**Effects of sowing dates and weed management practices on Growing Degree Days, Helio thermal and Photothermal units of summer sesame in some parts of India**

**Abstract**

The present study aimed to determines the effect of dates of sowing and weed management practices on summer sesame in new alluvial zone of West Bengal. For synchronizing different stages of plant growth with environmental conditions, the appropriate sowing date is considered one of the most important determining factors for obtaining optimum yield. Sesame is considered as a drought tolerant crop therefore mainly grown as dry land crop especially in Indian sub-continent where sowing time is dependent upon the availability of moisture, therefore sowing is delayed. A field experiment was conducted during the summers of 2022 and 2023 at the Instructional Farm, Jaguli. Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal, India. The experiment was laid out in a split-plot design with three main plot treatments (dates of sowing) and eight subplot treatments (weed management practices) replicated thrice. The sesame variety ‘Savitri was chosen for the experiment. Results indicated that only the thermal indices (growing degree days, helio thermal units, and photothermal units) of sesame were significantly influenced by the dates of sowings. Weed management practices and interaction between dates of sowing and weed management practices were found to be non-significant. Among the dates of sowings, sowing on March 22nd recorded maximum growing degree days (1811.10 °C), helio thermal units (13244.85 °C hour), and photothermal units (22695.76 °C hour), and the minimum was recorded at sowing on February 21st. Significant effect of sowing date on photothermal units of sesame was noticed for all the five phenophases as well as entire life cycle in the study and summed PTU for entire life cycle followed the same trend of as of summed Growing degree days (GDD) and summed Helio thermal units (HTU) for entire life cycle.

**Key words:** *Sowing date, weed management, growing degree days, helio**thermal units,*

*photothermal units.*

**INTRODUCTION**

India's agricultural economy has been based primarily on oilseed crops. In India, sesame is not only a major oilseed crop but also a valuable crop of high-grade protein. Climate change has reduced plant productivity and raised issues with food security. In this regard, sesamum reveals intriguing components that set it apart as a special oilseed crop to satisfy the oilseed requirement (Rajesh, 2024; Chavhan et al., 2023s). Sesame (*Sesamum indicum* L.) is one of the most important oilseed crops next to groundnut, rapeseed and mustard in India and the family of Pedaliaceae. It is one of the important oilseed crops in India. The crop has earned the poetic label “Queen of oilseeds” due to its high-quality poly-unsaturated stable fatty acid. Sesame is typically a crop of small farmers in developing countries and is considered as a drought-tolerant crop (Jefferson, 2003). Boureima *et al*. (2011) indicated that sesame is one of the stress-tolerant crop that produces sorts of chemical components, unavailable in other edible oil crops that provide a resistance to oxidative rancidity. Sesame is a short-day plant and flowers in 42-45 days when exposed to 10-hour day length (Weiss, 1983). It draws its importance from the fact that it is a food crop, a raw material for industry, as well as a leading export crop. Sesame seed contains about 50% oil, 25% protein, 20% carbohydrate in addition to amounts of vitamins, minerals, antioxidants and all essential amino and fatty acids. Also, seed meal is an excellent high protein (34-50%). Sesame oil cake is a very good cattle feed since it contains protein of high biological value and appreciable quantities of phosphorus and potash. It is widely grown in tropical and subtropical regions. Globally, India is the largest producer, consumer and exporter of sesame. Sesame yield is highly variable depending on the growing environment, cultural practices and cultivars (Brigham, 1985). The yielding ability of sesame crops is determined by many yield components, all of which are substantially influenced by environmental conditions and agronomic packages. Among them, sowing time and weed competition with crops is very important. Agro-meteorological indices like growing degree days (GDD), photothermal units (PTU) and hydrothermal units (HTU) are utilized for assessing the impact of climatic variables on a particular crop during different phenological stage. Distinct temperatures are necessary for a plant to complete different phenological phases. Accumulated heat units or GDD serve as a reliable indication for estimating the duration required for a crop to reach certain phenological phases (Mir et al., 2024).

For synchronizing different stages of plant growth with environmental conditions, the appropriate sowing date is considered one of the most important determining factors for obtaining optimum yield. Sesame is considered as a drought-tolerant crop therefore mainly grown as dry land crop, especially in Indian sub-continent where sowing time is dependent upon the availability of moisture, therefore sowing is delayed.

By selecting the appropriate sowing date, and different stages of plant growth with environmental conditions adapted that increase the efficiency of photosynthesis, thus assimilating stored seeds is desirable ( Erhart *et al*., 2005). Determining the optimum time of sowing, which in turn improves unit land area utilization and selecting a cultivar with a high average yield is a major factor in ensuring a profitable return of sesame (Hamza and Abd El Salam, 2015). Delayed sowing leads to discouraged growers resulting in less acerage under sesame cultivation. It increased the incidence of pests and diseases (El-Bakheit, 1985)**.** Delayed sowing consequently reduced the maturity period of sesame (Stumpf, 1959).

Among the several constraints in sesame production, weed infestation is one of the major factor limiting the yield of sesame. Sowing of sesame seeds is very difficult because of its small size and need to be placed precisely at an optimum depth of sowing for good germination and establishment. Further, sesame seedlings are small and tender coupled with slow initial growth compared to other oilseed crops resulting in increased weed infestation. The severity of yield loss depends upon the type of weed flora and the time of weed infestation in a given agro-climatic condition. The yield loss due to uncontrolled weed growth in sesame has been reported as high as 50 per cent (Dungarwal*et al.*, 2003).

Weeds limit the yield of sesame, as its seedling's growth are slow during the first four weeks making it a poor competitor at earlier stages of crop growth (Bennett *et al*., 2003). Weeds cause enormous stress at the initial growth stages that affect the economic yields of sesame. The presence of weeds can reduce the sesame yield up to 60% (Ibrahim *et al*., 1988). Amare *et al.* (2009) found a critical period of weed competition in sesame crops between 15 and 30 days after seedlings emergence. So, during that period, the crop ought to be maintained in weed-free condition in order to realize maximum yield. Though manual weeding is effective and eco-friendly yet they are tedious and time-consuming

Hand weeding is the commonest method of weed control by farmers, however, it is not only labour intensive, but also expensive and strenuous coupled with the non-availability of labour during peak periods of agricultural operations and high labour wages forcing the farmers for other options. Chemical weed management remains only as the viable option and herbicides offer ample scope for economic control of weeds right from the sowing.

A suitable, economically viable and ecologically safe combination of chemicals with manual weeding would help to achieve control of the weeds and reduce the yield loss. Keeping in view, the present study aimed to determine the effect of dates of sowing and weed management practices on summer sesame in new alluvial zone of West Bengal.

**MATERIALS AND METHODS**

A field experiment entitled “Effect of dates of sowing and weed management practices on summer sesame in the new alluvial zone of West Bengal was conducted during summer season of 2022 and 2023 at Instructional farm, Jaguli. Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal. The soil of the experimental site was clay loam in texture, near neutral in reaction (pH: 6.5) and non-saline (EC 0.3); medium in organic carbon (0.68), low available nitrogen (196.76 kg ha-1) and high in available phosphorus (24 P2O5 kg ha-1) and available potassium (294.5 K2O kg ha-1). The experiment was laid out in split plot design with three main plot treatments (dates of sowing) and eight subplot treatments (weed management practices) replicated thrice. Main plot treatments comprised of three dates of sowing i.e. D1: Sowing on February 21st, D2: Sowing on March 7th, and D3: Sowing on March 22nd.Sub plot treatments comprised of eight weed management practices i.e. W1. Pendimethalin @ 1 kg a.i. ha-1 [2 DAS (days after sowing)] + Hand weeding (30 DAS),W2:: Butachlor@ 1kga.i. ha-1(2 DAS)+Hand weeding(30 DAS),W3: Hand weeding(15DAS) + Quizalofop ethyl @ 50 g a.i. ha-1 (30 DAS), W4: Pendimethalin @ 1 kg a.i.ha-1 (2 DAS) + Quizalofop ethyl @ 50 ga.i. ha-1 (30 DAS), W5: Butachlor @ 1 kg a.i.ha-1 (2 DAS) + Quizalofop ethyl @ 50 g a.i. ha-1 (30 DAS),W6: Hand weeding (15 DAS) + Hand weeding(30DAS),W7:WeedycheckandW8:Weed free check. Sesamevariety ‘Savitri’was chosen for the experiment.

Throughout the crop's growing season, all advised cultural practices and plant protection techniques were followed. “Observation like plant height, dry matter accumulation, leaf area index, number of branches per plant, number of capsules per plants, number of seeds per capsule, seed yield and stalk yield were taken using standard procedures from five randomly selected tagged plants from each plot. Harvesting was done as per the treatments and maturity of crop, respectively. Threshing was done plot wise and the seed yield from the netplot was converted into kg ha-1to which the yield from five tagged plants was also added. For calculating gross return, net return and B:C ratio.

**RESULTS AND DISCUSSION**

1. **Growing degree days (GDD)**

From pooled data on growing degree days of sesame, crop revealed that there was significant influence with dates of sowing only. Interactions between dates of sowing and weed management practices were found to be non-significant.

From pooled data, it was observed that summed GDD for the entire life cycle of sesame was gradually increased with delay in sowing from 21st February to 22nd march during the summer season. Maximum (1811.10 oC ) growing degree days was noticed under 22nd march sowing and minimum ( 1777.17 oC)was observed under early sowing date i.e. 21st February. Weed management practices significantly not influence the growing degree days.

Increased growing degree days in sesame crop at late sowing was due to increasing temperatures with delay in sowing from 21st February to 22nd March in the study. Similar findings were reported by Adhikary *et al*. (2021).

**2. Helio thermal units (HTU)**

There was a variation in accumulated helio thermal units at different phenophases as well as life cycle of the sesame crop during summer season in 2022 and 2023, due to the variation in mean daily temperature and bright sunshine hour among three sowing dates studied in the experiment. Early sowing (21st February) of sesame recorded the lowest summed total HTU (12514.18 °C day hour) for the entire life cycle, which was gradually increased due to delay in sowing on 7th March ( 13208. 79 °C day hour) and 22nd March (13244.85 °C day hour) in the investigation due to increased bright sunshine hours in summer season. This might be due to increasing bright sunshine hours in the summer season with a delay in sowing from 21st February to 22nd March in the study. These results corroborated the findings of Adhikary *et al*. (2021).

**3.Photothermal units (PTU)**

Temperature generally governed the onset of different phenophases in sesame crop, but day length had also an influence on photothermal requirements of the crop. Significant effect of sowing date on photothermal units of sesame was noticed for all the five phenophases as well as the entire life cycle in the study and summed PTU for the entire life cycle followed the same trend as of summed GDD and summed HTU for the entire life cycle. i.e. early sowing (21st February) of sesame recorded the lowest summed total PTU (21578.33°C day hour) for the entire life cycle, which gradually increased with phenophases with delay in sowing from 21st February to 22nd March in the study due to increasing bright day length in summer season. These results were in accordance with the findings of Adhikary *et al*. (2021).

**Table.1 Effect of dates of sowing and weed management practices on growing degree days of summer sesame**

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| **Growing degree days, GDD (OC)** |
|  | **Sowing- emergence** | **Sowing-flower initiation** | **Days to 50% flowering** | **Flowering to maturity** | **Sowing to maturity** |
| **2022** | **2023** | **pooled** | **2022** | **2023** | **Pooled** | **2022** | **2023** | **Pooled** | **2022** | **2023** | **Pooled** | **2022** | **2023** | **Pooled** |
| **Date of sowing** |
| **D1** | 83.07 | 133.81 | 108.44 | 615.64 | 600.22 | 607.93 | 881.26 | 821.71 | 851.49 | 632.32 | 616.80 | 624.56 | 1775.75 | 1778.60 | 1777.17 |
| **D2** | 133.73 | 109.55 | 121.64 | 699.99 | 610.61 | 655.30 | 948.15 | 858.43 | 903.29 | 675.21 | 592.39 | 633.80 | 1829.71 | 1772.56 | 1801.13 |
| **D3** | 150.70 | 104.15 | 127.43 | 679.80 | 644.83 | 662.31 | 937.24 | 853.54 | 895.39 | 639.18 | 612.17 | 625.68 | 1828.98 | 1793.21 | 1811.10 |
| **SE (m±)** | 0.977 | 1.080 | 0.887 | 6.511 | 6.176 | 2.706 | 9.328 | 8.430 | 8.827 | 12.464 | 10.431 | 9.013 | 6.681 | 13.365 | 7.872 |
| **C.D.at 5%** | 3.835 | 4.240 | 3.481 | 25.563 | 24.245 | 10.622 | 36.622 | 33.094 | 34.653 | 48.931 | 40.950 | 35.385 | 26.228 | 52.468 | 30.906 |
| **Weed management practices** |
| **W1** | 128.25 | 122.68 | 125.46 | 713.17 | 661.71 | 687.44 | 973.11 | 898.88 | 935.99 | 688.94 | 659.26 | 674.10 | 1844.91 | 1854.34 | 1849.63 |
| **W2** | 123.16 | 117.17 | 120.16 | 669.60 | 620.07 | 644.84 | 937.07 | 856.15 | 896.61 | 666.13 | 618.11 | 642.12 | 1817.22 | 1781.43 | 1799.33 |
| **W3** | 121.98 | 113.17 | 117.58 | 651.08 | 608.31 | 629.70 | 914.19 | 836.97 | 875.58 | 647.78 | 602.33 | 625.06 | 1809.31 | 1759.57 | 1784.44 |
| **W4** | 116.53 | 110.17 | 113.35 | 623.49 | 585.11 | 604.30 | 869.94 | 791.17 | 830.55 | 594.17 | 553.37 | 573.77 | 1782.49 | 1716.90 | 1749.70 |
| **W5** | 120.55 | 111.31 | 115.93 | 630.32 | 589.84 | 610.08 | 891.58 | 813.92 | 852.75 | 622.86 | 580.11 | 601.48 | 1787.93 | 1737.00 | 1762.47 |
| **W6** | 126.94 | 120.14 | 123.54 | 695.05 | 643.47 | 669.26 | 956.49 | 875.81 | 916.15 | 671.17 | 637.92 | 654.54 | 1830.16 | 1812.71 | 1821.44 |
| **W7** | 106.04 | 103.39 | 104.71 | 603.41 | 560.78 | 582.09 | 838.91 | 761.44 | 800.18 | 570.13 | 526.90 | 548.51 | 1770.93 | 1707.48 | 1739.20 |
| **W8** | 136.54 | 128.65 | 132.59 | 735.03 | 679.12 | 707.07 | 996.47 | 922.14 | 959.31 | 730.06 | 678.94 | 704.50 | 1848.89 | 1882.21 | 1865.55 |
| **SEm±** | 2.956 | 1.939 | 1.642 | 4.399 | 4.678 | 4.041 | 5.342 | 5.656 | 5.387 | 43.931 | 38.950 | 36.385 | 28.228 | 56.468 | 33.906 |
| **C.D.at 5%** | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| **Interaction (DxW)** |
| **D1W1** | 92.30 | 141.55 | 116.925 | 660.50 | 638.20 | 649.35 | 932.55 | 885.70 | 909.13 | 666.60 | 662.38 | 664.49 | 1843.85 | 1841.98 | 1842.92 |
| **D1W2** | 80.23 | 134.30 | 107.267 | 622.33 | 604.10 | 613.21 | 898.16 | 829.96 | 864.07 | 641.50 | 623.27 | 632.38 | 1789.17 | 1782.03 | 1785.60 |
| **D1W3** | 80.10 | 130.30 | 105.200 | 603.05 | 593.36 | 598.20 | 870.06 | 816.36 | 843.22 | 628.73 | 613.25 | 620.99 | 1871.32 | 1739.95 | 1805.63 |
| **D1W4** | 80.10 | 127.30 | 103.700 | 577.30 | 581.11 | 579.20 | 827.80 | 763.43 | 795.62 | 577.30 | 570.30 | 573.80 | 1703.55 | 1762.05 | 1732.80 |

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| **D1W5** | 80.10 | 136.65 | 108.375 | 583.70 | 576.36 | 580.03 | 848.43 | 789.95 | 819.19 | 603.05 | 593.37 | 598.21 | 1755.43 | 1721.32 | 1738.38 |
| **D1W6** | 88.35 | 138.66 | 113.508 | 641.50 | 618.00 | 629.75 | 919.05 | 850.15 | 884.60 | 685.58 | 644.83 | 665.21 | 1689.67 | 1812.05 | 1750.86 |
| **D1W7** | 67.03 | 108.41 | 87.725 | 551.41 | 540.65 | 546.03 | 794.05 | 737.45 | 765.75 | 551.42 | 546.45 | 548.93 | 1736.15 | 1696.50 | 1716.33 |
| **D1W8** | 96.33 | 153.26 | 124.800 | 685.30 | 649.93 | 667.61 | 960.00 | 900.66 | 930.33 | 704.35 | 680.52 | 692.43 | 1816.88 | 1872.88 | 1844.88 |
| **D2W1** | 148.65 | 111.65 | 130.150 | 728.78 | 638.46 | 683.62 | 987.03 | 892.51 | 939.78 | 735.77 | 625.13 | 680.45 | 1903.33 | 1818.95 | 1861.14 |
| **D2W2** | 132.40 | 112.40 | 122.400 | 707.16 | 611.61 | 659.39 | 966.56 | 874.61 | 920.59 | 684.92 | 598.40 | 641.66 | 1877.33 | 1788.80 | 1833.07 |
| **D2W3** | 140.40 | 108.40 | 124.400 | 685.06 | 598.40 | 641.73 | 937.78 | 850.25 | 894.02 | 670.10 | 584.92 | 627.51 | 1819.57 | 1751.47 | 1785.52 |
| **D2W4** | 124.05 | 105.40 | 114.725 | 655.13 | 565.21 | 610.17 | 893.55 | 808.76 | 851.16 | 613.07 | 538.70 | 575.88 | 1791.47 | 1677.98 | 1734.73 |
| **D2W5** | 129.50 | 99.400 | 114.450 | 662.567 | 577.98 | 620.275 | 915.583 | 832.017 | 873.80 | 640.97 | 558.28 | 599.63 | 1737.05 | 1729.30 | 1733.18 |
| **D2W6** | 140.40 | 114.433 | 127.417 | 750.217 | 659.65 | 704.933 | 1001.21 | 904.450 | 952.83 | 713.97 | 652.68 | 683.33 | 1871.32 | 1847.02 | 1859.17 |
| **D2W7** | 118.83 | 103.950 | 111.392 | 640.533 | 551.68 | 596.108 | 857.400 | 774.717 | 816.06 | 585.78 | 506.37 | 546.08 | 1785.17 | 1692.93 | 1739.05 |
| **D2W8** | 135.57 | 120.750 | 128.158 | 770.483 | 681.85 | 726.167 | 1026.10 | 930.117 | 978.11 | 757.15 | 674.60 | 715.88 | 1852.47 | 1874.00 | 1863.23 |
| **D3W1** | 156.85 | 104.800 | 130.825 | 679.300 | 644.50 | 661.900 | 946.467 | 863.867 | 905.17 | 671.97 | 632.67 | 652.32 | 1785.17 | 1773.47 | 1779.32 |
| **D3W2** | 143.82 | 110.117 | 126.967 | 714.867 | 673.93 | 694.400 | 963.383 | 884.750 | 924.07 | 592.15 | 643.80 | 617.98 | 1897.48 | 1807.13 | 1852.31 |
| **D3W3** | 145.45 | 100.800 | 123.125 | 665.133 | 633.16 | 649.150 | 934.717 | 844.283 | 889.50 | 644.50 | 608.83 | 626.67 | 1737.05 | 1787.30 | 1762.18 |
| **D3W4** | 145.45 | 97.800 | 121.625 | 638.033 | 609.00 | 623.517 | 888.467 | 801.300 | 844.88 | 592.15 | 551.12 | 571.63 | 1852.47 | 1710.67 | 1781.57 |
| **D3W5** | 152.05 | 97.867 | 124.958 | 644.683 | 615.16 | 629.925 | 910.733 | 819.800 | 865.27 | 624.55 | 588.67 | 606.61 | 1871.32 | 1760.38 | 1815.85 |
| **D3W6** | 152.05 | 112.050 | 132.050 | 728.800 | 687.26 | 708.033 | 985.567 | 906.483 | 946.03 | 686.27 | 662.70 | 674.48 | 1819.57 | 1874.02 | 1846.79 |
| **D3W7** | 132.25 | 97.800 | 115.025 | 618.267 | 590.00 | 604.133 | 865.283 | 772.167 | 818.73 | 573.18 | 527.88 | 550.53 | 1791.47 | 1733.00 | 1762.23 |
| **D3W8** | 177.72 | 111.933 | 144.825 | 749.300 | 705.56 | 727.433 | 1003.32 | 935.633 | 969.48 | 728.67 | 681.70 | 705.18 | 1877.33 | 1899.73 | 1888.53 |
| **SE (m±)** |
| **D\*W** | 0.977 | 1.080 | 0.887 | 6.511 | 6.176 | 2.706 | 9.328 | 8.430 | 8.827 | 48.931 | 40.950 | 35.385 | 26.228 | 52.468 | 30.906 |
| **W\*D** | 2.956 | 1.939 | 1.642 | 4.399 | 4.678 | 4.041 | 5.342 | 5.656 | 5.387 | 43.931 | 38.950 | 36.385 | 28.228 | 56.468 | 33.906 |
| **C.D.at 5%** |
| **D\*W** | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| **W\*D** | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

**Table.2 Effect of dates of sowing and weed management practices on heliothermal units of summer sesame**

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| **Heliothermal units, HTU (OC day hour)** |
|  | **Sowing- emergence** | **Sowing-flower initiation** | **Days to 50% flowering** | **Flowering to maturity** | **Sowing to maturity** |
| **2022** | **2023** | **pooled** | **2022** | **2023** | **Pooled** | **2022** | **2023** | **Pooled** | **2022** | **2023** | **Pooled** | **2022** | **2023** | **Pooled** |
| **Date of sowing** |
| **D1** | 611.13 | 1002.03 | 806.58 | 4878.12 | 3790.62 | 4334.37 | 7030.89 | 5748.59 | 6389.74 | 5066.96 | 3920.43 | 4493.70 | 11676.20 | 13352.17 | 12514.18 |
| **D2** | 1241.74 | 691.88 | 966.81 | 5465.94 | 4025.05 | 4745.50 | 7608.75 | 6032.17 | 6820.46 | 5250.50 | 3846.44 | 4548.47 | 13271.29 | 13146.28 | 13208.79 |
| **D3** | 1034.49 | 855.89 | 945.19 | 5344.03 | 5240.14 | 5292.09 | 7095.59 | 6826.67 | 6961.13 | 5140.32 | 5023.95 | 5082.14 | 12973.31 | 13516.40 | 13244.85 |
| **SE (m±)** | 9.765 | 7.212 | 4.748 | 52.746 | 52.85 | 52.307 | 80.794 | 61.512 | 58.257 | 99.911 | 73.050 | 86.236 | 54.637 | 99.461 | 43.359 |
| **C.D.at 5%** | 38.338 | 28.315 | 18.640 | 207.075 | 207.48 | 205.353 | 317.188 | 241.491 | 228.711 | 392.239 | 286.788 | 338.552 | 214.498 | 390.472 | 170.225 |
| **Weed management practices** |
| **W1** | 1010.40 | 898.45 | 954.43 | 5487.99 | 4540.32 | 5014.16 | 7624.98 | 6673.68 | 7149.33 | 5607.43 | 4313.44 | 4960.44 | 12792.86 | 13729.22 | 13244.46 |
| **W2** | 978.12 | 868.45 | 923.29 | 5287.89 | 4340.90 | 4814.39 | 7310.28 | 6273.27 | 6791.78 | 5234.25 | 4271.32 | 4752.78 | 12755.95 | 13429.39 | 13092.67 |
| **W3** | 952.88 | 838.87 | 895.88 | 5141.20 | 4284.53 | 4712.86 | 7286.43 | 6119.61 | 6703.02 | 5087.11 | 4266.62 | 4676.86 | 12681.24 | 13246.88 | 12964.06 |
| **W4** | 908.08 | 802.98 | 855.53 | 4921.32 | 4193.84 | 4557.58 | 6836.71 | 5761.49 | 6299.10 | 4677.08 | 4208.51 | 4442.79 | 12451.12 | 12979.38 | 12715.25 |
| **W5** | 943.13 | 826.51 | 884.82 | 4977.30 | 4202.69 | 4590.00 | 7015.81 | 5927.92 | 6471.87 | 4909.40 | 4246.06 | 4577.73 | 12464.87 | 13022.48 | 12743.68 |
| **W6** | 998.88 | 880.25 | 939.56 | 5456.62 | 4486.22 | 4971.42 | 7529.68 | 6458.52 | 6994.10 | 5428.94 | 4291.66 | 4860.30 | 12759.69 | 13568.89 | 13164.29 |
| **W7** | 831.86 | 771.21 | 801.54 | 4748.33 | 4161.08 | 4454.71 | 6591.85 | 5532.66 | 6062.25 | 4494.87 | 4190.42 | 4342.65 | 12421.07 | 12845.38 | 12633.22 |
| **W8** | 1076.28 | 912.74 | 994.51 | 5814.25 | 4605.94 | 5210.10 | 7764.90 | 6872.64 | 7318.77 | 5781.67 | 4320.83 | 5051.25 | 12828.49 | 13884.63 | 13356.56 |
| **SEm±** | 23.223 | 17.583 | 13.638 | 35.679 | 35.797 | 26.776 | 47.350 | 46.431 | 44.018 | 30.541 | 35.883 | 26.527 | 41.894 | 52.952 | 25.627 |
| **C.D.at 5%** | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

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| **Interaction (DxW)** |
| **D1W1** | 579.62 | 1043.00 | 811.31 | 4979.43 | 3903.56 | 4441.49 | 7143.31 | 5823.26 | 6483.28 | 5095.95 | 3910.85 | 4503.40 | 12232.99 | 13257.93 | 12745.46 |
| **D1W2** | 648.75 | 1065.79 | 857.27 | 4694.66 | 4145.86 | 4420.26 | 7174.33 | 6034.44 | 6604.38 | 5295.83 | 4095.96 | 4695.89 | 11960.84 | 13367.48 | 12664.16 |
| **D1W3** | 589.37 | 1013.42 | 801.39 | 4868.34 | 3738.90 | 4303.62 | 7087.80 | 5690.16 | 6388.98 | 5019.75 | 3809.88 | 4414.81 | 11717.45 | 13125.34 | 12421.39 |
| **D1W4** | 579.62 | 977.52 | 778.57 | 4694.66 | 3211.29 | 3952.97 | 6752.10 | 5184.82 | 5968.46 | 4694.66 | 3603.45 | 4149.06 | 11348.00 | 13202.96 | 12275.48 |
| **D1W5** | 579.62 | 1041.05 | 810.33 | 4747.14 | 3419.51 | 4083.32 | 6904.24 | 5430.76 | 6167.50 | 4868.34 | 3812.89 | 4340.61 | 11399.06 | 13129.05 | 12264.05 |
| **D1W6** | 683.32 | 1087.78 | 885.55 | 50 95.95 | 4353.52 | 4724.73 | 7275.59 | 6373.67 | 6824.63 | 5454.55 | 4245.45 | 4850.00 | 11960.84 | 13482.69 | 12721.76 |
| **D1W7** | 512.73 | 882.47 | 697.60 | 4488.16 | 2976.61 | 3732.38 | 6566.81 | 4948.97 | 5757.89 | 4488.16 | 3466.70 | 3977.43 | 11274.37 | 13189.76 | 12232.06 |
| **D1W8** | 715.99 | 905.24 | 810.62 | 5456.63 | 4575.72 | 5016.17 | 7342.96 | 6502.62 | 6922.79 | 5618.49 | 4418.31 | 5018.40 | 11516.02 | 14062.18 | 12789.10 |
| **D2W1** | 1227.56 | 709.54 | 968.55 | 5455.44 | 3950.46 | 4702.95 | 7805.32 | 6107.55 | 6956.44 | 5391.64 | 3766.26 | 4578.95 | 13552.44 | 13390.68 | 13471.56 |
| **D2W2** | 1325.66 | 688.84 | 1007.25 | 5858.23 | 3990.85 | 4924.54 | 7952.51 | 6243.88 | 7098.20 | 5508.39 | 3540.82 | 4524.60 | 13263.70 | 13482.90 | 13373.30 |
| **D2W3** | 1237.31 | 679.96 | 958.63 | 5334.24 | 3977.14 | 4655.69 | 7551.79 | 5965.61 | 6758.70 | 5166.50 | 3946.24 | 4556.37 | 13705.76 | 13000.64 | 13353.20 |
| **D2W4** | 1178.51 | 644.06 | 911.28 | 5140.11 | 4170.46 | 4655.28 | 7124.11 | 5717.92 | 6421.02 | 4763.47 | 4399.58 | 4581.53 | 13077.27 | 12745.51 | 12911.39 |
| **D2W5** | 1227.56 | 620.61 | 924.08 | 5182.00 | 4031.17 | 4606.58 | 7341.53 | 5846.75 | 6594.14 | 5040.81 | 4097.50 | 4569.15 | 13214.27 | 12852.69 | 13033.48 |
| **D2W6** | **1325.66** | 688.84 | 1007.25 | 5858.23 | 3990.85 | 4924.54 | 7952.51 | 6243.88 | 7098.20 | 5508.39 | 3540.82 | 4524.60 | 13263.70 | 13482.90 | 13373.30 |
| **D2W7** | 1128.95 | 576.61 | 852.78 | 4971.48 | 4256.53 | 4614.00 | 6810.86 | 5474.42 | 6142.64 | 4588.99 | 4642.66 | 4615.82 | 12829.49 | 12570.40 | 12699.94 |
| **D2W8** | 1282.76 | 905.42 | 1094.09 | 6040.68 | 3902.63 | 4971.65 | 8210.77 | 6555.25 | 7383.01 | 5862.61 | 3040.81 | 4451.71 | 13263.70 | 13539.67 | 13401.69 |
| **D3W1** | 1127.18 | 852.82 | 990.00 | 5428.80 | 5168.69 | 5298.74 | 6982.21 | 6889.01 | 6935.61 | 5215.15 | 5136.84 | 5176.00 | 12482.41 | 13639.58 | 13060.99 |
| **D3W2** | 1022.22 | 886.12 | 954.17 | 5816.98 | 5321.96 | 5569.47 | 7462.21 | 7097.24 | 7279.72 | 5482.61 | 5238.22 | 5360.41 | 13054.53 | 13856.30 | 13455.41 |
| **D3W3** | 1031.97 | 823.24 | 927.61 | 5221.01 | 5137.53 | 5179.27 | 7219.69 | 6703.05 | 6961.37 | 5075.10 | 5043.73 | 5059.41 | 12620.50 | 13614.67 | 13117.59 |
| **D3W4** | 966.12 | 787.35 | 876.73 | 4929.19 | 5199.77 | 5064.48 | 6633.92 | 6381.73 | 6507.83 | 4573.10 | 4622.48 | 4597.79 | 12928.09 | 12989.67 | 12958.88 |
| **D3W5** | 1022.22 | 817.88 | 920.05 | 5002.78 | 5157.38 | 5080.08 | 6801.66 | 6506.26 | 6653.96 | 4819.05 | 4827.81 | 4823.43 | 12781.29 | 13085.69 | 12933.49 |
| **D3W6** | 1022.22 | 897.60 | 959.91 | 5622.66 | 5346.25 | 5484.45 | 7526.21 | 7301.41 | 7413.81 | 5686.18 | 5357.26 | 5521.72 | 13054.53 | 14117.25 | 13585.89 |
| **D3W7** | 853.92 | 854.56 | 854.24 | 4785.36 | 5250.11 | 5017.74 | 6397.89 | 6174.58 | 6286.23 | 4407.47 | 4461.91 | 4434.69 | 13159.34 | 12775.97 | 12967.65 |
| **D3W8** | 1230.10 | 927.56 | 1078.83 | 5945.46 | 5339.46 | 5642.46 | 7740.96 | 7560.07 | 7650.51 | 5863.90 | 5503.39 | 5683.64 | 13705.76 | 14052.05 | 13878.90 |
| **SE (m±)** |
| **D\*W** | 9.765 | 7.212 | 4.748 | 52.746 | 52.85 | 52.307 | 80.794 | 61.512 | 58.257 | 99.911 | 73.050 | 86.236 | 54.637 | 99.461 | 43.359 |
| **W\*D** | 23.223 | 17.583 | 13.638 | 35.679 | 35.797 | 26.776 | 47.350 | 46.431 | 44.018 | 30.541 | 35.883 | 26.527 | 41.894 | 52.952 | 25.627 |
| **C.D.at 5%** |
| **D\*W** | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| **W\*D** | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

**Table.3. Effect of dates of sowing and weed management practices on Photo-thermal units of summer sesame**

|  |
| --- |
| **Photo-thermal units, PTU (OC day hour)** |
|  | **Sowing- emergence** | **Sowing-flower initiation** | **Days to 50% flowering** | **Flowering to maturity** | **Sowing to maturity** |
| **2022** | **2023** | **pooled** | **2022** | **2023** | **Pooled** | **2022** | **2023** | **Pooled** | **2022** | **2023** | **Pooled** | **2022** | **2023** | **Pooled** |
| **Date of sowing** |
| **D1** | 1554.12 | 1268.78 | 1411.45 | 8209.89 | 7363.32 | 7786.61 | 10584.10 | 9822.45 | 10203.27 | 8271.61 | 7128.47 | 7700.04 | 22998.57 | 20158.09 | 21578.33 |
| **D2** | 968.11 | 1507.77 | 1237.94 | 7326.25 | 7079.52 | 7202.88 | 11571.87 | 10435.99 | 11003.93 | 7529.54 | 7338.01 | 7433.78 | 21954.13 | 21970.88 | 21962.50 |
| **D3** | 1853.61 | 1211.87 | 1532.74 | 8023.39 | 7903.62 | 7963.51 | 11547.29 | 10559.24 | 11053.26 | 8013.43 | 7485.73 | 7749.58 | 22457.27 | 22934.26 | 22695.76 |
| **SE (m±)** | 14.865 | 9.418 | 8.061 | 159.248 | 82.105 | 119.797 | 116.847 | 105.046 | 98.788 | 152.423 | 128.810 | 118.957 | 132.569 | 400.609 | 244.721 |
| **C.D.at 5%** | 58.360 | 36.976 | 31.645 | 625.191 | 322.336 | 470.310 | 458.729 | 412.400 | 387.830 | 598.395 | 505.694 | 467.011 | 520.452 | 1572.747 | 960.749 |
| **Weed management practices** |
| **W1** | 1523.24 | 1365.54 | 1444.39 | 8260.32 | 7992.22 | 8126.27 | 11872.05 | 10940.18 | 11406.12 | 8586.15 | 7959.35 | 8272.75 | 22752.12 | 23265.59 | 23008.85 |
| **W2** | 1484.16 | 1328.21 | 1406.18 | 7864.79 | 7478.34 | 7671.56 | 11419.14 | 10486.37 | 10952.76 | 8048.25 | 7452.45 | 7750.35 | 22537.28 | 21903.99 | 22220.64 |
| **W3** | 1454.46 | 1316.21 | 1385.34 | 7664.50 | 7333.53 | 7499.02 | 11133.36 | 10166.55 | 10649.96 | 7821.82 | 7257.53 | 7539.68 | 22345.63 | 21714.31 | 22029.97 |
| **W4** | 1384.20 | 1280.57 | 1332.38 | 7524.69 | 6954.58 | 7239.63 | 10579.76 | 9596.65 | 10088.20 | 7498.54 | 6655.55 | 7077.04 | 22201.78 | 20337.38 | 21269.58 |
| **W5** | 1432.46 | 1301.21 | 1366.84 | 7608.75 | 7106.35 | 7357.55 | 10850.24 | 9879.29 | 10364.77 | 7514.68 | 6984.34 | 7249.51 | 22229.91 | 21489.74 | 21859.82 |
| **W6** | 1507.41 | 1345.59 | 1426.50 | 8093.35 | 7767.54 | 7930.44 | 11662.69 | 10652.20 | 11157.45 | 8330.30 | 7696.09 | 8013.19 | 22712.99 | 22012.66 | 22362.82 |
| **W7** | 1259.48 | 1190.72 | 1225.10 | 7278.31 | 6750.29 | 7014.30 | 10192.78 | 9226.66 | 9709.72 | 6866.67 | 6331.38 | 6599.02 | 22149.87 | 19143.76 | 20646.81 |
| **W8** | 1623.49 | 1507.72 | 1565.61 | 8530.71 | 8207.72 | 8369.22 | 12165.33 | 11232.57 | 11698.95 | 8839.13 | 8202.56 | 8520.85 | 22830.34 | 23634.49 | 23232.42 |
| **SEm±** | 14.865 | 26.423 | 19.517 | 257.266 | 52.102 | 142.380 | 66.898 | 70.481 | 32.463 | 66.508 | 40.873 | 41.068 | 131.616 | 1085.973 | 538.780 |
| **C.D.at 5%** | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| **Interaction (DxW)** |
| **D1W1** |   | 1506.94 | 1218.98 | 7172.52 | 7161.02 | 7166.77 | 10792.17 | 9995.53 | 10393.85 | 7640.36 | 7467.00 | 7553.68 | 22128.09 | 21031.36 | 21579.73 |
| **D1W2** | **1026.00** | 1539.78 | 1282.89 | 7407.01 | 7329.70 | 7368.36 | 11050.72 | 10203.76 | 10627.24 | 7946.49 | 7742.58 | 7844.54 | 22491.51 | 21693.09 | 22092.30 |
| **D1W3** | **953.01** | 1494.94 | 1223.98 | 7640.36 | 7030.84 | 7335.60 | 10444.71 | 9683.16 | 10063.93 | 7484.93 | 7198.83 | 7341.88 | 21435.26 | 22212.10 | 21823.68 |
| **D1W4** | **931.01** | 1459.31 | 1195.16 | 6859.96 | 6603.20 | 6731.58 | 9923.29 | 9266.97 | 9595.13 | 6859.96 | 6566.18 | 6713.07 | 21686.97 | 19843.51 | 20765.24 |
| **D1W5** | **931.01** | 1535.28 | 1233.15 | 6937.50 | 6824.87 | 6881.19 | 10177.62 | 9398.81 | 9788.22 | 7172.52 | 6944.45 | 7058.49 | 21010.43 | 21965.86 | 21488.14 |
| **D1W6** | **1073.49** | 1564.91 | 1319.20 | 7871.87 | 7575.27 | 7723.57 | 11218.05 | 10448.93 | 10833.49 | 8178.26 | 8230.85 | 8204.56 | 23205.99 | 23801.71 | 23503.85 |
| **D1W7** | **778.67** | 1222.80 | 1000.73 | 6546.16 | 6393.13 | 6469.64 | 9507.64 | 8789.67 | 9148.65 | 6546.16 | 6219.93 | 6383.04 | 20829.60 | 18685.84 | 19757.72 |
| **D1W8** | **1120.66** | 1738.16 | 1429.41 | 8174.62 | 7718.13 | 7946.37 | 11558.59 | 10792.77 | 11175.68 | 8407.66 | 8334.25 | 8370.96 | 22845.20 | 26533.53 | 24689.36 |
| **D2W1** | **1533.85** | 1273.40 | 1403.63 | 8028.37 | 7375.09 | 7701.73 | 11688.20 | 10572.80 | 11130.50 | 8391.81 | 7241.42 | 7816.62 | 23162.80 | 21795.34 | 22479.07 |
| **D2W2** | **1663.70** | 1246.40 | 1455.05 | 8203.14 | 7705.92 | 7954.53 | 11903.49 | 10878.51 | 11391.00 | 8755.34 | 7431.06 | 8093.20 | 23603.55 | 21810.73 | 22707.14 |
| **D2W3** | **1555.85** | 1261.40 | 1408.63 | 8642.31 | 7212.34 | 7927.32 | 11538.95 | 10397.26 | 10968.11 | 8206.51 | 7017.42 | 7611.96 | 22383.15 | 19658.05 | 21020.60 |
| **D2W4** | **1468.92** | 1225.76 | 1347.34 | 7694.55 | 6804.54 | 7249.55 | 10952.30 | 9666.69 | 10309.50 | 7495.18 | 6577.60 | 7036.39 | 22726.71 | 20240.41 | 21483.56 |
| **D2W5** | 1533.85 | 1182.07 | 1357.96 | 7776.39 | 6961.2 | 7368.8 | 11234.4 | 10088.0 | 10661.2 | 7843.0 | 6829.89 | 7336.45 | 22130.56 | 19418.6 | 20774.6 |
| **D2W6** | 1663.70 | 1269.4 | 1466.58 | 8814.60 | 7967.3 | 8390.9 | 12186.2 | 11160.0 | 11673.1 | 9028.4 | 7695.13 | 8361.79 | 24223.71 | 21097.6 | 22660.6 |
| **D2W7** | 1406.86 | 1197.48 | 1302.17 | 7451.38 | 6638.3 | 7044.8 | 10658.6 | 9325.90 | 9992.28 | 7155.8 | 6280.93 | 6718.40 | 21803.15 | 19035.9 | 20419.5 |
| **D2W8** | 1606.21 | 1494.2 | 1550.24 | 9068.40 | 8241.6 | 8655.0 | 12412.6 | 11398.6 | 11905.6 | 9296.6 | 7954.33 | 8625.51 | 23954.89 | 18207.9 | 21081.4 |
| **D3W1** | 1987.62 | 1204.2 | 1595.95 | 8393.47 | 7898.9 | 8146.1 | 11777.0 | 10890.7 | 11333.9 | 8112.5 | 7648.93 | 7880.75 | 22320.96 | 22885.2 | 22603.11 |
| **D3W2** | 1832.53 | 1250.6 | 1541.57 | 8669.91 | 8266.9 | 8468.4 | 12033.8 | 10874.3 | 11454.1 | 8289.0 | 7914.61 | 8101.85 | 22043.89 | 22534.1 | 22289.0 |
| **D3W3** | 1854.53 | 1192.27 | 1523.40 | 6710.84 | 7757.4 | 7234.1 | 11416.4 | 10419.2 | 10917.8 | 7774.0 | 7556.35 | 7665.19 | 23218.47 | 23272.7 | 23245.6 |
| **D3W4** | 1752.65 | 1156.64 | 1454.64 | 8019.55 | 7455.9 | 7737.7 | 10863.6 | 9856.28 | 10359.9 | 8140.4 | 6822.86 | 7481.67 | 22191.67 | 20928.2 | 21559.9 |
| **D3W5** | 1832.53 | 1186.27 | 1509.40 | 8112.35 | 7532.8 | 7822.6 | 11138.6 | 10150.9 | 10644.8 | 7528.5 | 7178.68 | 7353.60 | 23548.73 | 23084.6 | 23316.7 |
| **D3W6** | 1832.53 | 1262.2 | 1547.38 | 8094.49 | 8434.0 | 8264.2 | 12211.8 | 11211.5 | 11711.7 | 8551.7 | 7952.07 | 8251.90 | 20826.66 | 24897.4 | 22862.0 |
| **D3W7** | 1592.91 | 1151.89 | 1372.40 | 7837.39 | 7219.3 | 7528.3 | 10412.0 | 9564.42 | 9988.23 | 6897.9 | 6493.28 | 6695.62 | 23816.85 | 19709.5 | 21763.1 |
| **D3W8** | 2143.61 | 1290.7 | 1717.17 | 8349.11 | 8663.4 | 8506.2 | 12524.7 | 11506.2 | 12015.5 | 8813.0 | 8319.10 | 8566.08 | 21690.94 | 26162.0 | 23926.4 |
| **SE (m±)** |
| **D\*W** | 14.865 | 9.418 | 8.061 | 159.248 | 82.105 | 119.797 | 116.847 | 105.046 | 98.788 | 152.423 | 128.810 | 118.957 | 132.569 | 400.609 | 244.721 |
| **W\*D** | 14.865 | 26.423 | 19.517 | 257.266 | 52.102 | 142.380 | 66.898 | 70.481 | 32.463 | 66.508 | 40.873 | 41.068 | 131.616 | 1085.973 | 538.780 |
| **C.D.at 5%** |
| **D\*W** | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| **W\*D** | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

**CONCLUSION:**

From the above results, it was concluded that thermal indices of summer sesame were significantly influenced by dates of sowing only. Interactions between dates of sowing and weed management practices were found to be non-significant. Among the sowing dates, maximum GDD, HTU, and PTU were noticed at sowing on March 22nd, and the minimum was observed at the February 21st sowing. Efficient methods are needed to keep the weeds under control. Even while hand weeding and inter-culturing are successful, they are always linked to weed regeneration since they necessitate regular cultural operations, which are not only expensive but also impractical because of the physical characteristics of the soil. It is discovered that chemical weed management is cost-effective and efficient during the early stages of growth. However, due to their selectivity, herbicides cannot completely eradicate weeds on their own. Furthermore, the issues with residual toxicity were made worse by the ongoing use of herbicides alone, even at greater dosages. In light of this, it is imperative to determine the ideal planting date and use weed control techniques in order to inhibit weed growth and maximise productivity. Thus, an experiment was designed to investigate the impact of weed control techniques as well as the effects of sowing dates on sesamum growth, yield, and economics.

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