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(Original Article)

Single Trait Selection in *Improving* Seed Yield of Sesame in Reclaimed Soil

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Abstract

Three cycles of pedigree selection started in the F_2 were conducted during the four summer seasons of 2020 to 2023 to study the effect of single trait selection on genetic variability, heritability and improving seed yield of Sesame. The experiments were carried out at reclaimed loamy sand soil. The third cycle was evaluated in the reclaimed and clay soils. The selection criteria were plant height cm (PH), length of fruiting zone cm (LFZ), number of capsules plant^{-1} (NCP), seed yield plant^{-1} g (SYP), seed index g (SI) and oil%. The genetic materials were F_2, F_3, F_4 and F_5- generations of sesame (*Sesamum indicum* L.). The genotypic coefficient of variation (GCV%) decreased dramatically from the F_2-generation to F_5-generation. However, the remaining variability in NCP, SYP and SI was sufficient for further cycles of selection. Both of broad sense and narrow sense heritability's increased by selection towards homozygosity. Results indicated the ability of single trait in changing the mean selection criterion but adversely affects some correlated traits. Therefore, selection index combined favorable traits could be recommended. The genetic gain in SYP in percentage of the MP was 27.12% when selection practiced for SYP, followed by selection for NCP (19.65%), PH (17.31%) and SI (10.14%) in reclaimed soil. Otherwise, the order for improving SYP in clay soil was NCP (20.98%), LFZ (20.23%), PH (18.59%), SYP (17.38%) and SI (12.04%). The difference in the preference of selective traits under both sites of evaluation for SYP improvement is due to the interaction of family performance with the environment.

Keywords: *Genetic coefficient of variability, Heritability, Observed genetic gain, Pedigree selection.*

Introduction

Sesame (*Sesamum indicum* L) is a diploid species with 2N=26 chromosomes belonging to family *Pedaliaceae*. It is a self-pollinated crop adapted to grow in tropical and subtropical regions (Menzir, 2012). Sesame has been grown in the Near East and Africa for over 5000 years for cooking and medicinal needs (Sharma *et al*., 2014). The seeds contain 45-60% oil, 13.5% carbohydrates, and 25% protein (Iman *et al*., 2011). The cultivated area of sesame in Egypt in the summer of 2023 season was about 37222 ha (88623 Feddan) which produced about 47325 tones with an average 1.27 t/h (Economic Affairs Sector, Ministry of Agriculture, Egypt, 2023). Through this production, Egypt came as the twentieth country in the global production of sesame

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seeds (FAOSTAT, 2022). Compared to previous seasons, the area and productivity of sesame have been decreased in Egypt, due to several factors, perhaps the most important one is infection with pathogens, especially fungi. Plant breeders are always looking to increase yields through selection programs. The pedigree method is the most followed by many breeders of self-pollinated crops. Yield is a complex character controlled by many genes, its heritability is low and highly influenced by the environment. There is a concept that selection merely based on yield is not as effective. Selection based on its components increases yield as they are not only less complex but also relatively simply inherited and are less influenced by environmental deviations. Pedigree selection for yield cycle after cycle decreased genotypic coefficient (GCV%) and increased heritability (Mahdy *et al*., 2015a and b; Abd-Elaziz, 2018; Abd-Elsaber and Mekhaile, 2020; Mahdy, 2021; Mahdy *et al*., 2021, 2022, 2023). The aim of this article was to compare the observed gain of pedigree for single trait selection in improving seed yield, and its impact on GCV% and heritability estimates in a segregating population of sesame.

Materials and Methods

1-Plant materials and field trials

Three cycles of pedigree selection were conducted during the four summer seasons of 2020 to 2023 to study the effect and compare of pedigree of single trait selection on the genetic variability and heritability in sesame (*Sesamum indicum* L.) (Table 1).

The experiments were carried out at Arab El-Awamer (reclaimed loamy sand soil) Research Station (ARC), Assiut, Egypt (latitude 27°, 03′ N, longitude 31°, 01′ E and the altitude of the area is 71 m), and Fac. Agric. Assiut Univ. Expr. Farm (Clay soil), Assiut, Egypt (Longitude: 31.125 N, Latitude: 27.25 E and Elevation :45m/148 Feet).

Table 1. Growing season, planting dates, genetic materials, experimental design, and site of evaluation

Season	Date	Generation	Experimental design	Site
2020	10th June 2020	F_2	Non- replicated experiment	Arab El-Awamer
2021	13th June 2021	F_3	RCBD with three replications	Arab El-Awamer
2022	15th June 2022	F_4	RCBD with three replications	Arab El-Awamer
2023	20th and 21th June	F_5	RCBD with three replications	Arab El-Awamer and University Farm

The recommended cultural practices for fertilization, irrigation and combat wilt and root rot diseases were adopted.

The genetic materials were F_2, F_3, F_4 and F_5- generations of sesame (*Sesamum indicum* L.) generated from a cross Shandaweel 3 × Sohag 2000. The F_2-generation was represented by 1000 single plants, and the data were recorded on 499 plants.

The recorded data in all seasons were days to first flower (DFF) in the F_2 and days to 50% flowering (DF) in the other generations, plant height (PH, cm), height to first capsules (HFC, cm), length of fruiting zone (LFZ, cm) as the difference between plant height and height to first capsule, number of capsules plant^{-1} (NCP), seed yield plant^{-1}

(SYP, g), 1000 seed weight (SW, g), seed oil percentage (oil %). Oil content (%) was determined by a Soxhlet extraction method according to AOAC (2002), and number of seeds capsule^{-1} (NSC) which was determined by counting seeds of 10 capsules/plant or family. Selection procedures were single trait selection for PH, LFZ, NCP, SYP, SW and oil%.

2-Field procedures

Season 2020 (F_2- generation)

In reclaimed soil, 1000 F_2-plants of the population Shandaweel 3 × Sohag 2000 were sown in non-replicated rows of 5 m long and 50 cm width. Seeds were sown in hills 10 cm apart. The two parents were sown in five rows each. After full emergence, seedlings were thinned to one plant per hill. Data was recorded on 499 plants of the F_2-population and on 25 plants from each parent. The best 40-plants for each of PH, LFZ, NCP, SYP, SW and oil % were saved for the next generation.

Season 2021 (F_3-generation)

In reclaimed soil, the selected F_3-families along with the two parents were sown in RCBD with three replications. The plot size for this and in subsequent generations was one row, 5 m long and 50 cm width, and seeds were sown in hills 10 cm apart. The characters were recorded as in the previous season as an average of 10 guarded plants from each family. After harvest, the best plant from the best 20 families for each single trait were saved for the next generation.

Season 2022 (F_4-generation)

In reclaimed soil, the selected F_4-families along with the two parents were sown as in the previous season. After harvest, the best plant from the best 10 families for each single trait were saved for the next generation.

Season 2023 (F_5-generation)

In both reclaimed and clay soils the selected F_5-families along with the two parents were sown in RCBD with three replications. The plot size was one row, 2 m long, 50 cm width and seeds were sown in hills 10 cm apart.

3-Statistical analysis

The analysis of variance, covariance, phenotypic (σ^2p) and genotypic variance (σ^2g) and significance tests were performed as Steel *et al.* (1997) on a plot-mean basis.

The genotypic (GCV) coefficient of variation and the genotypic correlations among pairs of traits were estimated as outlined by Miller *et al*. (1958) and Walker (1960).

Broad sense heritability (H) as estimated by intra-class correlation was computed using the formula adopted by Falconer (1989). Narrow sense heritability as parent-offspring regression was estimated as outlined by Smith and Kinman (1965).

Results and Discussion

1-The influence of single trait selection on variability and heritability

Analysis of variance and genotypic coefficient of variability

After three cycled of selection the entries mean squares (10 selected families + two parents) in the F_5-genaration for the traits under selection pressure (PH, LFZ, NCP, SYP, SW and oil%) and correlated traits was significant ($p \leq 0.05$ - $p \leq 0.01$) except for NSC at clay soil when selection practiced for LFZ (Table 2).

Table 2. Entries mean squares of the studied traits at reclaimed and clay soils in the F_5-generation

Sel. crit.	Eval. site	DF	PH	HFC	LFZ	NCP	SYP	SW	Oil%	NSC
PH	Reclaimed	28.27**	377.20**	321.0**	345.4**	657.1**	14.53**	0.34**	13.18**	391.28**
	Clay soil	26.51**	268.87**	349.97**	327.93**	740.45**	17.29**	0.46**	9.52**	127.96**
LFZ	Reclaimed	72.73**	212.36**	403.60**	475.84**	628.84**	29.47**	0.64**	22.17**	52.37*
	Clay soil	40.02**	217.46**	328.44**	434.54**	730.09**	28.98**	0.52**	15.27**	40.28
NC/P	Reclaimed	47.45**	334.089**	191.06**	653.70**	607.29**	21.98**	0.60**	7.24**	7.24**
	Clay soil	64.76**	265.79**	223.93**	582.61**	1046.63**	39.13**	0.62**	14.8**	50.24*
SY/P	Reclaimed	37.91**	350.39**	396.15**	396.19**	450.33**	26.52**	0.37**	14.21**	79.22**
	Clay soil	38.21**	189.11**	379.51**	495.46**	1555.79**	46.47**	0.40**	12.25**	37.24*
SW	Reclaimed	47.16**	339.95**	202.30**	620.99**	923.03**	30.27**	0.96**	12.21**	266.86**
	Clay soil	50.53**	255.41**	230.67**	560.57**	1302.15**	44.62**	0.68**	17.16**	87.70**
Oil%	Reclaimed	28.27**	377.178**	320.99**	345.36**	657.12**	14.53**	0.34**	13.18**	90.76*
	clay soil	34.69**	242.54**	301.66**	364.19**	448.44**	13.41**	0.36**	12.25**	73.74*

Sel. crit.= selection criterion, Eval. site=Evaluation site, DF=days to 50% flowering, PH= plant height, HFC= height to first capsule, LFZ= length of fruiting zone, NCP= number of capsulesplant^{-1}, SYP=seed yield plant-1, SW=1000sw, NSC=number of seedscapsules^{-1}, * and **= significant at 0.05 and 0.01 levels of probability, respectively.

The success of any breeding program depends mainly on genetic variation in the population of interest and the extent to which they are utilized. The gain from selection in a population depends on genetic variability within a population for a given trait, heritability and selection intensity (Falconer, 1989). The high estimate of genetic variation makes the breeder's task easier to make effective selection.

The genotypic coefficient of variation (GVC%) in PH decreased dramatically from 13.63 in the F_2-generation to 6.46 in reclaimed soil and 5.44 in clay soil after three cycles of pedigree selection for PH (Table 3). The GVC% in LFZ decreased from 20.67 in F_2 to 9.62 in reclaimed and to 7.10% in clay soil. However, NCP maintains its variability from F_2 to F_5- generation for further cycles of selection. Selection for SYP decreased the GCV% from 41.08 in the F_2 to 17.44 and 26.47 in reclaimed and clay soils, respectively. Such a decrease is expected, because the selection was for the highest portion of the curve, in which the selected plants became more similar. It is well known that selection favors heterozygosity. In the fourth or fifth generation, there is a high percentage of heterozygosity depending on the number of genes controlled the trait and the extent of the environmental influence on the trait. Falconer (1989) noted that in self-pollinated crops successive selection cycle after cycle leads to homozygosity; in consequence, the selection differential and genetic variance decreased. These results agree with those reported by Abd-Elaziz, 2018, Abd-Elsaber and Mekhail, 2020, and Mahdy *et al*., 2015a and b.

The remaining variability in SYP was sufficient for further cycles of selection. It could be concluded that variability in the traits under selection pressure decreased through selection from F_2- to F_5- generation. However, the remaining variability in NCP, SYP and SW was sufficient for further cycles of selection in this population. Otherwise, the variability was depleted for PH and oil% and selection for these traits could not be recommended. Mahdy (2021), Mahdy *et al* (2022) and Hemanth and Patil (2023) reached the same conclusion.

Table 3. Genotypic coefficient of variation (GCV%) for pedigree selection at clay and reclaimed soils in the F_5-generation for the traits under selection pressure and correlated traits

Sel. Site	Cycle	DF	PH	HFC	LFZ	NCP	SYP	SW	NSC	Oil%
	F_2	5.67	13.63	25.68	20.67	27.78	41.08	8.53	23.22	4.25
					Selection for PH					
	C1	9.17	8.14	24.79	19.24	23.96	32.09	12.74	23.15	6.60
Reclaimed soil	C2	6.36	5.91	15.77	11.84	20.30	16.45	16.19	20.72	8.04
	C3	4.74	6.46	18.79	8.56	20.82	18.95	7.40	24.81	4.37
Clay soil	C3	4.59	5.44	18.77	5.11	19.60	17.24	7.20	16.53	3.40
					Selection for LFZ					
	C1	10.70	8.05	39.18	19.46	26.36	31.26	14.84	25.89	5.26
Reclaimed soil	C2	6.37	8.17	23.27	13.66	21.32	19.42	12.81	20.25	6.52
	C3	10.36	4.46	25.08	9.62	17.42	27.41	10.46	9.88	5.88
Clay soil	C3	6.54	4.96	19.03	7.10	15.70	21.53	7.34	ns	4.36
					Selection for NCP					
	C1	9.64	7.71	26.26	15.83	21.69	29.79	12.79	21.14	5.92
Reclaimed soil	C2	7.04	5.96	22.18	13.83	18.70	15.76	9.17	14.11	6.61
	C3	8.09	6.43	11.01	8.95	16.07	17.64	9.47	22.12	2.29
Clay soil	C3	8.90	5.75	10.05	5.68	21.63	25.49	9.60	9.12	4.42
					Selection for SYP					
	C1	9.61	7.81	28.81	15.07	22.42	30.55	12.23	24.39	6.18
Reclaimed soil	C2	5.82	4.94	20.92	10.91	22.77	16.11	8.30	11.42	7.05
	C3	5.59	6.17	23.49	8.31	5.73	17.44	7.80	9.90	4.42
Clay soil	C3	6.27	3.96	21.18	6.64	23.06	26.47	7.70	ns	3.93
					Selection for SW					
	C1	6.10	10.73	35.50	19.44	23.23	29.51	15.34	26.48	5.69
Reclaimed soil	C2	6.09	6.68	27.51	12.85	26.14	21.84	10.60	19.99	6.76
	C3	7.85	6.67	11.54	9.13	23.52	25.13	14.07	23.86	3.68
Clay soil	C3	8.39	5.77	10.99	6.13	26.89	29.93	10.64	13.67	4.78
					Selection for Oil%					
	C1	9.84	7.62	30.45	14.43	20.88	28.00	13.90	27.56	5.94
Reclaimed soil	C2	8.10	7.73	19.65	14.26	28.24	21.38	9.07	16.91	5.31
	C3	4.74	6.46	18.79	8.56	20.82	18.95	7.40	ns	4.37
Clay soil	C3	5.48	5.55	18.80	4.21	13.80	15.09	5.79	9.34	3.97

DF=days to 50% flowering, PH= plant height, HFC= height to first capsule, LFZ= length of fruiting zone, NCP= number of capsulesplant^{-1}, SYP=seed yieldplant^{-1}, SW=1000sw, NSC=number of seedscapsules^{-1}, ns= not significant.

3-Heritability estimates

The heritability estimate plays an important role in determining the reliability and extent to which phenotypic value indicates breeding value and is useful in predicting the expected progress to be achieved through the process of selection. While genetic coefficient of variation along with heritability estimates provide a reliable estimate of the amount of genetic advance to be expected through phenotypic selection.

Broad sense heritability as estimated by intra-class correlation showed a general trend as it increased from cycle 1 to cycle 3 for all selection criteria and varied with evaluation site (Table 4). It increased for PH from 0.49 in cycle 1 to 0.92 and 0.75 in cycle 3 for reclaimed and clay soils, respectively. Number of capsules plant^{-1}, SYP, SW and oil% exhibited the same trend, and increased with increasing homozygosity in the F_5-generation. These results are in line with those found by Mohanty *et al*. (2020), Ahmed *et al*. (2022), Khan *et al*. 2022; Roy *et al*. 2022 and Sundari *et al*., 2022.

The high estimates of broad sense heritability could be because it contains additive, dominance and epistatic effects and their interaction with environment. Furthermore, the evaluation of the selected families in one site for one year inflates families mean squares by the interactions of families with years (Mahdy, 2021). However, the narrow-sense heritability (h^2), as estimated by parent–offspring regression of F5/F4 was low (Table 4). The low h^2 slightly increased for all selection criteria from cycle 1 to cycle 3 towards homozygosity. The main weakness in calculating the narrow sense heritability as parent-offspring regression is the genotype by environment interaction, in which the parents (F_4) were evaluated in a year and their offspring (F_5) in another year. These results are in line with those reported by Abd-Elaziz (2018), Abd-Elsaber and Mekhail (2020), Mahdy (2021) and Mahdy *et al*. (2021, 2022, 2023). It is interesting to mention that higher heritability estimates in broad sense did not necessarily provide higher value of genetic advance hence heritability alone provides no indication for amount of genetic progress that could be achieved through selection. However, genetic coefficient of variation along with heritability provides a reliable estimate of the amount of genetic advance to be expected through phenotypic selection.

Table 4. Broad sense heritability as intra-class correlation(H) and narrow sense heritability (h^2) as parent-offspring regression for traits under selection pressure in the F_5-generation

Selection cycle	PH		LFZ		NCP		SYP		SW		Oil%	
	H	h^2	H	h^2	H	h^2	H	h^2	H	h^2	H	h^2
C1	o.49	0.38	0.89	0.31	0.58	0.20	0.79	0.15	0.40	0.31	0.41	0.20
C2	0.88	0.37	0.88	0.37	0.83	0.38	0.92	0.39	0.40	0.33	0.50	0.20
C3 Reclaimed soil	0.92	0.42	0.89	0.43	0.68	0.42	0.95	0.41	0.90	0.41	0.90	0.30
C3 clay soil	0.75		0.85		0.84		0.95		0.90		0.60	

PH= plant height, LFZ= length of fruiting zone, NCP= number of capsules plant^{-1}, SYP=seed yield plant^{-1}, SW=1000sw, NSC=number of seeds capsules^{-1}

Comparing the direct and indirect observed gain of single trait selection in improving yield of sesame

1-Selection for plant height

Means and observed gains

In reclaimed soil mean PH increased by selection from 156.56cm in cycle 1 to 160.03 cm and 167.33 cm in cycle 3 in reclaimed and clay soil, respectively (Table 5). This shifting in mean values in desirable direction could largely be attributed to the predominance of additive and additive x additive type of gene action, and due to the possible accumulation of favorable alleles because of selection. Mean PH was better in clay than in reclaimed soil. Selection for PH caused an increase in the mean of the correlated traits of LFZ, NCP and SYP from cycle 1 to cycle 3.

After three cycles of selection for PH the observed direct genetic gain was significant ($p \leq 0.01$) from the MP and was 5.52 and 4.58% in reclaimed and clay soils, respectively (Table 5), accompanied with significant ($p \leq 0.01$) correlated gains in LFZ

(17.05, 21.12%), SY/P (17.31,18.59%) an SW (7.52, 9.13%) in reclaimed soil and clay soil, respectively. Otherwise, selection for PH showed unfavorable effects in DF, HFC, NSC and Oil%. Abd-Elaziz (2018), Abd-Elsaber and Mekhail (2020) and Mahdy *et al.* (2021, 2023) came to the same conclusion.

Table 5. Mean ±SE and the observed genetic gain (GA) from the mid-(MP) and better parent (BP) in the PH and correlated traits for the three cycles of pedigree selection

Selection for PH									
Item	**DF**	**P.H**	**HFC**	**LFZ**	**NCP**	**SYP**	**SW**	**NSC**	**OIL %**
Mean C1	42.43± 0.36	156.56± 3.86	74.72± 4.00	81.84± 4.89	60.25± 3.85	8.00± 0.74	3.61± 0.10	37.58± 3.46	49.63± 0.30
GA from MP% C1	-3.94**	6.02**	6.74**	5.38	5.70*	14.31**	0.70	10.43	2.32**
GA from BP% C1	2.64**	1.01	24.53**	1.88	-1.23	0.04	-2.43**	6.06	1.28**
Mean C2	46.35± 0.43	164.08± 3.36	70.33± 3.43	93.75± 4.51	69.25± 4.36	16.71± 0.63	3.86± 0.05	64.68± 4.27	47.45± 0.20
GA from MP% C2	4.16*	11.88**	9.36**	13.84**	18.71**	15.38**	8.54**	-9.74**	-3.82**
GA from BP% C2	13.05**	7.01	9.02*	5.08**	1.33**	8.09**	-3.40**	-19.11**	-4.46**
Mean C3 Reclaimed soil	46.00± 1.01	160.03± 0.90	51.77± 1.94	108.27± 2.80	73.13± 5.10	13.36± 0.42	4.05± 0.11	46.68± 4.67	49.80± 0.57
GA from MP%	2.22	5.52**	7.10	17.05**	8.88	17.31**	7.52**	3.43	-0.07
GA from BP%	15.00**	-2.02	41.18**	13.96**	3.00	6.80*	-0.41	-3.86	-2.35**
Mean C3 Clay soil	50.70± 0.61	167.33± 1.14	52.27± 1.14	115.07± 1.50	82.53± 2.97	15.16± 0.52	4.62± 0.12	40.57± 2.46	51.80± 0.44
GA from MP%	-1.87**	4.58**	2.82	21.12**	13.84**	18.59**	9.13**	-3.59	-1.33
GA from BP%	7.87**	-0.59	42.55**	9.59**	3.17	15.08**	-0.29	-7.26	-4.07**

C= cycle, * and ** significant at 0.05 and 0.01 levels of probability, respectively, DF= days to 50% flowering, PH= plant height, HFC=height to the first capsule, LFZ= length of fruiting zone, NCP= number of capsules plant^{-1}, SYP=seed yield plant^{-1}, SW=1000sw, NSC=number of seeds capsules^{-1}.

2-Selection for LFZ

Means and observed gains

The performance of the selected families in LFZ increased from 92.68cm in cycle 1 to 111.77 and 116.13cm in cycle 3 in reclaimed and clay soil, respectively, followed by decrease in HFC (favorable) and increase in NCP, SYP and SW (Table 6). The observed genetic gain in LFZ in percentage from the mid-parent was significant (p≤01) and increased from 19.32% in cycle 1 to 20.83% in cycle 3 in reclaimed soil, and 22.25% in clay soil (Table 6). Such increase in LFZ followed by positive correlated gain from the MP for PH (3.43%**, 3.06%*), NCP (21.04%**, 24.60%**), SYP (4.08%, 20.23%**), SW (11.77%**, 11.49%**), and decrease in NSC (-23.29**, -14.41%**) and oil%(-1.07%, -1.14%**) in reclaimed and clay soils, respectively. These results indicate that single trait selection increased the mean of the selection criterion accompanied with deleterious effects on some correlated traits. These results are in line with Abd-Elaziz (2018) and Mahdy *et al*. (2021, 2022, 2023).

3-Selection for NCP

Means and observed gains

The mean performance of the selected families of NCP increased from 65.96 in cycle 1 to 83.63 and 87.47 in cycle 3 in reclaimed and clay soils, respectively. Generally, the means were higher in clay than in reclaimed soil. This shifting in mean values in desirable direction could largely be attributed to the predominance of additive and additive x additive type of gene action and due to the accumulation of favorable genes as a result of selection. Selection for NCP increased the means of the correlated traits; PH, LFZ, SYP and SW.

The observed genetic gain in NCP as measured in percentage of MP significant increased from 14.83** in cycle 1 to 24.52**in reclaimed soil and 20.64** in clay soil in cycle 3 (Table 7). In reclaimed soil the correlated observed gain in percentage of MP reached 19.65** for SYP, 13.63** for SW, 4.35** for oil%, -26.55** for HFC and 2.79** for plant height, and in clay soil it was -8.45** for DF, -24.92** for HFC (favorable direction), 31.05** for LFZ, 20.98** for SYP and 7.01** for SW. These results are in line with those reported by Abd-Elaziz (2018) and Mahdy *et al*. (2015a, b, 2021, 2022, and 2023).

Table 6. Mean ±SE and the observed genetic gain (GA) from the mid-(MP) and better parent (BP) in the LFZ and correlated traits for the three cycles of pedigree selection

Selection for LFZ									
Item	**DF**	**P.H**	**HFC**	**LFZ**	**NCP**	**SYP**	**SW**	**NSC**	**OIL %**
Mean C1	39.93± 0.33	150.18± 3.94	57.50± 3.41	92.68± 4.87	62.65± 4.05	7.95± 0.84	3.76± 0.04	34.77± 3.30	50.60± 0.30
GA from MP% C1	-9.60**	1.70	-17.86**	19.32**	9.91*	13.57**	4.99**	2.20	4.33**
GA from BP% C1	-3.41**	-3.11*	-4.17	15.36**	2.70	-0.61	1.73**	-1.85	3.27**
Mean C2	44.15± 0.47	152.73± 2.95	52.08± 1.97	100.65± 5.19	69.36± 5.26	16.77± 0.60	3.89± 0.11	64.48± 5.17	49.90± 0.20
GA from MP% C2	-0.79	4.14**	-19.02**	22.22**	18.89**	15.81**	9.33**	-10.02**	1.15**
GA from BP% C2	7.68**	-0.39	-18.76**	12.81**	1.50	8.49**	-2.70	-19.37**	0.47
Mean C3 Reclaimed soil	45.80± 1.19	156.87± 1.55	45.10± 2.08	111.77± 5.86	81.30± 3.91	11.94± 0.48	4.21± 0.11	34.63± 2.40	49.30± 0.52
GA from MP%	1.78	3.43**	-6.69	20.83**	21.04**	4.85	11.77**	-23.29**	-1.07
GA from BP%	14.5**	-3.96**	23.00**	17.65	14.51**	-4.54	3.52	-28.69**	-3.33**
Mean C3 Clay soil	50.20± 0.54	164.90± 1.30	48.77± 1.52	116.13± 2.05	90.33± 4.99	15.37± 0.45	4.72± 0.10	36.01± 2.72	51.90± 0.73
GA from MP%	-2.84**	3.06*	-4.07	22.25**	24.60**	20.23**	11.49**	-14.41**	-1.14**
GA from BP%	6.81**	-2.04	33.0**	10.60**	12.92**	16.67**	1.87	-17.66**	-3.89**

*, ** significant at 0.05 and 0.01 levels of probability, respectively, C= cycle, DF= days to 50% flowering, PH= plant height, HFC=height to the first capsule, LFZ= length of fruiting zone, NCP= number of capsules plant^{-1}, SY/P=seed yield plant^{-1}, SW=1000sw, NSC=number of seeds capsules^{-1}.

Table 7. Mean ±SE and the observed genetic gain (GA) from the mid-(MP) and better parent (BP) in the NCP and correlated traits for the three cycles of pedigree selection

Selection for NCP									
Item	**DF**	**P.H**	**HFC**	**LFZ**	**NCP**	**SYP**	**SW**	**NSC**	**OIL %**
Mean C1	41.95± 0.21	154.34± 4.17	65.16± 4.65	89.18± 5.32	65.96± 4.02	8.10± 0.76	3.55± 0.04	35.24± 2.91	50.73± 0.33
GA from MP% C1	-5.02**	4.52*	-6.92	14.83**	15.722**	15.80**	-1.12	3.56	4.59**
GA from BP% C1	1.49**	-0.42	8.60	11.02*	8.14	1.35	-4.19**	-0.54	3.52**
Mean C2	46.95± 0.42	161.50± 2.64	66.32± 2.30	95.18± 3.22	68.10± 4.36	16.70± 0.58	3.84± 0.10	65.32± 4.58	49.00± 0.20
GA from MP% C2	5.51**	10.11**	3.11	15.58**	16.73**	15.29**	7.99**	-8.85*	-0.68**
GA from BP% C2	14.51**	5.33*	3.44	6.68**	-0.35	8.01*	-3.89*	-18.32**	-1.34**
Mean C3 Reclaimed soil	43.80± 0.97	155.90± 1.46	35.50± 1.35	120.40± 2.15	83.63± 3.63	13.62± 0.56	4.28± 0.11	38.95± 3.09	52.00± 0.60
GA from MP%	-2.67	2.79**	-26.55**	30.16**	24.52**	19.65**	13.63**	-13.70*	4.35**
GA from BP%	9.50**	-4.55**	-3.18	26.74**	17.79**	8.94*	5.25	-19.78**	1.96
Mean C3 Clay soil	47.30± 0.54	163.00± 1.84	38.17± 1.49	124.50± 1.98	87.47± 3.81	15.46± 3.81	4.53± 0.45	39.17± 0.11	52.20± 0.43
GA from MP%	-8.45**	1.88	-24.92**	31.05**	20.64**	20.98**	7.01**	-6.90	-0.57
GA from BP%	0.64	-3.17	4.09	18.57**	9.33*	17.39**	-2.23**	-10.44	-3.33**

*, ** significant at 0.05 and 0.01 levels of probability, respectively, DF= days to 50% flowering, PH= plant height, HFC=height to the first capsule, LFZ= length of fruiting zone, NCP= number of capsules plant^{-1}, SYP=seed yield plant^{-1}, SW=1000sw, NSC=number of seeds capsules^{-1}.

4-Selection for SYP

Means and observed gains

Mean SYP of the selected families in the F_5-generation was better in clay soil (15.01, g) than in reclaimed soil (14.47, g) (Table 8). Families' means of SYP in reclaimed soil exceeded from 8.15g in cycle 1 to 14.47 and 15.01g in reclaimed and clay soils, respectively. Shifted in the selection criterion means followed by a favorable increase in the correlated traits; PH, HFC, LFZ, NCP and SW. Otherwise, DF, HFC, NSC and oil% were negatively affected. These results agree with those noted by Mahdy *et al*. (2022, and 2023).

After cycle 3, the direct observed genetic gain in SYP was significant ($p \leq 0.01$) and reached 27.12% and 15.74% in reclaimed soil, and 17.38% and 13.91% in clay soil from the mid- and better parent, respectively (Table 8). In reclaimed soil, the correlated gain in percentage of the mid-parent was significant ($p \leq 0.01$) for PH, LFZ, NCP and SW. However, selection for SYP adversely affected DF and NSC. The results in clay soil almost showed the same trend. This confirms that selection for single traits could change the mean of the selection criterion and may negatively affects other traits. These results agree with Abd-Elaziz (2018), Abd-Elsaber and Mekhail (2020) and Mahdy *et al*. (2021, 2022, and 2023)

Table 8. Mean ±SE and the observed genetic gain (GA) from the mid-(MP) and better parent (BP) in the SYP and correlated traits for the three cycles of pedigree selection

Selection for SYP									
item	DF	P.H	HFC	LFZ	NCP	SYP	SW	NSC	OIL %
Mean C1	40.95± 0.21	152.54± 4.04	60.69± 4.52	91.85± 4.73	63.24± 4.31	8.15± 0.80	3.53± 0.04	37.34± 3.37	50.40± 0.31
GA from MP% C1	-7.28**	3.30	-13.29**	18.26**	10.95*	16.46**	-1.56**	9.75	3.92**
GA from BP% C1	-0.93*	-1.59	1.15	14.34**	3.68	1.92	-4.62**	5.40	2.86**
Mean C2	44.90± 0.46	159.10± 2.74	60.65± 2.09	98.45± 3.08	65.74± 4.09	16.90± 2.9	3.75± 0.10	70.33± 5.09	49.35± 0.20
GA from MP% C2	0.90	8.48**	-5.70**	19.55**	12.70**	16.66**	5.35**	-1.86	0.03
GA from BP% C2	9.51**	3.76*	-5.40	10.35**	-3.79	25.09**	-6.24*	-12.05*	-0.64
Mean C3 Reclaimed soil	48.00± 1.01	159.90± 1.58	48.30± 1.55	111.60± 2.54	94.53± 3.49	14.47± 0.51	4.06± 0.12	37.58± 2.35	50.60± 0.61
GA from MP%	6.67**	5.43**	-0.07	20.6**	40.74**	27.12**	7.79**	-16.74**	1.54**
GA from BP%	20.00**	-2.10	31.73**	17.47**	33.15**	15.74**	-0.16	-22.61**	-0.78
Mean C3 Clay soil	51.50± 0.54	168.67± 1.78	49.10± 1.13	119.50± 2.35	96.47± 4.46	15.01± 0.51	4.51± 0.12	34.31± 2.04	51.80± 0.44
GA from MP%	-0.32	5.42**	-3.41	25.79**	33.06**	17.38**	6.54**	-18.46**	-2.10**
GA from BP%	9.57**	0.20	33.91**	13.81**	20.58**	13.91**	-2.66	-21.56**	-4.81**

*, ** significant at 0.05 and 0.01 levels of probability, respectively, DF= days to 50% flowering, PH= plant height, HFC=height to the first capsule, LFZ= length of fruiting zone, NCP= number of capsules plant^{-1}, SYP=seed yield plant^{-1}, SW=1000sw, NSC=number of seeds capsules^{-1}.

5-Selection for SW

Means and observed gains

Mean selected families for SW increased from 3.68g in the first cycle to 4.41g in reclaimed soil and 4.11g in clay soil. Selection for SW positively affected the mean of correlated traits; LFZ, NCP and SYP (Table 9). These results are in line with those reported by Mahdy (2021) and Mahdy *et al*. (2015a, b, 2021, 2022, and 2023).

After cycle 3 the observed genetic gain in SW was 4.17%** and 9.12%** from the mid-parent in reclaimed and clay soils, respectively (Table 9). Selection for SW increased (p≤0.05-p≤0.01) the correlated traits; LFZ, NCP and SYP. But it adversely affected NSC. Almost the same trend was observed in clay soil. These results confirm that single trait selection is an effective method to change the means of the selected trait but may negatively affect some correlated traits.

Table 9. Mean ±SE and the observed genetic gain (GA) from the mid-(MP) and better parent (BP) in the SW and correlated traits for the three cycles of pedigree selection

Selection for SW									
Item	**DF**	**P.H**	**HFC**	**LFZ**	**NCP**	**SYP**	**SW**	**NSC**	**OIL %**
Mean C1	40.80± 3.35	152.21± 3.25	63.66± 3.68	88.55± 4.55	63.93± 4.72	7.80± 0.84	3.86± 0.94	32.58± 3.76	50.18± 0.30
GA from MP% C1	-7.62	3.08*	-9.06**	14.02**	12.15*	11.46	7.53**	-4.24	3.45**
GA from BP% C1	-1.29	-1.80	6.09	10.23*	4.80	-2.45	4.19**	-8.03	2.40**
Mean C2	45.35± 0.44	156.08± 3.63	61.78± 2.17	94.30± 4.44	65.99± 5.19	16.20± 0.64	3.88± 0.10	65.65± 5.48	48.95± 0.20
GA from MP% C2	1.91**	6.42**	-3.94	14.51**	13.13*	11.85**	8.96**	-8.38	-0.78**
GA from BP% C2	10.61**	1.79**	-3.63	5.69	-3.43	4.78	-3.03	-17.90**	-1.44**
Mean C3 Reclaimed soil	48.20± 1.12	160.53± 1.65	38.23± 1.36	121.97± 2.34	82.07± 3.50	14.08± 0.50	4.41± 0.11	39.32± 2.76	51.80± 0.57
GA from MP%	-6.71**	0.33	-24.79**	28.39**	13.20**	10.14**	4.17**	-6.56	-1.33
GA from BP%	2.55	-4.63	4.27	16.16**	2.58	6.88**	-4.82**	-10.12	-4.07**
Mean C3 Clay soil	44.90± 0.71	153.57± 1.64	34.73± 1.52	118.83± 1.85	78.17± 3.75	12.76± 0.87	4.11± 0.12	40.98± 2.18	51.80± 0.53
GA from MP%	-0.22	1.25	-28.14**	28.47**	16.38**	12.04**	9.12**	-9.20*	3.95**
GA from BP%	12.25**	-5.97**	-5.27*	25.09**	10.09*	2.00	1.07	-15.60**	1.57

DF= days to 50% flowering, PH= plant height, HFC=height to the first capsule, LFZ= length of fruiting zone, NCP= number of capsules plant^{-1}, SYP=seed yield plant^{-1}, SW=1000sw, NSC=number of seeds capsules^{-1}.

6-Selection for oil%

Means and observed gains

In both locations selection for oil% failed to improve oil% from the mid-parent. However, in reclaimed soil selection for oil% decreased (p≤0.01) NSC and HFC and increased LFZ, NCP and SW from the mid-parent. However, SYP was not affected. In clay soil the families performed the same except for DF which was earlier (p≤0.01) than the MP. In terms of direct genetic gain, oil% was decreased (p≤0.01) from the mid-parent in clay soil and was not affected in reclaimed soil. The correlated genetic gain was significant (p≤0.01) from the mid-parent for SW, NCP, LFZ and HFC in the favorable direction, and for negative direction for PH and NSC (Table 10). Therefore, selection for oil% could not be recommended. These results agree with those reported with Mahdy *et al*. (2021, 2023).

7-The genetic observed correlated gain (GA) in SYP for different single trait selection after three cycles of selection

Plant breeders always aim to increase the seed yield in breeding programs, therefore selection methods for single traits must be compared in terms of their improvement of seed yield. It should be recalled that the families selected under the condition of reclaimed soil are the same as those valued under the conditions of the two locations in the F_5-generation. The observed genetic gain in SYP was the best when selection practiced for SYP per se (Table 11). The genetic gain in SYP in percentage of the MP was 27.12% followed by selection for NCP (19.65%), PH (17.31%) and SW (10.14%) in reclaimed soil. Otherwise, the order in improving SYP in clay soil was NCP (20.98%), LFZ (20.23%), PH (18.59%), SYP (17.38%) and SW (12.04%). Otherwise, it is not possible to recommend selection based on the oil percentage. The difference in the preference of selective traits under both sites of evaluation for SYP improvement is due to the interaction of family performance with the environment.

Table 10. Mean ±SE and the observed genetic gain (GA) from the mid-(MP) and better parent (BP) in the oil% and correlated traits for the three cycles of pedigree selection

Selection for oil%									
Item	**DF**	**P.H**	**HFC**	**LFZ**	**NCP**	**SYP**	**SW**	**NSC**	**OIL %**
Mean C1	39.38± 0.23	146.36± 3.33	61.33± 2.65	85.03± 4.13	59.80± 4.85	7.60± 0.86	3.71± 0.04	35.27± 3.50	51.63± 0.33
GA from MP% C1	-10.85**	-0.89	-12.39**	-2.08*	-0.88	-2.83**	3.57**	3.64	6.44**
GA from BP% C1	-4.74**	-5.58**	2.21	-5.33	-7.38	-14.96**	0.35**	-0.46	5.36**
Mean C2	44.30± 0.43	149.50± 2.19	67.50± 2.03	82.00± 3.20	58.10± 4.55	13.10± 0.66	3.82± 0.10	53.82± 4.76	51.20± 0.19
GA from MP% C2	-0.45	1.93	4.96*	-0.43	-0.40	-9.55**	7.22**	-24.89**	3.78**
GA from BP% C2	8.05**	-2.50	5.29	-8.09**	-14.98**	-3.01	-4.58*	-32.69**	3.09**
Mean C3 Reclaimed soil	44.10± 1.01	152.83± 1.76	40.37± 1.94	112.47± 2.80	76.90± 5.10	11.60± 0.42	4.31± 0.11	35.31± 3.34	49.60± 0.57
GA from MP%	-2.00	0.77	-16.48**	21.59**	14.49*	1.84	14.42**	-21.77**	-0.47
GA from BP%	10.25**	-6.43**	10.09	18.39**	8.31	-7.28*	5.98*	-27.29**	-2.75*
Mean C3 Clay soil	48.90± 0.84	161.27± 1.74	43.17± 1.24	118.10± 1.61	83.23± 4.11	12.56± 0.33	4.61± 0.12	32.85± 2.06	51.40± 0.32
GA from MP%	-5.35**	0.79	-15.08**	24.32**	14.80**	-1.75	8.89**	-21.93**	-2.10**
GA from BP%	4.04**	-4.19*	17.73**	12.48**	4.04	-4.66	-0.50	-24.90**	-4.81**

*, ** significant at 0.05 and 0.01 levels of probability, respectively, DF= days to 50% flowering, PH= plant height, HFC=height to the first capsule, LFZ= length of fruiting zone, NCP= number of capsules plant^{-1}, SYP=seed yield plant^{-1}, SW=1000sw, NSC=number of seeds capsules^{-1}.

Table 11. The genetic observed correlated gain (GA) in SYP for different single trait selection after three cycles of selection

item	PH	LFZ	NCP	SYP	SW	Oil%
Mean C3 Reclaimed soil	13.36	11.94	13.62	14.47	14.08	11.60
GA from MP%	17.31**	4.85	19.65**	27.12**	10.14**	1.84
GA from BP%	6.80*	-4.54	8.94*	15.74**	6.88**	-7.28*
Mean C3 Clay soil	15.16	15.37	15.46	15.01	12.76	12.56
GA from MP%	18.59**	20.23**	20.98**	17.38**	12.04**	-1.75
GA from BP%	15.08**	16.67**	17.39**	13.91**	2.00	-4.66

*, ** significant at 0.05 and 0.01 levels of probability, respectively, PH= plant height, LFZ= length of fruiting zone, NCP= number of capsules plant^{-1}, SYP=seed yield plant^{-1}, SW=1000sw

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تحسين محصول البذرة في السمسم بالانتخاب للصفات المفردة في الأرض المستصلحة

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[2] قسم بحوث المحاصيل الزيتية، معهد المحاصيل الحقلية، مركز البحوث الزراعية، مصر.

الملخص

أجريت ثلاث دورات من الانتخاب المنسب بدأت من الجيل الثاني في أربعة مواسم صيفية بداية من 2020 حتى 2023 لدراسة تأثير الانتخاب لصفة واحدة لتحسين محصول البذرة وتأثير ذلك على التباين الوراثي ومعامل التوريث في السمسم. أجريت الدراسة في أرض جديدة الاستصلاح (طميية رملية). تم تقييم الدورة الثالثة في الأرض المستصلحة والأرض الطينية. وكانت الصفات الانتخابية هي طول النبات (سم)، ارتفاع أول كبسولة على النبات (سم)، طول المنطقة الثمرية (سم)، عدد كبسولات النبات، ومحصول البذرة للنبات (جم)، وزن 1000 بذرة (جم)، عدد بذور الكبسولة، النسبة المئوية للزيت في البذور. وكانت مواد البحث الجيل الثاني والثالث والرابع والخامس لعشيرة من السمسم (*Sesamum indicum* L.). حدث نقص في معامل الاختلاف الوراثي بداية من الجيل الثاني حتى الجيل الخامس. ولكن كانت الاختلافات الوراثية في صفات محصول البذرة للنبات، عدد الكبسولات على النبات ووزن الألف بذرة كافية لإجراء دورات انتخابية أخري. زاد معامل التوريث بالمعني العام والخاص في اتجاه الأصالة الوراثية. وتشير النتائج الى أن الانتخاب للصفة المفردة له القدرة على تحسين الصفة الانتخابية، ولكن كان لها تأثير سالب على بعض الصفات المرتبطة. وللتغلب على ذلك يمكن التوصية باستخدام أدلة الانتخاب التي تشمل الصفات المرغوبة. وكان التقدم الوراثي الملاحظ في محصول البذرة كنسبة من متوسط الابين وصل الى 27.12% عند الانتخاب لصفة وزن البذرة للنبات، يليها الانتخاب لعدد الكبسولات للنبات (19.65%)، ثم الانتخاب لطول النبات (17.31%) ثم الانتخاب لوزن الألف بذرة (10.14%) وذلك في الأرض المستصلحة. أختلف ترتيب التقدم الوراثي الملاحظ عن ذلك في الأرض الطينية، حيث كان أفضل تحسين عند الانتخاب لعدد الكبسولات للنبات (20.98%) تبعه الانتخاب لطول المنطقة الثمرية (20.23%) ثم طول النبات (18.59%) ثم الانتخاب لمحصول البذرة (17.38%) تم الانتخاب لوزن الالف بذرة (12.04%). ويرجع اختلاف أهمية الصفات الانتخابية في التحسين الوراثي الملاحظ لمحصول البذرة لتفاعل العائلات المنتخبة مع البيئة.

الكلمات المفتاحية: *الانتخاب الفردي، التحسين الوراثي الملاحظ، معامل التوريث، معامل الاختلاف الوراثي.*