Estimation of some genetic parameters under plant density in sunflower

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Abstract:

The objectives of this experiment were to evaluate the performance of two varieties of sunflower (*Helianthus annuus* L.) with three plant densities (40, 50 and 60 thousands of plants.ha^{-1}.) and estimate the phenotypic, genotypic and environment variation, phenotypic and genotypic coefficient of variation, heritability, stability and genetic resultant, for two seasons. The experiments were conducted during spring and fall seasons of 2013, using factorial experiment within RCBD with four replicates. The results showed the superiority of Shimoos variety, it gives seed yield 3.345 t.ha^{-1} compared with Aqmar variety which gave 2.375 t.ha^{-1} in spring season, at fall season Shimoos variety gave 6.265 t.ha^{-1}, while Aqmar variety gave 5.379 t.ha^{-1}. The yield increased with plant density increasing, it ranged from 2.425 to 3.222t.ha^{-1} in spring season and from 4.396 to 5.822t.ha^{-1} in fall season. The values of phenotypic stability were different according to differences between varieties and seasons. The high value was 93.75% for disc area followed by 90.13% for seed yield t.ha^{-1} for Aqmar in spring season and the higher value for Shimoos variety was 94.15 for disc area followed by 90.66% and 90.55% for 100 seed weight and number of seeds in disc respectively. . All values of genetic variation are higher than environment variation, and were closed to phenotypic variations for spring and fall seasons, except for seed number in disc in fall season which was less than environment variation. Hence the heritability for these traits were high and ranges from 63% for seed number in disc to 95% for shoot dry weight in spring season and from 33% for seed number in disc to 99.6% for disc area in fall season. So the genetic coefficient of variation for all traits is closed to phenotypic coefficient variation. The traits: plant growth rate and shoot dry weight for Aqmar, and leaf area index, plant growth rate and seeds yield for Shimoos showed non phenotypic stability in spring season. In fall season, seed yield t.ha^{-1} for Aqmar was the only trait non-phenotypic stable. The genetic results are ranged from 65.32% for shoot dry weight to 98.86% for seed number in disc for Aqmar and from 81.34% for seed number in disc to 114.79% for 100 seed weight for Shimoos in spring. In fall season, it ranges from 69.18 for leaf area index to 96.02% for seed number in disc for Aqmar and from 89.25% for seed number in disc to 107.32% for disc area for ShimoosIt is possible to conclude that Shimoos variety was superior in most of the traits. So we recommend planting Shimoos variety in the fall season, because it is more stable than Aqmar variety, while Aqmar variety can be cultivated in the spring season.

Key words: PCV, GCV, heritability, stability, plant densities, sunflower.

تقدير بعض المعالم الوراثية بتأثير الكثافة النباتية في زهرة الشمس

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المستخلص:

تتضمن اهداف التجربة تقويم اداء صنفين من زهرة الشمس(شموس واقمار) بثلاث كثافات نباتية (40000 و50000 و60000 نبات.هـ$^{-1}$)، وتقدير التغاير المظهري والوراثي والبيئي، ومعامل التغاير المظهري والوراثي ونسبة التوريث ودرجة الثبات والمحصلة الوراثية. لتحقيق هذه الاهداف طبقت تجربة خلال موسمين الربيعي والخريفي من عام 2013، باستخدام تجربة عاملية بتصميم القطاعات الكاملة المعشاة باربعة مكررات. اظهرت النتائج تفوق صنف شموس باعطائه حاصل بذور 3.345 طن.هـ$^{-1}$ مقارنة بصنف اقمار الذي اعطى 2.375 طن.هـ$^{-1}$ في الربيع، وفي الخريف اعطى شموس 6.265 طن هـ$^{-1}$ بينما اعطى اقمار 5.379 طن.هـ$^{-1}$. زاد الحاصل بزيادة الكثافة النباتية من 2.425 طن هـ$^{-1}$ الى 3.222 طن.هـ$^{-1}$ في الموسم الربيعي ومن 4.396 طن.هـ$^{-1}$ الى 5.822 طن.هـ$^{-1}$ في الموسم الخريفي بزيادة الكثافة من القليلة الى العالية. كانت كل قيم التباين الوراثي اعلى من التباين البيئي وقريبة من التباين المظهري للموسمين الربيعي والخريفي، باستثناء عدد البذور للموسم الخريفي اذ كانت اقل من التباين البيئي. لذا كانت نسبة التوريث لهذه الصفات عالية وتراوحت من 63% لعدد بذور القرص الى 95% لوزن النبات الجاف في الربيع ومن 33% لعدد بذور القرص الى 99.6% لمساحة القرص في الخريف. كذلك كانت قيم معامل التغاير الوراثي لكل الصفات قريبة من معامل التباين المظهري. اختلفت قيم الثبات المظهري وفقاً للاختلاف بين الاصناف وبين المواسم. كانت اعلى قيمة 93.75% لمساحة القرص تليها 90.13% لحاصل البذور طن هـ$^{-1}$ لصنف اقمار في الموسم الربيعي، وكانت اعلى قيمة لصنف شموس 94.15% لمساحة القرص تليها 90.66% و 90.55% لوزن البذرة وعدد بذور القرص على الترتيب. لم تكن صفات معدل نمو البذرة والوزن الجاف للنبات لصنف اقمار، ودليل مساحة الاوراق ومعدل نمو النبات وحاصل البذور لصنف شموس ثابتة مظهرياً في الربيع، وفي الخريف لم يظهر حاصل البذور لصنف اقمار ثباتا مظهريا. تراوحت المحصلة الوراثية من 65.32% للمادة الجافة الى 98.86% لصفة عدد البذور لصنف اقمار ومن 81.34% لعدد البذور الى 114.79% لوزن البذور لصنف شموس (في الموسم الربيعي) في الموسم الخريفي تراوحت المحصلة الوراثية من 69.18% لدليل مساحة الاوراق الى 96.02% لعدد البذور لصنف اقمار ومن 89.25% لعدد البذور الى 107.32% لمساحة القرص لصنف شموس يمكن الاستنتاج ان صنف شموس قد تفوق على صنف اقمار بمعظم الصفات ونوصي بزراعة صنف شموس في الخريف لانه اكثر ثباتا مظهريا من صنف اقمار بينما يمكن زراعة صنف اقمار في الربيع.

كلمات مفتاحية: معامل الاختلاف الوراثي والمظهري ، درجة التوريث، الثباتية، كثافات نباتية الشمس

Introduction :

Sun flower crop is one of the most important oil crops in the world and ranked fifth among oil crops worldwide. It is a drought tolerant crop adapted to a wide range of environmental conditions (4) Its oil content ranges from 40% to 50% and is an important source of unsaturated fatty acids such as Linoleic acid that of hygienic importance (14) Differences in phenotypes arise from genetic effects and the influences of environment, as well as the interactions between them. The amount of each effect depends on the number of genes governing a given trait and how the expression of these genes is affected by environmental conditions. For the difficulty of judgment on heterogeneity, whether inherited (genetic) or not (environmental), it is important to divide heterogeneity into its environmental and genetic components (13) and estimation of variability that contributes to crop improvement (1) and understanding some genetic parameters, such as phenotypic and genotypic coefficient of variance, heritability and genetic resultant. Hassan (8) found that the genotypic coefficient of variation (GCV) values are close to the phenotypic coefficient of variation (PCV) values for most of the studied traits and that these traits are genetically controlled because genetic variance constitutes the majority of phenotypic variation. And the ratio of genetic variation to environmental variation was high. The percentage of the broad sense heritability was high ranged between 83% and 98%, especially in the plant density of 60 thousand plants per hectare in the fall season led to an increase in genetic resultant, which ranged from 16% to 42%, and the number of seed in disc and 100-seed weight was considered as an index for the seed yield. Hassan, et al (9) mentioned a high heritability with an average genetic resultant. Khan, et al (12) found that the PCV value was higher than GCV for all studied traits, and the heritability ratio was high for 100-seed weight, but was low for the number of seed in disc. Elsahookie and Taweel (5) found that the lowest heritability ratio was 5% and that the highest ratio was for seed weight 24%. Janno and Elsahookie (10) found that the heritability of disc area after two rounds of election was 45.3%. High genetic resultant was associated with high heritability for the traits of 1000-seed weight and disc diameter (15). Hassan, at el (9) found significant differences for all studied traits in all genotypes. The heritability ratio was high and the genetic resultant was average. Elsahookie, at el (7) reported that the number of seeds in disc decreased by increasing of plant density. Results of Kareem (12) showed a high correlation between the increase of plant density and seed yield. The plant density of 88888 plants per hectare gave the highest yield of 4,962 and 4.739 tons per hectare. Janno and Elsahookie (10) found an increase in disk area by increasing the plant density to 60,000 plants per hectare, plant growth rate, shoot dry weight and seed number in disk. The increase in plant density reduced the 1000-seeds weight and disc diameter under normal irrigation conditions. The short hybrids gave the highest seed yield at 95230 plants per hectare (3). Safavi, at el (15) referred to genetic variation among genotypes for the studied traits. AL-Joburi, and AL- Rawi (2); Chikkadevaiah and Chikkadevaiah (3) showed that there are significant differences between genotypes. It was found that the degree of heritability of 100-seed weight, seed yield and seed number in disc was low (12). This study aimed to evaluate the performance of two varieties of sun flower under three plant densities and to estimate the genotypic, environmental and phenotypic variation and broad sense heritability as well as the estimation of phenotypic stability and genetic resultant.

Materials and methods

To evaluate the performance of two varieties of sun flower (Shimoos and Aqmar) with three plant densities (40, 50and 60 thousand of plants per hectare), and the estimation of phenotypic, genotypic and environmental variance, phenotypic and genotypic coefficient of variance, heritability, phenotypic stability and genetic resultant, a field experiment was conducted in Field Crops Department - College of Agriculture - University of Baghdad for spring and fall seasons 2013. A randomized complete block design with four replicates as factorial experiment was used. Seeding was carried out with 90 cm distance between rows, but the distances between plants were 27.8, 22.2 and 18.5 cm for the three plant densities (40, 50and 60 thousand of plants per hectare, respectively). At soil preparation, 350 $kg.ha^{-1}$ of compound fertilizer (18% N, 18% P_2O_5) was supplied. 350 $kg.ha^{-1}$ of urea fertilizer (46% N) was applied in two times. The first was after two weeks of germination and the second at the beginning of the flowering stage. A random sample of five plants was taken to study the following traits:

1 - Leaf area index
2 - Disc area (cm^2)
3 - Seed number in disc
4 – 100-seed weight (g)
5 - Plant growth rate (g/m^2/day): that obtained by dividing the shoot dry weight on the number of days to physiological maturation.
6 - Shoot dry weight (g)
7 - **Seed yield** per **unit area**.

The statistical analysis of each trait was analysed by using F test to investigate the significant effect of each factor. The mean was measured and compared using the Least Significant Difference (L.S.D) at a significant level of 0.05 for all the traits using Excel program 2014 and Gestate 2014.

Statistical standards and genetic parameters:

The coefficient of variance (CV%) was calculated to estimate the homogeneity of the samples, as well as the calculation of the standard error (SE) to estimate the homogeneity between the data for each trait and for each plant density and for each of the investigated trait. The differences in phenotypic, genetic, environmental variations and broad sense heritability were estimated as mentioned by Singh and Chuadhary (16) using SPAR2.0 software according to the following equations:

$$\sigma^2 g = \frac{MSg - MSE}{r}$$

$$\sigma^2 E = \text{MSE}$$

$$\sigma^2 P = \sigma^2 g + \sigma^2 e$$

$$.h^2_{b.s} = (\delta^2 g / \delta^2 p) \times 100$$

PCV= ($\sqrt{\sigma^2 p}$ $/\bar{x}$) ×100
GCV =($\sqrt{\sigma^2 g}$ $/\bar{x}$)*100
$\sigma^2 P, \sigma^2 g, \sigma^2 E$: Phenotypic, Genetic, and Environmental Variance.
MSg : Mean squares of genotypes
MSE : Mean squares for experimental error
R : Number of replicates
h^2b.s : broad sense heritability
The genetic coefficient of variation (GCV) and Phenotypic Coefficient of Variation (PCV) were estimated as in the following equations:
PCV= ($\sqrt{\sigma^2 p}$ $/\bar{x}$) ×100
GCV =($\sqrt{\sigma^2 g}$ $/\bar{x}$) ×100
Homeostasis% and Genetic Resultant were calculated following EL-Sahookie and AL-Rawi (6) and according to the following equations:
Homeostasis% = $(1-\frac{\sigma}{\bar{x}}) \times 100$
GR= Homeostasis% × $\frac{\overline{XI}}{\overline{XCI}}$
GR: genetic resultant
$\overline{XI}$: Average of the trait for the variety.
$\overline{XCI}$: Average of the trait for studied varieties.

Results and Dissectio

Coefficient of variation and standard error

Tables of studied traits (disk area, 100 seeds weight, plant growth rate, the weight of the dry plant and the seed yield) demonstrated that the values of the coefficient of variation and standard error of the varieties were low and within the acceptable limits for the two seasons, indicating the Homogeneity and similarity in sample data, except for standard error of seed number in disc was high, while the values of the coefficient of variation and the standard error of the traits (the leaf area index, disk area, number of disc seeds, 100 seed weight plant growth rate, dry plant weight and the seed yield) at the different densities were low values and within the acceptable limits for the two seasons.

Effect of plant density and genotypes in studied traits

Plant leaf area index

Table 1 shows the difference in the area of plant leaves between the two varieties used in the experiment. Shimoos variety surpassed Aqmar variety by 2.66 in plant leaf area index, with an increase of 46.3% for the spring season and 58% for the fall season compared with Aqmar variety. Leaf area index increased with the increase of plant density, it increased 26.3% with the increase of plant density from low to recommended density, and the increase was 26.3% with the increase of plant density from low to high density in spring season. As for fall season, when plant density increased from low to recommended, leaf area index increased 22.6%, while the increase rate of leaf area index was 24.5% as plant density increased from low to high density. There was significant interaction between two factors (plant density and varieties) on plant leaf area index for both seasons.

Table 1: Plant leaf area index for two varieties of sun flower, influenced by plant densities in spring and fall seasons

cultivar	Spring season						fall season					
	40000 p/h	50000 p/h	60000 p/h	mean	C.V%	S.E	40000 p/h	50000 p/h	60000 p/h	mean	C.V%	S.E
Aqmar	1.692	1.705	2.052	1.817	11.96	0.063	2.463	2.960	2.603	2.674	10.44	0.081
Shimoos	2.140	3.052	2.785	2.659	15.73	0.12	3.525	4.378	4.845	4.249	13.89	0.17
L.S.D.	0.217			0.161			0.298			0.085		
Average	1.916	2.379	2.419				2.994	3.668	3.724			
L.S.D.	0.124						0.293					
C.V.%	14.72	2.52	3.84				2.12	2.90	2.95			
S.E	0.14	0.03	0.05				0.04	0.05	0.04			

Disc area (cm^2)

Table 2 demonstrates the difference between varieties (Aqmar and Shimoos) on disk area. Shimoos variety surpassed Aqmar variety and gave the highest area of the disk with an increase of 42.2 cm^2 compared with Aqmar variety for spring season and 147.5 cm^2 for fall season. Disc area decreased with the increase of plant density for both season, but the decrease in fall season (62.2 cm^2) was more than that of the spring season (20.2 cm^2) due to the increase of leaf area index for the fall season that may lead to increase shading and reduce penetration of light into the plants and ultimately decreasing photosynthesis that affected disc area by reducing disk size at high density. The response of the variety was significantly different due to variety effect in deferent plant densities. The disk area trait of Aqmar variety was not affected by increasing the plant density from 40 to 50 thousand plants per hectare and for the two seasons, but the disk area decreased at a high density of 60 thousand plants per hectare. As for the area of the disk for Shimoos variety was less tolerant to increase the density from 40 to 50 thousand plants per hectare for the spring season, As for fall season, the highest disc area for Shimoos variety was in low plant density and then decreased with the plant density increase to 50 thousand plants per hectare and then increased in plant density of 60 thousand plants per hectare. This may be due to the increase in leaf area in this plant density.

Table 2: Disc area (cm^2) for two varieties of sun flower, influenced by plant densities for spring and fall seasons.

cultivar	Spring season						fall season					
	40000 p/h	50000 p/h	60000 p/h	mean	C.V%	S.E	40000 p/h	50000 p/h	60000 p/h	mean	C.V%	S.E
Aqmar	179.7	180.7	162.9	174.4	6.25	3.14	327.3	320.7	286.8	311.2	6.17	5.55
Shimoos	232.5	208.5	208.9	216.6	5.85	3.66	519.6	421.1	435.5	458.7	9.94	13.16
L.S.D.	9.22			5.89			8.66			3.72		
Average	206.1	194.6	185.9				423.5	370.9	361.2			
L.S.D.	7.12						8.17					
C.V%	3.91	3.79	0.88				1.32	1.04	0.70			
S.E	4.03	3.69	0.81				2.80	1.87	0.92			

Number of seeds in disc

Aqmar variety exceeded shimoos variety in the number of seeds in disc for two seasons (table 3). The number of seeds in disc of Aqmar increased by 22.6% compared with that of Shimoos variety for the spring season and 10.2% for the fall season. The increase in the number of seeds in disc of Aqmar variety was due to increased seed fertility of Aqmar variety. The number of seeds in disc decreased by the increasing of plant density. This decrease was 12 seed when plant density increased from low to recommended density, 40 seeds when plant density increased from recommended to high density and 52 seeds when plant density increased from low to high density for spring season. The decrease in the number of seeds in disc for the fall season, when plant density increased from low to recommended density was 31 seeds and 52 seeds when plant density increased from recommended to high density, thus the number of seeds in disc decrease 83 seeds when plant density increased from low to high density.

Table 3: Seed number in disc for two varieties of sun flower, influenced by plant density for spring and fall seasons.

cultivar	Spring season						fall season					
	40000 p/h	50000 p/h	60000 p/h	mean	C.V%	S.E	40000 p/h	50000 p/h	60000 p/h	Mean	C.V%	S.E
Aqmar	1116	995	963	1024	10.26	30.32	964	958	933	952	5.69	15.62
Shimoos	786	884	835	835	9.45	22.8	982	926	847	918	9.10	24.11
L.S.D.	Ns			99.7			34.13			21.52		
Average	951	939	899				973	942	890			
L.S.D.	29.9						26.78					
C.V%	10.02	9.33	9.20				6.18	1.48	1.34			
S.E	51.44	43.84	41.35				28.87	7.18	5.95			

The decrease in the number of seeds in disc in the fall season was more than that in the spring season due to the high decrease in the disk area for the fall season that account for 62.3 cm^2 compared with that for the spring season which reached 20.2 cm^2, these results agree with that of Suzer (17). Number of seeds in disc did not have any response to the two factors (variety and plant density) for the spring season, but both of these two factors affected the number of seeds in disc in the fall season. The difference in number of seeds was 83 seeds from low to high density.100-seed weight

Shimoos variety surpassed Aqmar variety in 100-seed weight trait by 70% for the spring season (table 4) because of the low number of seeds in disc, which reduced the competition between the seeds and increased their weight. For the same reason, Shimoos variety also outweighed Aqmar variety in seed weight for fall season with an increase of 25% and for the same reason, the weight of seeds decreased significantly by increasing the plant density. It decreased by 0.37 g and 0.28 g for the spring season, and 0.34 g and 1.04 g for the fall season when plant density increased from low to recommended density and from average to high density.

Table 4: Weight of 100-seed (g) for two varieties of sun flower, influenced by plant density for spring and fall seasons.

cultivar	Spring season						fall season					
	40000 p/h	50000 p/h	60000 p/h	Mean	C.V%	S.E	40000 p/h	50000 p/h	60000 p/h	mean	C.V%	S.E
Aqmar	4.94	4.66	4.57	4.72	8.49	0.12	9.94	9.62	9.11	9.56	6.88	0.19
Shimoos	8.54	8.09	7.61	8.04	9.35	0.22	12.72	12.36	10.80	11.96	9.47	0.33
L.S.D.	Ns			0.65			Ns			0.554		
Average	6.74	6.37	6.09				11.33	10.99	9.95			
L.S.D.	0.47						0.899					
C.V%	13.21	9.80	9.34				7.88	4.84	3.69			
S.E	0.45	0.31	0.28				0.39	0.27	0.20			

Plant growth rate (g/m^2/day)

As shown in Table 5, Shimoos variety surpassed Aqmar variety in plant growth rate by 41.7% and 25% for both spring and fall seasons respectively. The superiority of Shimoos variety in plant growth rate led to its superiority in leaf area index (Table 1), which resulted in its superiority in disk area and 100-seed weight (Table 2 and 4). Plant growth rate decreased significantly by increasing the plant density due to low shoot dry weight (Table 6).

Table 5: Plant Growth Rate (g/m^2/day) for two varieties of sun flower, influenced by plant density for spring and fall seasons.

cultivar	Spring season						fall season					
	40000 p/h	50000 p/h	60000 p/h	mean	C.V%	S.E	40000 p/h	50000 p/h	60000 p/h	mean	C.V%	S.E
Aqmar	1.932	1.547	1.354	1.611	17.84	0.083	2.677	2.427	2.235	2.447	7.85	0.055
Shimoos	2.353	2.592	1.904	2.283	16.82	0.111	3.670	2.765	2.747	3.061	14.78	0.131
L.S.D.	Ns			0.235			0.061			0.048		
Average	2.142	2.070	1.629				3.174	2.596	2.491			
L.S.D.	0.242						0.021					
C.V%	18.66	9.84	3.62				2.46	1.70	1.55			
S.E	0.19	0.10	0.03				0.03	0.03	0.02			

The plant growth rate decreased with the increase of plant density from low to high density by 31.5% and 27% for both fall and spring seasons respectively. There was no significant interaction between two factors (the variety and the plant density) for the spring season, while there was significant interaction on plant growth rate for the fall season, and the highest plant growth rate was in the lowest plant density for Shimoos variety (table 5).

Shoot dry weight (g)

Table 6 demonstrations the superiority of the Shimoos variety in shoot dry weight in a significant manner on Aqmar variety with an increase of 53% and 23% for spring and fall seasons respectively. The superiority of Shimoos variety is due to its superiority in leaf area index, disk area, seed weight, and plant growth rate (tables 1, 2, 4 and 5) and its superiority in plant height and leaf area (data presented for publication in another paper). The shoot dry weight was reduced by increasing the plant density due to an increase in the competition between plants on metabolites produced from photosynthesis. These metabolites in turn decreased by increasing plant density, which increase shading by increasing leaf area, that leads to reduction in photosynthesis (data presented for publication in another research). Shoot dry weight was reduced by increasing of plant density from low to recommended density and from low to high density by 16.5%, and 36% for the spring season, and 21.3% and 24.6% for the fall season, respectively. It can be noted from table 6 that the decrease ratio in dry weight of shoot from low to average density is greater than from average to high density. There was no significant interaction between the variety and the plant density for the spring season, while there was a significant response on the dry weight of shoot due to plant density. The highest dry weight of the shoot for Shimoos variety was at the plant density of 40 thousand plants per hectare, while Aqmar variety gave the lowest dry weight of shoot when grown in the high plant density.

Table 6. Dry weight of shoot (g) for two varieties of sun flower, influenced by plant density for spring and fall seasons.

cultivar	Spring season						fall season					
	40000 p/h	50000 p/h	60000 p/h	mean	C.V%	S.E	40000 p/h	50000 p/h	60000 p/h	Mean	C.V%	S.E
Aqmar	181.5	148.2	127.5	152.4	17.51	7.70	268.3	230.5	221.8	240.2	8.86	6.15
Shimoos	203.6	234.0	199.8	232.5	12.18	8.16	348.8	278.1	273.4	300.1	12.07	10.46
L.S.D.	ns			12.03			5.27			4.14		
Average	222.6	191.1	163.7				308.5	254.3	247.6			
L.S.D.	10.93						2.16					
C.V%	8.92	5.13	2.63				1.99	1.49	1.47			
S.E	9.93	4.90	2.15				2.53	2.30	1.84			

Seed yield ($ton.ha^{-1}$)

The superiority of Shimoos variety in all studied traits had an effect on its superiority in the seed yield per unit area (table 7). Seed yield of Shimoos variety surpassed that of Aqmar variety by 970 kg for the spring season and 886 kg for the fall season. Seed yield in plants grown in plant density of 50 thousand plants per hectare and 60 thousand plants per hectare was increased by 21% and 39% for the spring season and 6% and 32% for the fall season compared with plant density of 40 thousand plants per hectare, respectively Despite the decline in other studied traits with an increase in plant density but the increase in seed yield per unit area resulted from an increase in the number of plants that compensated for the decline of the rest of the traits. The increase for the fall season was more than for the spring season, whether for varieties or plant densities, but the increase through the plant density of the spring season was more than that of the fall season. There was a significant interaction between the two factors (variety and plant density) in the spring season and the highest seed yield per unit area of Aqmar variety was at the high density compared to the lowest seed yield per unit area of Aqmar variety at the low plant density. In the fall season there was no response in plant density due to varieties, but in general, Shimoos variety had a higher seed yield per unit area compared to that of Aqmar variety under all plant densities. From this, we conclude that the superiority of Shimoos variety in all studied traits led to its superiority in seed yield per unit area.

Table 7. Seed yield (ton.ha^{-1}) for two varieties of sun flower, influenced by plant density for spring and fall seasons.

cultivars	Spring season						fall season					
	40000 p/h	50000 p/h	60000 p/h	mean	C.V%	S.E	40000 p/h	50000 p/h	60000 p/h	Mean	C.V%	S.E
Aqmar	2.192	2.302	2.632	2.375	9.87	0.07	3.821	4.351	5.379	4.517	15.33	0.20
Shimoos	2.657	3.566	3.812	3.345	16.48	0.16	4.970	5.007	6.265	5.414	11.94	0.19
L.S.D.	0.271			0.204			Ns			0.157		
Average	2.425	2.934	3.222				4.396	4.679	5.822			
L.S.D.	0.145						0.215					
C.V%	6.88	3.97	10.08				2.87	2.73	4.02			
S.E	0.08	0.06	0.16				0.06	0.06	0.12			

Genetic variation and heritability

Coefficient of variation and standard error

Tables 8 and 9 demonstrate the low coefficient of variation for all studied traits of spring and fall seasons. The standard error was also low for both seasons. Only the number of seeds in disc and yield **the** seed per **unit area** as the standard error for them and for both seasons is high and higher than acceptable limits. The low values of the Coefficient of variation and standard error indicate the homogeneity and consistency of the recorded data of these traits. The genetic variance exceeded the environmental variance and consisted high proportion of the phenotypic variations for most traits. Only the number of seeds in the disk for the fall season underwent the opposite and the effects of environmental conditions were higher, thus its environmental variation was higher than genetic variation. The percentage of genetic variance to phenotypic variance was 94%, 63%, 90.4%, 95% and 79% for the spring season and 99.69%, 32.8%, 83%, 99% and 99% for the fall season for the traits : disk area, number seeds in disc, 100-seeds weight, biological yield respectively. It can be observed from these data that the lowest percentage of genetic variation to phenotypic variation was for the trait seed number in disk, while the rest of the traits seem to have the effect of the genetic action is greater, that is, it is controlled genetically and thus the improvement in breeding programs is faster and easier for it is less affected by environmental conditions. This result also confirms what we note on the percentage of the genetic coefficient of variance to the phenotypic coefficient of variance, as it makes up a large percentage, around 97%, 80%, 95%, 98%and 89% for the spring season, and 99.8%, 57%, 91%, 99.6% and 99.6% for the fall season, respectively. As it is obvious from the data in table 8, the genetic variations for all studied traits were high and consist high proportion of phenotype variance, the same for genetic coefficient of variance that reflected on the heritability of all traits which were high for all traits except for number of seeds in disc in fall season that accounts for 33% for the low genetic variation and it is effected by environmental conditions due to the high environmental variation. The percentage of heritability was high that accounts for 94%, 90% and 95% for the traits: disk area, 100-seeds weight and biological yield for the spring season, and 99.6%, 99% and 99% for the traits: disk area, the biological yield and plant growth rate for fall season. While percentage of heritability for number of seeds in disc and plant growth rate in spring season were 63% and 79% respectively, and 83% for the 100-seeds weight for the fall season.

Table 8: Genetic, phenotypic and environmental variations and their standard error with phenotypic and genetic coefficient of variations and heritability for the 2013 spring season.

Traits	SE	C.V	$\sigma^2 g$	$\sigma^2 e$	$\sigma^2 p$	P.C.V	G.C.V	$h^2_{.b.s\%}$
leaf area index	0.0749	6.6955	0.3120	0.0225	0.3345	25.843	24.691	0.932
disc area (cm^2)	3.0818	3.1524	639.754	37.989	677.56	13.3132	12.93458	0.944
Seeds number of disc	42.507	9.1440	12480.8	7227.6	19708.3	15.09959	12.01603	0.633
100 seed weight(g)	0.3001	9.3823	3.3938	0.3604	3.7541	30.2822	28.79213	0.904
Biological yield	5.7813	6.0081	2592.98	133.69	2726.68	27.1329	26.45936	0.951
plant growth rate($g/m^2/day$)	0.1166	11.979	0.2053	0.0544	0.2597	26.17339	23.27100	0.791
seed yield ($t.ha^{-1}$)	93.500	6.538	441885.7	34969	476854.7	24.145	23.243	0.926

Table 9: **Genetic, phenotypic and environmental variations and their standard error with phenotypic and genetic coefficient of variations and heritability for the 2013 fall** season.

Traits	SE	C.V	$\sigma^2 g$	$\sigma^2 e$	$\sigma^2 p$	P.C.V	G.C.V	$h^2_{.b.s\%}$
leaf area index	0.0838	4.842	0.942	0.0281	0.971	28.458	28.043	0.971
disc area (cm^2)	2.6266	1.3639	7809.75	27.597	7837.35	22.9845	22.9440	0.996
Seed number per disc	27.814	5.9499	1512.17	3094.5	4606.67	7.2595	4.1592	0.328
100 seed weight	0.3285	6.11	2.1069	0.4319	2.5388	14.8139	13.4952	0.8299
Biological yield	1.8246	1.3509	2032.00	13.317	2045.32	16.7415	16.6869	0.993
plant growth rate($g/m^2/day$)	0.0211	1.5305	0.2438	0.0018	0.2455	17.9943	17.9291	0.993
seed yield($t.ha^{-1}$)	86.18	3.471	702519.5	29712	732231.6	17.233	16.879	0.959

Phenotypic stability and genetic resultant:

Due to the low environmental effect on the studied traits and the increase in genetic variation, the values of phenotypic stability for these traits were high. The highest phenotypic stability was in spring season for Aqmar variety on disc area that account for 93.75% followed by 100-seed weight 91.51%, seed yield 90.13%, Seeds number per disc 89.74% and then leaf area index 88.04%, Whereas plant growth rate and shoot dry weight were below the acceptable limit that account for 82.16% and 82.49%, respectively. The values of phenotypic stability for Shimoos variety on the traits: disk area, number of seeds in disc and 100-seeds weight were high and more than that of shoot dry weight, while the values of phenotypic stability on the traits: leaf area index, plant growth rate and seed yield per unit area ($t.ha^{-1}$) were not acceptable for these traits. The highest value of genetic resultant for Shimoos variety in spring season was for the trait 100-seeds weight and then dry weight of shoot followed by disk area, leaf area index, seed yield per unit area and finally plant growth rate, where the values ranged from 97.53% for plant growth rate to 114.79% for 100-seeds weight. The values of phenotypic stability for traits of Aqmar variety in fall season were higher than that of spring season, except for seed yield per unit area, which decreased to 84.67% while in the spring season it was 90.13%. The highest values were for Seed number in disc 94.31%, followed by disk area 93.83% then 100-seed weight 93.13%, plant growth rate 92.15%, shoot dry weight 91.13%, and finally leaf area index 89.56%, Whereas the highest values of phenotypic stability of these traits for Shimoos variety for this season were of Seed number in disc, 100-seed weight and disc area, while the values of phenotypic stability of the traits: leaf area index and Shoot dry weight were more stable during the two seasons and did not change from spring season to fall season, although the values of phenotypic stability for these traits were less than those of the above-mentioned traits, as for seed yield per unit area trait wasn't the highest in this season, but it was higher than that in the previous season. As for the genetic resultant, disc area trait was the highest for Shimoos variety in fall season followed by leaf area index, 100-seed weight, shoot dry weight, seed yield per unit area and plant growth rate, and the lowest value was for Seed number in disc trait. We conclude from these data that the phenotypic stability and genetic resultant of these two varieties (Aqmar and Shimoos) have varied from one season to another for some traits, where some traits increased while others decreased and some others have maintained their phenotypic stability and genetic resultant during the two seasons, as well as the stability of some traits has not been proven, such as plant growth rate and shoot dry weight of Aqmar variety, and leaf area index, plant growth rate and seed yield per unit area of Shimoos variety for the spring season. As well as the seed yield per unit area of Aqmar variety for the fall season.

Table 10. The phenotypic stability (H %) and the genetic resultant (GR %) in different plant densities for the spring and fall seasons 2013.

	Spring season				fall season			
	Aqmar		Shimoos		Aqmar		Shimoos	
Traits	H%	GR%	H%	GR%	H%	GR%	H%	GR%
leaf area index	88.04	71.48	84.27	100.12	89.56	69.18	86.11	105.70
disc area (cm^2)	93.75	83.63	94.15	104.31	93.83	75.85	90.06	107.32
Seed number per disc	89.74	98.86	90.55	81.34	94.31	96.02	90.90	89.25
100 seed weight (g)	91.51	67.72	90.66	114.79	93.12	82.69	90.53	100.63
plant growth rate ($g/m^2/day$)	82.16	67.98	83.18	97.53	92.15	81.88	85.22	94.72
Shoot dry weight (g)	82.49	65.32	87.82	106.09	91.13	81.03	87.93	97.68
seed yield ($t.ha^{-1}$)	90.13	74.85	83.53	97.69	84.67	77.02	88.06	96.01

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