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Research Paper

Impact of dates of sowing and irrigation scheduling on growth and productivity at critical growth stages on sesame

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ABSTRACT

A field experiment was carried out during two consecutive summer seasons of the year 2018–19 and 2019–20 at Agricultural Research Station, College of Agriculture, Anand Agricultural University, Jabugam, Gujarat. The study aimed to identify the most appropriate dates of sowing and irrigation scheduling at critical growth stages for sesame (*Sesamum indicum* L.). The experiment was laid out in a Split Plot Design (SPD) with twelve treatment combinations, including three dates of sowing as the main plot treatment and four levels of irrigation scheduling as a subplot treatment, repeated three times. Various growth parameters like plant stand (initial and final), plant height (at 30, 60 DAS and at harvest) and yield attributing characters *viz*. branches/plant and capsules/plant as well as yield (seed and stover yield) were observed and analysed. The treatment combination of sowing in 3rd week of February with irrigation at branching, flowering, capsule formation and seed development was found to be the best in these parameters and can be recommended for higher yield and benefit of spring sesame in Gujarat and similar agroecological situations.

Key words: Dates of sowing, Irrigation scheduling, Sesame

One of the world's oldest crops, sesame (*Sesamum indicum* L.) has been cultivated in Asia for more than 5,000 years. The crop was first domesticated in India and East Africa. Today, China and India are the two biggest producers of sesame in the world followed by Ethiopia, Guatemala, Tanzania, Myanmar, Sudan, Uganda, Nigeria, Pakistan and Turkey. Sesame thrives in a variety of soil types and climates, is extremely drought-tolerant, and works well with various crop rotation (Bisht *et al*., 1998). India produces a wide variety of sesame seeds, varying in colour from white to red to black, with oil content varying from 40 to 50%. The major Indian states producing sesame are Gujarat, West Bengal, Tamil Nadu, Andhra Pradesh, Madhya Pradesh and Maharashtra. Gujarat occupies an area of 1.08 million hectares (M ha) and producing 1.01 million tonnes of sesame with a productivity of 932 kg/ha (DoA, Gujarat). Major summer sesame-growing districts in Gujarat includes Junagadh, Amreli, Gir Somnath, Surendranagar, Rajkot and Jamnagar. Sesame production in the state is the second highest in the country, contributing 16.98% to the total production. Sesame is primarily cultivated under moisture stress conditions by small holders (Cagurgan, 2006). It is oilseed crop with the highest oil content (46–64%) among the others. It's rich, nutty flavour makes it a staple in many international cuisines. Sesame seeds are rich in nutrients and offer numerous health benefits. They contain calories (573 kcal), protein (17.7 g), total fat (49.7 g), carbohydrates (23.5 g), dietary fiber (11.8 g), sugars (0.3 g), calcium (975 mg), iron (14.6 mg) and omega-6 fatty acids (21.3 g). Sesame oil with 85% unsaturated fatty acid, is highly stable and has reducing cholesterol and prevents coronary heart disease (Kumar and Goel, 1994). Hence, sesame is called as the "Queen of oil seeds" due to its excellent quality and utility. Selection of a suitable variety, the right time of sowing, appropriate planting geometry and agronomic technologies are paramount for increasing the productivity of sesame.

Although India is self-sufficient in grain food production, it needs to catch up in vegetable oil production. To fully utilize the genetic potential of sesame varieties, choosing the right sowing time for a particular location and region is essential. This ensures synchronization of ideal environmental conditions such as temperature, light, humidity and rainfall with the various crop growth phases, thereby enhancing summer sesame production. To realize the potential yield of summer sesame, it's critical to standardize irrigation and input levels-two of the most crucial

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inputs in contemporary agriculture-to boost crop productivity and oil quality. Scheduling irrigation according to essential growth stages is one of the most significant scientific practices available today. Our objective remains to evaluate the effect of effect of sowing times and irrigation scheduling at critical growth stages on sesame.

MATERIALS AND METHODS

A field experiment was carried out during the summer seasons of 2018–19 and 2019–20 at the Agricultural Research Station, College of Agriculture, Anand Agricultural University, Jabugam, Gujarat. The climate of this region is characterized by a warm humid monsoon, moderately cold winter, and fairly hot summer. The soil of the experimental site was loamy in texture, low in organic carbon, and available N, medium in available P_2O_5 and available K_2O with neutral condition of *p*H. The soil was free from any kind of salinity and sodicity hazards. The experiment was arranged in Split Plot Design (SPD) with twelve treatment combinations, which included three dates of sowing (D_1, 1st week of February, D_2-3rd week of February and D_3- 1st week of March) as the main plot treatment and four levels of irrigation scheduling, *viz*. (S_1, at branching, flowering, seed development; S_2, at branching, flowering, capsule development, seed development; S_3- at branching, capsule development, seed development; S_4, at flowering, capsule development) as a sub plot treatment and repeated three times.

Each plot measured 3.6 m × 5.0 m size while sesame crop was sown on 09 February 2019 (D_1), 22 February 2019 (D_2) and 07 March 2019 (D_3) for first season and 07 February 2020 (D_1), 21 February 2020 (D_2) and 07 March 2020 (D_3) for second season, respectively. The variety 'Gujarat Til3' was used for the experimentation. Sesame was sown at a distance of 45 cm × 10 cm row and plant spacing with 2.5 kg/ha of seed rate through drilling method of sowing. Inter-culturing and weeding operations were carried out throughout both seasons for all three dates of sowing, while thinning was required only in the first year of experiment. Urea (46% N) and single super phosphate (16% P_2O_5) were used as sources of nitrogen and phosphorus, respectively, and were applied after the first irrigation during both seasons. Inorganic fertilizers were applied as per the treatment just before sowing in the respective furrows of the experimental plots, followed by sowing. The crop was harvested on 25 May 2019 and 02 June 2019 for first season and 28 May 2020 and01 June 2020 for second season, respectively whereas, threshing operation was carried out on 30 May 2019 and 11 June 2019 for first season and 03 June 2020 and 11 June 2020 for second season, respectively. The dates of irrigation at different stages are given in Table 1.

RESULTS AND DISCUSSION

Effect on plant stands (Initial and final)

The initial and final plant stand (Table 2) of sesame were influenced significantly by the dates of sowing during the year 2019, but were found non-significant in the year 2020 and in the pooled results. In 2019, significantly higher initial and final plant populations were found in the treatment D_3 (1st week of March) which was at par with treatment D_2 (2nd week of February). Treatment D_1 (1st week of February) observed the lowest plant population (initial and final). Regarding the effect of irrigation scheduling on plant stand (initial and final), it was found non-significant during both the years, but significant in the pooled results. The significantly higher plant stand (initial and final) was observed in the treatment S_2 (Irrigation scheduling at branching, Flowering, Capsule development, Seed development), which was at par with treatments S_1 and S_3. Treatment S_4 recorded a significantly lower plant stand (initial and final). Interaction between years and dates of sowing was found significant for initial and final plant stand, while the remaining lower and higher level interactions were

Table 1. Irrigation given on different stages in sesame (year 2018–19 and 2019–20)

Stages \ Sowing dates	D_1	D_2	D_3
	09-02-2019	22-02-2019	07-03-2019
	07-02-2020	21-02-2020	07-03-2020
Branching	19-03-2019	25-03-2019	05-04-2019
	17-03-2020	26-03-2020	07-04-2020
Flowering	03-04-2019	08-04-2019	16-04-2019
	30-03-2020	07-04-2020	18-04-2020
Capsule development	16-04-2019	18-04-2019	24-04-2019
	15-04-2020	22-04-2020	30-04-2020
Seed development	26-04-2019	29-04-2019	04-05-2019
	28-04-2020	04-05-2020	14-05-2020

Table 2. Effect of dates of sowing and irrigation scheduling on plant stand and plant height of sesame

Treatment	Initial plant stand (No./10.8 m^2)			Final plant stand (No./10.8 m^2)			Plant height (30 DAS)			Plant height (60 DAS)			Plant height (At harvest)		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
Main plot: Dates of sowing (D)															
D_1	187.7	222.3	205.0	184.4	219.5	202.0	19.78	20.22	20.00	48.13	46.95	47.54	68.38	64.68	66.53
D_2	241.3	239.4	240.3	232.0	237.4	234.7	23.98	24.93	24.46	56.38	54.84	55.61	76.38	73.68	75.03
D_3	242.1	239.3	240.7	232.5	237.0	234.8	24.66	24.02	24.34	55.49	53.56	54.52	79.11	76.88	77.99
SEm±	6.38	5.21	10.68	4.15	5.21	8.70	0.55	0.67	0.43	1.57	1.47	1.07	2.43	2.23	1.65
CD (P=0.05)	25.10	NS	NS	16.28	NS	NS	2.18	2.64	1.42	6.17	5.77	3.51	NS	8.70	5.40
Y × D	-	-	Sig.	-	-	Sig.	-	-	NS	-	-	NS	-	-	NS
SEm±	-	-	5.83			4.71									
CD (P=0.05)	-	-	19.01			15.35									
CV%	9.89	7.73	8.83	6.64	7.80	7.29	8.44	10.12	9.33	10.21	9.85	10.04	11.31	10.81	11.08
Sub plot : Irrigation Scheduling (S)															
S_1	228.0	238.0	233.0	219.3	235.7	227.5	23.10	24.09	23.59	53.08	52.16	52.62	73.83	71.08	72.46
S_2	228.7	238.2	233.4	220.0	236.1	228.1	22.97	23.06	23.01	57.04	56.29	56.67	81.96	78.44	80.20
S_3	223.2	233.7	228.4	214.9	231.2	223.1	22.96	23.18	23.07	53.41	51.80	52.61	74.87	72.38	73.62
S_4	214.8	224.8	219.8	211.0	222.2	216.6	22.21	21.90	22.06	49.80	46.89	48.34	67.83	65.08	66.46
SEm±	4.15	4.80	3.17	3.56	4.84	3.00	0.37	0.52	0.32	1.14	1.33	0.87	1.77	2.10	1.38
CD (P=0.05)	NS	NS	9.10	NS	NS	8.61	NS	NS	0.92	3.40	3.95	2.52	5.27	6.25	3.95
Y × S	-	-	NS	-	-	NS	-	-	NS	-	-	NS	-	-	NS
Interaction															
D × S	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
SEm±	7.18	8.32	5.49	6.16	8.37	5.20	0.65	0.91	0.56	1.98	2.30	1.52	3.07	3.64	2.38
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Y × D × S	-	-	NS	-	-	NS	-	-	NS	-	-	NS	-	-	NS
CV%	5.56	6.17	5.88	4.93	6.27	5.69	4.97	6.84	5.99	6.44	7.72	7.09	7.13	8.80	7.98

(D_1, 1st week of February, D_2, 3rd week of February and D_3, 1st week of March), (S_1, at branching, flowering, seed development; S_2, at branching, flowering, capsule development, seed development; S_3, at branching, capsule development, seed development; S_4, at flowering, capsule development) found non-significant in this respect (Table 2).

The significant effect of sowing dates on plant stand is attributed to the conditions during early sowing in early February, which were not as favourable as those from mid-February. Medium late to late sowing provided sesame with higher bright sunshine hours, positively impacting both the initial and final plant stand.

The crop may have received the appropriate amount of irrigation water at the appropriate crop growth stages, maintaining optimal soil moisture content in the root zone, which ultimately improved plant population. These results are consistent with those reported by Chang *et al*. (2005) and Patra (2001).

Effect on plant height (30, 60 DAS and at harvest)

Plant height at 30, 60 DAS and at harvest were significantly influenced by dates of sowing and irrigation scheduling in sesame (Table 2). In both the pooled data and individual years, treatment D_3 (1st week of March) and treatment D_2 (2nd week of February) recorded significantly higher plant height at 30, 60 DAS and at harvest, while treatment D_1 (1st week of February) observed the lowest plant height throughout the entire period. Regarding irrigation scheduling, treatment S_1 (irrigation at branching, flowering, seed development) recorded significantly higher plant height at 30 DAS in the pooled data, being on par with treatment S_3, but during individual years, it was found to be non-significant (Table 2). For plant height at 60 DAS and at harvest, treatment S_2 (Irrigation scheduling at branching, flowering, capsule development, seed development) showed significantly the highest value in the pooled results as well as in both the years. Treatment S_4 (irrigation at flowering, capsule development) recorded significantly the lowest value for plant height at 60 DAS and at harvest. All higher and lower levels of interactions were found to be non-significant. The possible reason could be that medium late to late planted crops, which had a prolonged photoperiod (almost 30 days), utilized more assimilates in producing of vegetative growth compared to early sown crops. These results are in conformity with the findings of Rahman *et al*. (2007) and Sarkar *et al*. (2007).

Plant height has a big impact on the capture of light and radiation from the sun. Thefact that water is used for the chemical and biochemical interactions enabling plant absorption, and that a lack of water restricts cell division and growth, may explain the increase in plant stature with expanded irrigation systems. Adequate moisture promotes plant cell metabolism and increases the effectiveness of mineral supplementation. The favourable increase in plant height in sesame with irrigation is in conformity with findings of Sarkar *et al*. (2010).

Effect on branches per plant and capsules/plant

Branches per plant in sesame were significantly affected due to irrigation scheduling but remained non-significant due to dates of sowing. Significantly higher branches per plant observed in the treatment S_2 (Irrigation scheduling at branching, Flowering, Capsule development, Seed development) in pooled results and in the year 2019, which remained at par with the treatments S_3 and S_1. During the year 2020, branches per plant were non significantly affected by irrigation scheduling, while Treatment S_4 showed significantly lower branches per plant (Table 3). All the interactions (Y × D, Y × S, D × S and Y × D × S) were found to be non-significant for branches per plant.

The effect of dates of sowing and irrigation scheduling on capsules per plant was found significant in sesame (Table 3). Significantly higher capsules per plant were observed when the crop was sown during 3rd week of February (treatment D_2), which was being at par with treatment D_3 in the pooled result. Treatment D_1 produced significantly lower capsules per plant. In individual years, the number of capsules per plant remained non-significant due to different dates of sowing. Irrigation scheduling showed significant results for capsules per plant, with significantly higher capsules per plant found in treatment S_2 (Irrigation scheduling at branching, Flowering, Capsule development, Seed development), which was found at par with the treatment S_3in both pooled data and individual years. Treatment S_4 (irrigation at Flowering, Capsule development) recorded significantly the lowest value for capsules per plant. All the lower and higher level of interactions were found to be non-significant. The possible reason could be that the medium late to late planted crop, which had a prolonged photoperiod, utilized more assimilates in producing of capsules. These results are in conformity with the findings of Rahman *et al*. (2007) and Sarkar *et al*. (2007).

Increasing the number of irrigations increased the number of capsules per plant, with the maximum number of capsules per plant (72.56 on a pooled basis) recorded when four irrigations were scheduled each at various growth stages *i.e*., at branching, flowering, capsule development and seed development stages. These findings are closely related to those of Chauhan *et al*. (2016), Mallick (2018) and Mekonnen and Sintayehu (2020). Test weight was not significantly influenced by dates of sowing and irrigation scheduling or their interactions during both the years and in pooled data (Table 3).

Effect on test weight (g) and water use efficiency

Test weight was not significantly influenced by dates of sowing, irrigation scheduling or their interactions during both the year and in pooled data (Table 3). Data on water

Table 3. Effect of dates of sowing and irrigation scheduling on various yield attributes, yield and economics of sesame

Treat.	Branches/ plant			Capsules/ plant			Test weight (g)			Seed yield (kg/ha)			Stover yield (kg/ha)			Net Income (Rs/ha)	B:C Ratio
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled		
Main plot: Dates of sowing (D)																	
D_1	3.73	3.73	3.73	63.17	61.17	62.17	3.38	3.38	3.38	691	627	659	1,017	1,220	1,118	27,038	2.49
D_2	3.70	3.70	3.70	70.92	67.60	69.26	3.44	3.43	3.44	981	912	946	1,366	1,302	1,334	46,712	3.58
D_3	3.63	3.62	3.63	67.34	64.33	65.84	3.40	3.39	3.39	944	905	924	1,326	1,242	1,284	45,204	3.49
S.Em.±	0.10	0.11	0.07	2.08	2.06	1.46	0.03	0.03	0.02	32	29	22	37	47	80	-	-
CD (P=0.05)	NS	NS	NS	NS	NS	4.77	NS	NS	NS	129	112	71	147	NS	NS	-	-
Y × D	-	-	NS	-	-	NS	-	-	NS	-	-	NS	-	-	Sig.	-	-
CV%	9.04	10.40	9.74	10.74	11.07	10.90	2.93	3.32	3.13	13.10	12.15	12.67	10.49	12.85	11.74	-	-
Sub plot: Irrigation Scheduling (S)																	
S_1	3.71	3.76	3.73	68.63	65.42	67.03	3.39	3.39	3.39	880	821	850	1,259	1,109	1,184	35,691	2.58
S_2	3.84	3.82	3.83	73.58	71.53	72.56	3.46	3.43	3.44	1,022	941	981	1,380	1,225	1,302	43,171	2.79
S_3	3.76	3.71	3.73	71.41	68.36	69.88	3.41	3.40	3.40	936	895	916	1,312	1,354	1,333	40,215	2.78
S_4	3.44	3.44	3.44	54.96	52.16	53.56	3.38	3.38	3.38	649	602	626	995	1,330	1,163	21,835	2.04
SEm±	0.09	0.10	0.07	1.47	1.91	1.21	0.03	0.04	0.02	19	25	16	38	43	115	-	-
CD (P=0.05)	0.28	NS	0.20	4.38	5.68	3.46	NS	NS	NS	56	74	45	113	129	NS	-	-
Y × S	-	-	NS	-	-	NS	-	-	NS	-	-	NS	-	-	Sig.	-	-
Interaction																	
D × S	NS	NS	NS	NS	NS	NS	NS	NS	NS	Sig.	Sig.	Sig.	NS	NS	NS	-	-
SEm±	0.16	0.17	0.12	2.55	3.31	2.09	0.05	0.06	0.04	33	43	27	66	75	50	-	-
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	97	129	78	NS	NS	NS	-	-
Y×D×S	-	-	NS	-	-	NS	-	-	NS	-	-	NS	-	-	NS	-	-
CV%	7.65	8.03	7.84	6.58	8.90	7.78	2.44	3.06	2.76	6.48	9.21	7.88	9.26	10.34	9.82	-	-

(D_1, 1st week of February, D_2, 3rd week of February and D_3, 1st week of March), (S_1, at branching, flowering, seed development; S_2, at branching, flowering, capsule development, seed development; S_3, at branching, capsule development, seed development; S_4, at flowering, capsule development) use efficiency (Fig. 1) shows a significant effect due to dates of sowing and irrigation scheduling. Treatment D_2 (3rd week of February) gave significantly higher water use efficiency (471.6 kg/ha/mm), which was at par with treatment D_3 (1st week of March, 469.2 kg/ha/mm) in pooled result. The same trend was observed during the individual years in case of WUE. Significantly the lowest WUE (328.7 kg/ha/mm) was observed in the treatment D_1 (1st week of February) in the pooled result, with a similar trend was found during both the years. Treatment S_3 (Irrigation scheduling at branching, capsule development, seed development) gave significantly higher WUE (457.8 kg/ha/mm) in summer sesame in pooled results, and also similar results were found during both the years. The second highest WUE was observed in treatment S_1, which was found at par with treatment S_4. Treatment S_2 (irrigation at branching, flowering, capsule development, seed development) recorded significantly the lowest value for WUE during individual years as well as in pooled data.

Interaction between dates of sowing and irrigation scheduling was significant during both the year as well as in pooled data for water use efficiency (Table 4). Treatment combination D_2S_3 (Crop sown during 3rd week of February and irrigation at branching, Capsule development, Seed development) produced significantly the higher WUE (516.2 kg/ha/mm) in pooled data and in both the years, but it was at par with treatment combinations D_3S_4, D_2S_1, D_3S_3 and D_3S_1. Significantly lower WUE (287.8 kg/ha/mm) was observed in treatment combination D_1S_1 in pooled result. All the other interactions for WUE were found not significant.Timely sown sesame crop utilized water at their maximum rate, while early or late-sown crops utilized water at a lower rate during crop-growth period. This may be due to the fact that the early or late-sown crop produces less photo synthates than normal sown crops, as recorded by Dhaliwal *et al*. (2020).

Effect on yield (seed and stover)

Seed yield and stover yield in summer sesame were

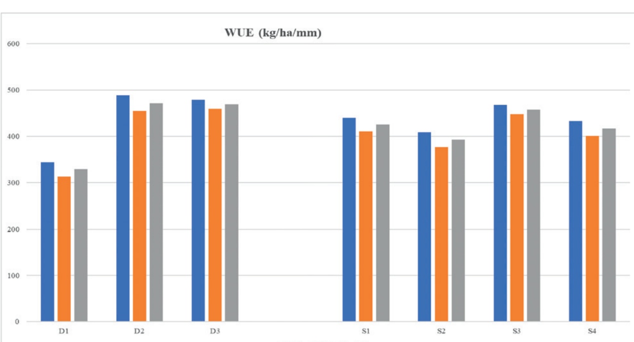

Fig. 1. Water use efficiency of sesame as influenced by various dates of sowing and irrigation scheduli

significantly influenced by different dates of sowing and irrigation scheduling (Table 3). Treatment D_2 (3rd week of February) gave significantly higher seed yield (946 kg/ha), which was at par with treatment D_3 (1st week of March, 924 kg/ha) in the pooled result. This trend was consistent during the individual years in case of seed yield. The lowest seed yield (659 kg/ha) was observed in the treatment D_1 (1st week of February) in the pooled result, showing a similar trend in both the years. Treatment D_2 produced 43.55% higher yield than treatment D_1, while Treatment S_2 (irrigation scheduling at branching, flowering, capsule development, seed development) produced significantly the highest seed yield (981 kg/ha) in pooled results, with similar results were found during both the years. The second highest yield was produced by treatment S_3, which was found at par with treatment S_1. Treatment S_4 (irrigation at flowering, capsule development) recorded significantly the lowest value for seed yield during both individual years and in pooled data (626 kg/ha). Treatment S_2 produced 56.70, 15.41 and 07.09% higher yield than treatment S_4, S_1 and S_3, respectively.

Sowing on February 22nd and 21st of the year 2019 and 2020, respectively recorded significantly higher seed and stover yield compared to delayed sowing. This may be attributed for favourable climatic conditions, less pest and disease occurence, and harnessing of more solar radiation, as evidenced by larger LAI, higher DMP and higher values for all the yield contributing traits which in turn has increased the seed yield. These results align with the findings of Sivagamy and Rammohan (2013). Medium late to late sowing dates resulted in significantly higher seed yield, as noted by Bhardwaj *et al*. (2014). Abdalla *et al*. (2004) found that flowering and maturity periods were reduced by 18 days due to delayed sowing. Similar finding was recorded by Sondarva *et al*. (2014) regarding the higher rate of thermal heat units available from 16th February to 1st March. For stover yield (Table 3), it was found to be non-significant due to dates of sowing in pooled data as well as in the second year of experiment but during first year, treatment D_2 produced significantly higher stover yield and at par with treatment D_3. Irrigation scheduling did not significantly affected the stover yield in pooled results, but it was significant during individual years. In the first year treatment S_2 and in second year treatment S_3 produced significantly higher stover yield. Interaction between dates of sowing and irrigation scheduling was found to be significant during both the year as well as in pooled data for seed yield (Table 3). Treatment combination D_2S_2 (Crop sown during 3rd week of February and irrigation at branching, Flowering, Capsule development, Seed development) produced significantly the highest seed yield (1111 kg/ha) in pooled data and during the year 2019. However, in 2020,

Table 4. Interaction effect of dates of sowing and irrigation scheduling on seed yield and water use efficiency (WUE) of sesame

Treatment	Seed yield (kg/ha)			WUE (kg/ha/mm)		
	2019	2020	Pooled	2019	2020	Pooled
D_1 S_1	623	528	576	311.7	263.9	287.8
D_1 S_2	877	796	836	350.6	318.5	334.6
D_1 S_3	759	722	741	379.6	361.1	370.4
D_1 S_4	503	463	483	335.4	308.6	322.0
D_2 S_1	1,028	1,000	1,014	513.9	500.0	506.9
D_2 S_2	1,176	1,046	1,111	470.4	418.5	444.4
D_2 S_3	1,056	,1009	1,032	527.8	504.6	516.2
D_2 S_4	664	593	628	442.4	395.1	418.7
D_3 S_1	988	935	961	493.8	467.6	480.7
D_3 S_2	1,012	981	997	404.9	392.6	398.8
D_3 S_3	994	954	974	496.9	476.9	486.9
D_3 S_4	781	750	765	520.6	500.0	510.3
SEm±	33	43	27	17.7	24.1	15.0
CD (P=0.05)	97	129	78	52.6	71.6	42.9

(D_1, 1st week of February, D_2, 3rd week of February and D_3, 1st week of March), (S_1, at branching, flowering, seed development; S_2, at branching, flowering, capsule development, seed development; S_3, at branching, capsule development, seed development; S_4, at flowering, capsule development)

it was at par with treatment combinations D_2S_3, D_2S_1, D_3S_2, D_3S_3 and D_3S_1. The lowest seed yield (483 kg/ha) was observed in treatment combination D_1S_4 in pooled results. A similar trend was observed during both the individual years. Treatment combination D_2S_2 produced 130.0% higher yield than treatment combination D_1S_4 on pooled basis. All the other interactions for seed yield were found not significant. Interaction between Y × D and Y × S in stover yield were found to be significant (Table 3), while other interactions remained non-significant in case of stover yield. Increase yield under irrigation withS_3 or S_2 might be due to thefact that the crop received the right quantity of irrigationwater at the right crop growth stage, maintaining optimal soil moisture content in the surrounding root zone area. This led to improvements in the number of branches, capsules/plant, seeds/capsule, seed yield/plant, thereby increasing sesame seed and stover yield. These findings are in close agreement with the resultsobtained by Patra (2001) and Chang *et al*. (2005). Singh *et al.* (2024), Howmik & Jha (2010), Sarkar *et al,* (2010).

Economics

The economics of different treatments is presented in Table 3. The data reveals that maximum net return (Rs. 46,712) and benefit-cost ratio (BCR) of3.58 were obtained when sesame was sown during 3rd week of February (Treatment D_2) followed by treatment D_3 (1st week of March sowing) with a net return of Rs. 45204 per hectare and a BCR of 3.49. Treatment D_1 recorded the minimum net return as well as BCR. Regarding the different irrigation treatments, treatment S_2 (irrigation at branching, Flowering, Capsule development, Seed development) provided the highest net return (Rs. 43,171) with a BCR of 2.79, followed by treatment S_3 with a net return of Rs. 40,215 per hectare and a BCR of 2.78. The lowest net return (Rs. 21,835) and BCR (2.04) were recorded in treatment S_4. For the different treatment combinations, the combination ofD_2S_2 (Crop sown during 3rd week of February and irrigation at branching, Flowering, Capsule development, Seed development) achieved the highest net return (Rs. 52,082) with a BCR of 3.16. This was closely followed by treatment combinations, D_2S_3 and D_2S_1. The lowest net return (Rs.12,033) with a BCR of 1.57 was recorded in the treatment combination D_1S_4 followed by treatment combination D_1S_1.

Correlation Studies

The result recorded on correlation (Table 5) indicates that several factors were extremely positively correlated with seed yield of sesame. Specially, stover yield (r=0.887), capsules/plant (r=0.910), plant height at harvest (r=0.944) and final plant stand (r=0.824) were extremely positively correlated with seed yield of sesame. Notably, no data were found to be negatively correlated with seed yield except water use efficiency (WUE), which was negatively correlated with branches per plan. However, the relationship between WUE and branches per plant was found to be non-significant. The positive correlation between growth

Table 5. Correlation coefficient (r) between yield, yield attributing characters and growth parameters of sesame

Particulars	Seed yield	Stover yield	WUE	Branches/ plant	Capsules/ plant	Plant height @ harvest	Final plant stand	Test weight
Seed yield	1.000**							
Stover yield	0.887**	1.000**						
WUE	0.590NS	0.732NS	1.000**					
Branches/plant	0.623NS	0.354NS	-0.195NS	1.000**				
Capsules/plant	0.910**	0.729NS	0.272NS	0.883**	1.000**			
Plant height @ harvest	0.944**	0.799*	0.485NS	0.546NS	0.811*	1.000**		
Final plant stand	0.824**	0.769*	0.848*	0.129NS	0.541NS	0.806*	1.000**	
Test weight	0.745NS	0.733NS	0.280NS	0.543NS	0.718NS	0.701NS	0.572NS	1.000**

parameters such as final plant stand and plant height at harvest, as well as yield attributes and yield viz. capsules/ plant, test weight and stover yield increase with increase in seed yield of sesame. The correlation matrix also indicates that while WUE was inversely correlated with branches per plant, this specific relationship did not have a significant impact on overall yield.

From the above results for achieving higher yield and net return in sesame cultivation, it can be concluded that the sesame sown during 3rd week of February and follow an irrigation scheduling that includes at branching, Flowering, Capsule development, and Seed development stages.

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