EC.
- **Field Preparation:** Harrowing, ploughing, and ridging with disc equipment; farmyard manure applied (10 tonnes/ha) one month before planting.
- **Sowing Method:** Line sowing on ridges; spacing of 30 cm x 15 cm.
- **Study Focus:** Evaluate growth, yield, and quality of sesame under organic management; identify high-yielding varieties suited to the region.

Results

- **Capsules per Plant:**
  - **Highest**: Suprava (T-8 treatment) with 140.67 capsules per plant.
  - **Lowest**: GT-6 (T-6 treatment) with 48.67 capsules per plant.
  - **Reference**: Bhattacharjee et al. (2021) and Ali et al. (2022).

- **Seeds per Capsule:**
  - **Highest:** Smarak (T-7 treatment) with 110.67 seeds per capsule.
  - **Lowest:** GT-10 (T-3 treatment) with 68.67 seeds per capsule.
  - **Reference:** Sahu et al. (2022).
- **Capsule Length:**
  - **Longest:** GT-6 (T-6 treatment) at 4.10 cm.
  - **Shortest:** GT-2 (T-1 treatment) at 2.45 cm.
  - Longer capsules generally contribute to higher yields.

- **Seed Yield:**
  - **Highest:** Smarak (T-7 treatment) with 1765 kg/ha.
  - **Intermediate:** Suprava and GT-3 with 1230 kg/ha and 1160 kg/ha, respectively.
  - **Lowest:** GT-6 (T-6 treatment) with 770 kg/ha.
  - **Reference:** Sahu et al. (2022) with a maximum yield of 1934 kg/ha.

- **Oil Content:**
  - **Highest:** GT-3 (T-2 treatment) at 52.95%.
  - **Close:** GT-4 at 52.93% and Smarak at 52.64%.
  - **Lowest:** GT-2 (T-1 treatment) at 45.6%.

- **Leaf Count:**
  - **15 Days After Sowing (DAS):** T-4 and T-9 treatments showed the highest leaf counts.
  - **30 DAS:** JLT-5 (T-9 treatment) had the most leaves; GT-3 (T-2 treatment) maintained a high count through 75 DAS.
  - **60 DAS:** Leaf numbers decreased across varieties, with GT-3 (T-2 treatment) showing the highest count.

- **Plant Height:**
  - **15 DAS:** GT-4 and T-4 treatments showed the tallest plants.
  - **30 DAS:** JLT-5 (T-9 treatment) had the tallest plants.
  - **At Harvest:** GT-10 (T-3 treatment) recorded the highest height.
- **Number of Branches:**
- **Most Branches:** Savitri (T-5 treatment).
- **None:** GT-6.
- Branching affects plant structure and yield but not always capsule production.

Conclusion:The sesame trial in West Bengal highlights 'Smarak' and 'GT-4' as top performers for yield, oil content, and growth. 'Suprava' matches their performance but has lower market value. 'GT-3' excels in oil content, while 'GT-2' underperforms. 'Savitri' shows notable yield and oil content.

Table of Contents

1. Introduction

India, with its 2021 Census recording a population of 1.408 billion, is on the brink of becoming the world's most populous country (GFSI, 2022). Despite its vast agricultural resources, India faces significant food security challenges, highlighted by a 16.3% prevalence of undernutrition (GFSI, 2022). Agriculture, supporting 70% of the population, remains the backbone of the Indian economy.

The per capita consumption of oilseeds in India is projected to reach 102.3 million tonnes by 2030 (Chauhan et al., 2021). ***Despite being a major producer and exporter of oilseeds, India imports 60-65% of its edible oil consumption***. By 2030-31, imports are expected to reach 7.2 million tonnes, valued at Rs. 70,000 crore. Efforts like the Yellow Revolution (1986-87) and the current National Mission on Edible Oil–Oil Palm (NME–P) aim to boost local production and reduce import dependency, with mustard seed cultivation being a strategic alternative (CIT).

Sesame (Sesamum indicum L.), known as the "Queen of oilseeds" for its high-quality oil, is predominantly grown in the northern plains of India. West Bengal, a significant agricultural region, cultivates various sesame varieties during the Pre-kharif, Kharif, and Zaid seasons. The selection of varieties such as Tilottama (B-67), Rama, Savitri, Tilkut, and B-55 is influenced by climate, soil type, and local preferences.

1.1 Importance of Varietal Trials in Organic Farming

Varietal trials in organic farming are crucial for identifying the best-performing varieties that ensure high yields, disease resistance, and efficient nutrient utilisation. These trials minimise reliance on external inputs, optimise production, improve resource efficiency, and contribute to a sustainable and profitable farming system

1.2 Necessity of Organic Oilseed Cultivation in India

Organic oilseed cultivation is vital for reducing India's edible oil imports and enhancing food security. Conventional farming practices have led to soil degradation and fertility decline. Organic farming, with its emphasis on natural nutrient cycling and soil enrichment, reverses these trends, ensuring sustainable agricultural productivity. Organic oilseeds, free from synthetic chemicals, offer healthier alternatives to consumers.

1.3 Significance of Organic Farming

Organic farming sustains soil, ecosystems, and human health through ecological processes and biodiversity. ***The Indian government, through the National Programme for Organic Production (NPP) since 2001, promotes organic farming to avoid synthetic fertilisers, pesticides, and GMOs***. Organic farming maintains soil quality, improves productivity, and positions India as a potential major supplier of organic products (Babu et al., 2015).

1.4 Sesame as an Oilseed

Sesame is an ancient indigenous oilseed crop valued for its high-quality oil, stability, and health benefits, including anticancer, antioxidant, and cholesterol-lowering properties (Abbas et al., 2022). The seed coat colour, ranging from white to black, affects marketability and consumer preference, influencing market dynamics.

1.5 Cultivation of Organic Sesame

Organic sesame is gaining global popularity due to its nutritional and economic benefits. ***Bio-fertilizers enhance sesame plant growth and yield, improving productivity and soil health (Ghosh and Mohiuddin, 2000).*** The demand for organic sesame is driven by health-conscious consumers, commanding a premium in the market.

1.6 Current Status and Importance in India

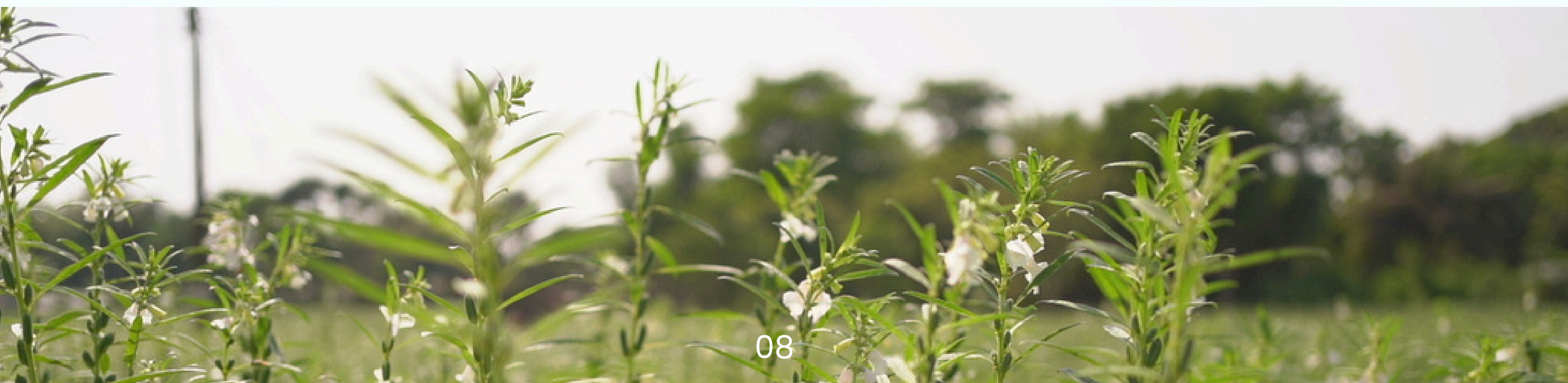
India ranks third in global sesame production, with significant cultivation in states like Rajasthan, Gujarat, West Bengal, Maharashtra, Uttar Pradesh, Madhya Pradesh, and Andhra Pradesh. Despite its importance, sesame research has been limited, necessitating efforts to improve germplasm resources, planting time, and management practices (Adhikary et al., 2020; Sharma, 2005).

This study on multi-varietal trials of sesame under organic management in the Gangetic plains of West Bengal aims to identify the best-performing varieties suited to local agro-climatic conditions. This research is essential for enhancing sesame yield, reducing dependence on edible oil imports, and promoting sustainable agricultural practices in West Bengal.

2. Aims & Objectives

This study aims to ***screen and select high-yielding lines of sesame to encourage and stimulate farmers' interest in its commercial cultivation*** in the New Alluvial Zone of West Bengal.

1. To identify *high market potential sesame varieties suitable* for the indo-gangetic plains of West Bengal.
2. To study the *effect of organic packages of practices on the growth, and yield* of white and black-seeded cultivars.
3. To study the *economics of different varieties under an organic package of practices in multi-location* to improve farmers’ profitability.



3. Review of Literature

The rising demand for sesame has led to the extensive use of artificial fertilisers and pesticides, which are unsustainable and harmful to soil, water, and health. Chemical fertilisers, in particular, damage the environment and soil health. Thus, using organic manures and bio-fertilizers is recommended to enhance biological activity, produce high-quality, pollutant-free crops, and improve soil properties. This literature review explores the significance of organic versus conventional sesame farming, focusing on varietal performance, agronomic practices, environmental influences, and field experiment outcomes.

3.1 Organic vs. Conventional Farming Practices in sesame cultivation

Various studies have explored the comparative effectiveness of organic and conventional farming practices for sesame. Kumar et al. (2022) found that *among ten sesame varieties tested under organic management in the Sikkim Himalayas, the GT10 variety exhibited the best performance* in terms of plant height, dry matter accumulation, capsule production per plant, and seed production per capsule, making it the most productive and profitable. On the other hand, Gopinath et al. (2018) reported a 16.6% reduction in sesame yield under organic management compared to conventional methods but noted improvements in soil properties, such as increased soil organic carbon, available nutrients, and microbial activity. In this scenario, mixed use of organic and chemical fertilisers may give a better result as per Lokhande et al. (2020). This specific study highlighted the benefits of *using a combination of urea and poultry manure leading to increased growth attributes and yield parameters in sesame.*

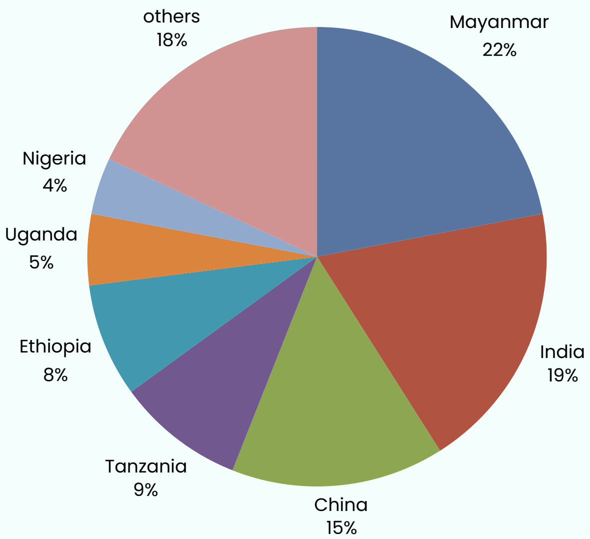


Figure 1: Major Sesame producing countries in the world

Source: FASTAT, 2012-13

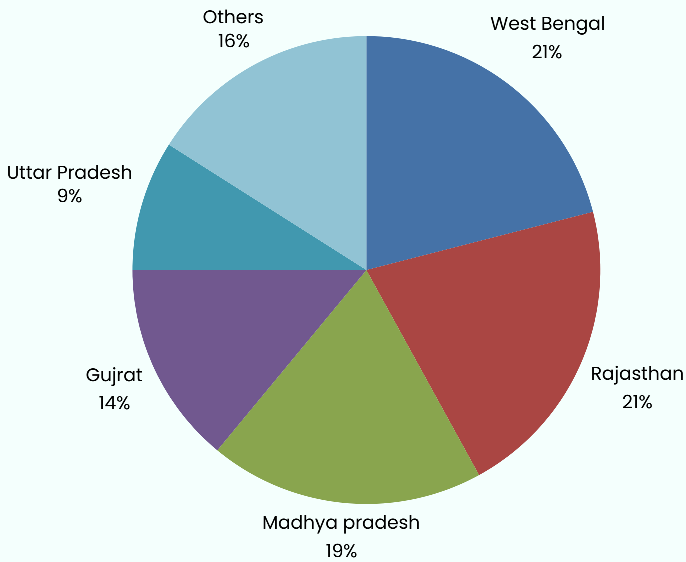


Figure 2: Major Sesame Producing States of India

Source: Ministry of Agriculture, GI (2012-13)

3.2 Varietal Performance and Agronomic Practices

It is evident from the existing studies that there is a difference in the performance of different sesame varieties and agronomic practices. Ali et al. (2022) evaluated the impact of line sowing and broadcasting methods on sesame varieties in West Bengal. The study found that the ***GT4 variety produced the highest number of capsules per plant in the climate of West Bengal.*** Bhattacharjee et al. (2021) assessed the phenotypic variability of sesame genotypes from different regions, noting better performance in genotypes like CUMS 17 and CUHY 57. Evidences from other subcontinental countries offer additional insights, that can be experimented with here based on the climatic resemblance. Khan et al. (2021) studied the effect of various environments and nutrition on sesame cultivars in Pakistan, identifying SG-30 as the highest yielding. Myint et al. (2020) highlighted the benefits of mechanised harvesting and breeder-engineer collaboration in sustainable sesame production in Myanmar.

3.3 Environmental and Climatic Influences

Environmental and climatic factors significantly impact sesame yield. ***Low temperatures and less bright sunshine during the reproductive stage were desirable for better seed yield and oil content for the state of West Bengal*** as per the study on the influence of thermal indices on sesame yields in West Bengal by Adhikary et al. (2020). As per the review of Chandaka et al. (2020), sesame production in India emphasised the need for improved post-harvest handling and high-yielding, disease-resistant varieties. Lastly, Aghili et al. (2015) recommended late June planting and the use of manure for the highest seed oil content in sesame varieties in Iran.

3.4 Field Experiments and Yield Analysis

Field experiments and yield analysis have been crucial in identifying high-performing sesame varieties. Singh et al. (2018) found that the Sabatri variety produced the maximum number of capsules per plant in Sikkim. Mishra et al. (2018) identified Prachi and SSel 84 as the best-performing varieties for the N-E Ghat zone in Odisha. The ***Rama sesame cultivar in West Bengal is found to be cost-effective for small farmers (Bera et al., 2017).***

3.5 Regional Studies and Specific Varietal Trials

Several studies have focused on specific regions and sesame varieties. Monapara (2016) reported that Gujarat Til-5 had a ***higher yield than Til-3 in Saurashtra. Chongdar et al. (2015) found that the Rama cultivar yielded the highest when sown in early March in North Bengal.*** Solanki et al. (2011) noted that the GT-3 variety had superior growth attributes compared to GT-2 in Gujarat.

3.6 Additional Studies and Observations:

Other notable studies include Sagar & Chandra (2004), who found that the Tilottma variety yielded higher than Rama in West Bengal. Begum et al. (2001) reported that while Lal Til produced more branches and stalks, T6 performed better in terms of seed yield. Santhosh (1988) identified the Surya variety as superior across multiple growth parameters when examining the effects of plant density and nitrogen levels.

4.Materials and Methods

4.1 Study Area

This study involves a field experiment conducted in the New Alluvial Zone of the Nadia district in West Bengal in 2023 to evaluate the impact of an organic package of practices on the growth, yield, and quality of various sesame varieties.

Table 1: Study Area

Location Name	Landholder name	Type of land
Gopalpur (Nadia)	Madan Mondal	Upland

4.2 Experimented Seeds

The experiment includes nine improved sesame varieties: GT-2, GT-3, GT-4, GT-6, GT-10, JLT-5, Savitri, Smarak, and Suprava. The soil of the experimental plot, as detailed in Table 1, is predominantly sandy loam to clay in texture and is well-drained. The soils in this area are generally fertile and typically do not face salinity issues, with an electrical conductivity (EC) value of less than 2 dS/m and a nearly neutral pH.

Table 2: Types of sesame seed (Based on seed colour)

SI No.	Types	Characteristics	Use
1	White Sesame	Contains less ash and carbohydrateContains more protein and oil (Kermani et al., 2019)	A condiment for baking purposes Mostly sprinkled over buns and cakes and also making sweets.
2	Brown Sesame	High content of oil around 45-50% (MFPI, GI)	Used for extraction of oil
3	Red Sesame	Rich in aroma (MFPI, GI)	Used for making different dishes like sweets etc.
4	Black Sesame	Rich in nutrients and flavour (Wang et al., 2018).	Used for medicinal purposes

Table 3: Varietal details Treatment details:

<table>
<tr><th>Sl No.</th><th>Name of the Variety</th><th>Salient features</th><th>Crop growing period (in days)</th><th>Estimated yield (kg/ha)</th><th>Estimated oil content (%)</th></tr>
<tr><td>1</td><td>GT-2</td><td>White seedbranching typemulti capsularSingle skin, Opposite arrangement, hairytolerant to macrophomina</td><td>88-92</td><td rowspan="5">750-800</td><td rowspan="6">45-52</td></tr>
<tr><td>2</td><td>GT-3</td><td>White bold seedmedium maturingSingle skinOpposite arrangement, broad, oblong capsules</td><td>84-88</td></tr>
<tr><td>3</td><td>GT-4</td><td>White seed, early maturingmulti capsuleSingle skin, capsule alternate arrangement, glabrous, narrow oblong capsules</td><td>79-83</td></tr>
<tr><td>4</td><td>GT-6</td><td>White bold seedlate maturingnarrow oblong more than one, Single skin, opposite arrangement long capsules</td><td>87-94</td></tr>
<tr><td>5</td><td>GT-10</td><td>Black seedprofusely branchedSingle skin, alternate capsule flower colour pinkish whiteresistant to powdery mildew</td><td>88-92</td></tr>
<tr><td>6</td><td>JLT-5</td><td>White in colourbolder in sizeSingle-coatedapproved by the house for cultivation in the summer season</td><td>90-92</td><td>1000-1200</td></tr>
<tr><td>7</td><td>Savitri</td><td>Light brown seederect branching typetolerant to lodgingleaves deep greenflower light pink colourtetra locular capsules double coatedtolerant to macrophomina</td><td>84-88</td><td>1100-1400</td><td>48-50</td></tr>
<tr><td>8</td><td>Smarak</td><td>Golden yellow bold seeddouble coateddelayed shatteringSynchronous maturitytolerant to macrophomina and alternaria leaf spot</td><td>80-85</td><td>800-900</td><td>48-52</td></tr>
<tr><td>9</td><td>Suprava (CUMS-17)</td><td>Light brown Coloured Double coated, resistant to root rot phyllody and powdery mildew adaptability under high heat and drought situations</td><td>88-92</td><td>900-1200</td><td>48-50</td></tr>
</table>

Table 4: Treatment details

Treatment details	Variety
T-1	GT-2
T-2	GT-3
T-3	GT-10
T-4	GT-4
T-5	Savitri
T-6	GT-6
T-7	Smarak
T-8	Suprava
T-9	JLT-5

4.3 Soil Sample Collection:

Soil samples have been collected from the farming sites and are analysed regularly to ensure the soil quality parameters like PH, soil moisture, N, P, K & Electrical Conductivity (EC), etc. are maintained.

4.4 Field preparation:

The experimental land is prepared using harrowing, ploughing, and ridging with disc equipment mounted on tractors. One month before soil preparation, farmyard manure is applied at a rate of 10 tonnes per hectare. After the manure application, the field is prepared according to the appropriate layout design.

4.5 Sowing time, method and Spacing:

For this experiment, sesame crops are sown in by line sowing method which is carried out on ridges at a spacing of 30cm x 15cm.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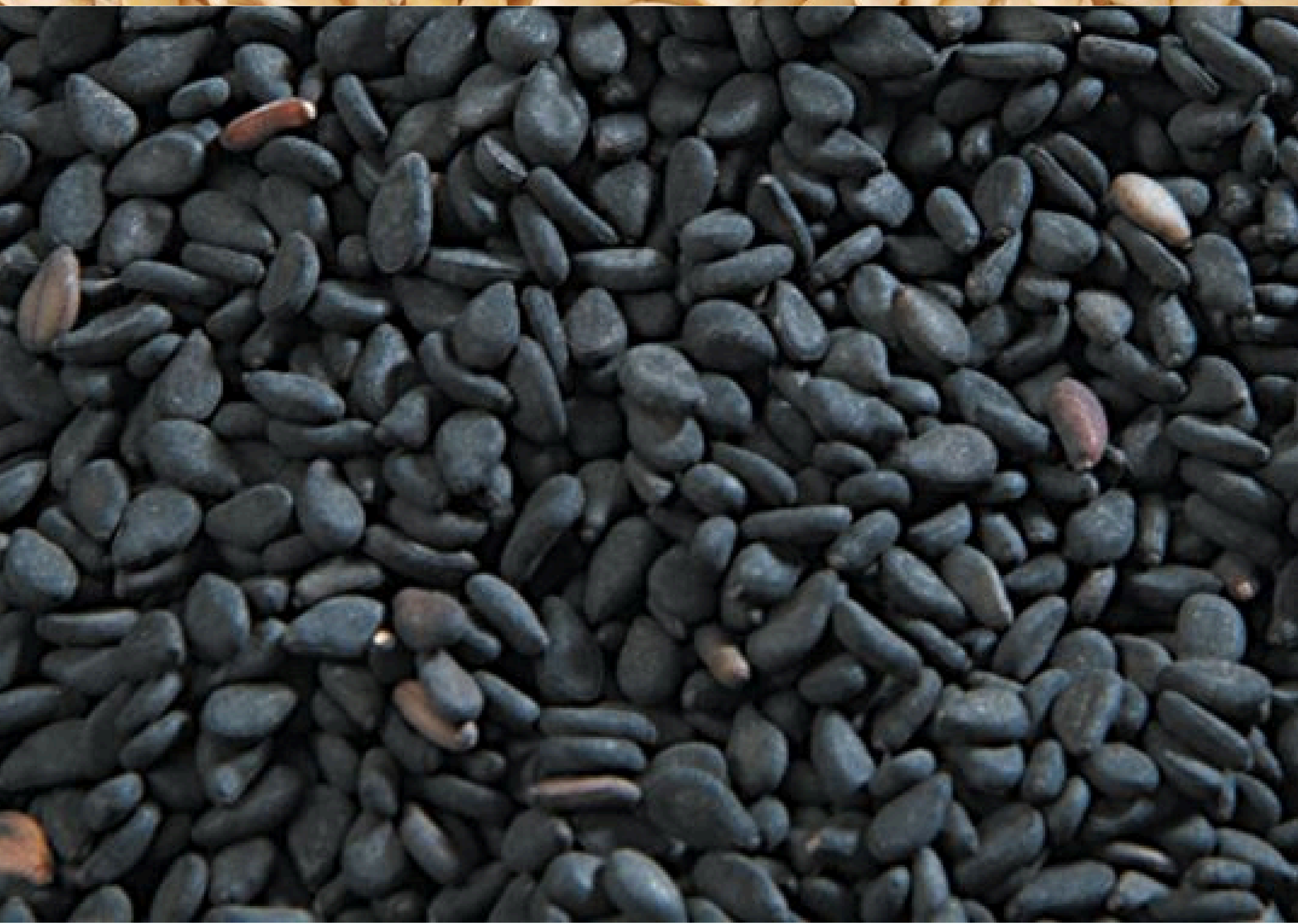

5.Result

5.1 Yield and Yield attributes

In terms of the sesame crop, the main focuses are yield-related factors such as the number of capsules per plant, the number of seeds per capsule, the length of the capsules, and the overall yield of the crop. They specifically examined elements that affect crop productivity, including the number of capsules per plant, the number of seeds per capsule, the length of the capsules, and the overall yield.

5.2 Number of capsules/plant

Capsules number per plant is the most important component of yield in sesame crops. Analysis of sesame data (see Table 5) revealed the following results:

- The Suprava variety in the T-8 treatment produced the most capsules per plant, with a mean value of 140.67.
- T-7 treatment followed, with a mean value of 113.33 capsules per plant.
- The GT-6 variety in T-6 treatment produced the least number of capsules per plant, with a mean value of 48.67.
- The GT-2 strain also had fewer capsules per plant, averaging 61.

These findings confirm Bhattacharjee et al. (2021) findings that Suprava yielded higher components such as capsules per plant, capsule length, 1000 seed weight, and seed yield compared to check varieties TKG 22 and GT 10. Simultaneously, Ali et al. (2022) showcased that the GT-6 variety had the fewest capsules per plant, with a mean value of 37.2. Treatment T-4, T-9, and T-2 showed medium numbers of capsules per plant, with mean values of 103.33, 93.13, and 86.67, respectively.

5.3 Number of seeds/capsules

- Each capsule contains a varying number of seeds depending on the sesame variety.
- The maximum number of seeds per capsule was found in:
    - Treatment T-7, Smarak sesame variety, with 110.67 seeds.
    - GT-4 sesame variety, with 102.67 seeds.
- Treatments T-2, T-8, and T-6 had 93.33, 92, and 91.33 seeds per capsule, respectively.
- The lowest number of seeds per capsule was found in:
    - Treatment T-3, GT-10 sesame variety, with 68.67 seeds.

Similar findings are reported by Sahu et al. (2022), who found that the GT-10 variety had the lowest number of seeds per capsule among 19 genotypes.

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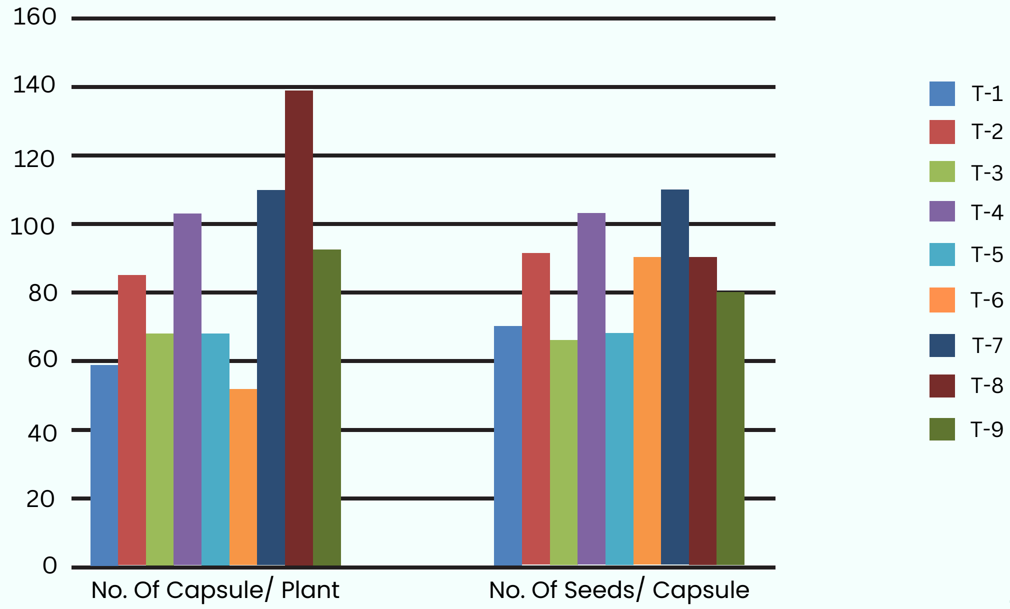

Figure 3: Graphically represent the no. of capsules/plant & no. of seeds/capsules of different sesame varieties on different days after sowing.

5.4 Length of capsules (cm)

The main factor influencing yield, which varies across many sesame varieties, is capsule length. The highest capsule length was found from the T-6 treatment (4.10), which refers to the sesame type GT-6; followed by T-4, T-7 & T-9 treatments 3.67, 3.66 & 3.55 while the lowest was obtained from the T-1 treatment, GT-2 (2.45).

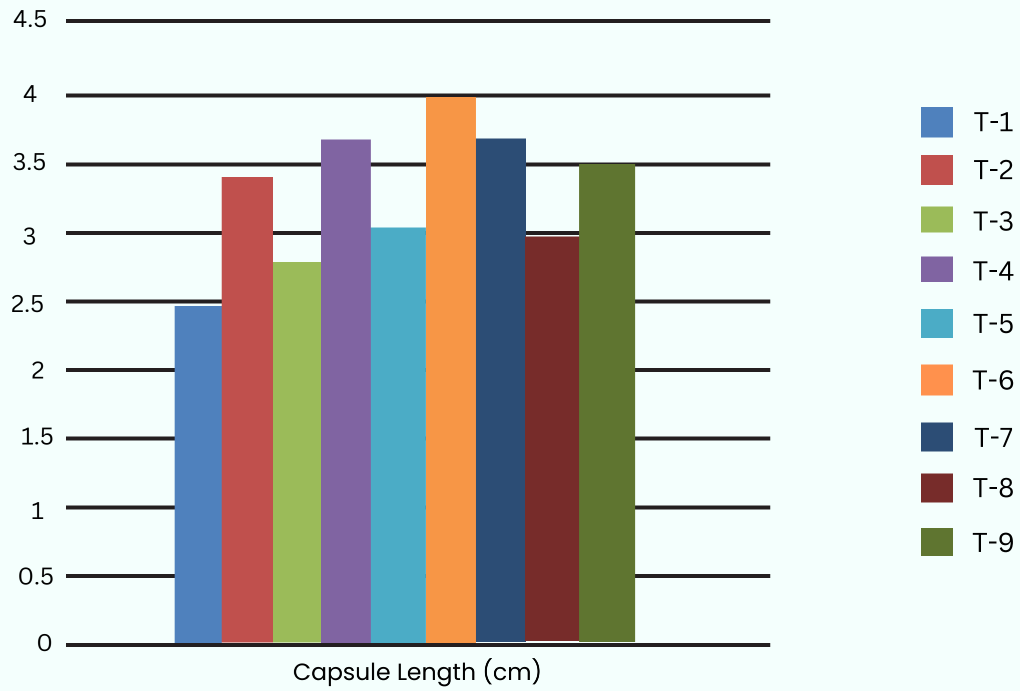

Figure 4: Graphically represent the capsule length (cm) of different sesame varieties on different days after sowing

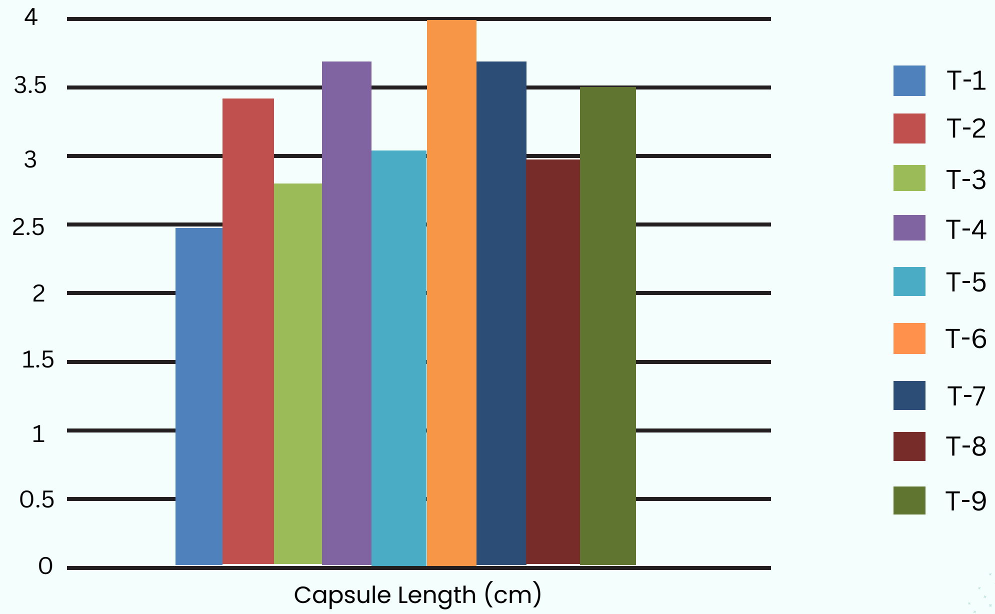

Figure 3: Graphically represent the no. of capsules/plant & no. of seeds/capsules of different sesame varieties on different days after sowing.

5.5 Seed Yield (kg/ha)

The table below describes the seed yield of different sesame varieties. The T-7 treatment, statistically comparable to treatment T-5 (1375 kg/ha), produces the highest seed yield (1765 kg/ha) from the Smarak variety of sesame. Other varieties, such as Suprava, GT-3, JLT-5, and GT-2, also perform well, yielding 1230 kg/ha, 1160 kg/ha, 1110 kg/ha, and 1005 kg/ha, respectively. The T-6 treatment (GT-6) yields the lowest 770 kg/ha yield. Sahu et al. (2022) confirm these findings, reporting a sesame yield of 1934 kg/ha. They examined 19 genotype cultivars of sesame from various parts of India, noting eight morphological traits: days to 50% flowering, plant height, number of branches per plant, capsule length, number of capsules per plant, number of seeds per capsule, 1000-seed weight, and seed yield per plant.

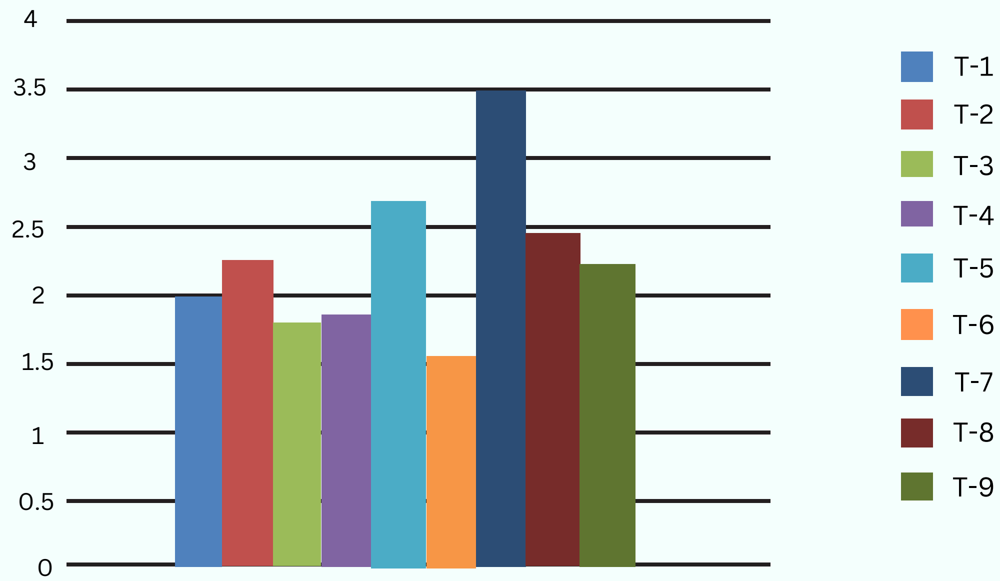

Figure 5: Graphically represents the yield of different sesame variety

5.6 Oil content (%):

The GT-3 sesame cultivar's T-2 treatment yields the highest oil content at 52.95%, followed by GT-4 (52.93%) and Smarak (52.64%). Sesame seeds from the Savitri variety, treated with T-5, contain 51.63% oil. The GT-2 T-1 treatment has the lowest oil content at 45.6%, followed by the T-9 treatment with the JLT-5 sesame variety at 45.84%. Other sesame types, including GT-10 and Suprava, contain between 49% and 50% oil.

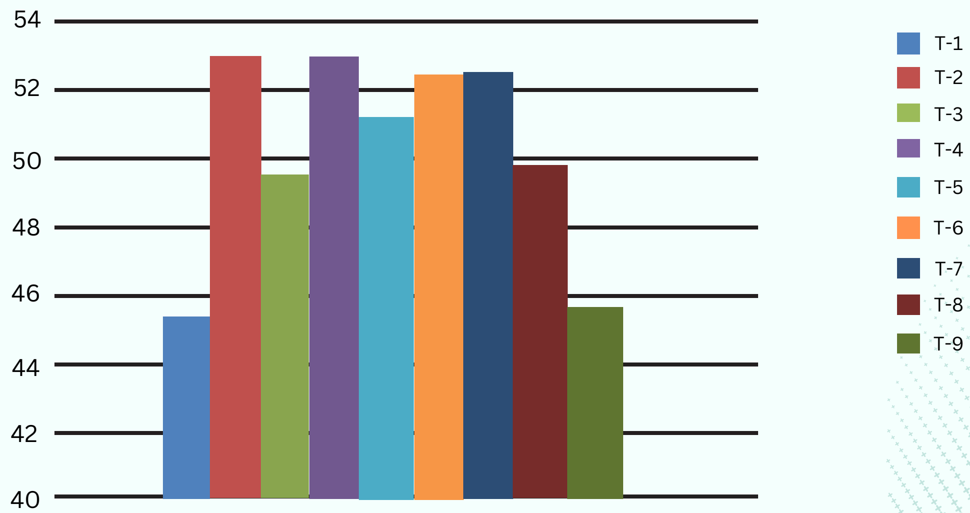

Figure 6: Graphically represent the oil content of different sesame variety

Table 5: Yield and yield attributes of sesame crop

Treatments	Varieties	No. of capsules/plant	No. of seeds/ capsules	Capsule length (cm)	Yield (kg/plot)	oil content (%)
T-1	GT-2	61.00	72.67	2.45	2.01	45.6
T-2	GT-3	86.67	93.33	3.40	2.32	52.95
T-3	GT-10	70.33	68.67	2.76	1.88	49.54
T-4	GT-4	103.33	102.67	3.67	1.86	52.93
T-5	Savitri	69.67	71.33	3.09	2.75	51.63
T-6	GT-6	48.67	91.33	4.10	1.54	52.49
T-7	Smarak	113.33	110.67	3.66	3.53	52.64
T-8	Suprava	140.67	92	2.97	2.46	49.84
T-9	JLT-5	93.13	80.67	3.55	2.22	45.84
SEm±		3.13	1.03	0.02	0.24	
CD (P=0.05)		9.39	3.10	0.06	0.71	

5.7 Growth attributes

The data is collected and analysed for different growth parameters of sesame (Table 6 and Table 7). Among the treatments, it is found that plant height and leaf did not vary significantly at the early stage but with the advancement of the crop age, higher plant height is found under line sowing as compared to broadcasting.

5.7.1 No. Of Leafs

The data on periodic plant height have been presented in (Table 6).

- **15 DAS Leaf:** The plant leaf count is not substantial at the beginning of the sesame crop. Treatments T-4 and T-9, corresponding to the sesame varieties GT-4 and JLT-5, respectively, show the highest leaf count in the early stages of development with 7.33 leaves. Treatments T-1, T-5, T-6, T-7, and T-8 also display the same quantity of leaves, with averages of 7, 6.67, 7, 6.67, and 7, respectively. Treatments T-2 and T-3, which correspond to the varieties GT-3 and GT-10, produce the lowest leaf count at 6.

- **30 DAS Leaf:** The variety JLT-5, treatment T-9, generated the most leaves after 30 days after planting. This was followed by the T-1 treatment, GT-2 variety of sesame, which had a mean value of 43.75 and the T-2 treatment, GT-3 variety of sesame (38.20), both of which had comparable results. In terms of leaf production, the GT-4 sesame variety produced the fewest (30.13), followed by T-7, T-6, and T-3 at 30.60, 31.33, and 32.57, respectively.

- **45 DAS Leaf:** After 45 days after sowing (DAS), the GT-3 variety under treatment T-2 has the maximum number of leaves (98). This is followed by the T-1 treatment (88), while the JLT-5 variety under treatment T-9 has the lowest number of leaves (61.33). The GT-10, Smarak, Suprava, and Savitri varieties also have notable leaf counts, with mean values of 79.33, 82.33, 73.67, and 68.33, respectively.

- **60 DAS Leaf:** After 60 days of sowing, the T-2 treatment (GT-3) has the most leaves, with an average of 100.33. The T-6 treatment (GT-6) has the fewest leaves, with an average of 40.67. Treatments T-1 and T-7 show similar results to T-2, with mean values of 90.33 and 87.67, respectively. The T-3, T-8, and T-5 treatments follow, with average leaf counts of 82.67, 76.67, and 70.67, respectively.

- **75 DAS Leaf:** The GT-3 variety under treatment T-2 yields the most leaves, with an average of 84.67. This is followed by the T-1 and T-3 treatments, with mean values of 75.33 and 71.17, respectively. The T-7, T-8, T-5, and T-4 treatments produce a moderate number of leaves, with average values of 67.33, 63.67, 55.33, and 52, respectively. The GT-6 variety under treatment T-6 has the fewest leaves, with an average of 32.5, while the T-9 treatment (JLT-5 variety) has a slightly higher average of 41.83.

- **Harvest Leaf:** Sesame with treatment T-3 (GT-10) has the most leaves, averaging 18.03, while sesame with treatment T-9 (JLT-5) has the fewest leaves, averaging 7.37. Treatments T-4, T-5, T-6, and T-8 record a moderate number of leaves, with mean values of 14.43, 14.30, 14.73, and 14.87, respectively. Treatments T-1, T-2, and T-7 each contain around 12 leaves.

Table 6: Growth attributes of sesame crop (No. of Leaf)

Treatments	No. of Leaf					
	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	Harvest time
T-1	7.00	43.75	88.00	90.33	75.33	12.33
T-2	6.00	38.20	98.00	100.33	84.67	12.80
T-3	6.00	32.57	79.33	82.67	71.17	18.03
T-4	7.33	30.13	62.67	65.00	52.00	14.43
T-5	6.67	34.33	68.33	70.67	55.33	14.30
T-6	7.00	31.33	39.00	40.67	32.50	14.73
T-7	6.67	30.60	82.33	87.67	67.33	12.13
T-8	7.00	35.30	73.67	76.67	63.67	14.87
T-9	7.33	43.83	61.33	65.67	41.83	7.37
SEm±	0.48	1.82	3.70	3.89	2.73	0.81
CD (P=0.05)	1.44	5.45	11.09	11.67	8.20	2.42

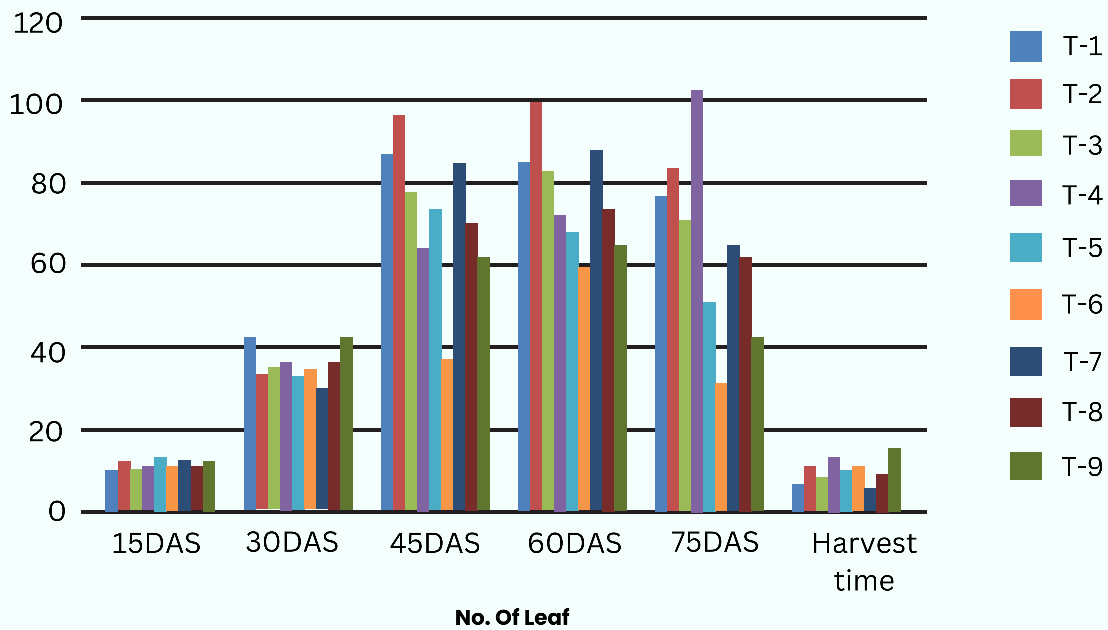

Figure 7: Graphically represent the no. of leaves of different sesame varieties on different days after sowing

5.7.2 Plant height (cm)

The data on periodic plant height have been presented in (Table 7). The result shows a significant effect on the stem elongation but in the early stage, there was no significant difference.

- **15 DAS Height:** Although plant height varies among varieties, it is not a significant factor in the early stages of sesame growth. After 15 days of planting, the GT-4 variety and T-4 treatment (8.83), as well as the GT-2 and JLT-5 varieties (with mean values of 7.87 and 7.57, respectively), have the highest plant heights. The sesame treatments including T-8, T-6, T-7, T-3, and T-5 exhibit medium plant heights at 15 DAS, with respective mean values of 6.83, 6.83, 6.73, 6.72, and 6.47. Meanwhile, the T-2 treatment of the GT-2 variety has the lowest plant height (5.10).

- **30 DAS Height:** After 30 days of sowing, the JLT-5 variety with T-9 treatment achieves the highest height (20.44), while the Suprava variety with T-8 treatment has the lowest height (12.86). The T-9 treatment is found to be the same height as the T-4 treatment (18.34), while the T-7 treatment matches the height of the T-8 treatment (13.35). The remaining sesame varieties display similar moderate heights.

- **45 DAS Height:** The Smarak variety of sesame with T-7 treatment produces the tallest plants (39.30). Similar results are observed with T-5 and T-3 treatments, having mean values of 38.30 and 38.03, respectively. The mean plant heights for the other sesame treatments, T-1, T-2, and T-8, are 36.23, 36.33, and 36.77, respectively. Low to medium plant heights are also present in the T-4 and T-6 treatments. After 45 DAS, the minimum height is recorded for the JLT-5 variety with T-9 treatment (31.20).

- **75 DAS Height:** The Suprava variety of sesame with T-8 treatment produces the tallest plants (52.17 cm), followed by T-7, T-5, and T-3 treatments, with mean values of 51.17, 51.03, and 50.10 cm, respectively. The T-1 treatment in GT-2 generates the shortest plants (43.90 cm), with T-4 treatment producing the next shortest plants (44.73 cm).

- **Harvest Height:** At harvest, the GT-10 variety of sesame with T-3 treatment produces the tallest plants (58.03 cm), followed by T-8 treatment (56.60 cm). The GT-2 variety with T-1 treatment has the shortest plants (46.77 cm). Other sesame cultivar treatments, including T-7, T-2, T-6, T-9, T-4, T-5, and T-1, result in plants with medium height, with mean values of 51.77, 49.23, 49.03, 48.80, 48.57, 47.53, and 46.77 cm, respectively. According to Sahu et al. (2022), a study on 19 sesame genotypes in various regions of India found that the GT-10 variety's plant height was 76.23 cm.

- **No. of Branches:** Data collected during the sesame harvest is entered in Table 7. In the T-5 treatment, the Savitri variety has the most branches (11.05), while the GT-4 variety has the fewest (2.10). The GT-6 type lacks branches entirely. Following the T-5 treatment, other varieties like GT-10, Suprava, and Savitri also contain the majority of the branches. The least number of branches are found in T-9, T-1, and T-2 treatments, with respective mean values of 3.17, 3.97, and 4.60.

Table 7: Growth attributes of sesame crop (Plant height & No. of Branches)

Treatments	Plant height					No. of Branches
	15 DAS	30 DAS	45 DAS	75 DAS	Harvest time	
T-1	7.87	16.89	36.23	43.90	46.77	3.97
T-2	5.10	16.75	36.33	46.07	49.23	4.60
T-3	6.72	15.51	38.03	50.10	58.03	9.30
T-4	8.83	18.34	33.30	44.73	48.57	2.10
T-5	6.47	17.24	38.30	51.03	47.53	11.07
T-6	6.83	16.66	33.47	45.73	49.03	0.00
T-7	6.73	13.35	39.30	51.17	51.77	6.97
T-8	6.83	12.86	36.77	52.17	56.60	8.07
T-9	7.57	20.44	31.20	45.07	48.80	3.17
SEm±	0.87	0.73	0.69	0.59	0.37	0.47
CD (P=0.05)	2.62	2.20	2.07	1.78	1.11	1.40

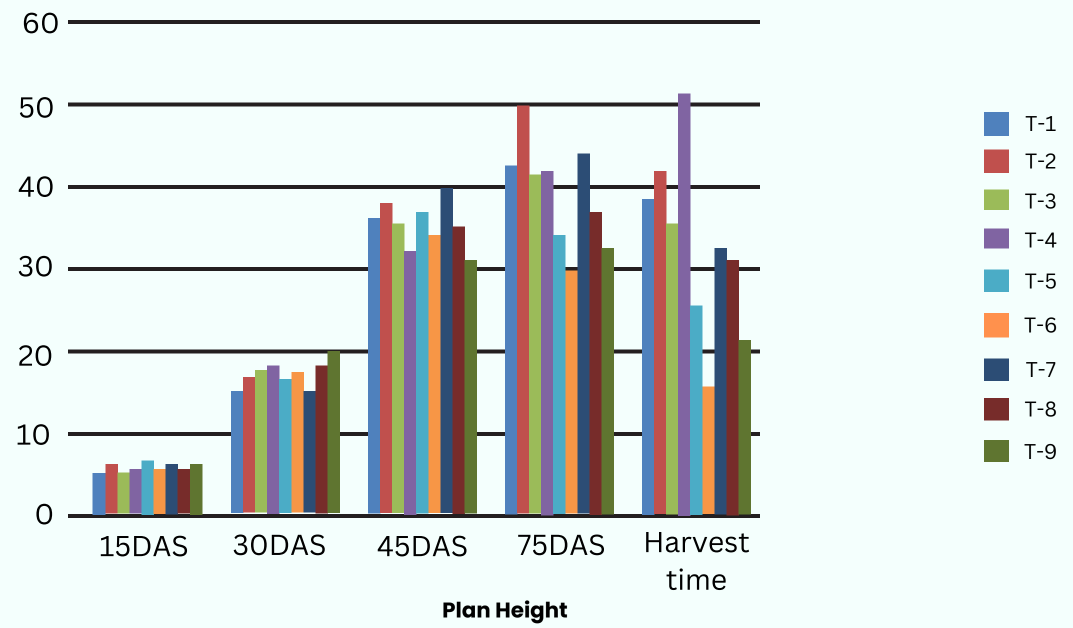

Figure 8: Graphical representation of the plant height of different sesame varieties on different days after sowing

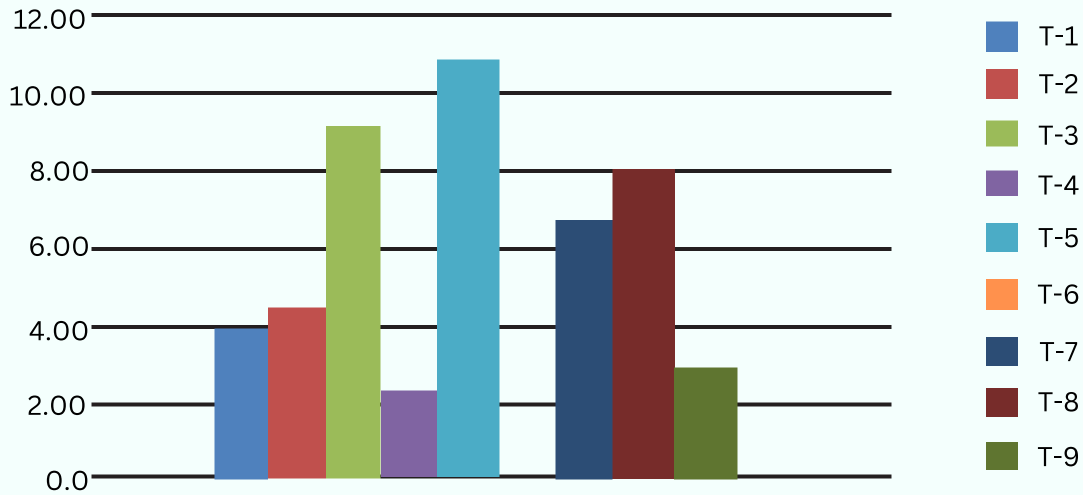

Figure 9: Graphical representation of the number of branches of different sesame varieties on different days after sowing

6. Discussion

6.1 Yield and yield attributes:

Through this study, it is discovered which sesame variety excels in terms of the ***number of capsules per plant, number of seeds per capsule, yield, and oil content.*** The 'Smarak' and 'GT-4' sesame varieties outperform all others in these aspects. Smarak is a bright yellow, bold-seeded sesame type, while GT-4 is a white sesame variety. Both have significant market value due to their ***high yield, total oil content, number of capsules per plant, number of seeds per capsule, and length of capsules.***

Despite the ***lower market value of the 'Suprava'*** brown-seeded sesame variety compared to Smarak and GT-4, it still ***outperforms the other seven sesame varieties*** in these key metrics.

India, ranking third in global sesame production, has significant cultivation in states such as Rajasthan, Gujarat, West Bengal, Maharashtra, Uttar Pradesh, Madhya Pradesh, and Andhra Pradesh. Despite its importance, sesame research has been limited, highlighting the need to improve germplasm resources, planting times, and management practices.

Other sesame varieties, such as ***JLT-5, also show better performance in terms of the number of capsules per plant, number of seeds per capsule, and length of capsules.*** However, the oil content of JLT-5 is low to moderate at around 45%, with a modest yield of 1110 kg/ha. This variety maintains a strong market value.

In contrast, the white 'GT-2' sesame variety performs poorly, with the fewest capsules per plant (61), fewest seeds per capsule (72.67), lowest yield (2.01 kg/plot), and an oil content of 45.6%. This poor performance may be attributed to climatic changes.

6.2 Growth and growth attributes:

The analysis of sesame data under different growing conditions reveals that sesame varieties exhibit distinct behaviours. The amount of leaves varies among different sesame varieties, depending on the number of leaves per plant at 15, 30, 45, 60, and 75 days after sowing (DAS), as well as at harvest time. At 15, 30, 45, and 60 DAS, most sesame varieties still have a majority of their leaves. However, after 60 days, the number of leaves decreases significantly, with many varieties having only a few leaves left by harvest time.
Two other crucial growth factors are plant height and the number of branches. Plant height is measured using a tape measure, with the height of five randomly chosen plants in each plot averaged in centimetres (cm) at crop maturity. Sesame cultivars generally exhibit moderate to high natural heights, with GT-10 and Suprava being taller than other cultivars.
The number of branches varies among sesame cultivars, but this does not necessarily correlate with the number of capsules produced. The cultivar with the most branches is Savitri, followed by GT-10 and Suprava. In contrast, the GT-6 cultivar has no branches, while the other cultivars have a moderate to low number of branches.

7. Conclusion

The multi-varietal trial of sesame (Sesamum indicum L.) under organic management in the Gangetic plains of West Bengal has yielded significant insights. Among the varieties tested, 'Smarak' and 'GT-4' have emerged as top performers. These varieties excel in yield, total oil content, capsule characteristics, and growth parameters, indicating their potential for large-scale cultivation. The brown-seeded variety 'Suprava' also shows comparable performance to 'Smarak' and 'GT-4', but its double-coated seeds reduce its market value.

In the category of white sesame varieties, 'GT-3' stands out for its high oil content and robust growth characteristics. In contrast, 'GT-2' underperforms in both yield and oil content, making it less favourable for cultivation. The black sesame variety 'GT-10' and the brown-seeded 'Suprava' exhibit modest growth and yield parameters, suggesting limited commercial viability.

Overall, ***'GT-4' is identified as the best white sesame variety,*** followed by 'GT-3', 'JLT-5', 'Smarak', and 'GT-6'. The brown-seeded variety ***'Savitri' has excelled in both yield and oil content, positioning it as a strong candidate for cultivation despite its market challenges.*** These findings highlight 'GT-4' and 'Savitri' as promising varieties for optimizing sesame production under organic management in this region.

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