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Performance of summer sesame (*Sesamum indicum* L.) cultivars under varying dates of sowing in prevailing agro-climatic condition of North Bengal

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To study the effect of dates of sowing and improved cultivars on growth and yield of summer sesame in North Bengal five different dates of sowing (10th February, 20th February, 2nd March, 12th March and 22nd March and three cultivars of sesame (Rama, Savitri and Tillotama) with three replications. The highest (114.66 and 115.83 cm) plant height was recorded when sesame sown on 12th March (D_4) and which was statistically at par with 2nd March (D_3). Among the varying date of sowing, the highest dry matter accumulation, leaf area index and crop growth rate was recorded in 2nd day of March compared to the other date of sowing. Among the improved cultivars of sesame, the variety Rama recorded higher plant height, dry matter accumulation, leaf area index and crop growth rate compared to Savitri and Tillotoma. The highest yield was recorded when sesame sown on 2nd March which was 55.99 and 40.85% higher than the crops sown on 22nd March during 2013 and 2014 respectively. Rama also exhibited highest seed yield recording 17.70 and 12.06% higher than the cultivars Tillotama and Savitri. The date of sowing significantly influenced the yield attributes and highest yield attributes was recorded when sesame sown on 2nd March. Improved cultivar, Rama recorded the highest yield attributing characters compared to the Savitri and Tillotoma. It can be concluded that sowing of sesame within 2nd March to 12th March is the optimum sowing dates of sesame to have optimum seed yield if grown as late summer crop. Result indicated that cultivar Rama can be adopted in *terai* zone of West Bengal during summer season, because of its highest seed yield ability.

Key words: Sesame, cultivars, date of sowing, growth, yield, yield attributes.

INTRODUCTION

Sesame (*Sesamum indicum* L.), the queen of vegetable oils belonging to family Pedaliaceae is one of the oldest oil-rich plants in the world (Janick and Whipkey, 2002) and that originated in Africa (Brar and Ahuja, 1979; Ram et al., 1990). It is widely grown in tropical and subtropical regions. Its production is often concentrated in marginal and sub marginal lands (Ashri, 1998). India ranks among the top six world producers of sesame seed. Thus, production growth and quality improvement of oilseeds can substantially contribute to the economic development at national, regional and at family level. It is a non-leguminous annual flowering green plant cultivated

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primarily for its small edible seeds rich in oil and protein of about 50 and 25% respectively (Langham et al., 2006). There are also intermediate coloured varieties varying from red to rose or from brown or grey.

The low yields coupled with problems encountered during harvesting sesame have tended to discourage growers, leading to a decline in the total area devoted to its cultivation. In general, the production constraints include poor agronomic practice, pest and disease, weed infestation, poor soil fertility, low yielding cultivars. However, crop improvement in sesame has been practiced for a long time. Yet a major breakthrough could not be made in realizing high yields in sesame varieties. One of the reasons is that there is limited genetic variability in the source material. It is a seasonal and location bound crop hence, a particular variety does not perform uniformly in all locations and in all seasons. The yielding ability of sesame crop is determined by many yield components, all of which are substantially influenced by environmental conditions and agronomic packages. The grain yield of sesame is significantly influenced by sowing date and cultivars (Hazarika, 1998). Moreover, temperature and variety affected seed yield variation by 69 and 39%, respectively (Sharma, 2005). The effect of photoperiodism on sesame has been thoroughly studied, since this is a major factor influencing seed yield. According to El-Bakheit (1985) delaying of sesame sowing increased the incidence of pests and diseases. Therefore, for successful production of crop most optimum sowing time and cultivars are indispensable (Ali et al., 2005).

In this region sesame is cultivated as a rainfed crop during pre- kharif and kharif season but it is also grown during summer season in residual soil moisture under poor management practices. Hence, the yield of sesame in this region is generally low due to use of low yielding cultivars (local) with poor agronomic management practices. Research works are limited on sowing time and cultivars under *terai* agro-climatic situation of West Bengal. Hence, here is a need of research effort is to be under taken to identify the sesame cultivars with desirable character. Considering the above mentioned reason, a study on growth and yield improved sesame cultivars under varying date of sowing was carried out under this region.

MATERIALS AND METHODS

A field experiment was conducted at the Instructional farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India during 2013 to 2014 to study the effect of dates of sowing and improved cultivars on growth and yield of summer sesame (*Sesamum indicum* L.). The treatment consisted of five different dates of sowing that is, 10th February, 20th February, 2nd March, 12th March and 22nd March (symbolized as D_1, D_2, D_3, D_4 and D_5, respectively) in the main plots and three cultivars that is, Rama, Savitri and Tillotama (symbolized as V_1, V_2 and V_3, respectively) in the sub plot, in a split plot design with three replication. The farm is situated at 26°19′86″ N latitude and 89°23′53″ E longitude and at an elevation of 43 m above mean sea level. The soil of the experimental field was sandy loam in texture with pH 5.7. The results were analyzed taking consideration of pre harvest parameters like plant height (cm), dry matter accumulation (DMA), Leaf area index (LAI) calculated according to the formula given by Watson (1947).

$$\text{Leaf area index (LAI)} = \frac{\text{Area of total number of leaves surface}}{\text{Ground area from which leaf sample were collected}}$$

Then the mean LAI (L) was calculated as per the formula given below.

$$\textbf{Mean LAI } (\bar{L}) = \frac{L_2 - L_1}{\text{Log}_e L_2 - \text{Log}_e L_1}$$

Where, L_1 and L_2 are the leaf area indices at two successive occasions on time t_1 and t_2 respectively.

Crop growth rate (CGR) expresses the gain in dry matter production of the crop per unit land area per unit time and is expressed as gram per meter square per day (g m^{-2} day^{-1}). It is calculated according to the formula given by Watson (1952).

$$CGR = \frac{W_2 - W_1}{t_2 - t_1}$$

Where, $W_1$and W_2 were the dry weight of the aerial plants per unit area gained at time t_1 and t_2 respectively. Postharvest parameters like number of branches $plant^{-1}$, number of capsules $plant^{-1}$, number of seed $capsule^{-1}$ and test weight of seed [1000 seed weight (g)], seed yield (t ha^{-1}), stem yield (t ha^{-1}) and harvest index (%). Data were analyzed by using INDO-STAT- software for analysis of variance following split- plot design treatment means were separated by applying critical difference (CD) test at 5% level of significance.

RESULTS AND DISCUSSION

Effect of date of sowing and improved cultivars on growth attributing characters of sesame

Effect of treatments on growth

Irrespective of date of sowing and improved cultivars of sesame, plant height kept on increasing till the last observation recorded at harvest. The plant height increased with the advancement of the crop age due to its growth and reached its maximum at harvest irrespective of the treatments tried (Table 1). LAI was low at the early stages of crop growth (Table 2) and kept on increasing with advancement of crop age up to 75 DAS when reached at its peak. Thereafter it decline towards maturity of the crop touches which was stopped at the reproductive stages of the crop. Another reason may be attributed to senescence of the leaves at the later stage of crop growth. Dry matter accumulation was lowest at 30 DAS thereafter rapid accumulation of dry matter was noticed till at harvest. The rate of accumulation became slower and it reaches at its maximum value till the last

Table 1. Effect of dates of sowing and improved cultivars on plant height (cm) of sesame.

Treatment	Plant height (cm)											
	Days after sowing											
	30			60			75			At harvest		
	YI	YII	Pooled	YI	YII	Pooled	YI	YII	Pooled	YI	YII	Pooled
D_1	6.81	4.83	5.82	31.92	23.07	27.49	61.77	56.88	59.33	99.77	91.00	95.38
D_2	8.47	8.47	8.47	44.22	35.22	39.72	74.85	65.77	70.31	107.11	102.16	104.64
D_3	13.00	11.38	12.19	63.16	62.66	62.91	95.66	87.33	91.50	112.11	114.66	113.38
D_4	13.41	12.72	13.07	66.00	69.33	67.66	96.77	92.44	94.61	114.66	115.83	115.25
D_5	12.39	9.47	10.93	62.12	48.88	55.50	92.87	78.22	85.54	109.55	112.83	111.19
S. Em. ($\pm$)	**0.44**	**0.54**	**0.39**	**2.89**	**1.78**	**1.66**	**3.44**	**4.64**	**3.03**	**3.76**	**4.50**	**2.02**
C.D. (0.05)	**1.43**	**1.78**	**1.29**	**9.44**	**5.80**	**5.43**	**11.22**	**15.13**	**9.90**	**12.27**	**14.70**	**6.59**
V_1	11.26	9.82	10.54	56.03	49.35	52.69	86.44	78.60	82.52	112.53	108.68	110.61
V_2	10.86	9.26	10.06	54.43	47.68	51.06	84.28	75.46	79.87	108.13	107.23	107.68
V_3	10.34	9.05	9.69	49.99	46.46	48.23	82.43	74.33	78.38	105.26	105.97	105.62
S. Em. ($\pm$)	**0.16**	**0.24**	**0.15**	**2.12**	**0.99**	**1.14**	**1.85**	**1.83**	**1.11**	**1.22**	**2.58**	**1.20**
C.D. (0.05)	**0.49**	**NS**	**0.45**	**NS**	**NS**	**3.36**	**NS**	**NS**	**3.29**	**3.62**	**NS**	**3.56**
D_1V_1	7.26	5.01	6.14	35.33	23.26	29.30	65.83	60.66	63.25	106.00	92.00	99.00
D_1V_2	6.93	4.76	5.85	31.83	23.11	27.47	60.66	55.66	58.16	98.66	91.00	94.83
D_1V_3	6.23	4.73	5.48	28.60	22.83	25.72	58.83	54.33	56.58	94.66	90.00	92.33
D_2V_1	9.03	8.83	8.93	45.66	37.16	41.41	76.33	69.33	72.83	110.00	103.61	106.80
D_2V_2	8.50	8.50	8.50	44.33	35.00	39.66	75.22	64.66	69.94	107.00	102.66	104.83
D_2V_3	7.90	8.10	8.00	42.66	33.50	38.08	73.00	63.33	68.16	104.33	100.22	102.28
D_3V_1	13.50	11.83	12.66	65.50	63.83	64.66	96.55	88.00	92.27	115.33	116.33	115.83
D_3V_2	13.00	11.33	12.16	65.33	62.66	64.00	95.77	87.33	91.55	111.66	114.33	113.00
D_3V_3	12.50	11.00	11.75	58.66	61.50	60.08	94.66	86.66	90.66	109.33	113.33	111.33
D_4V_1	13.56	13.66	13.61	68.66	72.33	70.50	98.50	95.66	97.08	119.33	117.33	118.33
D_4V_2	13.26	12.33	12.80	67.33	68.00	67.66	96.33	91.00	93.66	114.33	115.16	114.75
D_4V_3	13.41	12.16	12.79	62.00	67.66	64.83	95.50	90.66	93.08	110.33	115.00	112.66
D_5V_1	12.93	9.76	11.35	65.00	50.16	57.58	95.00	79.33	87.16	112.00	114.16	113.08
D_5V_2	12.60	9.27	10.98	63.33	49.66	56.50	93.44	78.66	86.05	109.00	113.00	111.00
D_5V_3	11.65	9.37	10.46	58.04	46.83	52.43	90.16	76.66	83.41	107.66	111.33	109.50

Treatment	30 YI D X V	30 YI V X D	30 YII D X V	30 YII V X D	30 Pooled D X V	30 Pooled V X D	60 YI D X V	60 YI V X D	60 YII D X V	60 YII V X D	60 Pooled D X V	60 Pooled V X D	75 YI D X V	75 YI V X D	75 YII D X V	75 YII V X D	75 Pooled D X V	75 Pooled V X D	At harvest YI D X V	At harvest YI V X D	At harvest YII D X V	At harvest YII V X D	At harvest Pooled D X V	At harvest Pooled V X D
S. Em. ($\pm$)	**0.37**	**0.53**	**0.55**	**0.71**	**1.24**	**1.17**	**4.75**	**4.84**	**2.21**	**2.53**	**2.55**	**2.66**	**4.14**	**4.82**	**4.09**	**5.72**	**2.49**	**3.65**	**2.74**	**4.38**	**5.78**	**6.53**	**2.70**	**2.99**
C.D. (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

YI= 2013 & YII=2014; DI=10th February, D2=20th February, D3=2nd March, D4=12th March, D5=22nd March and V1= Rama, V2= Savitri & V3= Tillotama.

observation at harvest increased at an increasing rate up to harvest and thereafter it increased with decreasing rate, irrespective of date of sowing and improved cultivars. This indicate that the initial growth rate (Table 3). The rate of dry matter accumulationas measured by the dry matter accumulation was packed up as the crop passes through the seed filling and maturity stage. Crop growth rate was low at the early stages of crop

Table 2. Effect of dates of sowing and improved cultivars on leaf area index of sesame.

Treatment	Leaf area index											
	Days after sowing											
	30			60			75			At harvest		
	YI	YII	Pooled	YI	YII	Pooled	YI	YII	Pooled	YI	YII	Pooled
D_1	0.14	0.15	0.15	1.14	0.83	0.98	1.61	1.23	1.42	0.61	0.55	0.58
D_2	0.29	0.20	0.24	1.40	1.05	1.22	1.83	1.43	1.63	0.75	0.61	0.68
D_3	0.33	0.30	0.31	1.71	1.44	1.57	2.20	1.82	2.01	0.93	0.97	0.95
D_4	0.30	0.29	0.29	1.45	1.22	1.33	2.12	1.72	1.92	0.84	0.81	0.82
D_5	0.24	0.29	0.26	1.20	0.90	1.05	1.72	1.38	1.55	0.69	0.68	0.68
S. Em. (±)	**0.01**	**0.01**	**0.007**	**0.03**	**0.05**	**0.03**	**0.04**	**0.04**	**0.03**	**0.04**	**0.03**	**0.03**
C.D. (0.05)	**0.03**	**0.04**	**0.02**	**0.11**	**0.18**	**0.09**	**0.13**	**0.14**	**0.11**	**0.15**	**0.12**	**0.09**
V_1	0.28	0.26	0.27	1.51	1.16	1.33	1.98	1.59	1.78	0.80	0.78	0.79
V_2	0.25	0.24	0.25	1.36	1.08	1.22	1.89	1.50	1.70	0.76	0.71	0.74
V_3	0.24	0.23	0.24	1.27	1.02	1.15	1.82	1.45	1.63	0.73	0.67	0.70
S. Em. (±)	**0.004**	**0.01**	**0.006**	**0.03**	**0.03**	**0.02**	**0.04**	**0.03**	**0.03**	**0.02**	**0.01**	**0.01**
C.D. (0.05)	**0.01**	**0.02**	**0.01**	**NS**	**0.09**	**0.07**	**NS**	**0.12**	**0.11**	**0.06**	**0.04**	**0.05**
D_1V_1	0.15	0.19	0.16	1.32	0.86	1.09	1.69	1.27	1.48	0.64	0.58	0.61
D_1V_2	0.15	0.14	0.14	1.13	0.83	0.98	1.60	1.23	1.41	0.62	0.56	0.59
D_1V_3	0.14	0.13	0.14	0.97	0.78	0.88	1.53	1.18	1.35	0.58	0.51	0.54
D_2V_1	0.30	0.20	0.25	1.50	1.14	1.32	1.93	1.50	1.72	0.78	0.67	0.73
D_2V_2	0.28	0.20	0.24	1.36	1.01	1.19	1.79	1.42	1.60	0.07	0.60	0.68
D_2V_3	0.27	0.19	0.23	1.34	0.98	1.16	1.76	1.37	1.56	0.72	0.56	0.64
D_3V_1	0.38	0.32	0.35	1.76	1.53	1.64	2.28	1.92	2.10	1.01	1.00	1.00
D_3V_2	0.31	0.30	0.30	1.72	1.40	1.56	2.22	1.80	2.01	0.91	0.97	0.94
D_3V_3	0.30	0.27	0.28	1.65	1.39	1.52	2.11	1.76	1.93	0.87	0.94	0.90
D_4V_1	0.30	0.31	0.30	1.56	1.30	1.43	2.21	1.83	2.02	0.88	0.93	0.90
D_4V_2	0.28	0.28	0.28	1.43	1.24	1.33	2.12	1.70	1.91	0.83	0.77	0.80
D_4V_3	0.29	0.28	0.28	1.36	1.13	1.24	2.05	1.62	1.83	0.80	0.74	0.77
D_5V_1	0.27	0.30	0.29	1.42	0.96	1.19	1.79	1.41	1.60	0.70	0.73	0.72
D_5V_2	0.22	0.29	0.26	1.16	0.89	1.03	1.72	1.38	1.55	0.68	0.66	0.67
D_5V_3	0.21	0.28	0.25	1.03	0.82	0.93	1.66	1.32	1.49	0.66	0.63	0.65
	D X V / V X D	**D X V / V X D**	**D X V / V X D**	**D X V / V X D**	**D X V / V X D**	**D X V / V X D**	**D X V / V X D**	**D X V / V X D**	**D X V / V X D**	**D X V / V X D**	**D X V / V X D**	**D X V / V X D**
S. Em. (±)	**0.01 / 0.01**	**0.02 / 0.02**	**0.01 / 0.01**	**0.07 / 0.06**	**0.07 / 0.08**	**0.05 / 0.05**	**0.09 / 0.28**	**0.08 / 0.08**	**0.08 / 0.07**	**0.05 / 0.06**	**0.03 / 0.04**	**0.03 / 0.04**
C.D. (0.05)	**NS / NS**	**NS / NS**	**NS / NS**	**NS / NS**	**NS / NS**	**NS / NS**	**NS / NS**	**NS / NS**	**NS / NS**	**NS / NS**	**NS / NS**	**NS / NS**

YI= 2013 & YII=2014; DI=10th February, D2=20th February, D3=2nd March, D4=12th March, D5=22nd March and V1= Rama, V2= Savitri & V3= Tillotama.

growth (Table 4) and kept on increasing with advancement of crop slow at vegetative stages of crop growth which age up to 60-75 DAS when reached at its peak and after it decline towards maturity of the crop.

Date of sowing was significantly influenced height of the plant at all stages of crop growth upto harvest (Table 1). Among the date of sowing, the highest (114.66 and 115.83) plant height at

Table 3. Effect of dates of sowing and improved cultivars on dry matter accumulation of sesame.

Treatment	Dry matter accumulation (g m^{-2})											
	Days after sowing											
	30			60			75			At harvest		
	YI	YII	Pooled	YI	YII	Pooled	YI	YII	Pooled	YI	YII	Pooled
D_1	15.79	12.90	14.35	180.00	176.73	178.36	386.44	381.20	383.82	539.66	499.22	516.84
D_2	17.12	14.83	15.98	195.00	193.70	194.35	422.22	387.74	404.98	581.77	536.33	556.95
D_3	18.55	18.34	18.45	225.11	217.18	221.14	488.00	471.84	479.92	696.33	660.88	676.33
D_4	17.04	16.48	16.76	206.22	200.31	203.26	455.77	411.36	433.56	629.77	561.11	592.33
D_5	16.05	16.07	16.06	189.88	174.00	181.94	404.11	379.33	391.72	542.55	496.55	519.56
S. Em. ($\pm$)	**0.52**	**1.13**	**0.66**	**8.03**	**8.41**	**5.62**	**6.10**	**13.46**	**8.27**	**6.99**	**14.01**	**9.18**
C.D. (0.05)	**1.70**	**3.69**	**2.16**	**26.19**	**27.45**	**18.33**	**19.91**	**43.90**	**26.97**	**22.81**	**45.70**	**29.95**
V_1	17.57	17.03	17.30	210.30	204.03	207.17	454.26	429.54	441.90	634.00	589.73	607.91
V_2	16.99	15.72	16.36	197.89	192.05	194.97	428.73	407.28	418.00	593.33	551.06	571.30
V_3	16.17	14.42	15.29	189.53	181.07	185.30	410.93	382.05	396.49	566.73	511.66	538.00
S. Em. ($\pm$)	**0.27**	**0.47**	**0.29**	**3.15**	**7.69**	**4.37**	**6.85**	**8.12**	**5.53**	**6.33**	**9.29**	**6.05**
C.D. (0.05)	**0.82**	**1.40**	**0.87**	**9.31**	**NS**	**12.89**	**20.22**	**23.95**	**16.31**	**18.68**	**27.43**	**17.86**
D_1V_1	16.10	14.50	15.30	188.33	184.33	186.33	405.66	394.76	400.21	571.33	521.66	540.33
D_1V_2	15.71	12.45	14.08	181.33	177.33	179.33	388.00	384.77	386.38	538.00	505.00	519.84
D_1V_3	15.57	11.75	13.66	170.33	168.53	169.43	365.66	364.06	364.86	509.66	471.00	490.33
D_2V_1	17.52	15.3	16.45	206.66	206.37	206.52	444.33	417.66	431.00	622.00	580.33	594.84
D_2V_2	17.40	13.80	15.60	192.66	193.82	193.24	419.33	390.19	404.76	573.33	538.66	556.00
D_2V_3	16.46	15.30	15.88	185.66	180.92	183.29	403.00	355.36	379.18	550.00	490.00	520.00
D_3V_1	19.08	22.21	20.65	237.66	231.03	234.34	514.0	498.20	506.10	736.33	709.00	720.50
D_3V_2	18.86	19.52	19.19	224.33	213.66	219.00	481.66	471.42	476.54	685.33	659.66	672.33
D_3V_3	17.71	13.30	15.51	213.33	206.88	210.10	468.33	445.90	457.11	667.33	614.00	636.16
D_4V_1	18.36	16.73	17.55	220.66	210.66	215.66	480.00	440.10	460.05	670.00	608.33	634.00
D_4V_2	16.94	16.58	16.76	200.33	205.09	202.71	448.00	415.68	431.84	618.66	562.66	588.00
D_4V_3	15.80	16.13	15.97	197.66	185.17	191.42	439.33	378.30	408.81	600.66	512.33	555.00
D_5V_1	16.80	16.32	16.56	198.20	187.80	193.00	427.33	397.00	412.16	570.33	529.33	549.84
D_5V_2	16.06	16.27	16.17	190.80	170.33	180.56	406.66	374.33	390.50	551.33	489.33	520.33
D_5V_3	15.28	15.63	15.46	180.66	163.86	172.26	378.33	366.66	372.50	506.00	471.00	488.50

	D X V	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**
S. Em. ($\pm$)	**0.62**	**2.59**	**1.06**	**1.42**	**0.65**	**0.85**	**7.06**	**9.88**	**17.2**	**16.4**	**9.77**	**9.76**	**15.3**	**13.9**	**18.2**	**20.3**	**12.4**	**13.05**	**14.2**	**13.5**	**20.9**	**22.1**	**13.5**	**14.6**
C.D. (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

YI= 2013 & YII=2014; DI=10th February, D2=20th February, D3=2nd March, D4=12th March, D5=22nd March and V1= Rama, V2= Savitri & V3= Tillotama.

harvest was recorded in sowing of sesame on 12th March (D_4) and which was statistically at par with 2nd March (D_3). Peter and Yakubu (2012) reported that plant heights significantly influenced due to sowing were delayed. Sowing of sesame on 2nd day of March (D_3) recorded significantly higher leaf area index (2.20 and 1.82) as compared to other dates of sowing and sesame sown on 10th February (D_1) gave the lowest leaf area index

Table 4. Effect of dates of sowing and improved cultivars on crop growth rate of sesame.

Treatment	Crop growth rate (g m^{-2} day^{-1})								
	Days after sowing								
	45-60			60-75			75-90		
	YI	YII	Pooled	YI	YII	Pooled	YI	YII	Pooled
D_1	9.75	9.61	9.68	13.76	13.63	13.69	5.72	4.63	5.17
D_2	10.27	10.46	10.36	15.14	12.93	14.02	6.09	5.93	6.01
D_3	11.72	11.28	11.50	17.52	16.97	17.25	8.37	7.56	7.97
D_4	10.97	10.59	10.78	16.63	14.07	15.35	6.74	5.67	6.20
D_5	10.11	9.04	9.58	14.28	13.68	13.98	5.88	4.91	5.40
S. Em. (±)	**0.50**	**0 .62**	**0.38**	**0.67**	**0.93**	**0.58**	**0.37**	**0.34**	**0.20**
C.D. (0.05)	**1.65**	**2.02**	**1.24**	**2.19**	**3.05**	**1.91**	**1.21**	**1.13**	**0.67**
V_1	11.08	10.79	10.93	16.26	15.03	15.64	6.94	6.48	6.71
V_2	10.50	10.16	10.33	15.38	14.34	14.86	6.48	5.68	6.08
V_3	10.12	9.64	9.88	14.76	13.39	14.07	6.26	5.06	5.66
S. Em. (±)	**0.21**	**0.52**	**0.31**	**0.48**	**0.57**	**0.41**	**0.26**	**0.34**	**0.23**
C.D. (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**1.22**	**NS**	**NS**	**NS**
D_1V_1	10.04	10.01	10.03	14.48	14.02	14.25	5.86	5.22	5.54
D_1V_2	9.81	9.65	9.73	13.78	13.82	13.80	5.68	4.84	5.26
D_1V_3	9.41	9.31	9.29	13.02	13.03	13.02	5.62	3.82	4.72
D_2V_1	10.91	11.06	10.99	15.84	14.08	14.96	6.55	6.40	6.47
D_2V_2	10.15	10.46	10.30	15.11	13.09	14.10	6.04	5.87	5.96
D_2V_3	9.75	9.84	9.80	14.49	11.62	13.05	5.69	5.53	5.61
D_3V_1	12.22	11.89	12.06	18.42	17.81	18.11	8.95	8.58	8.77
D_3V_2	11.75	11.04	11.40	17.15	17.18	17.17	8.20	7.46	7.83
D_3V_3	11.20	10.89	11.04	17.00	15.93	16.46	7.97	6.65	7.31
D_4V_1	11.70	11.11	11.40	17.28	15.29	16.29	7.31	6.34	6.83
D_4V_2	10.63	10.88	10.76	16.51	14.03	15.27	6.64	5.48	6.06
D_4V_3	10.60	9.78	10.19	16.11	12.87	14.49	6.26	5.18	5.72
D_5V_1	10.52	9.87	10.19	15.27	13.94	14.61	6.02	5.86	5.94
D_5V_2	10.18	8.76	9.47	14.39	13.60	13.99	5.86	4.75	5.31
D_5V_3	9.64	8.48	9.06	13.18	13.52	13.34	5.75	4.13	4.94

	D X V	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**	**D X V**	**V X D**
S. Em. (±)	**0.47**	**0.63**	**1.17**	**1.14**	**0.69**	**0.68**	**1.08**	**1.10**	**1.29**	**1.40**	**0.93**	**0.95**	**0.59**	**0.61**	**0.77**	**0.71**	**0.52**	**0.47**
C.D. (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

YI= 2013 & YII=2014; DI=10th February, D2=20th February, D3=2nd March, D4=12th March, D5=22nd March and V1= Rama, V2= Savitri & V3= Tillotama.

(1.61 and 1.23 during both the years of experimentation respectively) at 75 DAS (2). Dry matter production was found to increase starting from 30 DAS onwards and continued up-to harvest with all the date of sowing. The highest (696.33 and 660.88) amount of dry matter accumulation was recorded from when sesame shown on 2nd March (D_3) (Table 3). The better sink capacity might be attributed to the better dry matter production owing to better photosynthetic capacity of plant during reproductive phase of crop. The present results are in conformity with earlier findings of Pawar (1991) and Kanabur (1998).

The crop growth rate was found to be notably significant due to the effect of dates of sowing during both years of experimentation respectively. The highest (17.52 and 16.97) crop growth rate was recorded when sesame shown on 2nd day of March (D_3) and lowest crop growth rate (13.76 and 13.63) was recorded when crop shown on 10th February (D_1) between 60-75 DAS during both the years of experimentation respectively (Table 4).

Plant height was significantly influenced by the improved sesame cultivars at 30, 90 and at harvest in first year of experimentation (Table 1). Among the cultivars, Rama recorded highest (112.53 and 108.68 at harvest) plant height followed by Savitri and Tillotoma at all stages of crop growth. This might be due to genetic makeup and climatic condition which enhanced the growth and development of sesame. Among the improved cultivars highest (1.98 and 1.59) leaf area index was recorded in cultivars Rama followed by Savitri and Tillotoma at all stages crop growth (Table 2). This might be due to absorption and utilization of moisture, nutrients and light by crop which significantly influenced the leaf area. Similar observation was made by Pawar (1991). The highest (634.00 and 589.73) dry matter accumulation was recorded in cultivars Rama followed by Savitri and Tillotoma at all stages crop growth (Table 3). This might be due to higher translocation of photosynthetic was possible due to better sink capacity of cv. Rama than cv. Savitri and Tillotoma as indicated by higher number of capsules and seed weight plant^{-1} in cv. Rama. Crop growth rate not found to be significant. The highest (16.26 and 15.03 in between 60-75 DAS) was recorded in cultivar Rama followed by Savitri and Tillotoma during both the years of experimentation respectively (Table 4). The interaction effect of date of sowing and cultivars was not significant for all growth parameters.

Effect of dates of sowing and cultivars on yield components of sesame

Irrespective of sowing dates and improved cultivars, the number of branches plant kept on increasing till the last observation recorded at harvest. The number of branches plant^{-1} increased with the advancement of the crop age due to its growth and reached its maximum at harvest irrespective of the treatments tried (Table 5). The number of branches plant^{-1} was found significant due to the effect of date of sowing however, it was found non-significant due to the effect of cultivars. This might be influenced by the environment which could have counted for the fewer branches in sown crops because of the change in the environmental condition that forces the crop to reduce vegetative growth and commence reproductive phase as reported by Kifiriti and Deckers (2001). Peter and Yakubu (2012) reported that number of branches per plant decreased due to delay in time of sowing. The number of capsules plant^{-1}, number of grains capsule^{-1} and test weight of seed (1000 seed weight) was found significant due to the effect of date of sowing and cultivars. Among the varying date of sowing, 2nd day of March (D_3) recorded significantly higher number of branches plant, number of capsule plant, number of seeds plant and test weight as compared to other dates of sowing and 10th February (D_1) was recorded the lowest number of branches plant^{-1}, number of capsule plant^{-1}, number of seeds capsule^{-1} and test weight during both years of experimentation respectively (Table 5). The increase in the number of capsule plant^{-1} might be due to the environment and length of growth period has significantly influenced on number of capsule plant^{-1}. Similar result also made by Kifiriti and Deckers (2001). This might be due to the increased growth of crop and better utilization of light by crop. Abdel et al. (2007) reported that delaying the sowing date decreased number of capsules plant^{-1} and test weight (1000-seed). However, Patil et al*.* (1992) reported that increased number of capsule plant^{-1} with delaying sowing might be due to difference in genetic makeup and climatic conditions. This finding was in agreement with the result obtained by Nath et al*.* (2000) and Rai et al*.* (1999).

Among the different cultivars number of branches plant^{-1}, number of capsule plant^{-1}, number of seeds capsule^{-1} of sesame was found significantly influenced due to the effect of cultivars but test weight of sesame was not significantly influenced due to the effect of cultivars. However, variety Rama (V_1) was recorded higher number of branches plant^{-1}, number of capsule plant^{-1}, number of seeds capsule^{-1} and test weight as compared to Savitri and Tillotama during both the years of experimentation respectively (Table 5). This might be due to improved crop growth duration, availability of soil moisture and absorption of nutrients by crops which enhanced the crop growth, increase in yield attributing characters and ultimately yield. Increasing seed rate significantly decreased the number of capsules plant^{-1} and seed yield per sesame plant (Sudan Ahmed et al., 2012) and protein content (Caliskan et al*.*, 2004). The interaction effect between date of sowing and cultivars was non-significant.

Seed yield, stem yield and harvest index

Irrespective of different sowing dates of sesame, 2nd day

Table 5. Effect of dates of sowing and cultivars on yield attributes of sesame.

Treatments	Yield attributes											
	No. of branches plant^{-1}			No. of capsules plant^{-1}			No. of seeds capsule^{-1}			Test weight (g)		
	YI	YII	Pooled	YI	YII	Pooled	YI	YII	Pooled	YI	YII	Pooled
D_1	4.22	2.90	3.56	54.44	53.22	53.83	46.66	43.22	44.94	2.40	2.33	2.36
D_2	4.03	3.26	3.65	57.55	59.37	58.46	47.85	47.29	47.57	2.54	2.55	2.54
D_3	4.91	4.09	4.50	72.11	65.25	68.68	50.70	50.29	50.50	2.74	2.60	2.67
D_4	4.77	3.48	4.12	64.07	58.88	61.48	47.96	49.14	48.55	2.67	2.54	2.61
D_5	4.47	3.14	3.81	60.74	54.48	57.61	47.96	46.48	46.55	2.50	2.57	2.54
S. Em. (+)	**0.12**	**0.24**	**0.14**	**2.92**	**1.59**	**1.98**	**1.12**	**1.80**	**1.36**	**0.01**	**0.08**	**0.04**
C.D. (0.05)	**0.41**	**0.81**	**0.48**	**9.54**	**5.20**	**6.46**	**3.68**	**5.88**	**4.46**	**0.05**	**0.26**	**0.13**
V_1	4.75	3.61	4.18	65.35	62.17	63.76	49.68	49.48	49.58	2.68	2.61	2.65
V_2	4.41	3.44	3.92	61.68	59.06	60.37	47.86	47.51	47.68	2.57	2.57	2.57
V_3	4.28	3.08	3.68	58.31	53.48	55.90	46.33	44.86	45.60	2.46	2.37	2.41
S. Em. (+)	**0.14**	**0.15**	**0.12**	**2.31**	**2.25**	**1.45**	**0.71**	**1.33**	**0.70**	**0.02**	**0.04**	**0.02**
C.D. (0.05)	**NS**	**NS**	**NS**	**NS**	**6.65**	**4.28**	**2.10**	**NS**	**2.09**	**NS**	**NS**	**NS**
D_1V_1	4.55	3.10	3.82	57.00	57.66	57.33	48.77	46.00	47.38	2.48	2.33	2.40
D_1V_2	4.33	2.93	3.63	55.33	53.33	54.33	46.00	44.00	45.00	2.40	2.56	2.48
D_1V_3	3.78	2.68	3.23	51.00	48.66	49.83	45.22	39.66	42.44	2.32	2.10	2.21
D_2V_1	4.22	3.56	3.89	63.33	64.33	63.83	49.11	49.77	49.44	2.64	2.69	2.67
D_2V_2	4.11	3.40	3.58	57.44	60.77	59.11	47.67	47.67	47.66	2.54	2.56	2.55
D_2V_3	5.44	2.83	3.47	51.88	53.00	52.44	46.77	44.44	45.61	2.43	2.40	2.41
D_3V_1	4.72	4.30	4.87	75.00	67.22	71.11	52.11	52.66	52.38	2.85	2.73	2.79
D_3V_2	4.56	4.09	4.40	71.88	65.11	68.50	50.77	49.89	50.33	2.73	2.63	2.68
D_3V_3	5.00	3.88	4.22	69.44	63.44	66.44	49.22	48.33	48.77	2.63	2.43	2.53
D_4V_1	4.66	3.77	4.38	66.55	62.66	64.61	49.66	50.55	50.11	2.80	2.70	2.75
D_4V_2	4.64	3.55	4.11	63.77	61.33	62.55	48.33	49.00	48.66	2.69	2.53	2.61
D_4V_3	4.56	3.11	3.87	61.88	52.66	57.27	45.89	47.89	46.88	2.54	2.40	2.47
D_5V_1	4.55	3.33	3.95	64.88	59.00	61.94	48.77	48.44	48.61	2.62	2.63	2.62
D_5V_2	4.31	3.22	3.88	60.00	54.77	57.38	46.55	47.00	46.77	2.52	2.56	2.54
D_5V_3	4.48	2.89	3.59	57.33	49.66	53.50	44.55	44.00	44.27	2.37	2.53	2.45
	DX V / VX D	**DX V / VX D**	**D X V / V X D**	**DX V / V X D**	**D X V / V X D**	**D X V / V X D**	**D X V / V X D**	**D X V / V X D**	**D X V / V X D**	**D X V / VX D**	**D X V / VX D**	**DX V / V X D**
S. Em. (+)	**0.33 / 0.30**	**0.35 / 0.37**	**0.27 / 0.26**	**5.18 / 5.14**	**5.04 / 4.41**	**3.24 / 3.30**	**1.59 / 1.72**	**2.98 / 3.03**	**1.58 / 1.88**	**0.04 / 0.04**	**0.09 / 0.11**	**0.04 / 0.05**
C.D. (0.05)	**NS / NS**	**NS / NS**	**NS / NS**	**NS / NS**	**NS / NS**	**NS / NS**	**NS / NS**	**NS / NS**	**NS / NS**	**NS / NS**	**NS / NS**	**NS / NS**

YI= 2013 & YII=2014; DI=10th February, D2=20th February, D3=2nd March, D4=12th March, D5=22nd March and V1= Rama, V2= Savitri & V3= Tillotama.

of March (D_3) significantly produced highest seed and stem yield as compared to other dates of sowing. The highest seed yield with the sowing date of 2nd March was due to significantly higher number of primary branches, number of capsules plant^{-1}, number seeds capsule^{-1}, test weight (1000 seed weight), total dry matter accumulation and number of branches plant^{-1}. Sesame yield was significantly influenced by sowing dates and genotype. The lowest seed yield and stem yield was recorded when sesame was shown on 22nd March (D_5). Increased seed yield might be due to number of factors, which has direct or indirect impact. The main factors, responsible for high seed yield are the seed weight plant^{-1}, number of capsule plant^{-1}, number of seeds capsule^{-1}, test weight (1000-seed weight) and harvest index. Early and late sowing of sesame decreased its

Table 6. Effect of dates of sowing and cultivars on grain yield, stover yield and harvest index of sesame.

Treatments	Seed yield (kg ha^{-1})			Stem yield (kg ha^{-1})			Harvest index (%)		
	YI	YII	Pooled	YI	YII	Pooled	YI	YII	Pooled
D_1	493.72	480.11	486.91	1975.33	1982.22	1978.77	19.96	19.53	19.74
D_2	542.18	536.66	539.42	2462.22	2362.22	2412.22	18.23	18.75	18.51
D_3	648.53	609.11	628.82	2733.33	2633.33	2683.33	19.41	19.05	19.24
D_4	620.37	558.88	589.63	2705.56	2605.57	2655.55	19.31	18.35	18.85
D_5	415.74	432.44	424.09	2253.33	2141.22	2197.27	15.80	16.86	16.30
S. Em. (±)	**19.16**	**19.29**	**13.44**	**146.38**	**141.84**	**140.42**	**1.02**	**1.03**	**0.86**
C.D. (0.05)	**62.51**	**62.94**	**43.84**	**477.38**	**462.58**	**457.97**	**NS**	**NS**	**NS**
V_1	593.23	556.13	574.68	2467.00	2404.67	2435.83	19.49	18.93	19.21
V_2	535.10	517.93	526.51	2415.00	2334.40	2374.70	18.46	18.49	18.48
V_3	504.00	496.26	500.13	2395.86	2295.66	2345.76	17.68	18.11	17.89
S. Em. (±)	**13.78**	**10.64**	**7.50**	**60.10**	**54.11**	**54.94**	**0.46**	**0.49**	**0.35**
C.D. (0.05)	**40.67**	**31.40**	**22.13**	**NS**	**NS**	**NS**	**1.37**	**NS**	**1.03**
D_1V_1	525.55	495.00	510.27	2041.66	2016.67	2029.16	20.35	19.75	20.05
D_1V_2	500.94	486.66	493.80	1988.33	1985.33	1986.83	20.17	19.68	19.94
D_1V_3	454.66	458.66	456.66	1896.00	1944.67	1920.33	19.36	19.15	19.22
D_2V_1	610.66	577.66	594.16	2483.33	2383.33	2433.33	20.05	19.79	19.93
D_2V_2	514.89	519.66	617.27	2470.00	2370.00	2420.00	17.53	18.16	17.85
D_2V_3	501.00	512.66	506.83	2433.33	2333.33	2383.33	17.12	18.31	17.74
D_3V_1	713.66	648.66	681.16	2850.00	2750.00	2800.00	20.21	19.28	19.76
D_3V_2	627.78	606.66	617.22	2650.00	2550.00	2600.00	19.57	19.73	19.65
D_3V_3	604.16	572.00	588.08	2700.00	2600.00	2650.00	18.46	18.15	18.32
D_4V_1	667.66	610.00	638.83	2716.68	2616.67	2666.66	20.05	19.14	19.61
D_4V_2	609.66	545.66	577.66	2800.00	2700.00	2750.00	18.67	17.61	18.16
D_4V_3	583.77	521.00	552.38	2600.00	2500.00	2550.00	19.23	18.31	18.79
D_5V_1	448.61	449.33	8.97	2243.33	2256.67	2250.00	16.82	16.67	16.72
D_5V_2	422.22	431.00	426.61	2166.67	2066.67	2116.66	16.35	17.28	16.83
D_5V_3	376.39	417.00	396.69	2350.00	2100.33	2225.16	14.23	16.64	15.36

	D X V	V X D	D X V	V X D	D X V	V X D	D X V	V X D	D X V	V X D	D X V	V X D	D X V	V X D	D X V	V X D	V X D	V X D
S. Em. (±)	**30.83**	**31.64**	**23.80**	**27.39**	**16.77**	**19.19**	**134.38**	**182.94**	**0.78**	**172.86**	**122.85**	**172.57**	**1.03**	**1.32**	**1.10**	**1.37**	**1.11**	**1.07**
C.D. (0.05)	**NS**	**96.95**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

YI= 2013 & YII=2014; DI=10th February, D2=20th February, D3=2nd March, D4=12th March, D5=22nd March and V1= Rama, V2= Savitri & V3= Tillotama.

seed yield (Rai et al., 1999; Saha et al., 1993). This result closely resembles to that obtained by Ieda et al. (1999) who also opined that delaying in sowing decreased seed yields of sesame. The results indicated that sowing of sesame within 2nd March to 12th March is the optimum sowing date for sesame to have optimum seed yield. Among the varieties, Rama (V_1) recorded significantly highest seed and stem yield as compared to Savitri (V_2) and Tillotama (V_3) during both the years of experimentation respectively (Table 6). However, the yield of Savitri (V_2) was statistically at par with Tillotama (V_3) (Table 6). This might be due to difference in genetic makeup of crop plants, varying date of sowing and climatic condition. These result also corroborated with the findings of several workers Suryavanshi et al. (1993) and Sarkar et al. (2007). Such differences in cultivars with respect to seed yield have been reported by Dixit et al. (1997) and Basavaraj et al. (2000).

Harvest index (HI) is another important parameter to assess the translocation efficiency. Seed yield is related to biological yield through harvest index (Yoshida, 1972). Further, it was also reported that the yielding potentiality of a cultivar is associated with increased seed to stalk ratio (HI). Harvest index was not significantly influenced due to the effect of dates of sowing. However, it was significantly influenced due to the effect of cultivars during both years of experimentation respectively (Table 6). The highest harvest index was recorded under 10th February (D_1) (19.96 and 19.53%) and lowest harvest index was recorded on 22nd March (D_5) (15.80 and 16.86%). Ali et al. (2005) reported that harvest index significantly influenced by date of sowing. Among the varieties, Rama (V_1) recorded higher harvest index (19.49 and 18.93%) as compared to Savitri (17.78 and 18.23%) and Tillotama recorded (17.68 and 18.11%) during both the years of experimentation respectively. Interaction effect between date of sowing and cultivars was not significant.

Conclusion

It may be inferred that the cultivar Rama can be adopted in North Bengal during summer season, because of its highest seed yield ability and 2nd March to 12th March is the optimum sowing dates of sesame to have optimum seed yield if grown as late summer crop.

Conflict of Interest

The authors have not declared any conflict of interest.

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