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Effect of Sowing Dates and Weed Management Practices on Yield Attributes of Summer Sesame (*Sesamum indicum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present study aimed to determine the Effect of Dates of Sowing and Weed Management Practices on Summer Sesame in the New Alluvial Zone of West Bengal to explore the optimal strategies for weed control and improve sesame yield. The appropriate sowing date is a crucial factor in aligning plant growth stages with environmental conditions to achieve optimal yield. Sesame, known for its drought tolerance, is primarily grown as a dryland crop, particularly in the Indian subcontinent. A field experiment was conducted during the summer season of 2022 and

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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 P_2O_5 kg ha^{-1}) and available potassium (294.5 K_2O kg ha^{-1}). The experiment was laid out in split plot design having dates of sowing i.e. D1: February 21st, D2: March 7th, and D3: March 22nd in main plot and Sub plot treatments comprised of 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-Weedycheck and W8-Weed free check and replicated thrice. The sesame variety 'Savitri' was chosen for the experiment. The yield attributes and yield associated characters like number of branches plant-1, number of capsules $plant^{-1}$, number of seeds capsule-1 and number of seeds plant-1 were significantly influenced by dates of sowing and weed management practices; however, 1000 seed weight (test weight) was not influenced by dates of sowing and weed management practices. Sowing on 7th March (D2) recorded a significantly higher number of branches $plant^{-1}$(6.26), number of capsules $plant^{-1}$ (52.97), number of seeds $capsule^{-1}$ (45.74) and number of seeds $plant^{-1}$(2137.37). Among weed management treatments, weed-free check (W8) inscribed significantly more number of branches $plant^{-1}$(8.12), number of capsules $plant^{-1}$(58.13), number of seeds $capsule^{-1}$ (50.12) and number of seeds $plant^{-1}$ (2462.36 and 2232.96) and it was at par with Pendimethalin @ 1 kg a.i. ha^{-1} (2 DAS) + Hand weeding (30 DAS) i.e. W1. No significant effect had been observed among the interactions with respect to the yield attributing characters. Determining the optimal sowing time, which enhances the efficient use of the land area, along with selecting a cultivar that offers a high average yield, is a key factor in ensuring a profitable return from sesame cultivation.

Keywords: Sesame; dates of sowing; weed management; capsules; herbicides.

1. 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; Issahaku et al., 2023). Sesame (*Sesamum indicum* L.) is one of the most significant oilseed crops next to groundnut, rapeseed and mustard in India. The crop's superior polyunsaturated stable fatty acid has given it the evocative moniker "Queen of oilseeds.". Small farmers in underdeveloped nations usually grow sesame because it is thought to be a drought-tolerant crop (Jefferson, 2003). Boureima et al. (2011) pointed out that sesame is a stress-tolerant crop that produces unique chemical compounds, which are not found in other edible oil crops. These compounds help protect sesame oil from oxidative rancidity, enhancing its stability and shelf life. Sesame is a short-day plant that typically flowers in 42-45 days when exposed to a 10-hour day length (Weiss, 1983). Its significance lies in its dual role as a food crop and a raw material for various industries, making it a major export crop. Sesame seeds are rich in nutrients, containing approximately 50% oil, 25% protein, and 20% carbohydrates, along with vitamins, minerals, antioxidants, and all essential amino and fatty acids. Also, seed meal is an excellent high protein (34-50%). The presence of weeds is a major obstacle in sesame production and can negatively influence sesame yield. The initial slow growth of sesame seedlings makes itself a poor competitor with more vigorous weeds. The low competitiveness of this crop with weeds is directly linked to its slow initial growth (Venu et al., 2022).

Sesame oil cake is an excellent cattle feed due to its high-quality protein and significant amounts of phosphorus and potash. It is commonly cultivated in tropical and subtropical regions. India is the largest producer, consumer, and exporter of sesame globally. However, sesame yields can vary significantly based on factors such as the growing environment, cultural practices, and the specific cultivars used (Brigham, 1985). The yield potential of sesame is determined by several yield components, each of which is significantly influenced by environmental factors and agronomic practices. Among them, sowing time and weed competition with crops is very important.

The appropriate sowing date is a crucial factor in aligning plant growth stages with environmental conditions to achieve optimal yield. Sesame, known for its drought tolerance, is primarily grown as a dryland crop, particularly in the Indian subcontinent, where the timing of sowing depends on the availability of moisture. As a result, sowing is often delayed to ensure the crop receives sufficient water for proper growth.

By choosing the right sowing date, different stages of plant growth can be better synchronized with environmental conditions, which enhances the efficiency of photosynthesis. This, in turn, promotes the assimilation and storage of nutrients in seeds, leading to improved crop productivity (Erhart *et al*., 2005). Determining the optimal sowing time, which enhances the efficient use of the land area, along with selecting a cultivar that offers a high average yield, is a key factor in ensuring a profitable return from sesame cultivation (Hamza & Abd El Salam, 2015). Delayed sowing discourages growers, leading to a reduction in the area dedicated to sesame cultivation. It also increases the susceptibility to pests and diseases, further impacting crop health and yield (El-Bakheit, 1985)**.** Delayed sowing consequently shortens the maturity period of sesame, which can affect its overall growth and yield potential (Stumpf, 1959).

Weed infestation is one of the major constraints limiting sesame yield. Additionally, sowing sesame seeds is challenging due to their small size, requiring precise placement at the optimal depth for successful germination and establishment. Moreover, sesame seedlings are small, tender, and exhibit slow initial growth compared to other oilseed crops, which leads to increased weed infestation. The extent of yield loss depends on the type of weed flora and the timing of weed infestation under specific agro-climatic conditions. Uncontrolled weed growth in sesame has been reported to cause yield losses of up to 50% (Dungarwal *et al.*, 2003).

Weeds limit sesame yield because their seedlings grow slowly during the first four weeks, making sesame a weak competitor against weeds in the early stages of growth (Bennett *et al*., 2003). Weeds impose significant stress during the early growth stages, which negatively impacts the economic yield of sesame. The presence of weeds can reduce sesame yield by 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 conditions in order to realize maximum yield.

Hand weeding is the most common method of weed control used by farmers, but it is labour-intensive, costly, and physically demanding. Additionally, the non-availability of labor during peak agricultural periods and high labor wages push farmers to explore alternative options. Chemical weed management, particularly the use of herbicides, has become a viable solution, offering an effective and economically feasible way to control weeds from sowing onward.

A suitable, economically viable, and ecologically safe combination of chemical and manual weeding could effectively control weeds and reduce yield loss. In light of this, this study determines the Effect of Dates of Sowing and Weed Management Practices on Summer Sesame in the New Alluvial Zone of West Bengalto explore the optimal strategies for weed control and improve sesame yield in the region.

2. 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 P_2O_5 kg ha^{-1}) and available potassium (294.5 K_2O 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. D_1: Sowing on February 21^{st}, D_2: Sowing on March 7th, and D_3: Sowing on March 22^{nd}. Sub plot treatments comprised of eight weed management practices i.e. W_1. Pendimethalin @ 1 kg a.i. ha^{-1} (2 DAS) + Hand weeding (30 DAS),W_2: Butachlor@ 1kg a.i. ha^{-1}(2 DAS)+Hand weeding(30 DAS),W_3: Hand weeding(15DAS) + Quizalofop ethyl @ 50 g a.i. ha^{-1} (30 DAS), W_4: Pendimethalin @ 1 kg a.i.ha^{-1} (2 DAS) +

Quizalofop ethyl @ 50 ga.i. ha^{-1} (30 DAS), W_5: Butachlor @ 1 kg a.i.ha^{-1} (2 DAS) + Quizalofop ethyl @ 50 g a.i. ha^{-1} (30 DAS),W_6: Hand weeding (15 DAS) + Hand weeding(30 DAS),W_7:Weedy check and W_8:Weed free check. 'Savitri' was chosen for the experiment.

Throughout the crop growing season, all advised agronomic practices and plant protection measures were followed. "Observations 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 net plot 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.

3. RESULTS AND DISCUSSION

3.1 Number of Branches Plant^{-1}

From the data, it was clearly indicated that among the sowing dates, D_2 (March 7th sowing) recorded significantly the highest number of branches per plant at harvest (6.26). Whereas, February 21st sowing (D_1) determined significantly the lowest number of branches plant^{-1} at harvest (3.00) irrespective of sub plot treatments i.e., different weed management practices. More number of branches plant^{-1} at harvest were observed with D_2 (March 7th sowing) this might be due to favorable weather conditions during the crop growth period, resulting in higher rate of plant growth leads to increase in number of branches plant-1. These results confirmed the findings of Tahir *et al.* (2012).

Among the weed management practices, weed-free condition (W8) confirmed a significantly higher number of branches plant^{-1} (7.80) which was statistically at par with W_1 (Pendimethalin @ 1 kg a.i ha^{-1} (2 DAS) + one hand weeding (HW) at 30 DAS (7.69) and W_6 (Hand weeding (HW) at 15 DAS and 30 DAS (7.64). While, W_7 (weedy check) observed significantly the lowest number of branches plant^{-1} at harvest (4.33) regardless of main plot treatments i.e. different dates of sowings.

A higher number of branches plant^{-1} under weed management treatments recorded (W_2, W_5 and W_3) might be due to effective control of weeds during critical stages of crop which enhanced the availability of growth resources to the crop leading to a higher number of branches plant^{-1} in sesamum. These results were in agreement with the findings of Sujithra *et al*. (2018).

3.2 Number of Capsules Plant^{-1}

From the pooled data of two years, it was confirmed that March 7th sowing noted significantly the highest number of capsules plant^{-1} (52.97). Whereas, 21st February sowing (D_1) recorded significantly the lowest number of capsules plant^{-1} at harvest (35.97). The possible reason could be that the crop sown at March 7th has prolonged photoperiod which utilized more assimilates in producing of capsules as compared to other sowing dates. Similar results were obtained with Sarkar *et al*. (2007).

From analysis of data indicated that among the weed management practices, the treatment W_8 (weed-free) recorded a significantly higher number of capsules plant^{-1} at harvest (58.13) which was statistically at par with the W1 (Pendimethalin @ 1 kg a.i ha^{-1} (2 DAS) + one hand weeding (HW) at 30 DAS (57.33) and W_6 (Hand weeding (HW) at 15 DAS and 30 DAS (57.13). While, W_7 (weedy check) recorded significantly the lowest number of capsules plant^{-1} at harvest (30.14) (Table 1). A higher number of capsules per plant under weed management treatments recorded in W_8, W_1 and W_6 treatments might be due to effective control of weeds during critical stages of the crop which enhanced the availability of growth resources to the crop leading to a higher number of capsules plant^{-1} in sesamum. These results were in accordance with the findings of Sutradhar and Das (2017).

3.3 Number of Seeds Capsule^{-1}

From the two years of experiment, it was concluded that, among the main plot treatments, (D_2) March 7th sowing recorded significantly the highest number of seeds capsule-^{1} (45.74). Whereas, February 21st sowing (D_1) found a significantly lower number of seeds capsule^{-1} (34.43). This may be due to crop sown at March 7th might be owing to better translocation of assimilates from the source to the sink. Another reason could be that the crop sown at March 7th has a prolonged photoperiod which utilized more assimilates in producing a higher number of seeds capsule^{-1} as compared to other sowing dates. These results were in accordance with the findings of Abdel *et al*. (2007).

Table 1. Effect of dates of sowing and weed management practices on yield attributes and yield associated characters of summer sesame

	Branches Plant^{-1}			Capsule Plant^{-1}			Seeds Capsule^{-1}			Seeds Plant^{-1}			Test weight (g)		
	2022	2023	pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
Date of sowing															
D1	3.13	2.85	3.00	30.74	41.20	35.97	31.95	36.91	34.43	1489.30	1488.60	1488.95	2.27	2.50	2.38
D2	6.42	6.11	6.26	49.90	56.05	52.97	43.49	47.99	45.74	2124.52	2150.22	2137.37	2.52	2.71	2.62
D3	5.83	4.85	5.34	44.20	47.67	45.93	39.30	41.41	40.36	1777.76	1775.44	1776.60	2.46	2.60	2.53
SE (m±)	0.074	0.071	0.072	1.253	1.561	1.392	0.733	1.076	0.896	88.087	92.78	90.350	0.009	0.020	0.014
C.D.at 5%	0.212	0.220	0.219	4.218	4.327	4.466	2.877	4.222	3.517	345.821	364.23	354.705	NS	NS	NS
Weed management practices															
W1	7.38	8.00	7.69	55.32	59.35	57.33	44.99	53.66	49.32	2232.96	2241.63	2232.96	2.53	2.72	2.625
W2	6.41	7.05	6.73	44.12	51.12	47.62	39.76	43.20	41.48	1877.44	1884.67	1877.44	2.47	2.65	2.56
W3	6.09	6.74	6.42	39.66	48.43	44.05	37.41	40.50	38.95	1710.65	1717.10	1710.65	2.43	2.62	2.525
W4	5.63	5.77	5.70	33.51	38.42	35.96	32.52	34.62	33.57	1405.47	1410.56	1405.47	2.40	2.58	2.49
W5	5.81	6.45	6.13	35.41	44.85	40.13	35.71	36.83	36.27	1539.56	1545.09	1539.56	2.41	2.59	2.5
W6	7.34	7.95	7.64	55.12	59.15	57.13	44.68	53.12	48.90	2049.07	2056.88	2049.07	2.51	2.70	2.605
W7	4.01	4.65	4.33	27.59	32.68	30.14	28.35	28.84	28.60	1130.28	1110.20	1130.28	2.03	2.34	2.185
W8	7.48	8.12	7.80	55.51	60.75	58.13	45.59	54.64	50.12	2462.36	2471.90	2462.36	2.57	2.75	2.66
SEm±	0.043	0.059	0.049	0.317	0.498	0.249	0.345	0.599	0.407	11.918	12.879	10.681	0.027	0.013	0.02
C.D.at 5%	0.153	0.189	0.149	0.993	1.610	1.305	1.076	1.870	1.225	37.308	41.750	33.479	NS	NS	0.02
Interaction (D*W)															
D1W1	4.300	5.609	4.955	41.067	50.729	45.898	39.517	47.913	43.715	1918.3	1939.4	1928.8	2.463	2.648	2.556
D1W2	3.800	5.109	4.455	34.967	45.509	40.238	34.883	39.455	37.169	1587.8	1606.3	1597.1	2.397	2.581	2.489
D1W3	3.483	4.792	4.138	30.500	43.008	36.754	32.533	36.757	34.645	1434.6	1451.6	1443.1	2.363	2.548	2.456
D1W4	3.017	3.826	3.421	24.350	32.993	28.672	27.650	30.873	29.262	1154.4	1169.0	1161.7	2.327	2.511	2.419
D1W5	3.200	4.509	3.855	26.250	39.427	32.839	30.833	33.083	31.958	1277.5	1292.9	1285.2	2.338	2.523	2.431
D1W6	4.067	5.376	4.721	37.733	48.586	43.160	37.380	42.757	40.069	1747.6	1767.1	1757.3	2.445	2.629	2.537
D1W7	1.363	1.70	01.53	4.713	13.997	9.355	12.057	12.503	12.280	661.1	527.0	594.1	1.320	1.867	1.593
D1W8	4.533	6.342	5.438	46.350	55.323	50.836	40.717	51.898	46.307	2133.0	2155.6	2144.3	2.502	2.686	2.594
D2W1	8.950	8.759	8.855	57.650	63.062	60.356	46.780	51.664	49.222	2371.2	2399.1	2385.	2.580	2.764	2.672
D2W2	8.717	8.526	8.621	54.317	60.919	57.618	44.283	48.361	46.322	2188.1	2214.6	2201.4	2.532	2.716	2.624

	Branches Plant^{-1}			**Capsule Plant^{-1}**			**Seeds Capsule^{-1}**			**Seeds Plant^{-1}**			**Test weight (g)**		
	2022	**2023**	**pooled**	**2022**	**2023**	**Pooled**	**2022**	**2023**	**Pooled**	**2022**	**2023**	**Pooled**	**2022**	**2023**	**Pooled**
D2W3	8.133	7.942	8.038	47.083	55.340	51.212	41.933	45.664	43.799	2008.5	2033.2	2020.9	2.498	2.683	2.591
D2W4	7.667	6.976	7.321	40.933	45.326	43.130	37.050	39.780	38.415	1679.6	1701.4	1690.5	2.462	2.646	2.554
D2W5	7.85	7.659	7.755	42.833	51.760	47.297	40.233	41.989	41.111	1824.2	1846.9	1835.5	2.473	2.658	2.566
D2W6	8.717	8.526	8.621	54.31	60.91	57.618	44.283	48.36	46.322	2188.1	2214.6	2201.4	2.532	2.716	2.624
D2W7	7.43	7.24	7.33	41.883	46.217	44.050	38.583	40.305	39.444	1546.3	1566.8	1556.6	2.417	2.601	2.509
D2W8	10.183	9.492	9.838	62.933	67.655	65.294	50.117	59.304	54.710	2810.7	2842.4	2826.6	2.637	2.821	2.729
D3W1	7.483	8.292	7.888	51.950	54.678	53.314	44.733	50.241	47.487	2187.0	2188.2	2187.6	2.535	2.719	2.627
D3W2	7.250	8.059	7.655	48.617	52.535	50.576	42.597	45.085	43.841	2004.9	2004.5	2004.7	2.517	2.701	2.609
D3W3	6.667	7.476	7.071	41.383	46.957	44.170	37.750	39.085	38.418	1669.6	1666.4	1668.0	2.435	2.619	2.527
D3W4	6.200	6.509	6.355	35.233	36.942	36.088	32.867	33.201	33.034	1367.1	1361.3	1364.2	2.398	2.583	2.491
D3W5	6.383	7.192	6.788	37.133	43.377	40.255	36.050	35.411	35.730	1500.4	1495.5	1498.0	2.410	2.594	2.502
D3W6	7.250	8.059	7.655	48.617	52.535	50.576	42.597	45.085	43.841	2004.9	2004.5	2004.7	2.517	2.701	2.609
D3W7	5.967	6.776	6.371	36.183	37.833	37.008	34.400	33.726	34.063	1243.6	1236.8	1240.2	2.353	2.538	2.446
D3W8	7.717	8.526	8.121	57.233	59.272	58.253	45.933	52.725	49.329	2414.7	2417.6	2416.2	2.573	2.758	2.666
SE (m±)															
D*W	0.074	0.071	0.072	1.253	1.561	1.392	0.733	1.076	0.896	88.087	92.78	90.350	0.009	0.020	0.014
W*D	0.043	0.059	0.049	0.317	0.498	0.249	0.345	0.599	0.407	11.918	12.879	10.681	0.027	0.013	0.017
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

W8 (weed free plot) recorded a significantly higher number of seeds capsule^{-1} at harvest (50.12) which was statistically at par with the treatments W_1 (Pendimethalin @ 1 kg a.i ha^{-1} (2 DAS) + one hand weeding (HW) at 30 DAS (49.32) and W_6 (Hand weeding (HW) at 15 DAS and 30 DAS (48.90). While, W_7 (weedy check) noticed significantly the lowest number of seeds capsule^{-1} at harvest (28.60). In all these weed management practices (W_8, W_1 and W_6), a higher number of seeds capsule^{-1} were effective against weed flora associated with sesamum which facilitated favorable environment for enhanced translocation of photosynthates from source to developing seeds. These results were in consonance with the work done by Ambika and Sundari (2019).

3.4 Number of Seeds Plant^{-1}

Among the main plot treatments, it was mentioned that D_2 (March 7th sowing) revealed significantly the highest number of seeds plant^{-1} (2137.37). Whereas, D_1 (February 21st sowing) found significantly the lowest number of seeds per plant at harvest (1488.95).

From pooled date, it was noted that among the weed management practices, W_8 (weed free) observed significantly maximum number of seeds plant$_{-1}$ at harvest (2462.36) which was statistically at par with W_1 (Pendimethalin @ 1 kg a.i ha^{-1} (2 DAS) + one hand weeding (HW) at 30 DAS (2232.96) and W_6 (Hand weeding (HW) at 15 DAS and 30 DAS (2049.07). However, W_7 (weedy check) recorded significantly the lowest number of seeds plant^{-1} (1130.28).

3.5 Test Weight

There was no significant difference was noticed in 1000 seed weight (g) across t main plot, sub plot and their interactions, however numerically maximum test weight observed in March 7th. Among the weed management practices, maximum test weight observed in weed-free (W1) condition and W1 (Pendimethalin @ 1 kg a.i ha-1 (2 DAS) + one hand weeding (HW) at 30 DAS.

4. CONCLUSION

By choosing the right sowing date, different stages of plant growth can be better synchronized with environmental conditions, which enhances the efficiency of photosynthesis. This, in turn, promotes the assimilation and storage of nutrients in seeds, leading to improved crop productivity.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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