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Article

Effect of plant distance and cultivation methods on the growth and yield of three sesame cultivars

Bushra Sh J. ALobaidy [1], Malath A. Hamed [1], Ahmed Shehab Abd-allah Ramadan [1], Muayad Malik Ibrahim [2], and Ali Fadaam Almehemdi [3]*
[1] University of Anbar, College of Agriculture, Department of Field Crops
[2] University of Anbar - College of Basic Education \ Haditha - Department of Science.
[3] Ministry of Agriculture, Iraq.
[4]Center of Desert Studies University of Anbar. Iraq.
** Correspondence:ag.bushra.shaker@uoanbar.edu.iq.*
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ABSTRACT

A field experiment was carried out in Al-Saqlawiyah region, west of Baghdad, during the 2020 agricultural season in silty clay soil to study the effect of planting pattern and the Row spacing on the growth and yield of three sesame cultivars. The experiment was carried out in a split-split plot design according to a randomized complete block design (RCBD) with three replications, where the planting pattern occupied the main plots (seed prose, seedling pattern). The cultivars occupied the subplot (Haad, Sumer, Rafidain,), while the row distance occupied the sub-sub plot (40, 60, 80 cm). The statistical analysis results indicated a significant effect of the cultivation pattern, as the cultivation pattern with seeds prose recorded the highest values in all the studied traits. The seed prose method recorded the highest seed yield (364.5 gm plant^{-1}) compared to the seedling method (290.2 gm plant^{-1}). There was also a significant genetic variance ($P<0.05$) in the response of the studied sesame cultivars to the planting pattern treatments and the between-row spacing. The cultivar Haad scored the highest values in most of the studied traits and thus gave the highest seed yield (452.1 g plant^{-1}) compared with the rest of the studied cultivars. The row spacing of 80 cm between the lines gave the highest yield (350.4 g plant^{-1}).

Keywords: plant distance, cultivation methods, growth, sesame cultivars

INTRODUCTION

Vegetable oils are important in the human diet, directly or in the food and non-food industries, and oilseed residues are used as animal feed. Sesame is one of the important oil crops in the world, as sesame seeds are used to decorate some types of bread, pastries and sweets. Sesame has been planted since ancient times to obtain its seeds, among the richest crops in fatty substances. Its oil content ranges between 50% and 65%, and its protein content ranges between 22% and 25% [1]. Farmers and plant breeders are in a race against time. The population increase in the world is accelerating, which requires more food in return for decreasing areas of arable land. On the other hand, the challenges brought about by climatic changes are increasing daily. Temperature and greenhouse factors

have affected some new areas during the growing seasons, bringing drought and pests from one agricultural area to another. Continuous improvements in crops can help to meet the challenges of overpopulation [2]. Among the constraints to sesame production is the problem of low germination rate, which requires raising the seed rate or treating them with fungal disinfectants to protect the germinated seeds and seedlings from fungal infections [3]. The use of wilt-tolerant varieties and seedling culture technology may help sesame plants improve their yield because it includes ease of care for the seedlings and the prevention of disease and insect infestations; in addition, it gives the roots of plants faster access to nutrients and oxygen. One of the reasons for preferring seedling cultivation over planting seeds directly in the permanent place is the economy in the land area, as seedlings save a lot of land area by planting seeds in a small area and then transferring them later to the permanent land, as well as early planting time, weather conditions in the region may not allow early planting, and in this case, seedlings can be produced in a warm environment. Determining the optimal plant density per unit area is one of the necessary requirements that allows obtaining the highest crop production by reducing the intensity of competition and increasing the light interception between plants, allowing the plant to make the most of the growth inputs such as moisture, light, nutrients and others with higher efficiency towards increasing production. Therefore, determining plant density is an important scientific practice that determines crop production [4]. A good yield of any crop can only be obtained with perfect spacing. The highest yield of sesame was obtained at a distance of 30 cm between lines, and the yield was lower at a distance of 45 cm [5]. When the space between the lines is reduced, the height of the plant increases, and the number of capsules decreases [6]. Thus, a plant density of 200 thousand to 400 thousand plants is recommended to obtain plant branches. Therefore, five planting patterns were tested, they are 30 x 10, 30 x 15, 30 x 20, 30 x 25, and 30 x 30, and it was concluded that the seed yield increased by 417, 552 and 561 kg ha-1 with an increase in the distance between the rows from 10 to 20 cm and that the wider distances 25 to 30 cm reduced the yield to 510 and 395 kg ha-1 [7]. The highest plant height was recorded (158.9 cm), the number of plants per square meter (60 plants), the number of capsules (24.90 capsules per plant), biological yield (4.003 Mg ha^{-1}), seed yield (0.857 Mg ha^{-1}) and harvest index (21.42%) when planting sesame with a distance of 15 cm [8]. One of the most important factors that prompted the conduct of this study is the reasons related to the reality of sesame cultivation in the Iraqi country in terms of the lack of sufficient local studies on this crop to benefit from them in identifying the most important varieties and agricultural applications and improving their management in order to increase productivity and expand the cultivation of this crop, especially after it witnessed in recent years a significant decline in its cultivation areas. Hence, the research aimed to evaluate three sesame cultivars (Haad, Sumer, and Al-Rafidain) under different planting patterns and distances between lines.

MATERIALS AND METHODS

A field experiment was carried out in the Al-Saqlawiyah region, west of Baghdad, during the 2020 agricultural season in silty clay soil in the arrangement of a split-split plot design according to a randomized complete block design (RCBD) with three replications, where the planting pattern occupied the main plots (seed prose, seedling pattern). The cultivars occupied the subplot (Haad, Sumer, Al-Rafidain,), while the row distance occupied the sub-subplot (40, 60, 80 cm). The experiment included 54 experimental units, and each replicate contained 18 experimental units (3 x 3 m). After the soil was prepared by plowing, smoothing, leveling and dividing into experimental units, the treatments

were randomly allocated to the experimental units. The seedlings were prepared in plastic dishes of dimensions (28 cm x 58 cm x 3 cm) filled with fine soil, and after wetting it to the point of saturation, the seeds were prepared for the cultivars. Then, the dishes were placed in the nursery to obtain better growth of the seedlings. The dishes were placed next to each other and covered with a light cloth to prevent seedlings damage by birds, rodents and direct sunlight. The seedlings were transferred to the permanent field when they reached a height of 4 cm on 15-5-2019. The experimental units were fertilized by adding phosphate fertilizer 80 kg ha^{-1} mixed with the soil before planting. Urea fertilizer 80 kg ha^{-1} (46%N) was added in two equal batches: the first batch 10 days after planting the seedlings and the second one a month after the first. Whereas for the experimental units cultivated with a dry seed pattern, urea fertilizer 80 kg ha^{-1} (N 46%) was added in two equal batches, the first batch at planting and the second after a month of germination. After the appearance of signs of maturity, ten plants were randomly selected from the midlines of each experimental unit at harvest to calculate the plant height (cm), the number of capsules on the main stem and fruiting branches, the weight of a thousand seeds and the yield of the plant.

RESULTS

Plant height

The results indicate no significant difference between the average plant height grown in seed prose and plants grown in seedling pattern Table 1. The results showed that the cultivar Haad had the highest plant height of 173.00 cm. In comparison, the Sumer cultivar recorded the lowest average of 164.44 cm, which did not differ significantly from the Rafidain cultivar of 166.86 cm.

The table indicates that the row spacing of 40 cm gave the highest average plant height (169.72 cm), followed by the spacing of 80 cm (168.30 cm), and they did not differ significantly. In contrast, the plants planted at a spacing of 60 cm between rows gave the lowest height of 166.61 cm. The results also indicated that the cultivar Haad recorded the highest plant height in both types of cultivation, with an average of 174.22 and 171.78 cm, respectively. This was followed by the Rafidain cultivar planted with the prose pattern, which averaged 168.00 cm, while the Sumer cultivar gave the lowest average of 163.22 cm when planted with the prose pattern.

Table 1 showed that there was no significant effect between the treatments of the seeding pattern and Row spacing. Whereas the cultivars differed significantly in their behavior towards the row spacing; for example, the cultivar Haad, planted with a row spacing of 40 cm, recorded the highest plant height of 175.17 cm and thus differed significantly from the rest of the treatments. On the contrary, the Rafidain cultivar planted with a spacing of 60 cm recorded the lowest average of 162.50 cm. The results in Table 1 showed a significant interaction between the study factors, which indicates the difference in the behavior of the cultivars towards the parameters of the cultivation pattern and row distances. The type of interaction was a difference in the amount of response, which indicates that the cultivars behaved differently in the direction of Row spacings and the cultivation pattern. For example, it was found that the averages of the cultivar Haad planted with a seed prose pattern at a row spacing of 40 cm, 60 cm and 80 cm were outperformed in this trait (175.33, 173.33 and 174.00 cm), respectively and differed significantly from all other treatments. This indicates that the height of the plant is a genetic trait; on the contrary, the two cultivars, Sumer and Rafidain, were planted with the seed prose pattern and at the same row distance.

Cultivation method	Cultivars	Row spacing			Cultivation method x Cultivars
		40 cm	60 cm	80 cm	
Prose	Haad	175.33	173.33	174.00	174.22
Prose	Rafidian	171.67	162.00	170.33	168.00
Prose	Summer	160.67	169.67	159.33	163.22
Seedling	Haad	175.00	170.00	170.33	171.78
Seedling	Rafidian	170.33	163.00	164.00	165.78
Seedling	Summer	165.33	161.67	170.00	165.67
LSD 0.05		3.832			2.482
Cultivation method					
Cultivation method X Row spacing	Prose	169.22	168.33	167.89	168.48
	Seedling	170.22	164.89	168.11	167.74
LSD 0.05		2.016			N.S
Cultivars					
Cultivars X Row spacing	Haad	175.17	171.67	172.17	173.00
	Rafidian	171.00	162.50	167.17	166.86
	Summer	163.00	165.67	164.67	164.44
LSD 0.05		2.861			2.055
Row spacing		169.72	166.61	168.00	
LSD 0.05		1.571			

Table 1. Effect of row spacing and cultivation methods on the height of three sesame cultivars

Number of branches per plant

Table 2 shows that the average number of branches in the type of seed prose cultivation was more (6.499 branch plant^{-1}) than the seedling cultivation (5.957 branch plant^{-1}); perhaps the reason is that the process of branching, in general, begins after the completion of the third to fourth leaf, and since the plants planted with seeds begin to branch after reaching this stage and to take a sufficient time to complete the branching, for their stability. As for the seedling, it causes damage to the plant due to the process of transferring the seedlings, or some of the leaves that branches come out from their axil are damaged, or the lagging of some branches or the shortening of the time for branching, or perhaps the close row spacing of 40 cm between seedlings has contributed to reducing the number of branches compared to the row spacing of 80 cm in which the plant density is less at the level of the area.

It is noted from the table that the cultivar Haad gave the highest number of branches per plant (7.095 branch plant^{-1}), while the average number of branches was similar in the two cultivars Sumer and Rafidain (5.791 and 5.799 branch plant^{-1}). The increase in the number of branches of Haad cultivar may be related to the genetic nature of the variety, or the varieties with high branching ability are expected to give the highest number of capsules per plant.

Cultivation method	Cultivar	Row spacing			Cultivation method x Cultivar
		40 cm	60 cm	80 cm	
Prose	Haad	5.641	6.333	10.000	7.325
Prose	Rafidian	4.561	6.223	7.667	6.150
Prose	Summer	5.000	6.012	7.056	6.023
Seedling	Haad	5.641	6.210	8.745	6.865
Seedling	Rafidian	4.667	5.654	6.021	5.447
Seedling	Summer	5.000	5.000	6.678	5.559
LSD 0.05				1.159	
Cultivation method					
Cultivation method X Row spacing	Prose	5.067	6.189	8.241	6.499
	Seedling	5.103	5.621	7.148	5.957
LSD 0.05				0.575	
Cultivar					
Cultivar X Row spacing	Haad	5.641	6.272	9.373	7.095
	Rafidian	4.614	5.939	6.844	5.799
	Summer	5.000	5.506	6.867	5.791
LSD 0.05				0.879	
The Row spacing			5.085	5.905	7.695
LSD 0.05				0.482	

Table 2. Effect of row spacing and cultivation methods on the branch number of three sesame cultivars

The results indicate that the plants planted at a row spacing of 80 cm gave the highest average number of branches (7.695 branches plant^{-1}), while the plants planted at a row spacing of 40 cm gave the lowest number of branches (5.085 branches plant^{-1}). The results also confirm the superiority of the cultivar Haad planted by the prose seeding with the highest number of branches amounting to 7.325 branches plant^{-1}, which differed significantly from all other treatments. In comparison, the two cultivars Sumer and Rafidain planted by the seedling pattern gave the lowest number of branches (5.559 and 5.447 branches plant^{-1}) respectively.

The table mentioned above also confirmed that the plants planted by the seed prose pattern with a row spacing of 80 cm gave the highest average of 8.241 branches plant^{-1}. In comparison, the plants planted by the seed prose pattern with a row spacing of 40 cm gave the lowest average of 5.067 branches plant^{-1}.

The significant three-way interaction in Table 2 shows differences between the cultivars and the two types of cultivation, according to the row spacing. It shows that there is a difference in the amount of response of the cultivars towards the parameters of the cultivation pattern and the row spacings; for example, we note in this character that the difference in the number of branches decreases with an increase in the row spacings for both types of cultivation and all varieties.

Number of capsules per plant

The results showed the superiority of the plants planted with seeds prose in the number of capsules (149.6 capsules plant-1), while the plants planted with the seedling pattern gave 135.5 capsules plant^{-1} Table 3. The superiority of the seed prose pattern in this trait may be due to its superiority in the number of branches Table 2. The sesame cultivars Haad, Rafidain and Sumer averaged the number of capsules (139.3, 120.7, and 112.9 capsules plant^{-1}) for the cultivars, respectively. The superiority of Haad cultivar in the number of capsules may be attributed to its superiority in the number of branches Table 2.

Planting at a row spacing of 80 cm gave the highest average of 152. capsules plant^{-1}, while planting at a row spacing of 40 cm gave the lowest average of 133.4 plant^{-1} (Table 3). The increase in the number of capsules per plant with the increase in row spacing may be attributed to the fact that in the case of plants grown over a wide distance, the competition was less between them for light and nutrients necessary for the growth and development of flower buds, which in turn works to increase the percentage of fruit set and increase the number of capsules. Increasing the row spacing led to a significant increase in the number of branches Table 2, which contributed to an increase in the capsule-bearing branches of the plant.

Cultivation method	Cultivars	Row spacing			Cultivation method x Cultivars
		40 cm	60 cm	80 cm	
Prose	Haad	180.3	208.3	251.7	213.4
Prose	Rafidian	105.0	121.7	133.3	120.0
Prose	Sumer	98.3	111.7	131.3	113.8
Seedling	Haad	164.0	170.3	185.0	173.1
Seedling	Rafidian	125.0	135.0	104.0	121.3
Seedling	Summer	127.7	100.7	108.0	112.1
LSD 0.05				12.48	6.97
Cultivation method					
Cultivation method X Row spacing	Prose	127.9	147.2	172.1	149.1
	Seedling	138.9	135.3	132.3	135.5
LSD 0.05				7.66	8.23
Cultivars					
Cultivars X Row spacing	Haad	172.2	189.3	218.3	139.3
	Rafidian	115.0	128.3	118.7	120.7
	Summer	113.0	106.2	119.7	112.9
LSD 0.05				8.72	4.67
	Row spacing	133.4	141.3	152.2	
LSD 0.05				5.50	

Table 3. Effect of row spacing and cultivation methods on the number of capsules of three sesame cultivars

The results indicate that the interaction of the cultivation seed prose pattern by and row spacing of 80 cm gave the highest average of 172.1 capsule plant-1, while the cultivation of the seedling pattern and the row spacing of 40 cm gave the lowest average of 127.9 capsule plant-1. The results also showed that the Haad cultivar outperformed the number of capsules when planted in seed prose and seedling pattern with 213.4 and 173.1, capsule plant^{-1}.

The result indicates a significant three-way interaction between the cultivars, the planting pattern and the row spacing on the average number of capsules per plant. This indicates the different response of the cultivars to the cultivation pattern and according to the row spacing; for example, the Haad cultivar, planted with a seeding prose pattern, with a spacing of 80 cm between the lines, with an average of 251.7 capsule plant^{-1}, outperformed the rest of the treatments. At the same time, the Sumer cultivar planted with seeds prose at a row spacing of 40 cm gave the lowest average of 98.3 capsule plant^{-1}.

Weight of 1000 seeds

Table 4 shows that the highest weight of 1000 seeds was 3.696 gm, attained by the plants planted with the seeding prose pattern, while the plants planted with the seedling pattern gave 3.013 gm for the 1000-seed weight. The table shows that the Rafidain cultivar had the heaviest seeds, with an average of 3.586 g, followed by the Sumer cultivar (3.359 g). In comparison, the cultivar Haad attained the lowest average of 3.258 g. As for the superiority of the Rafidain variety in this characteristic, it may be due to the increase in the height of its plants, which affects the increase in the weight of the dry matter in the stems, which subsequently contributes to the filling of the grains, as the sources of the filling of the grains are what is transferred from the products of photosynthesis to the green tissues throughout filling, as well as the dry matter temporarily stored in plant parts, as well as the transferred dry matter stored in stems, especially before flowering stage. The fewer capsules in the variety may have contributed to the lack of competition for the products of photosynthesis, less than in the Haad cultivar, which has the greatest number of capsules.

The results indicate that the plants planted with a row spacing of 80 cm gave the highest weight of 1000 seeds (3.673 g), while the plants planted at a row spacing of 40 cm gave 3.222 g. This decrease may be attributed to the lack of dry matter deposition in the seeds due to the intense competition for nutrients between plants per unit area at short distances.

The results indicate a significant interaction between the cultivars and the two planting patterns, as the cultivar Rafidain with the seeding prose pattern gave the highest weight of 1000 seeds (3.88 g), and it did not differ significantly from the Sumer cultivar, which was sown with the seeding prose pattern (3.789 g). The Sumer cultivar gave the lowest average of 2.930 g when planted in the seedling pattern.

The results also showed that the row spacing of 80 cm of sesame plants interacted with the two types of cultivation seeds, prose and seedlings; their averages converged and amounted to 3.700 and 3.644 g, respectively. At the same time, the average of plants planted with row spacing of 40 cm in a seedling pattern showed the lowest value for this trait of 2.844 g.

Cultivation method	Cultivars	Row spacing			Cultivation method x Cultivars
		40 cm	60 cm	80 cm	
Prose	Haad	2.967	4.300	3.233	3.500
Prose	Rafidian	4.033	3.433	3.933	3.800
Prose	Summer	3.800	3.633	3.933	3.789
Seedling	Haad	2.767	2.747	3.533	3.016
Seedling	Rafidian	2.633	3.483	4.000	3.372
Seedling	Summer	3.133	2.257	3.400	2.930
LSD 0.05	0.692				0.467
Cultivation method					
Cultivation method X Row spacing	Prose	3.600	3.789	3.700	3.696
	Seedling	2.844	2.829	3.644	3.106
LSD 0.05	0.428				0.513
Cultivars					
Cultivars X Row spacing	Haad	2.867	3.523	3.383	3.258
	Rafidian	3.333	3.458	3.967	3.586
	Summer	3.467	2.945	3.667	3.359
LSD 0.05	0.490				0.337
Row spacing		3.222	3.309	3.672	
LSD 0.05	0.278				

Table 4. Effect of row spacing and cultivation methods on the 1000 seed weight of three sesame cultivars

The results also indicate a significant interaction between the cultivars and the row spacing; the Rafidain cultivar planted at a row spacing of 80 cm was superior to the highest average of 3.967 g., while the cultivar Haad, planted at a row spacing of 40 cm, gave the lowest average of 2.867 g. The results indicate a significant three-way interaction between study factors in 1000 seed weight. This indicates the different response of the cultivars to the two types of cultivation pattern and according to the row spacing; for example, the cultivar Haad, planted with a seed prose pattern with a row spacing of 60 cm, outperformed with the highest average of the trait amounted to 4.300 g. On the contrary, the behavior of the Haad cultivar was planted in a seedling pattern with a row spacing of 60 cm, which gave 2.257 g.

Grain yield

The results showed that the seed prose sowing pattern gave the highest yield of 364.5 g. plant^{-1} compared to the seedling sowing pattern, which gave 290.2 g. plant^{-1} Table 5. This may be due to the increase in the number of capsules per plant grown in the seeding prose pattern (Table 3); several researchers found that the seed yield is positively related to the number of capsules more than the two yield components (the number of seeds and the weight of 1000 seeds).

Cultivation method	Cultivars	Row spacing			Cultivation method x Cultivars
		40 cm	60 cm	80 cm	
Prose	Haad	563.3	612.3	600.0	591.9
Prose	Rafidian	195.7	222.7	272.3	230.2
Prose	Summer	258.3	268.7	287.0	271.3
Seedling	Haad	271.3	288.7	376.7	312.2
Seedling	Rafidian	282.7	278.3	276.0	279.0
Seedling	Summer	282.7	265.3	290.3	279.4
LSD 0.05	14.390				11.490
Cultivation method					
Cultivation method X Row spacing	Prose	339.1	367.9	386.4	364.5
	Seedling	314.3	277.4	278.9	290.2
LSD 0.05	11.190				14.780
Cultivars					
Cultivars X Row spacing	Haad	417.3	450.5	488.3	452.1
	Rafidian	239.2	250.5	274.2	254.6
	Summer	270.5	267.0	288.7	275.4
LSD 0.05	9.220				6.180
Row spacing		309.0	322.7	350.4	
LSD 0.05	5.310				

Table 5. Effect of row spacing and cultivation methods on the plant seed yield of three sesame cultivars

The results show that the plants of Haad cultivar outperformed the rest of the cultivars in seed yield, with an average of 452.1 g. plant^{-1}, while Sumer and Rafidain cultivars' yield decreased to 275.4 and 254.6 gm plant^{-1}. This may be due to the fact that Haad cultivar has excelled in the number of branches and the number of capsules per plant Tables 2, 3. This means that this cultivar is more efficient than other cultivars in achieving a balance between the source (leaves) and the sink (seeds).

The results confirmed that planting at a row spacing of 80 cm was superior by giving the highest seed yield of 350.4 g. plant^{-1}, while the row spacing of 60 cm was 322.7 g. plant^{-1}, and the lowest plant yield recorded by the treatment of row spacing of 40 cm, which is averaged at 309.0 g. plant^{-1}. This may be because the plants planted at a wide distance had a good opportunity to absorb the mineral elements from the soil in addition to the availability of the appropriate environment surrounding the plant, such as light interception. Thus, photosynthesis is better, which results in making enough nutrients for the growth and development of flower buds. In addition, the row spacing of 80 cm outperformed the average number of capsules and the 1000 seeds weight of Tables 3 and 4. The interaction between the two cultivation patterns and cultivars, the cultivar Haad, planted by the seeding prose pattern, had the highest seed yield of 591.9 g. plant^{-1}, while the Rafidain cultivar planted by seeding prose pattern gave the lowest average plant yield of 230.2 g. plant^{-1}. It was also found from the mentioned table that the interaction of plants planted with a row spacing of 80 cm and the seeding prose pattern gave the highest average of 386.4 g. plant^{-1}, while the interaction of plants planted with a row spacing of 60 cm and the

seedling pattern gave the lowest average of 277.4 g. plant^{-1}. The results indicate the superiority of the plants of the cultivar Haad planted with a row distance of 80 cm in seed yield, with an average of 488.3 g. plant^{-1}, while the seed yield of the Rafidain cultivar plants planted with a row spacing of 40 cm decreased to 239.2 g. plant^{-1}.

The cultivar Haad, planted with a seeding prose pattern and row spacing of 60 cm, had the highest average plant yield of 612.3 g. plant^{-1}. On the contrary, the behavior of the Rafidain cultivar was planted by seed prose pattern, with a row distance of 40 cm, with the lowest average plant yield of 195.7 gm plant^{-1}.

DISCUSSION

The results showed that the cultivar Haad had the highest plant height, while the Sumer cultivar recorded the lowest average, which did not differ significantly from the Rafidain cultivar. This result agrees with [9,10], who emphasized that sesame cultivars differ in their genetic structure, which was reflected in an increase in their height. Besides, it is noted from the results that the cultivar Haad gave the highest number of branches per plant, while the average number of branches was similar in the two cultivars Sumer and Rafidain. This confirmed the findings 9 when he confirmed that the cultivars vary in their genetic composition, which is reflected in the number of branches in the plant. In addition to the development of the growth of capsules well, the wide distance gives a good opportunity for phosphorous compounds to move and transform easily from the old leaves and plant organs to the new leaves, open flowers and developed seeds 11.

CONCLUSION

It was concluded that the sesame crop should be planted with seeds. Moreover, it was concluded that the seed yield increased with increased distance between the rows. The results also showed a significant three-way interaction; this indicates the different responses of the cultivars to the two types of cultivation patterns and according to the row spacing.

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