



Effect of Irrigation Frequency and Weed Management on Growth and Yield of Sesame

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Authors' contributions

This work was carried out in collaboration among all authors. Authors ZI & MSI designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors KS managed the analyses of the study, wrote the final draft, did all the editing after submitting the paper and correspondence. All authors read and approved the final manuscript.

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ABSTRACT

Sesame (*Sesamum indicum* L.), a vital oilseed crop, faces productivity challenges due to irrigation and weed management issues. This study aimed to investigate the impact of irrigation frequency and weed management on the growth and yield of sesame, conducted at Sher-e-Bangla Agricultural University, Bangladesh, using a split-plot design with four levels of irrigation (I_0 : no irrigation, I_1 : one irrigation at 20 DAS, I_2 : two irrigations at 20 and 40 DAS, I_3 : three irrigations at 20, 40, and 60 DAS) and four weed management strategies (W_0 : no weeding, W_1 : one hand weeding at 20 DAS, W_2 : two hand weeding at 20 and 40 DAS, W_3 : post-emergent herbicide application at

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20 and 40 DAS). Results showed that three irrigations (I_3) significantly increased plant height, branching, and seed yield (1.282 t ha^{-1}), while weed control using herbicides (W_3) or combined hand weeding (W_2) minimized competition, yielding the highest seed output (1.171 t ha^{-1}). Differences were statistically significant ($p < 0.05$). These findings emphasize that adopting efficient irrigation schedules and integrated weed management can sustainably boost sesame productivity, providing valuable insights for farmers and researchers targeting yield improvements in resource-limited settings.

Keywords: Sesame; seed yield; farmers; herbicides; irrigation.

1. INTRODUCTION

Sesame (*Sesamum indicum* L.), one of the oldest oilseed crops, is renowned for its high nutritional value and adaptability to harsh environments. Originating in India and Africa, it now thrives in tropical and subtropical regions, with India, China, and Sudan being the top producers. Globally, sesame is cultivated over approximately 9.5 million hectares, yielding around 6.5 million metric tons annually (FAO, 2023). Its seeds contain 50–60% oil, rich in antioxidants like sesamin and sesamol, contributing to health benefits such as reducing cholesterol and offering anti-inflammatory properties (Teklu et al., 2021; Dossa, et al., 2017).

Despite its economic significance, sesame production faces constraints such as irregular irrigation, weed infestations, and the crop's vulnerability to biotic and abiotic stresses (Schwartz-Lazaro et al., 2021). These issues can lead to significant yield losses, exacerbated by climate change and limited water resources. Understanding the interplay between irrigation and weed control is essential to ensure the crop's profitability and sustainability. Weeds alone can reduce sesame yields by up to 70% in poorly managed fields (Teklu et al., 2021).

Effective solutions include optimizing irrigation schedules and employing integrated weed management strategies, such as mulching, crop rotation, and selective herbicides (Dossa et al., 2017; Zhao et al., 2022).

This study aims to evaluate the effects of irrigation frequency and weed management on sesame growth and yield, contributing to a broader effort to enhance its production in regions where it holds economic and social significance. Insights gained can guide the development of more resilient production systems to meet growing global demand (Teklu et al., 2021).

2. MATERIALS AND METHODS

2.1 Experiment Site and Soil

A field experiment was conducted at the Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh during *Kharif-1* (March – June), 2014 to study the effect of irrigation frequency and weed management practices on growth and yield of sesame. The experimental field is located at $23^{\circ} 41' \text{ N}$ latitude and $90^{\circ} 22' \text{ E}$ longitude at a height of 8.6 m above the mean sea level. It belongs to the AEZ 28, (Madhupur Tract). It was Deep Red Brown Terrace soil and belonged to Nodda cultivated series. The soil was sandy loam in texture having pH ranged from 5.47 to 5.63, a member of hyperthermic Aeric Haplaquept under the order Inceptisol having only few horizons.

2.2 Climate

The experimental field was situated under Sub-tropical climate; usually the rainfall is heavy during *kharif* season (April to September) and scanty in *rabi* season (October to March). In *rabi* season, temperature is generally low and there is a plenty of sunshine. The temperature tends to increase from February as the season proceeds towards *kharif*. The site, where the experiment was conducted, has a subtropical climate *kharif-1* season extends from March to early June.

2.3 Crop

BARI Til-4 (*Sesamum indicum* L.) is a broadleaf plant of about 0.9-1.2m tall, although height dependent on the variety and growing conditions. Large, white, bell-shaped flowers, each about an inch long, appear from leaf axils on the lower stem, then gradually appear up the stem over a period of weeks as the stem keeps elongating. Depending on the variety, either one or three seed capsules will develop at each leaf axil. Seed capsules are 1 to 1 1/2 inches long, with 8

rows of seeds in each capsule. Some varieties are branched, while others are unbranched.

2.4 Treatments

Four levels of irrigation and four levels of weed management and their interaction were used in the experiment. These were:

Factor- A: Four levels of irrigation

- I_0 = No irrigation
- I_1 = One irrigation at 20 DAS
- I_2 = Two irrigation at 20 and 40 DAS
- I_3 = Three irrigation at 20, 40 and 60 DAS

Factor- B: Four levels of weed management

- W_0 = No weeding
- W_1 = One hand weeding at 20DAS
- W_2 = Two hand weeding at 20 DAS and 40 DAS
- W_3 = Post emergent herbicide (Whip Super 10% EC) at 20 DAS and 40 DAS

2.5 Experimental Design

The experiment was laid out in Split plot design with 3 replications. Irrigation frequency was applied in main plot and weed management in sub plot. The size of unit plot was 2.0 m x 2.0 m. The total number of treatments was (4 levels of irrigation x 4 levels of weed management) 16 and the number of plots were 48 as there was three numbers of replication.

2.6 Layout of the Experiment

The experiment was laid out on March 12, 2014. The whole area was divided into 48 plots. The replications were separated by 0.75m distance and plots were separated by 0.25m. Cowdung at the rate of 10 tons per hectare was applied during land preparation. Other fertilizer- nutrients, at the rate of 125 kg Urea ha⁻¹, 150 kg TSP ha⁻¹, 50 kg MP ha⁻¹ and 110 kg Gypsum ha⁻¹ were applied at the time of final land preparation. All fertilizers were broadcasted and incorporated into the soil before sowing of seeds. Additional quantity of 20 kg Urea per hectare was top dressed during flower initiation.

2.7 Land Preparation

The experimental land was ploughed with a tractor followed by harrowing to attain a desirable filth. All uprooted weeds and stubbles of the previous crop were removed from the

experimental field. The land was finally prepared with power tiller to ensure a good land preparation. The land was leveled by tractor drawn leveler.

2.8 Sowing

The seeds of the variety BARI Til-4 were collected from the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. Seeds were subjected to germination test and were treated with Vitavex-200 at the rate of 2.5 g kg⁻¹ of seeds before sowing. Seeds were sown on March 15, 2014 in solid lines. Three to five seeds were sown per hill. Missing hills were sown with seeds to maintain desired plant population.

2.9 Cultural Practices

The desired population density was maintained by thinning plants 8 days after emergence. Irrigation and weeding were performed as per treatments. Plant protection measures were performed as needed to uniform germination, better crop establishment and proper plant growth.

2.10 Sampling

The sampling was done first at 15 days after sowing and it was continued at an interval of 15 days, viz. 30, 45, 60 days after sowing (DAS). At each harvest, three plants were selected randomly from each plot. The selected plants of each plot were uprooted carefully by a khurpi and washed in running tap water to remove the soil. The number of leaves, branches and pods were recorded separately. The components were oven dried at 60^o for 72 hours to record constant dry weight. From each plot the weight of the straw were taken. Biological yield and the harvest index were also calculated from this data.

2.11 Data Collection

The data on the following parameters of three plants were recorded at each harvest.

- Plant height (cm)
- Number of branch plant⁻¹
- Number of leaves plant⁻¹
- Number of capsule plant⁻¹
- Number of seeds capsule⁻¹
- 1000 seeds weight (g)
- Yield plant⁻¹(g)
- Total seed yield(t ha⁻¹)

- Stover yield (t ha⁻¹)
- Harvest Index

2.12 Harvesting

Harvesting at maturity, the crop was harvested from an area of 1 m² from each plot. The data on agronomic parameters and yield components of sampled plants were recorded. The harvested plants were segmented into components such as straw (leaf, branch and stem together) and seed. The straw and capsule were then dried in a drier at 70°C for 72 hours and weighed. The seeds were dried in the sun and weighed. The seed weight was adjusted at 8% moisture content.

2.13 Statistical Analysis

The data collected on different parameters were statistically analyzed to obtain the level of significance using the MSTAT- C computer package program. Mean difference among the treatments were tested with least significant differences (LSD) at 5% level of significance.

3. RESULTS AND DISCUSSION

3.1 Plant Height

Effect of irrigation frequency: Plant height of sesame was significantly influenced by irrigation frequency (Fig. 1). Higher irrigation frequency resulted in increased plant height at different days after sowing. At 30, 45, 60 DAS, and harvest, the highest plant height was observed with three irrigations (I₃) at 25.54, 47.26, 98.04, and 103.2 cm, respectively. The lowest plant

height was recorded with no irrigation (I₀) at 23.17, 41.85, 75.62, and 89.45 cm, respectively. The significant effect on growth might be due to improved nutrient availability from irrigation.

This observation aligns with findings from several studies. For instance, Sezen et al. (2022) demonstrated that deficit irrigation practices enhanced water use efficiency and plant growth, including height, in *Salvia splendens* L. This suggests that controlled irrigation positively influences plant height even under limited water resources (Sezen et al., 2022). Similarly, Si et al. (2020) observed that higher irrigation frequency significantly boosted the growth and yield of winter wheat, underlining the importance of consistent water availability during critical growth stages (Si et al., 2020). Additionally, Romero et al. (2004) found that regulated deficit irrigation improved vegetative growth, including plant height, in almond trees when applied at optimal intervals (Romero et al., 2004).

Effect of weed management: Weed management significantly influenced plant height in sesame (Fig. 2). While there was no significant effect at 15 and 30 DAS, the highest plant heights at 45 DAS, 60 DAS, and harvest were observed with herbicide application (W₃) at 47.37 cm, 92.71 cm, and 101.5 cm, respectively. These results were not significantly different from two hand weedings (W₂). The lowest plant heights were recorded with no weeding (W₀) at 41.94 cm, 82.09 cm, and 93.56 cm, respectively, likely due to reduced competition from weeds.

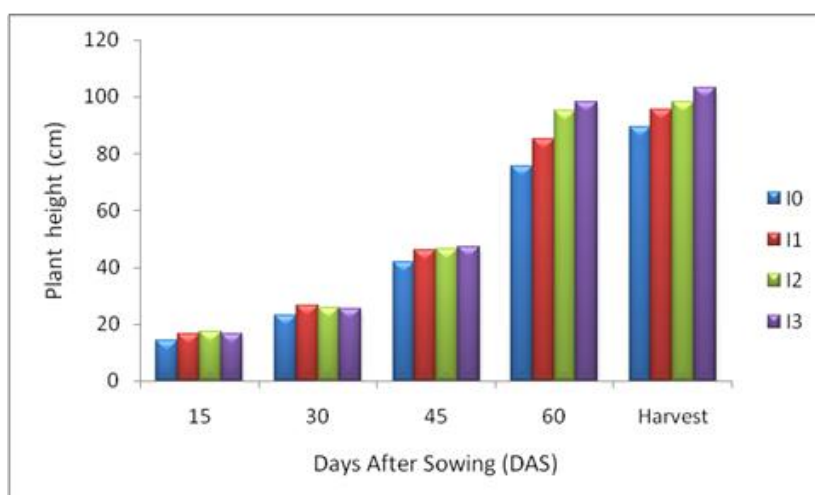


Fig. 1. Effect of irrigation frequency on plant height of sesame at different days after sowing (I₀ = No irrigation; I₁ = Single irrigation at 20 DAS; I₂ = Two times irrigation at 20 and 40 DAS; I₃ = Three times irrigation at 20, 40 and 60 DAS)

This pattern highlights the critical role of weed management in optimizing plant growth. Herbicide-based control, such as the use of glyphosate, has been shown to significantly reduce weed competition, allowing for better growth conditions for sesame and other crops. The effectiveness of herbicides, particularly in combination with manual weeding, has been demonstrated in numerous studies (Singh et al., 2024; Hasan et al., 2021). In contrast, the lack of weed management results in reduced plant vigor and yield, as plants face increased competition for water, nutrients, and light. Thus, efficient weed control is essential for achieving optimal growth and yield in sesame.

3.2 Number of Branches Plant⁻¹

Effect of irrigation frequency: The number of branches per plant in sesame was significantly influenced by irrigation frequency (Fig. 3). Higher irrigation frequency resulted in more branches per plant, while lower frequency resulted in fewer branches. At 45, 60 DAS, and harvest, the highest number of branches per plant was recorded with three irrigations (I3) at 5.003, 5.317, and 6.015, respectively. The lowest number of branches per plant was recorded with no irrigation (I0) at 3.485, 3.961, and 4.210, respectively.

These findings align with broader research indicating that precise irrigation management positively impacts crop growth parameters. For instance, Guo and Li (2024) reviewed the effects of drip irrigation, highlighting its ability to improve crop growth by maintaining optimal soil moisture, which supports processes like photosynthesis

and nutrient mobilization. Similarly, Wang et al. (2022) emphasized the role of consistent irrigation in reducing water stress and enhancing vegetative growth, which is critical for branching. This suggests that improved water availability under higher irrigation frequencies promotes better plant performance by enabling efficient physiological and metabolic processes.

Effect of weed management: Weed management significantly influenced the number of branches per plant in sesame (Fig. 4). At 45 and 60 DAS, the highest number of branches per plant was observed with two hand weeding (W2) at 4.692 and 4.950, respectively, which was similar to herbicide application (W3). At harvest, W3 showed the highest number of branches per plant, comparable to W2. The lowest number of branches per plant was recorded with no weeding (W0).

These results align with broader studies on weed management's impact on crop morphology. Su (2024) emphasized that integrated weed management (IWM), combining chemical and manual approaches, effectively improves crop growth by mitigating weed competition during critical growth stages. Manual weeding and herbicide application both reduce resource competition, allowing plants to allocate more resources to secondary growth, such as branch formation. Furthermore, research highlights that environmental factors and herbicide efficacy are interconnected, influencing crop-weed interactions and overall plant development (Frontiers, 2024). Effective weed management not only improves branching but also enhances overall crop yield and quality.

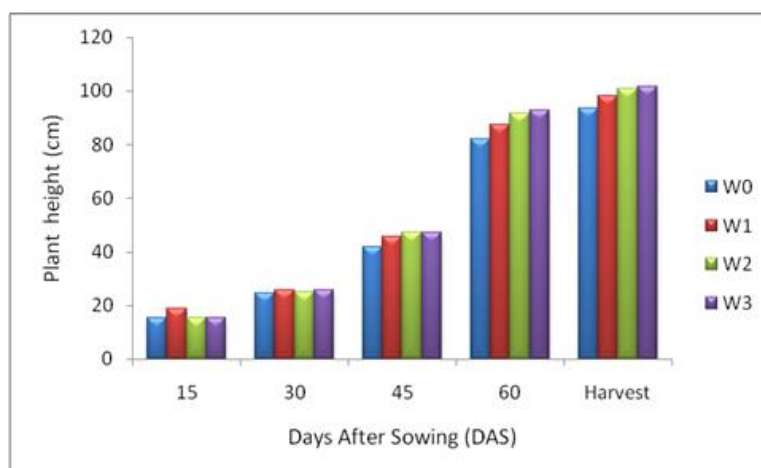


Fig. 2. Effect of weed management on plant height of sesame at different days after sowing (W₀ = No weeding; W₁ = One hand weeding at 20 DAS; W₂ = Two hand weeding at 20 and 40 DAS; W₃ = Application of herbicide at 20 and 40 DAS)

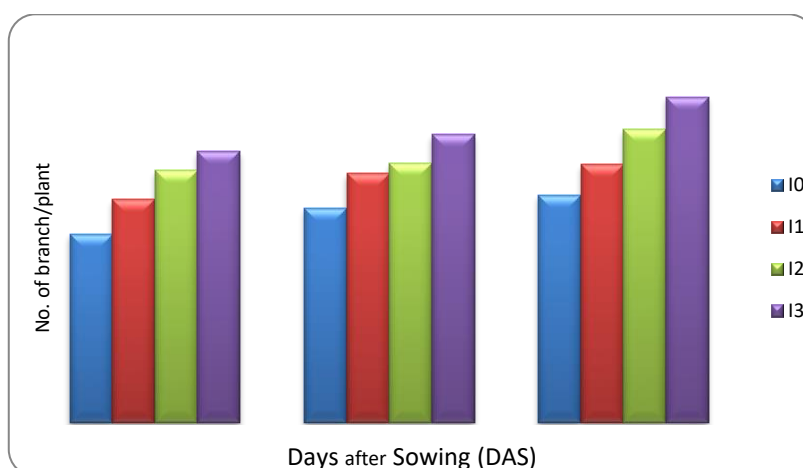


Fig. 3. Effect of irrigation frequency on number of branches plant⁻¹ of sesame at different days after sowing (I₀ = No irrigation; I₁ = Single irrigation at 20 DAS; I₂ = Two times irrigation at 20 and 40 DAS; I₃ = Three times irrigation at 20, 40 and 60 DAS)

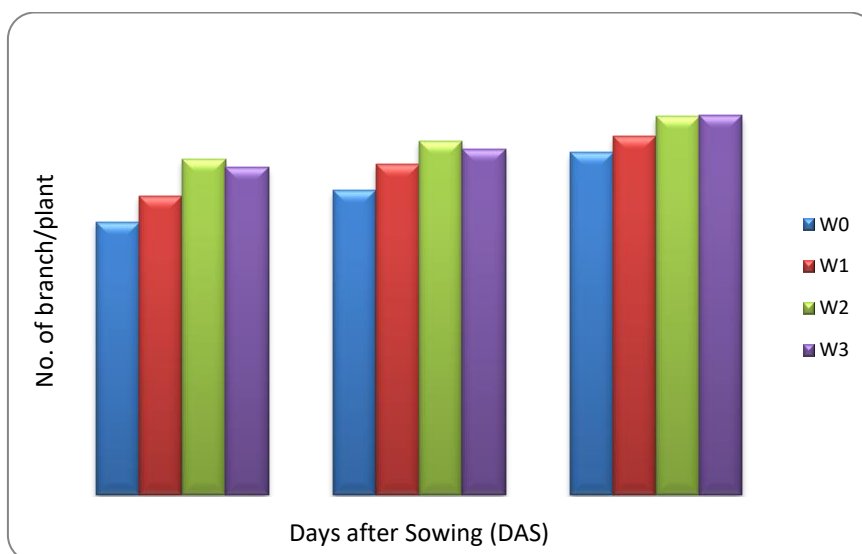


Fig. 4. Effect of weed management on number of branches plant⁻¹ of sesame at different days after sowing (W₀ = No weeding; W₁ = One hand weeding at 20 DAS; W₂ = Two hand weeding at 20 and 40 DAS; W₃ = Application of herbicide at 20 and 40 DAS)

3.3 Number of Leaves Plant⁻¹

Effect of irrigation frequency: Irrigation frequency significantly influenced the number of leaves per plant in sesame (Fig. 5). Higher irrigation frequency resulted in more leaves per plant. At 30, 45, and 60 DAS, plants receiving three irrigations (I₃) demonstrated the highest number of leaves per plant, with 13.08, 69.13, and 96.61 leaves, respectively. The lowest number of leaves per plant was recorded under no irrigation (I₀) at 11.47, 56.86, and 69.39 leaves, respectively.

These findings are consistent with studies indicating that improved water availability promotes photosynthesis and nutrient uptake, which are critical for leaf development. Rakibuzzaman et al. (2024) highlighted that precision irrigation enhances water use efficiency and supports optimal crop growth, particularly under water-sensitive conditions. Similarly, research by YH et al. (2024) emphasized the role of irrigation in delaying leaf senescence and improving photosynthetic efficiency, thereby increasing assimilate accumulation and leaf area. This underscores the importance of efficient

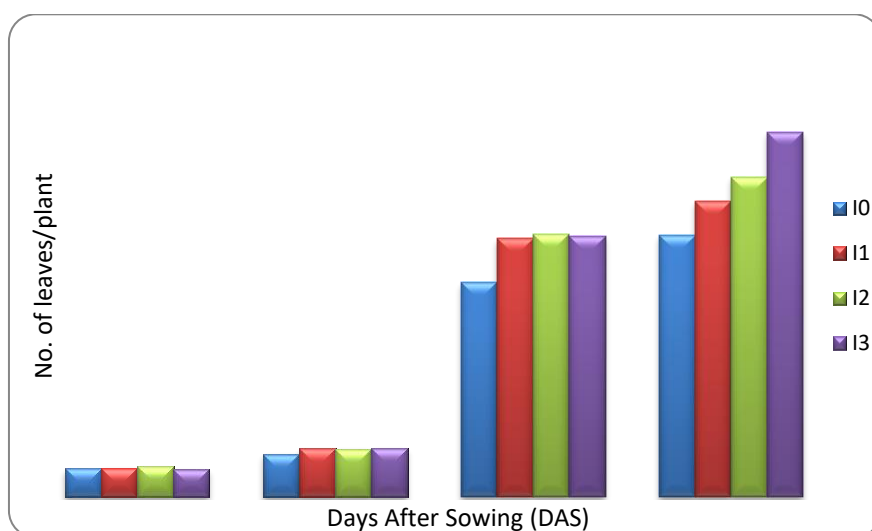


Fig. 5. Effect of irrigation frequency on number of leaves plant⁻¹ of sesame at different days after sowing (I₀ = No irrigation; I₁ = Single irrigation at 20 DAS; I₂ = Two times irrigation at 20 and 40 DAS; I₃ = Three times irrigation at 20, 40 and 60 DAS)

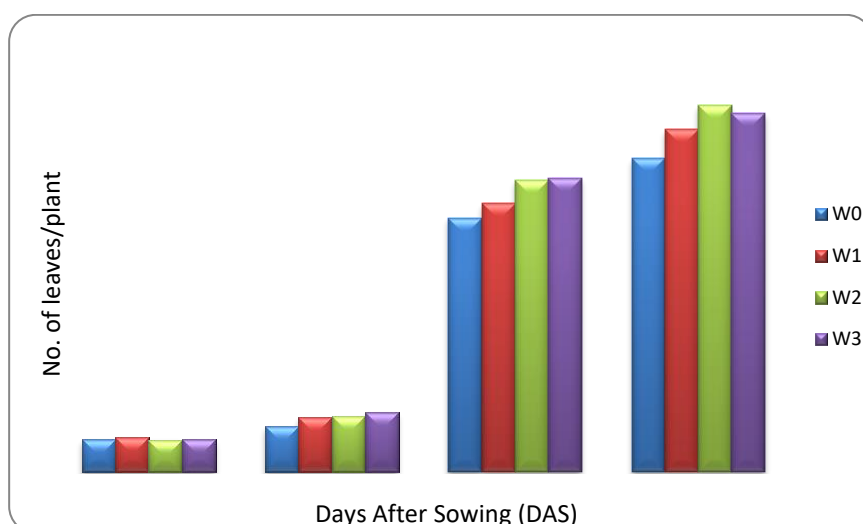


Fig. 6. Effect of weed management on number of leaves plant⁻¹ of sesame at different days after sowing (W₀ = No weeding; W₁ = One hand weeding at 20 DAS; W₂ = Two hand weeding at 20 and 40 DAS; W₃ = Application of herbicide at 20 and 40 DAS)

irrigation management in boosting sesame growth and yield potential.

Effect of weed management: Weed management significantly influenced the number of leaves per plant in sesame at different days after sowing (Fig. 6). At 30 and 45 DAS, the highest number of leaves per plant was observed with herbicide application at 20 and 40 DAS (W₃), showing 14.14 and 70.00 leaves, respectively. This result was significantly similar to two hand weedings at 20 and 40 DAS (W₂) at 45 DAS. At 60 DAS, the highest number of

leaves per plant was recorded with W₂. The lowest number of leaves per plant was consistently observed with no weeding (W₀).

This observation aligns with broader findings on weed management practices. Herbicide application, when timed appropriately, can significantly enhance plant growth by reducing competition for nutrients, water, and light. Mechanical weed control, such as hand weeding, has also proven effective in reducing weed density and improving plant vigor, especially when applied during critical growth stages

(Unger & McCalla, 1980). Moreover, sustainable practices like mulching suppress weed growth by preventing germination and blocking light, while simultaneously improving soil conditions (Weston, 1996; Verdeguer et al., 2020). These strategies underscore the importance of integrated weed management approaches in enhancing crop performance, including leaf production.

3.4 Effect of Irrigation Frequency on Number of Capsules Plant⁻¹, Number of Seeds Capsule⁻¹ and Weight of 1000 Seeds (g)

Irrigation frequency significantly influences sesame's growth and yield components, including the number of capsules per plant and seeds per capsule. Studies have shown that optimized irrigation schedules enhance these parameters. In this context, three irrigations at 20, 40, and 60 days after sowing (DAS) resulted in the highest number of capsules per plant (51.99) and seeds per capsule (56.29). Conversely, no irrigation resulted in the lowest values (45.21 capsules per plant and 49.98 seeds per capsule). Intermediate results were observed with two irrigations (I₂). The weight of 1000 seeds was also highest (3.172 g) with three irrigations (I₃), while no irrigation (I₀) resulted in the lowest weight (2.963 g), not significantly differing from one irrigation (I₁).

Advanced irrigation technologies, such as Variable Rate Irrigation (VRI) systems, have demonstrated improved water use efficiency, crucial for sesame cultivation in water-scarce regions (Ahmed et al., 2023). Additionally, seed treatments, including pelleting, are known to enhance plant height, lateral branching, and the number of capsules per plant, highlighting the role of pre-sowing interventions alongside irrigation management (Afzal et al., 2020). Seed priming techniques further improve germination uniformity and yield under stress conditions, which may complement irrigation strategies for better crop performance (Corbineau et al., 2023).

3.5 Effect of Weed Management on Number of Capsules Plant⁻¹, Number of Seeds Capsule⁻¹ and Weight of 1000 Seeds (g)

Weed management significantly influenced the number of capsules per plant, seeds per capsule, and the weight of 1000 seeds in sesame. The application of herbicides at 20 and 40 DAS (W₃) resulted in the highest number of capsules per plant (49.67) and seeds per capsule (54.48), with the lowest values recorded in the no weeding treatment (W₀) at 44.92 capsules per plant and 49.97 seeds per capsule. Similarly, the highest 1000 seed weight (3.132 g) was observed with W₃, while the lowest (3.026 g) was recorded with W₀. These findings are consistent with studies by Bhadauria et al. (2012).

Table 1. Effect of irrigation frequency on different yield contributing characters of sesame

Treatments	Number of capsules plant ⁻¹	Number of seeds capsule ⁻¹	Weight of 1000 seeds (g)
I ₀	45.21 d	49.98 d	2.963 b
I ₁	46.14 c	52.56 c	3.082 b
I ₂	48.97 b	53.97 b	3.155 a
I ₃	51.99 a	56.29 a	3.172 a
CV%	7.22	6.12	6.87
LSD (0.05)	0.80	0.18	0.091

I₀ = No irrigation; I₁ = Single irrigation at 20 DAS; I₂ = Two times irrigation at 20 and 40 DAS; I₃ = Three times irrigation at 20, 40 and 60 DAS

Table 2. Effect of weed management on different yield contributing characters of sesame

Treatments	Number of capsules plant ⁻¹	Number of seeds capsule ⁻¹	Weight of 1000 seeds (g)
W ₀	44.92 d	49.97 c	3.026 b
W ₁	48.22 c	53.93 b	3.091 b
W ₂	49.51 b	54.41 a	3.122 a
W ₃	49.67 a	54.48 a	3.132 a
CV%	5.23	6.42	7.62
LSD (0.05)	0.15	0.45	0.041

W₀ = No weeding; W₁ = One hand weeding at 20 DAS; W₂ = Two hand weeding at 20 and 40 DAS; W₃ = Application of herbicide at 20 and 40 DAS

Table 3. Effect of irrigation frequency on yield parameters of sesame

Treatments	Yield plant ⁻¹	Seed yield (tha ⁻¹)	Stover yield (tha ⁻¹)	Harvest Index (%)
I ₀	6.798 d	0.957 c	2.669 d	26.43 b
I ₁	7.434 c	1.025 bc	2.955 c	25.74 c
I ₂	8.257 b	1.144 ab	3.338 b	25.48 c
I ₃	9.261 a	1.282 a	3.424 a	27.13 a
CV%	5.37	7.40	8.53	9.35
LSD (0.05)	0.532	0.155	0.059	0.547

I₀ = No irrigation; I₁ = Single irrigation at 20 DAS; I₂ = Two times irrigation at 20 and 40 DAS; I₃ = Three times irrigation at 20, 40 and 60 DAS

Table 4. Effect weed management practices on yield parameters of sesame

Treatments	Seed yield plant ⁻¹	Seed yield (tha ⁻¹)	Stover yield (tha ⁻¹)	Harvest Index (%)
W ₀	6.804 c	0.967 c	3.002 c	24.54 c
W ₁	8.071 b	1.106 b	3.104 b	26.24 b
W ₂	8.425 a	1.164 a	3.119 a	27.08 a
W ₃	8.451 a	1.171 a	3.162 a	26.93 a
CV%	8.20	8.60	7.79	8.25
LSD (0.05)	0.026	0.053	0.057	0.381

W₀ = No weeding; W₁ = One hand weeding at 20 DAS; W₂ = Two hand weeding at 20 and 40 DAS; W₃ = Application of herbicide at 20 and 40 DAS

3.6 Effect of Irrigation Frequency on Seed Yield Plant⁻¹ (g) Seed Yield (tha⁻¹) Stover yield (tha⁻¹) and Harvest Index (%)

Seed yield per plant and per hectare, along with stover yield and harvest index, were significantly influenced by irrigation frequency (Table 3). Three irrigations at 20, 40, and 60 DAS (I₃) resulted in the highest seed yield per plant (9.261 g) and per hectare (1.28 t ha⁻¹), stover yield (3.424 t ha⁻¹), and harvest index (27.13%). The lowest values for these metrics were recorded with no irrigation (I₀). Two irrigations (I₂) and a single irrigation (I₁) showed intermediate results, consistent with findings by Zhang et al. (2021), Garai and Datta (1999), El-Sayed et al. (2024), and Islam et al. (2024)

3.7 Effect of Weed Management on Seed Yield plant⁻¹ (g), Seed Yield (tha⁻¹), STOVER Yield (tha⁻¹) and Harvest Index (%)

Weed management significantly influenced seed yield per plant, total seed yield, stover yield, and harvest index in sesame (Table 4). The highest seed yield per plant (8.451 g) and total seed yield (1.171 t ha⁻¹) were observed with herbicide application at 20 and 40 DAS (W₃), which was statistically similar to two hand weedings at the

same times (W₂). The lowest yields were recorded with no weeding (W₀). Similarly, the highest stover yield (3.162 t ha⁻¹) and harvest index (27.08%) were observed with W₃, while the lowest values were recorded with W₀. Intermediate results were seen with other weed management practices. These findings align with results reported by Ahmad (2010) and Singh (2001), as well as Garai and Datta (1999) and Chaudhuri and Ghosh (2020).

4. CONCLUSION

The study highlights that three irrigations applied at 20, 40, and 60 days after sowing (I₃) significantly enhanced sesame growth and yield, outperforming all other irrigation treatments. Among weed management strategies, post-emergent herbicide application at 20 and 40 DAS (W₃) demonstrated superior results, minimizing weed competition and optimizing crop performance. The interaction between irrigation and weed treatments was statistically significant, with the combination of three irrigations (I₃) and post-emergent herbicide application (W₃) yielding the highest seed output (1.282 t ha⁻¹). This suggests that integrated irrigation schedules and herbicide-based weed control can synergistically maximize sesame productivity. These findings are particularly valuable for farmers and researchers aiming to enhance yields in resource-limited agricultural systems.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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