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GENETIC VARIABILITY, HERITABILITY AND EXPECTED GENETIC ADVANCE FOR EARLINESS AND SEED YIELD FROM SELECTION IN LENTIL

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Abstract

Development of early maturing lentil varieties is an important aim in lentil breeding program at ARC, Egypt. The present study aimed to estimate variability, heritability, and genetic advance from selection for earliness and seed yield characters for 24 lentil genotypes to provide information that could be useful in lentil breeding programs. The experiments were carried out at Sids research station in 1997/98 and 1998/99, and at Giza research station in 1998/99 season. The environments (season and location) showed major effects on the performance of genotypes. High phenotypic variation was observed for number of pods and seeds/plant. Considering wide variability, heritability and genetic advance, progress could be expected from selection for number of seeds/ plant and seed yield/plant. The early maturing genotypes Sina 1, FLIP 87-21L and FLIP 92-54L could be recommended for planting in case the earliness in maturity is more important than seed yield. On the other hand, the high yielding genotypes FLIP 89-71L, FLIP 95-68L, 89503, FLIP 92-48L and FLIP 95-50L could be recommended for planting in case the high yield potential is more important than earliness in maturity.

INTRODUCTION

Lentil (*Lens culinaris* Medikus) is the second important food legume crop after faba bean in Egypt. Its cultivated area has declined sharply during last three years to 5000 feddan only (Anonymous, 2001). The main reason behind this is the competition from other winter crops as wheat, berseem (clover) and vegetables that are more profitable to the farmers, and which now occupy much of the area previously used for lentil (Hamdi, 1998). To achieve self-sufficiency in lentil, the Egyptian government is planning to increase its cultivated areas to 50,000 feddan. The way to increase lentil area in Egypt is expanding lentil planting in the new reclaimed lands and in rainfed areas out side the Nile Valley and insert lentil planting before cotton in cotton rotation in the old lands (Hamdi, 1998). Although lentil has recently spread to outside the Nile valley, its area in these new regions is still limited reaching about 705 feddan in the reclaimed desert lands and 902 feddan in rainfed areas (Average of 1993-99).

To grow lentil successfully in new reclaimed lands, rainfed areas and before cotton in cotton rotation in old lands, early maturing short duration lentil varieties should be available. Currently available early maturing lentil varieties are mostly adapted to dry environments due to their drought escaping (Hamdi et al. 1992, Silim *et al.* 1993). A few accessions of cultivated lentil (Hamdi *et al.* 1992) and wild lentil (Hamdi and Erskine, 1996) have been identified as being adapted to drought due to their early maturity. Because lentil has low water requirement, it is suitable for planting in reclaimed lands where water may be is insufficient. In addition, growing early maturing lentil varieties before cotton may allow farmers to plant cotton in proper time. Therefore, releasing early maturing lentil varieties is an important aim in lentil breeding program at ARC in Egypt. Hence earliness characters are the main selection criteria used in varietal development.

The importance of genetic variability in lentil breeding is well documented as it provides a basis for effective selection (Hamdi and Rabeia, 1991; Chauhan and Singh, 1998). Heritability serves as a guide to the reliability of phenotypic variability in the selection program, and hence determines its success (Hamdi and Erskine, 1990; Hamdi, 1992). Genetic advance is also of considerable importance because it indicates the magnitude of the expected genetic gain from one cycle of selection.

Consequently, the present study aimed to estimate variability, heritability, and genetic advance of seed yield and earliness characters for 24 lentil genotypes to provide information that could be useful in lentil breeding programs aimed to improve earliness characters.

MATERIALS AND METHODS

Twenty-four lentil genotypes randomly selected from the germplasm collection in Lentil Breeding Program at ARC were used in this study (Table 1). The experiments were carried out at the following three environments: Sids research station at Beni Suef Governorate in the two successive seasons 1997/98 and 1998/99, and at Giza research station in 1998/99 season. In each experiment a randomized complete block design, with 4 replicates and 4.2m^2 plot size (4 rows, 3.5 m long and 0.3 m wide, with 330 plants/m^2) was used. Sowing was done at all experiments between 13 and 16 November. Fertilizer, irrigation and all agronomic practices were applied as recommended. At harvest, lentil plants in the central 3.m^2 in each experimental plot were pulled by hand (the remaining plot area was discarded to avoid border effect), placed in cotton sacks, air dried, weighed, then threshed by hand and clean seeds weighed.

In all experimental plots the following characters were recorded on 10 randomly selected competitive plants,: plant height, total number of branches/ plant, seed yield/plant, number of pods/plant, number of seeds/plant, and 100-seed weight. The following earliness characters: days to 50% flowering, days to 100% flowering, flowering duration, days to 50% poding, days to 100% poding, poding duration, and days to 90% maturity were recorded on the plot basis.

The analysis of variance was made for each environment separately, and then a combined analysis of variance was performed for the three environments (Gomez and Gomez, 1984). The variance components and coefficients of variation were estimated by the formulae suggested by Burton (1952). The broad sense heritability and genetic advance were estimated using the formulae suggested by Allard (1960).

RESULTS AND DISCUSSION

The combined analysis of variance indicated significant differences for all environments, genotypes and genotype x environment interaction for all studied characters, except the environmental effect of days to maturity.

Environmental Effect (seasons and locations):

The average performance of all characters in each environment overall genotypes (Table 2) show that all characters were significantly influenced by seasonal effect, except days to maturity and 100-seed weight. Days to 50% flowering increased from 70.1 days in the first season to 76.1 days in the second season. Similar trend was observed for days to podding. Plant height and number of branches/plant were also largely influenced by seasonal effect. For example, the average plant height in the first season was 28.2 cm, while it recorded 46.7 in the second season. In addition seed yield/plant increased from 0.9 g in the first season to 2.2 g/plant in the second season. Similarly numbers of pods and seeds/ plant were also higher in the second season. These data reveal that the growth conditions at Sids were more favorable in the second season than in the first season. The average maximum and minimum air temperatures in the first season (November-April) were 22.7and 8.5°C, respectively, while the corresponding temperatures in the second season were warmer and recorded 24 and 9.6°C. Moreover, the minimum air temperature during pod development stage (in March) was relatively cool in the first season (7.2°C) comparing with the second season (12°C). Summerfield (1981) stated that the optimum air temperature to grow lentil is around 22°C. Therefore, the warm temperature in the second season prolonged the vegetative growth period (days to flowering and poding) and increased plant height and branches/plant and hence increased seed yield/plant. The importance of seasonal conditions on various lentil characters was reported previously by Hamdi *et al.* (1991).

The locations also have significant effects on the performance of all characters, except days to maturity. For example, days to 50% flowering and 50% poding at Giza were 78.3 and 97.7, respectively, while the corresponding values at Sids (average of two seasons) recorded 73.1 and 89.3 days (Table 2). The average seed yield at Sids was also significantly higher (1.6 g/plant) than those at Giza (0.7g/plant). Similarly, Sids performed higher pods and seeds/plant. The differences between locations reflecting the differences of soil type and fertility and other environmental conditions, and suggesting the possibility to raise yield level by improving management practices as soil fertility, irrigation and other agronomic practices. The importance of location effect on various lentil characters has been reported by several researchers (Hamdi *et al.*, 1991; Hamdi and Rabeia, 1991; Hamdi *et al.*, 1992).

Performance of lentil characters:

Earliness characters:

The average days to 50% flowering for all genotypes were 74.8 days with a range of 65.3-81.4 (Table 3). The earliest genotypes in flowering, podding and maturity were Sinai 1, FLIP 92-54L and FLIP 87-21L. These genotypes could be exploited as a source of earliness in lentil breeding program. Sinai 1 was found to be the earliest in maturity among lentil germplasm in Egypt (Hamdi, 1998). Several late flowering genotypes (as nos. 3 and 11) had short flowering duration and several early flowering genotypes had relatively long duration (as nos. 8 and 9). It seems that there is no relation between time to beginning and termination of flowering, that is confirmed by the insignificant correlation between 50% flowering and flowering duration (r = 0.182).

Morphological characters:

Plant height exhibited a narrow range of 32.5-41.1 cm with an average of 37-cm (Table 4). The tallest genotypes (above 40 cm) were FLIP 95-68L; FLIP 95-67L and FLIP 96-1L, while the local check Giza 9 had 34.7-cm height. If not subjected to lodging, tall plants are preferred, since they have more bud bearing nodes with the potential for higher seed yield and are also suitable for mechanical harvesting. The average plant height obtained in the present study is within the range of those found by Selim (2000) in Egypt. Number of branches/plant ranged from 4.4 for FLIP 95-52L to 8.2 for FLIP 95-67L. Giza 9 showed relatively low branches/plant (5.8). In previous studies, the range of number of branches/plant was 4.1-6.2 (Selim, 2000).

Seed yield and yield component characters:

The overall mean of seed yield/plant was 1.28 g with a range of 0.69-1.89 g/plant. Fourteen genotypes gave significantly higher seed yield than Giza 9 Table 4. Amongst, FLIP 89-71L (no. 3) gave the highest average seed yield, followed by the genotypes nos. 14, 20 and 6 with no significant differences between them. These genotypes can be exploited in lentil breeding program. The genotype no. 3 also showed the highest pods/plant and the genotype no. 14 gave the highest seeds/plant Table 4. In addition 15 genotypes gave significantly greater numbers of pods and seeds/plant than Giza 9. Despite the significant differences among genotypes in 100-seed weight, all of them can be characterized as small seeded type and ranging from 1.9 to 2.98 g/100 seeds. Sinai 1 was the only genotype, with seed weight with medium seed size of 3.13 g/100 seeds. The range of numbers of pods and seeds/plant obtained in this study were similar to those reported by Ezatt and Ashmawy (1999) and Selim (2000).

Genetic parameters of the studied characters:

Estimates of phenotypic and genotypic variances are presented in Table 5. The highest magnitude of phenotypic variance was observed for number of pods and seeds/plant, indicating the possibility for selection for these traits. All earliness characters had high heritability estimates, which ranged from 86.3% for 100% flowering to 67.3% for maturity. Plant height, number of branches/plant, seed yield and yield components showed low heritability estimates, while 100-seed weight had relatively high heritability of 62.5%. High broad sense heritability for 100-seed weight of lentil was also reported by Chauhan and Singh (1998). The expected genetic advance was relatively high for seeds/plant (30.3%) and seed yield/plant (22.2%).

Johanson *et al.* (1955) stated that heritability estimates together with genetic advance are more important than heritability alone to predict the resulting effect of selecting the best individuals. Therefore, pronounced progress should be expected from selection between genotypes for number of seeds/plant and seed yield/plant. Moderate progress would be expected from selection for 100-seed weight, number of branches/plant and number of pods/plant. However, low genetic gain could be expected from selection for earliness characters and plant height. There are some genotypes showing superiority in some characters and should be exploited in breeding program. For example, the early maturing genotypes Sina 1, FLIP 87-21L and FLIP 92-54L could be recommended for planting in case the earliness in maturity is more important than seed yield. On the other hand, the high yielding genotypes FLIP 89-71L, FLIP 95-68L, 89503, FLIP 92-48L and FLIP 95-50L could be recommended for planting in case the high yield potential is more important than earliness in maturity. In addition it could be recommended that the genotypes, Sina 1, FLIP 87-21L and FLIP 92-54L can be used as parents in hybridization program to produce early populations and selection for earliness in maturity in these populations will be useful. The following genotypes: FLIP 89-71L, FLIP 95-68L, 89503, FLIP 92-48L and FLIP 95-50L could be used as parents to produce high yielding populations.

Table 1. Name, pedigree and country of origin of the 24 lentil genotypes.

Genotype	Pedigree	Origin
1- FLIP 87-21L	ILL 4349 X ILL 4605	ICARDA
2- FLIP 89-67L	ILL 4407 X ILL 99	ICARDA
3- FLIP 98-71L	ILL 4407 X ILL 574	ICARDA
4- FLIP 92-28L	ILL 5588 X ILL 5883	ICARDA
5- FLIP 92-47L	ILL 4354 X ILL 6003	ICARDA
6- FLIP 92-48L	ILL 5583 X ILL 5726	ICARDA
7- FLIP 92-54L	ILL 4605 X ILL 2581	ICARDA
8- FLIP 94-1L	ILL 7616	ICARDA
9- FLIP 95-25L	ILL 7681	ICARDA
10-FLIP 95-50L	ILL 7706	ICARDA
11-FLIP 95-52L	ILL 7708	ICARDA
12-FLIP 95-63L	ILL 7719	ICARDA
13-FLIP 95-67L	ILL 7723	ICARDA
14-FLIP 95-68L	ILL 7724	ICARDA
15-FLIP 96-1L	ILL 5486 X ILL 5748	ICARDA
16-FLIP 96-10L	ILL 2126 X ILL 6002	ICARDA
17-FLIP 96-48L	ILL 7980	ICARDA
18-87515	ILL 340X ILL 2501	Pakistan
19-87519	ILL 1 X ILL 2573	Pakistan
20-89503	ILL 7723	Pakistan
21-Sinai 1	Selection from Precoz	Argentina
22-Giza 9	Wide spread cultivar	Egypt
23-Family 29 .	Landrace cu	Egypt
24-Giza 370	Wide spread ltivar	Egypt

ILL: International Legume Lentil.

Table 2. The overall means for studied characters of lentil genotypes evaluated at three environments (Sids, 1997- 98 and 1998-99) and Giza (1998-99).

Characters	Sids				Giza	Differences between locations	Differences Between Environment (LSD 0.05)
	1997-98 (1)	1998-99 (2)	Average (3)	Differences Between seasons	1998-99 (4)		
Earliness characters							
Days to 50% flowering	70.1	76.1	73.1	*	78.3	*	0.59
Days to 100% flowering	83.9	82.5	83.2	*	90.2	*	0.5
Flowering duration	13.9	6.7	10.3	*	12	*	0.54
Days to 50% poding	86.7	91.8	89.3	*	97.7	*	0.85
Days to 100% poding	100.7	104.3	102.5	*	106.9	*	0.68
Poding duration	15.8	12.8	14.3	*	8.8	*	1.13
Days to 90% maturity	138.2	138.7	138.5	NS	138.3	NS	NS
Morphological							
Plant height (cm)	28.2	46.7	37.5	*	35.9	*	3.62
Number of branches	4.3	8.1	6.2	*	7	*	0.56
Yield & its components							
Seed yield/plant (g)	0.9	2.2	1.6	*	0.7	*	0.08
Number of pods/plant	19.8	60.8	40.3	*	28.7	*	1.6
Number of seeds/plant	26.4	90.6	58.5	*	35	*	3.2
100-seed wight (g)	2.7	2.6	2.7	NS	1.9	*	0.04

- Differences between seasons: To compare between means in coloumns 1 and 2.
- Differences between locations: To compare between means in coloumns 3, and 4.
- Differences between environments: To compare between means in coloumns 1, 2 and 4.
- *: Significant differences.
- NS: Not significant.

Table 3. The overall means of 24 lentil genotypes evaluated in three environments for earliness characters.

Genotype	50% flowering (day)	100% flowering (day)	Flowering duration (day)	50% poding (day)	100% poding (day)	Poding duration (day)	90% maturity (day)
1- FLIP 87-21L	66.08	74.42	8.34	82.17	93.67	11.5	131.58
2- FLIP 89-67L	75.77	89.92	14.75	96.25	107.92	11.67	138.83
3- FLIP 98-71L	81.42	89.67	8.25	96.42	106	9.58	139.92
4- FLIP 92-28L	76.08	88.92	12.84	96.33	106.83	10.5	140.83
5- FLIP 92-47L	74.92	87.5	12.58	94.33	106.5	12.17	139.83
6- FLIP 92-48L	76	87.5	11.5	94.42	106.5	12.08	141.33
7- FLIP 92-54L	68.08	74	5.92	80.67	92.33	11.66	130.83
8- FLIP 94-1L	75.25	89.17	13.92	94.67	107.33	12.66	139.67
9- FLIP 95-25L	67	77.75	10.75	86.25	97.17	10.92	134.58
10-FLIP 95-50L	76.58	86.5	9.92	91.58	104.42	12.84	140.67
11-FLIP 95-52L	80.42	89.92	9.5	91.17	109.17	13	141.67
12-FLIP 95-63L	73.5	85.08	11.58	91.58	105.17	13.59	139.83
13-FLIP 95-67L	76.17	87	10.83	94.08	108.42	14.34	141.08
14-FLIP 95-68L	77.08	87.83	10.83	95.25	106.08	10.83	141.5
15-FLIP 96-1L	77.08	87.08	10	94.58	108.83	14.25	139.58
16-FLIP 96-10L	76.58	87.25	10.67	94.5	108.17	13.67	138.75
17-FLIP 96-48L	77.83	88.25	10.42	95.5	105.67	10.17	137.25
18-87515	77.08	90	12.92	96.58	107.08	10.5	139.25
19-87519	78.58	89.33	10.75	95	104.25	9.25	140.25
20-89503	77.25	87.58	10.33	94.42	106.17	11.75	141.25
21-Sinai 1	65.33	72.08	6.67	78.92	92.17	13.25	130.58
22-Giza 9	74.58	88	13.42	90.42	102.25	11.83	135.92
23-Family 29	74.33	84.08	9.75	87.83	100.58	12.75	136.58
24-Giza 370	73.25	84	10.75	91.25	101.92	10.67	140.33
Average	74.82	85.54	10.85	92.05	103.94	12.48	138.41
Range Min.	65.3	72.1	5.4	78.9	92.2	9.3	130.6
Max.	81.4	90	14.8	96.6	109.2	14.3	141.7
LSD 0.05	1.382	0.204	1.434	1.043	1.037	1.447	1.158

Table 4. The overall means of 24 lentil genotypes evaluated in three environments for morphological, seed yield/plant and yield component characters.

Genotype	Plant Height (cm)	No. of Branches/ plant	Seed yield Per plant (g)	No. of Pods/ plant	No. of Seeds/ plant	100-seed weight (g)
1- FLIP 87-21L	36.62	5.8	1.11	24.55	38.63	2.87
2- FLIP 89-67L	37.92	4.88	1.43	41.73	56.47	2.33
3- FLIP 98-71L	35.4	6.54	1.89	61.68	74.98	2.37
4- FLIP 92-28L	34.67	6.14	1.43	45.38	56.48	2.5
5- FLIP 92-47L	34.16	5.99	1.31	30.78	53.95	2.09
6- FLIP 92-48L	35.95	7.77	1.56	40.77	51.18	2.69
7- FLIP 92-54L	32.48	6.04	0.86	22.02	32.35	2.21
8- FLIP 94-1L	36.6	6.2	1.42	45.73	67.22	1.9
9- FLIP 95-25L	37.38	5.8	0.78	20.87	29.45	2.13
10-FLIP 95-50L	38.07	6.47	1.54	47.73	62.98	2.43
11-FLIP 95-52L	39.93	4.4	1.43	39.83	69.07	1.97
12-FLIP 95-63L	39.43	6.79	1.3	28.33	51.73	2.38
13-FLIP 95-67L	40.8	8.18	1.48	38.37	54.58	2.38
14-FLIP 95-68L	41.07	6.02	1.79	46.47	82.65	2.13
15-FLIP 96-1L	40.13	7.58	1.47	41.82	45.57	2.98
16-FLIP 96-10L	32.98	6.63	0.87	24.3	26.82	2.98
17-FLIP 96-48L	35.48	6.41	0.69	23.98	24.37	2.6
18-87515	36.22	6.57	1.17	46.1	52.75	2.13
19-87519	36.35	9.08	1.54	50.97	56.47	2.19
20-89503	39.8	7.63	1.57	39.93	63.77	2.4
21-Sinai 1	37.07	6.42	1.02	19.8	28.9	3.13
22-Giza 9	34.72	5.8	0.81	24.25	36.1	1.93
23-Family 29	37.59	5.28	0.83	25.12	38.37	2.06
24-Giza 370	36.53	6.98	1.48	43.83	61.85	2.31
Average	36.96	6.43	1.28	36.43	50.7	2.38
Range Min.	32.5	4.4	0.69	19.8	24.37	1.9
Max.	41.1	8.2	1.89	61.68	82.65	3.1
LSD 0.05	3.65	0.56	0.238	3.61	10.52	0.095

Table 5. Estimates of phenotypic (O^2 ph) and genotypic (O^2 g) variance components, atio of genotype x environment (O^2 ge) to phenotypic variance, genetic oefficient of variation (G.C.V.), broad sense heritability (h^2 b.s %) and xpected genetic advance from selection as percentage of the mean (GA%) of lentil characters.

Character	O^2 ph	O^2 g	O^2 ge/e O^2 ph	G.C.V.	h^2 b.s %	GA%
Earliness characters						
Days to 50% flowering	17.5	14.1	0.19	5	80.8	9.3
Days to 100% flowering	28.4	24.5	0.14	5.8	86.3	11.1
Days to 50% poding	26.8	21.3	0.2	5	79.8	9.3
Days to 100% poding	26.4	19.9	0.24	4.3	75.6	7.7
Days to 90% maturity	11.3	7.6	0.33	2	67.3	3.4
Morphological						
Plant height (cm)	3.9	1.7	0.55	3.5	43.5	4.8
Number of branches	0.99	0.45	0.54	10.4	45.5	14.5
Yield & its components						
Seed yield/plant (g)	0.106	0.04	0.57	16.5	42.4	22.2
Number of pods/plant	130.53	37.14	0.71	16.7	28.5	18.4
Number of seeds/plant	241.08	115.91	0.52	21.2	48.1	30.3
100-seed wight (g)	0.12	0.07	0.37	11.4	62.5	18.5

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التباين الوراثي ونسبة التوريث والتقدم الوراثي المتوقع من الإنتخاب لصفات التبكير والمحصول في العدس

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إن إستنباط أصناف مبكرة في النضج هو أحد الأهداف الرئيسية في برنامج تربية محصول العدس في مركز البحوث الزراعية، ولذلك يهدف هذا البحث إلى تقدير التباين الوراثي ونسبة التوريث والتقدم الوراثي المتوقع من الإنتخاب لصفات التبكير والمحصول لأربع وعشرين أصل وراثي للعدس لإمداد مربى العدس ببعض الحقائق الوراثية التي تساعدهم عند الإنتخاب لتلك الصفات، وقد أقيمت ثلاث تجارب حقلية في كل من محطة البحوث الزراعية بسدس (موسمي ١٩٩٧ / ٩٨ و١٩٩٨ / ٩٩) حيث يمثلون ثلاث بيئات مختلفة.

وقد أظهرت النتائج وجود تباين وراثي كبير لصفتي عدد القرون والبذور للنبات، كما أوضحت النتائج أيضاً أن الانتخاب لصفتي عدد البذور للنبات ومحصول البذور للنبات سوف يحقق تحسيناً ملحوظاً، وقد كانت السلالات الثلاثة الآتية: سيناء١، فليب ٧٨-٢١ل، فيلب ٩٢-٥٤ل أكثر تبكيراً في النضج عن كل السلالات المختبرة مما يوصي بزراعتها في حالة ما إذا كان التبكير في النضج أكثر أهمية من المحصول، أما إذا كانت الانتاجية أكثر أهمية من التبكير فينصح بزراعة السلالات عالية المحصول الآتية: فليب ٨٩-٧١ل، فليب ٩٥-٦٨، ٨٩٥٠٤، فليب ٩٢-٤٨ل، وفليب ٩٥-٥٠ل.