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RESEARCH ARTICLE

Effect of planting dates and methods of sowing on productivity of sesame under Toshka conditions

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Abstract

A study was conducted during 2018 and 2019 summer seasons at Toshka Agricultural Research Station, Agric. Res., Cent., Ministry of Agriculture, Egypt, with the objective to study the effect of sowing date and planting methods on productivity and oil content of three sesame varieties. The experiment was laid out in a split-split plot arrangement was based on a randomized complete block design (RCBD) with four replications. Sowing dates were assigned to the main plots while planting methods in sup-plot and varieties in sub-sub-plot. There was a significant effect of the interaction between sowing dates, sowing method and varieties on study traits (capsule length, capsule width, 1000-seed weight, seed yield per Faddan and seed oil content). The highest values of capsule length were obtained from the interaction of $D_1M_3V_3$, capsule width from $D_3M_2V_3$, number of capsules per plant from $D_1M_2V_1$. The interaction $D_2M_2V_2$ gave the highest values of 1000-seed weight, seed yield per Faddan and seed oil content.

Keywords: Oil content; Sesame; Sowing date; Sowing methods.

1. Introduction

Sesame (*Sesamum indicum* L.) is an important oil seed crop and widely grown in tropical and subtropical regions of the world. It is fourth major oilseed crop in the world (Mamatha *et al.*, 2015). Sesame is known as the king of oil seeds due to the high oil content (50 - 60%) of its seed. Sesame seed oil is edible, semi-drying and important in the manufacture of bakery, soap, paints, perfumes, margarine and pharmaceutical products. Sesame oil contain 47% oleic acid, 39% linoleic acid and enough amount of Omega 6 fatty acid. Sesame oil-cake is good feed for poultry, goat, sheep, fish and cattle. The seed cake is rich in protein and is used in compounding protein-rich feeds for livestock **(**Oplinger *et al.*, 1990).

Date of sowing is one of the important factors for higher production as it determines the optimum time of sowing of the crop. An optimum time of sowing enhances the efficiency of sesame by exploiting growth factors in an effective manner. Early sowing date of sesame recorded higher yield in comparison to late sown crop (Sivagamy and Rammohan, 2013; Bhardwaj *et al.*, 2014; Salem, 2016; Hakeem *et al.*, 2020). Delay in planting decreases sesame productivity (Hamza and El-Salam, 2015; Hakeem *et al.*, 2017).

Planting method is an important aspect of advanced production technology which not only ensures better crop establishment but also results in water saving when the crop is sown on ridges. Due to differences in crop stand establishment, sesame productivity was significantly affected by different sowing methods (Bahale *et al.*, 2001; Caliskan *et al.*, 2004; Islam *et al.*, 2008). Islam *et al.* (2015) recorded that bed planting at 90cm apart beds gave maximum grain yield followed

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by ridge planting. The lowest yield was obtained from conventional method of sowing.

Using the appropriate sowing date, planting method and variety gave the highest mean values for number of capsules/plant, seed weight plant^{-1} and 100-seed weight. Low yield of sesame may be attributed to the lesser availability of good quality seed, sowing method and sowing date; early or late sowing (Hakeem *et al.*, 2020).

For this reason, the current study was performed to assess the effect of sowing dates and sowing methods on productivity of some sesame varieties under Toshka conditions.

2. Materials and methods

The experiment was carried out at Toshka Agricultural Research Station, Agric. Res., Cent., Ministry of Agriculture, Egypt, during 2018 and 2019 summer seasons to determine the effect of sowing date and planting methods on growth, yield and quality traits of three sesame varieties. The soil of the experimental field was sandy loam having pH 8.09, electrical conductivity 0.94 ds/m, organic carbon 0.08% and available NPK of 126.3, 7.25 and 143.0 ppm, respectively.

The experiment was laid out in a randomized complete block design (RCBD) with spilt-split-plot arrangement with four replicates. Sowing dates were randomized in main plots while planting methods in sup-plot and varieties in sub-sub-plot. There were three different sowing dates i.e., D_1 (15th of March), D_2 (1st of April) and D_3 (15th of April), three planting methods i.e., M_1 (Rows; 60 cm apart, one lateral line), M_2 (Furrows; 60 cm apart, one lateral line) and M_3 (Raised bed; 120 cm apart, two laterals line) and three varieties i.e., V_1 (Giza 25), V_2 (Giza 32) and V_3 (Shandaweel 3). Drip irrigation method was used in this research, so that the distance between the lateral lines 60 cm and between the drippers 20 cm. The sub-sub-plot size was 9 m^2 (3 × 3 m). The recommended cultural practices of sesame production were adopted throughout in the two seasons.

Observations were recorded on each sub-sub plot basis for all traits under study as follow:

2.1. Yield and yield attributes

2.1.1. Capsule length (cm)

It was measured as the average length of the ten random capsules from each plant.

2.1.2. Capsule width (cm)

It was measured as the average width of the ten random capsules from each plant.

2.1.3. Number of capsules/plant

2.1.4. Thousand-seed weight (g)

It was calculated by counting 1000-seeds from harvested seed yield.

2.1.5. Seed yield/fad. (Ardab/fad.)

It was determined from the weight of seeds of each experimental plot in terms of kg/plot and converted to Ardab per faddan (Ardab = 120 kg).

2.2. Seed oil content (%)

Oil (%): It was determined according to A.O.A.C. (2000).

2.3. Statistical analysis

The data collected from the field and laboratory was analyzed statistically according to Gomez and Gomez (1984) and treatment means were compared by least significant difference (LSD) procedures at 5% level of probability. The data were analyzed by the "MSTAT-C" statistical package on a computer (Freed *et al.*, 1991).

3. Results and discussion

3.1. Yield and yield attributes

3.1.1. Capsule length

Average capsule length was significantly affected by sowing dates in both seasons. Data regarding capsule length given in Table 1 demonstrated that crop sown on the second date (1st of April) produced the longest capsules (3.012 and 3.024 cm) followed by the first date; 15th of March (2.983 and 2.975 cm) in the first and second seasons, respectively. On the other hand, the shortest capsules (2.910 and 2.890 cm) were obtained when crop sown on the third date (15th of April in the first and second seasons, respectively). It might be due to early sown crop had avail prolonged photoperiod for vegetative growth as a result plant attained maximum

capsule length as compared to late sown crop. These results are agrees with those reported by Hamza and Salama (2015).

Data in Table 1 demonstrated that capsule length was significantly affected by planting methods in both seasons. M_3 (Raised bed planting method) gave the longest capsule length (3.091 and 3.088 cm in the two respective seasons). Capsule length was at par under M_1 (Rows method) and M_2 (Furrows method) in both seasons. The shortest capsules (2.814 and 2.812 cm) were found for the first planting method (Rows method).

Table 1. Mean effect of sowing dates, planting methods, varieties and their interactions on capsule length in 2018 and 2019 summer seasons.

Planting Methods (M)	Varieties (V)	2018			Mean	2019			Mean
		Sowing dates (D)				Sowing dates (D)			
		D_1	D_2	D_3		D_1	D_2	D_3	
	V_1	2.290	2.595	2.385	2.423	2.288	2.625	2.323	2.412
M_1	V_2	2.913	3.173	2.568	2.884	2.965	3.123	2.530	2.873
	V_3	3.048	3.290	3.063	3.133	3.048	3.360	3.048	3.152
Mean		2.750	3.019	2.672	2.814	2.767	3.036	2.633	2.812
	V_1	2.548	2.460	2.483	2.497	2.520	2.448	2.500	2.489
M_2	V_2	3.398	2.995	3.208	3.200	3.385	3.003	3.163	3.183
	V_3	3.293	3.208	3.413	3.304	3.265	3.223	3.400	3.296
Mean		3.079	2.888	3.034	3.000	3.057	2.891	3.021	2.989
M_3	V_1	2.563	2.458	2.320	2.447	2.535	2.460	2.358	2.451
	V_2	3.240	3.448	3.333	3.340	3.240	3.483	3.315	3.346
	V_3	3.555	3.485	3.420	3.487	3.530	3.495	3.375	3.467
Mean		3.119	3.130	3.024	3.091	3.102	3.146	3.016	3.088
	V_1	2.467	2.504	2.396	2.456	2.448	2.511	2.393	2.451
D x V	V_2	3.183	3.205	3.036	3.141	3.197	3.203	3.003	3.134
	V_3	3.298	3.328	3.298	3.308	3.281	3.359	3.274	3.305
Mean		2.983	3.012	2.910	2.968	2.975	3.024	2.890	2.963
LSD at 0.05 for:									
D			0.078				0.078		
M			0.067				0.042		
V			0.064				0.044		
D × M			0.067				0.067		
D × V			0.064				0.064		
M × V			0.064				0.064		
D × M × V			0.063				0.063		

Variety of sesame also produced significant results, as illustrated in Table 1. The variety Shandaweel 3 produced the longest capsules (3.308 and 3.305 cm), which was followed by the variety Giza 32 (3.141 and 3.134 cm) in the first and second season, respectively. The slightest capsule length (2.465 and 2.451 cm) was found for the variety Giza 25 in 2018 and 2019 season, respectively. These results mainly due to the differences in the genetical constitution of the varieties. These results are in agreement with those obtained by Ali and Jan (2014), Hamza and Salama (2015) and Ismaan *et al.* (2020).

The interaction effect of D × M, D × V, M × V and D × M × V showed significant variation on capsule length in both seasons (Table 1). The longest capsules were observed by the interactions D_2M_3 (3.130 and 3.146 cm), D_2V_3 (3.328 and 3.359 cm), M_3V_3 (3.487 and 3.467 cm) and $D_1M_3V_3$ (3.555 and 3.530 cm) in the first and second season, respectively. But shortest capsules were exhibited by the interactions D_3M_1 (2.672 and 2.633 cm), D_3V_1 (2.396 and 2.393 cm), M_1V_1 (2.423 and 2.412 cm) and $D_1M_1V_1$ (2.290 and 2.288 cm in the first and second season, respectively). These results are in line with those

obtained by Ali and Jan (2014) and Hamza and Abd El-Salam (2015).

3.1.2. Capsule width

Data in Table 2 show that the first sowing date (15th of March) of sesame gave the widest capsule in both years although the differences among sowing dates were found as significant only in the second season. The widest capsule width (0.519 and 0.518 cm) was found at D_1 (15th of March) followed by the second date; 1st of April (0.513 and 0.509 cm) in the first and second season, respectively. On the other hand, the third date (15th of April) gave the narrowest (0.509 and 0.507 cm) capsule width in the same respective seasons, respectively.

Average capsule width was significantly affected by planting methods in both seasons (Table 2). The widest capsule width (0.539 and 0.538 cm) was obtained under M_3 (Raised bed planting method) in the first and second season, respectively. Capsule width was at par under the rows and furrows planting method in both seasons. The rows planting method had the narrowest capsule width (0.496 and 0.498 cm) in the first and second season, respectively.

Table 2. Mean effect of sowing dates, planting methods, varieties and their interactions on capsule width in 2018 and 2019 summer seasons.

Planting Methods (M)	Varieties (V)	2018			Mean	2019			Mean
		Sowing dates (D)				Sowing dates (D)			
		D_1	D_2	D_3		D_1	D_2	D_3	
	V_1	0.460	0.480	0.465	0.468	0.458	0.480	0.468	0.468
M_1	V_2	0.508	0.525	0.448	0.493	0.508	0.523	0.463	0.498
	V_3	0.525	0.543	0.508	0.525	0.523	0.553	0.510	0.528
Mean		0.498	0.516	0.473	0.496	0.496	0.518	0.480	0.498
	V_1	0.518	0.413	0.425	0.452	0.510	0.403	0.423	0.445
M_2	V_2	0.505	0.498	0.525	0.509	0.510	0.480	0.523	0.504
	V_3	0.525	0.525	0.625	0.558	0.538	0.535	0.623	0.565
Mean		0.516	0.478	0.525	0.506	0.519	0.473	0.523	0.505
	V_1	0.448	0.450	0.478	0.458	0.448	0.445	0.470	0.454
M_3	V_2	0.558	0.565	0.560	0.561	0.550	0.560	0.545	0.552
	V_3	0.628	0.623	0.548	0.599	0.620	0.608	0.543	0.590
Mean		0.544	0.546	0.528	0.539	0.539	0.538	0.519	0.532
	V_1	0.475	0.448	0.456	0.459	0.472	0.443	0.453	0.472
D x V	V_2	0.523	0.529	0.511	0.521	0.523	0.521	0.510	0.523
	V_3	0.559	0.563	0.560	0.561	0.560	0.565	0.558	0.560
Mean		0.519	0.513	0.509	0.514	0.518	0.509	0.507	0.512
LSD at 0.05 for:									
D			0.032				0.010		
M			0.015				0.016		
V			0.013				0.009		
D × M			0.026				0.027		
D × V			0.023				0.016		
M × V			0.023				0.016		
D × M × V			0.040				0.028		

Capsule width was influenced significantly by the varieties of sesame. The variety Shandaweel 3 produced the widest capsule width (0.561 and 0.560 cm) in the first and second season, respectively. The narrowest capsule width (0.459 and 0.472 cm in the two respective seasons) was found for the variety Giza 25 in both seasons.

There was significant effect of the first order interaction (D × M, D × V and M × V) as well as the second order one (D × M × V) on capsule width in both seasons except D × V in the first

season. The widest capsule width were obtained by the interactions $D_2 \times M_3$ (0.546 cm) and $D_1 \times M_3$ (0.539 cm), $D_2 \times V_3$ (0.563 and 0.565 cm), $M_3 \times V_2$ (0.561 cm) and $M_3 \times V_3$ (0.590 cm) and $D_1 \times M_3 \times V_3$ (0.628 cm) and $D_3 \times M_2 \times V_3$ (0.623 cm) in 1st and 2nd season, respectively. The narrowest capsule width was observed by the interactions $D_3 \times M_1$ (0.473 and 0.480 cm), $D_2 \times V_1$ (0.448 and 0.443 cm), $M_2 \times V_1$ (0.452 and 0.445 cm) and $D_2 \times M_2 \times V_1$ (0.413 and 0.403 cm) in the first and second season, respectively.

3.1.3. Number of capsules/plant

Sowing dates had significant influence on number of capsules/plant (Table 3). Number of capsules/plant was achieved under first sowing date (15th of March) for 81.35 and 81.85, which was drastically reduced to 61.16 and 61.74 under late date (15th of April) in the first and second seasons, respectively. The second and third sowing dates were statistically at par in number of capsules/plant in both seasons. It could be the effect of prolonged photoperiod which might have resulted in more assimilates in capsules resulting in larger number of capsules per plant. Similar results were obtained by Salem (2016) and Hakeem *et al.* (2020).

Table 3. Mean effect of sowing dates, planting methods, varieties and their interactions on number of capsules/plant in 2018 and 2019 summer seasons.

Planting Methods (M)	Varieties (V)	2018			Mean	2019			Mean
		Sowing dates (D)				Sowing dates (D)			
		D_1	D_2	D_3		D_1	D_2	D_3	
	V_1	101.29	75.89	77.10	84.76	105.21	75.78	78.40	86.46
M_1	V_2	65.64	44.22	65.82	58.56	68.03	45.78	65.68	59.83
	V_3	68.97	40.19	64.38	57.85	69.03	39.14	64.79	57.65
Mean		78.63	53.43	69.10	67.05	80.75	53.56	69.62	67.98
	V_1	131.29	77.73	55.31	88.11	123.54	77.43	55.70	85.55
M_2	V_2	78.57	59.75	61.07	66.46	79.26	58.91	59.43	65.87
	V_3	76.12	53.81	54.39	61.44	77.04	55.53	56.61	63.06
Mean		95.33	63.76	56.92	72.00	93.28	63.96	57.24	71.49
M_3	V_1	83.20	81.59	55.62	73.47	81.81	82.57	56.20	73.52
	V_2	57.37	63.39	59.83	60.20	59.45	61.28	61.83	60.85
	V_3	69.69	63.89	56.97	63.52	73.30	62.11	57.02	64.14
Mean		70.08	69.62	57.47	65.73	71.52	68.65	58.35	66.17
	V_1	105.26	78.40	62.67	82.11	103.52	78.59	63.43	81.85
D x V	V_2	67.19	55.79	62.24	61.74	68.91	55.32	62.31	62.18
	V_3	71.59	52.63	58.58	60.93	73.12	52.26	59.47	61.62
Mean		81.35	62.27	61.16	68.26	81.85	62.06	61.74	68.55
LSD at 0.05 for:									
D			5.55				2.15		
M			2.67				3.24		
V			2.88				2.84		
D × M			4.64				5.61		
D × V			4.96				4.92		
M × V			4.96				4.92		
D × M × V			8.60				8.52		

Different planting methods had a significant influence on number of capsules/plant in both seasons (Table 3). The highest number of capsules/plant (72.00 and 71.49 in the first and second seasons, respectively) was obtained by second planting method (Furrows method). The first and third planting methods were statistically at par in number of capsules/plant in both seasons. Nevertheless, the lowest values of number of capsules/plant were obtained from

third planting method (65.73 and 66.17), respectively. Similar results were obtained by Mahmoud *et al.* (2020).

Number of capsules/plant was significantly affected by varieties in both seasons. The highest number of capsules/plant (82.11 and 81.85 in the first and second season, respectively) was obtained from the variety Giza 32. Two other varieties i.e., Giza 25 and Shandaweel 3 were statistically at par in number of capsules/plant in the same respective seasons. The variety Shandaweel 3 gave the lowest number of capsules/plant (60.93 and 61.62 in the first and second season, respectively). Our results are in harmony with those obtained by Hamza and Abd El-Salam (2015), Salem (2016), Ali *et al.* (2020) and Hakeem *et al.* (2020).

Different interactions; D × M, D × V and M × V and D × M × V were significant influence on number of capsules/plant in both seasons (Table 3). The interactions $D_1 \times M_2$ (95.33 and 93.28), $D_1 \times V_1$ (105.26 and 103.52), $M_2 \times V_1$ (88.11 and 86.46) and $D_1 \times M_2 \times V_1$ (131.29 and 123.54) gave the highest number of capsules/plant in the first and second season, respectively. The lowest number of capsules/plant was observed by the interactions $D_2 \times M_1$ (53.43 and 53.56), $D_2 \times V_3$ (52.63 and 52.26), $M_1 \times V_3$ (57.85 and 57.65) and $D_2 \times M_1 \times V_3$ (40.19 and 39.14) in the same respective seasons, respectively. These results are in conformity with the findings of El Mahdi *et al.* (2007), Ali and Jan (2014) and Salem (2016).

3.1.4. Thousand- seed weight (g)

Significant data was found for sowing dates in case of seed index in both seasons (Table 4). The 2nd sowing date (1st of April) gave the heaviest 1000-seed weight of 5.973 and 5.935 g in the first and second seasons, respectively. The lightest 1000-seed weight (4.653 and 4.676 g) was recorded at the 3rd sowing date (15th of April) in the same respective seasons, respectively. Earlier sown crop gained prolonged growth period with ideal growth condition as result heavier grains was produced as compared to late sown. Similar notations were reported by Salem (2016) and Hakeem *et al.* (2020).

thousand-seed weight was significantly affected by planting methods in both seasons. The furrows planting method gave the heaviest 1000-seed weight of 5.717 and 5.748 g in the first and second seasons, respectively. Two other planting methods i.e., rows and raised bed were statistically at par in 1000-seed weight in the same respective seasons. The first planting method (Rows planting method) gave the lightest 1000-seed weight (5.072 and 5.102 g) in the first and second season, respectively. Similar results were obtained by Islam *et al.* (2008) and Mahmoud *et al.* (2020). The effect of sesame varieties was significant on 1000-seed weight in both seasons (Table 4). The variety Giza 32 gave the highest (5.514 and 5.538 g) in 1000-seed weight in the first and second season, respectively. Two other varieties; Giza 25 and Shandaweel 3 were statistically at par in 1000-seed weight in the same respective seasons. These findings are in agreement with Hamza and Abd El-Salam (2015), Salem (2016), Ali *et al.* (2020) and Hakeem *et al.* (2020).

Data in Table 4 indicates that there was significant effect of different interactions; D × M, D × V and M × V and D × M × V on 1000-seed weight in both seasons. The heaviest 1000-seed weight was observed with the interactions $D_2 \times M_2$ (6.377 and 6.176 g), $D_2 \times V_2$ (6.592 and 6.286 g), $M_2 \times V_2$ (5.904 and 5.936 g) and $D_2 \times M_2 \times V_2$ (6.783 and 6.618 g) in the first and second season, respectively. These results are in conformity with the findings of Ali and Jan (2014) and Salem (2016).

Table 4. Mean effect of sowing dates, planting methods, varieties and their interaction on thousand seed weight (g) in 2018 and 2019 summer seasons.

Planting Methods (M)	Varieties (V)	2018			Mean	2019			Mean
		Sowing dates (D)				Sowing dates (D)			
		D_1	D_2	D_3		D_1	D_2	D_3	
	V_1	5.125	5.983	4.263	5.123	5.100	5.865	4.153	5.039
M_1	V_2	5.940	5.765	3.578	5.094	5.928	5.945	3.530	5.134
	V_3	5.738	5.043	4.215	4.998	5.950	4.940	4.508	5.133
Mean		5.601	5.597	4.018	5.072	5.659	5.583	4.063	5.102
	V_1	5.245	5.808	5.793	5.615	5.425	5.880	5.738	5.681
M_2	V_2	5.058	6.783	5.873	5.904	5.160	6.660	5.988	5.936
	V_3	4.870	6.540	5.483	5.631	4.875	6.618	5.395	5.629
Mean		5.058	6.377	5.716	5.717	5.153	6.386	5.707	5.748
M_3	V_1	4.903	6.138	3.688	4.909	5.035	5.975	3.810	4.940
	V_2	5.420	6.338	4.870	5.543	5.438	6.295	4.940	5.558
	V_3	4.945	5.363	4.115	4.808	4.813	5.233	4.025	4.690
Mean		5.089	5.946	4.224	5.086	5.095	5.834	4.258	5.062
	V_1	5.091	5.976	4.581	5.216	5.187	5.907	4.567	5.220
D x V	V_2	5.473	6.295	4.774	5.514	5.508	6.286	4.819	5.538
	V_3	5.184	5.648	4.604	5.146	5.213	5.611	4.643	5.155
Mean		5.249	5.973	4.653	5.292	5.303	5.935	4.676	5.304
LSD at 0.05 for:									
D			0.174				0.154		
M			0.351				0.200		
V			0.220				0.178		
D × M			0.613				1.456		
D × V			0.380				0.310		
M × V			0.380				0.310		
D × M × V			0.654				0.532		

3.1.5. Seed yield (Ardab/fad.)

Data in Table 5 show that seed yield was significantly affected by sowing dates in both seasons. Crop sown under April 1st registered the highest seed yield of 3.591 and 3.636 Ardab/faddan, which 33.42 and 37.60% higher than the crop was sown under late (April 15) condition in the first and second seasons, respectively. The higher yield in timely sowing condition could be attributed to favorable temperature at grain development stage which in turn increased the photosynthetic rate, assimilates the supply for seed and seed growth rate in timely sown crops. Higher seed yield of sesame under timely sown condition as compared to other sowing dates of sesame was also reported by a several of workers (Hamza and Abd El-Salam, 2015; Salem, 2016; Hakeem *et al.*, 2020).

Seed yield of sesame was significantly influenced by the planting methods (Table 5). Among the different planting methods, M_2 (Furrows planting method) gave the highest seed yield (3.802 and 3.794 Ardab/fad.) in the first and second seasons, respectively. But the lowest values (2.732 and 2.659 Ardab/fad.) of this trait was observed by using M_1 (Rows planting method) in the first and second seasons, respectively. These results confirm the findings of Mahmoud *et al.* (2020).

Seed yield of sesame varieties was significantly affected by different varieties in both seasons. The variety Giza 32 gave the highest (3.590 and 3.282 Ardab/fad.) in seed yield followed by Giza 25 in the first and second season, respectively. On the other hand, the lowest seed yield (2.878 and 2.994 Ard/fad.) was recorded by Shandaweel 3 in the same respective season, respectively. These findings are in agreement with Salem (2016), Ali *et al.* (2020) and Hakeem *et al.* (2020). Results in Table 5 show that significant effect of the different interactions on seed yield in both seasons. The highest seed yield was obtained by

the interactions $D_2 \times M_2$ (4.547 and 4.736 Ard/fad.), $D_2 \times V_2$ (3.860 and 4.091 Ard/fad.), $M_2 \times V_2$ (4.328 and 4.202 Ard/fad.) and $D_2 \times M_2 \times V_2$ (5.781 and 5.671 Ard/fad.) in the first and second season, respectively. But the lowest seed yield was observed by the interactions $D_3 \times M_1$ (1.881 and 1.878Ard/fad.), $D_3 \times V_3$ (2.240 and 2.192 Ard/fad.), $M_1 \times V_3$ (2.352 and 2.359 Ard/fad.) and $D_3 \times M_3 \times V_1$ (1.780 and 1.679 Ard/fad.) in the first and second season, respectively. These results are in conformity with the findings of Ali and Jan (2014) and Salem (2016).

Table 5. Mean effect of sowing dates, planting methods, varieties and their interaction on seed yield Ardb/faddan in 2018 and 2019 summer seasons.

Planting Methods (M)	Varieties (V)	2018			Mean	2019			Mean
		Sowing dates (D)				Sowing dates (D)			
		D_1	D_2	D_3		D_1	D_2	D_3	
	V_1	2.823	2.822	2.041	2.562	3.959	2.129	2.832	2.973
M_1	V_2	4.207	2.079	3.556	3.280	2.892	3.085	1.953	2.643
	V_3	2.144	3.109	1.804	2.352	2.019	3.258	1.802	2.359
Mean		3.058	2.670	2.467	2.732	2.956	2.824	2.195	2.659
	V_1	4.406	4.265	2.103	3.591	4.306	4.342	2.067	3.572
M_2	V_2	3.789	5.781	3.415	4.328	3.748	5.671	3.188	4.202
	V_3	3.908	3.597	2.957	3.487	3.687	4.196	2.945	3.610
Mean		4.035	4.547	2.825	3.802	3.914	4.736	2.733	3.794
M_3	V_1	3.285	3.899	1.904	3.029	3.875	3.134	1.679	2.896
	V_2	3.985	3.720	1.780	3.162	3.497	3.517	1.990	3.001
	V_3	3.375	3.047	1.960	2.794	3.677	3.396	1.966	3.013
Mean		3.548	3.555	1.881	2.995	3.683	3.349	1.878	2.970
	V_1	3.505	3.662	2.016	3.016	4.047	3.202	2.192	3.147
D x V	V_2	3.994	3.860	2.917	3.590	3.379	4.091	2.377	3.282
	V_3	3.142	3.251	2.240	2.878	3.128	3.617	2.237	2.994
Mean		3.547	3.591	2.391	3.176	3.518	3.636	2.269	3.141
LSD at 0.05 for:									
D			0.445				0.289		
M			0.221				0.132		
V			0.236				0.110		
D × M			0.376				0.231		
D × V			0.414				0.200		
M × V			0.414				0.200		
D × M × V			0.722				0.340		

3.2. Seed oil content (%)

The results in Table 6 reveal that the percentage of oil in seeds was significantly affected by sowing dates in the first and second season. The highest values (48.72 and 48.62% in the first and second seasons, respectively) of oil percentage were obtained by sowing under 15th of March followed by 1st of April (47.74 and 47.86% in the first and second seasons, respectively). Similar trend was obtained by Hamza and Abd El-Salam (2015) and Salem (2015).

Also, in the same Table the results illustrated that the percentage of oil in seeds was significantly affected by using different planting methods. The highest values (46.52 and 48.14%) of oil percentage were obtained by using M_2 (Furrows planting method) followed by M_3 (Raised bed planting method) in the first and second seasons, respectively. These findings confirmed with those obtained by Hamza and Abd El-Salam (2015), Salem (2015) and Mahmoud *et al.* (2020). Oil percentage was significantly affected by varieties in both seasons. The highest oil percentage (48.55 and 48.61%) was obtained from the variety Giza 32 followed by Giza 25 in the first and second season, respectively. The

variety Shandaweel 3 gave the lowest oil percentage (46.27 and 46.17%) in the first and second season, respectively. These findings are in agreement with Caliskan *et al.* (2004) and Mahmoud *et al.* (2020). Concerning the effect of the interactions was significant on oil percentage in both seasons (Table 6). The interactions $D_1 \times M_1$, $D_1 \times V_1$, $M_2 \times V_2$ and $D_1 \times M_2 \times V_2$ markedly increased oil percentage in both seasons. But, the decreased oil percentage under the interactions $D_3 \times M_1$, $D_2 \times V_3$, $M_3 \times V_3$ and $D_3 \times M_1 \times V_3$ in both seasons. These results were obtained by Hamza and Abd El-Salam (2015), Salem (2016) and Mahmoud *et al.* (2020).

Table 6. Mean effect of sowing dates, planting methods, varieties and their interaction on oil% in 2018 and 2019 summer seasons.

Planting Methods (M)	Varieties (V)	2018				2019			
		Sowing dates (D)			Mean	Sowing dates (D)			Mean
		D_1	D_2	D_3		D_1	D_2	D_3	
	V_1	45.84	50.77	47.11	47.91	45.63	50.50	47.10	47.74
M_1	V_2	51.15	49.14	44.97	48.42	50.02	47.93	45.49	47.81
	V_3	45.86	50.87	44.59	47.11	46.26	51.22	43.46	46.98
Mean		47.61	50.26	45.56	47.81	47.30	49.88	45.35	47.51
	V_1	51.82	47.60	46.04	48.49	52.43	47.67	46.40	48.83
M_2	V_2	46.83	53.13	47.00	48.99	47.46	53.55	47.96	49.66
	V_3	45.86	46.56	46.51	46.31	46.11	45.91	45.77	45.93
Mean		48.17	49.10	46.52	47.93	48.66	49.04	46.71	48.14
M_3	V_1	49.01	45.26	46.84	47.03	48.83	45.47	45.96	46.75
	V_2	49.79	48.71	46.20	48.23	50.40	48.39	46.31	48.36
	V_3	43.49	46.44	46.20	45.38	43.61	46.93	46.26	45.60
Mean		47.43	46.80	46.41	46.88	47.61	46.93	46.18	46.91
	V_1	48.89	47.87	46.66	47.81	48.96	47.88	46.48	47.77
	V_2	49.26	50.33	46.06	48.55	49.29	49.96	46.58	48.61
	V_3	45.07	47.96	45.77	46.27	45.33	48.02	45.16	46.17
Mean		47.74	48.72	46.16	47.54	47.86	48.62	46.08	47.52
LSD at 0.05 for:									
D			1.49				0.78		
M			1.26				0.92		
V			0.78				0.80		
D × M			2.16				1.58		
D × V			1.34				1.38		
M × V			1.34				1.38		
D × M × V			2.32				2.38		

4. Conclusions

In the light of aforementioned results, it can be safely concluded that planting date at 1st of April under furrows planting method and use Giza 32 variety is optimal for yield and quality of sesame grown under Toshka conditions.

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