

EVALUATION OF SOME LENTIL GENOTYPES FOR EARLINESS, YIELD, YIELD COMPONENTS AND SEED QUALITY

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Abstract

The study aimed to evaluate 30 exotic and Egyptian lentil genotypes for earliness, yield, yield components, seed protein content, hydration coefficient before and after cooking, total soluble solids and seed cookability characters. Correlation and factor analysis procedures were used to determine the contributing characters in yield variation. The field trials were carried out at Giza Research Station in 2001/2002 and 2002/2003 seasons.

Genotypes FLIP 88-42L, PKVL-1, FLIP 96-52L, FLIP 97-30L, FLIP 97-33L and Sinai 1 were the earliest in flowering and maturity. FLIP 88-34L had the highest number of pods and seeds/plant and hence produced the highest seed yield/fed recording 4.10 ardab, surpassing Giza 9 by 35 %. This genotype also showed the highest rate of seed yield formation d^{-1} of crop cycle.

Average seed protein content was 22.1 %. Eight genotypes had protein content above average ranged from 23.5 to 25.5 %. Amongst, the new released variety Giza 51 had 25 % seed protein content. Most genotypes gave high percentages of cookability above 85 %.

Significant and positive associations were detected between seed weight/plant and each of plant height, number of branches, pods and seeds/plant and weight of 100 seeds. Factor analysis grouped seven yield contributing characters into two main factors accounting for 74.13 % of the total variability in the dependence structure. Factor 1 was responsible for 42.66 % of the total variation and contained plant height, number of branches, pods and seeds/plant. Factor II included number of days to 50 % flowering and maturity and weight of 100 seeds and contributed 31.47 % of the total variability.

INTRODUCTION

Lentil (*Lens culinaris Medikus*) is one of the most important food legumes in Egypt being a good source of protein (20-30 %) and carbohydrates (60-71 %), Hamdi and El-Emery (1996), and fairly a good source of thiamin, niacin, calcium and iron. The cultivated area of lentil in Egypt has declined drastically since 1980, reaching about 5000 feddan in 2001 and the total lentil production is still below the country

requirements. Increasing lentil production is one of the major targets of the agricultural policy that can be achieved by increasing both lentil cultivated area and productivity. The lentil area can be expanded in reclaimed lands under rainfed conditions outside the Nile Valley and by planting lentil as a catch crop before cotton in the old land (Hamdi and Ezzat, 1998). Therefore, early maturing-short duration lentil varieties should be available to achieve this goal. Earliness is important since drought escape is the main mechanism for drought resistance in lentil. Hence, earliness is an important trait among selection criteria used in variety development.

Correlation studies between agronomic traits such as yield and its components would help plant breeders and agronomists to enhance crop growth and yield attributes (Ezzat and Ashmawy, 1999).

Determining the most important contributing characters to the total variability of yield is of major importance to successfully achieve a breeding strategy to develop high yielding genotypes of a given crop. Walton (1972) criticized some statistical procedures (multiple regression in both full model and stepwise as well as standard partial regression known as path coefficient) and mentioned that biologists must seek for right assistance from statistical methodology. He recommended factor analysis as a type of multivariate technique. Factor analysis reduces a large number of correlated variables to a small number of main factors, and is used as an approach to determine characters related to yield. This technique has been used in faba bean by Ashmawy *et al.*(1998).

The objectives of the study were to: 1- evaluate some exotic and local lentil genotypes to identify early maturing-high yielding genotypes with high protein content adapted to Egyptian conditions, 2- study the variability of lentil genotypes with respect to the important characters, and, 3- use factor analysis procedure to assist the dependent relationships between yield and yield components in lentil, which would be helpful to plan appropriate selection strategies.

MATERIALS AND METHODS

A total of 30 exotic and Egyptian lentil genotypes were used in this study (Table 1). The exotic materials were received from the International Center for Agricultural Research in the Dry Areas (ICARDA). The wide spread Egyptian variety Giza 9 was used as a check. Accessions were grown at Giza Agricultural Research Station, ARC, Egypt during 2001/2002 and 2002/2003 winter seasons in a randomized

complete block design with three replications. Each plot consisted of 4 rows 3.5 m long and 30 cm apart with plot area of 4.2 m².

Sowing was done on 16th and 19th November in the first and second seasons, respectively. Fertilizer was applied at the rate of 30 kg P₂O₅ and 15 kg N/fed prior to planting. Cultural practices were maintained at optimum levels for maximum lentil productivity. At maturity, lentil plants in the central 3 m² in each experimental plot were hand harvested, while the remaining plot area was discarded to avoid border effect.

Studied characters:

A- Earliness:

Days from planting to first flower, 50 % flowering, 100 % flowering, 50 % podding, 100 % podding and to 95 % maturity were recorded on plot basis.

B- Growth and yield components:

At harvest, a random sample of 10 guarded plants was collected from the central 3 m² in each plot to record characters of plant height, number of branches, pods, seeds and seed weight/plant. Seed yield/fed, crop efficiency (kg seed produced d⁻¹ of crop duration) and 100-seed weight were determined on plot basis.

C- Seed quality:

- 1- Seed protein content obtained by multiplying the total seed nitrogen % by 6.25 according to the method of A. O. A. C. (1990).
- 2- Seed hydration coefficient before cooking (H.C.B): 10 g of dry seeds from each experimental plot were soaked in tap water for 8 hrs, then H. C. B. was calculated as $[(\text{Weight of soaked seeds} - \text{weight of dry seeds}) / \text{weight of dry seeds}] \times 100$.
- 3- Seed hydration coefficient after cooking (H.C.A): was calculated by placing 10 g of dry seeds from each experimental plot in 100 cm³ glass tube containing enough water. The tubes were put in an oven for 2 hrs at 100° C. The Hydration coefficient after cooking (H.C.A.) was determined in cooked seeds according to the method of Fahmy *et al.* (1996) as $\text{H.C.A \%} = [(\text{weight of cooked seeds} - \text{weight of dry seeds}) / \text{weight of dry seeds}] \times 100$.
- 4- The total soluble solids (T. S. S %) was determined in (3) above by drying at 60 °C over night. T.S.S % was calculated as $\text{T.S.S} = [(\text{weight drying} - \text{weight of empty pot}) / \text{initial weight}] \times 100$.
- 5- Seed cookability percentage (cook %): The ability of cooked seeds was measured by using the normal press of fingers and comparing between the cooked seeds for their hardness, which means the maximum force throughout their test. The cooking percentage was determined according to Selim (2000).

Table 1. Origin and pedigree of studied lentil genotypes.

Genotypes	Origin	Pedigree
1- FLIP 86 – 2L	ICARDA	ILL 466 X ILL 212
2- FLIP 87 – 21L	ICARDA	ILL 4349 X ILL 4605
3- Pant L 406	India	Land race
4- FLIP 87 – 70L	ICARDA	ILL 526 X ILL 253
5- FLIP 88 – 7L	ICARDA	ILL 5582 X SH 901
6- FLIP 88 – 42L	ICARDA	ILL 4605 X ILL 5506
7- L E N 8830	ICARDA	LEN 8830
8- XG 88 – 16	Egypt	Selection from hybrid line
9- FLIP 97 – 13L	ICARDA	ILL 5700 X ILL 5722
10- FLIP 98 – 7 L	ICARDA	ILL 6245 X ILL 1939
11- PKVL –1	India	ILL 7558
12- FLIP 92 – 48L	ICARDA	ILL 5583 X ILL 5724
13- FLIP 93 – 1L	ICARDA	ILL 5588 X ILL 5883
14- FLIP 95 – 1L	ICARDA	ILL 7657
15- FLIP 95 – 11L	ICARDA	ILL 5746 X ILL 5700
16- FLIP 96 – 18L	ICARDA	ILL 6245 X ILL 5883
17- FLIP 96 – 52L	ICARDA	ILL 298 X ILL 4605
18- FLIP 2001 – 3L	ICARDA	ILL 5883 X ILL 6999
19- FLIP 97 – 30L	ICARDA	UJ 88286L X ILL 6205
20- FLIP 97 – 33L	ICARDA	ILL 6471 X ILL 4404
21- XG98 – 13	Egypt	Selection from hybrid line
22- FLIP 2000 – 4L	ICARDA	ILL 5588 X ILL 6451
23- FLIP 2001 – 5L	ICARDA	ILL 6980 X ILL 5883
24- FLIP 88 – 34L	ICARDA	ILL 5584 X ILL 2501
25-Line(Fam300Xprecoz)	Egypt	Family 300 X precoz
26- Family 29	Egypt	Landrace
27- ILL 590	Turkey	ILL 590
28- Giza 9	Egypt	Wide spread cultivar
29- Giza 51	ICARDA	Selection from Flip84-51L
30- Sinai 1	Argentina	Selection from precoz

Statistical procedures:**1-Analysis of variance:**

A combined analysis of variance of randomized complete block design over 2001/2002 and 2002/2003 seasons was performed according to Snedecor and Cochran (1980). Duncan's multiple range test was used to detect the significant differences between treatment means.

2- Correlation analysis:

Simple correlation coefficients were computed among seed weight/plant and its components and seed quality characters.

3- Factor analysis:

The factor analysis procedure basically reduces a large number of correlated variables to a small number of uncorrelated factors, Cattle (1965). When the contribution of a factor to the total percentage of the trace is less than 10 %, the process stops. After extraction, the matrix of factors is transmitted to a varimax orthogonal rotation, as applied by Kaiser (1958). The effect of rotation is to accentuate the larger loading in each factor and to prevent the minor loading coefficient for improving the opportunity to achieve a meaningful biological

interpretation of each factor. A communality (h^2) is the variance amount of a variable accounted for the common factors together. Since the purpose was to determine the way in which yield components are related to each other, yield was not included in this structure. Factor analysis was performed using SPSS computer statistical package.

Correlation and factor analysis techniques were applied to the means of both seasons for characters of number of days to 50 % flowering and maturity, plant height, number of branches, pods and seeds/plant, weight of 100 seeds and seed weight/plant as well as seed quality characters.

RESULTS AND DISCUSSION

Combined analysis of variance over the two seasons revealed significant differences between genotypes for all studied characters indicating wide genetic variation among genotypes.

1-Earliness:

Means of earliness are presented in Table 2. Average number of days to first, 50 % and 100 % flowering were 66, 73 and 80.5 days, respectively. A wide range of variation existed in these characters. Six genotypes namely: PKVL-1, FLIP 88-42L, FLIP 96-52L, FLIP 97-30L, FLIP 97-33L and Sinai 1 were the earliest in first, 50 and 100 % flowering. These promising genotypes were earlier than Giza 9 (the check) by 32.2, 32.2, 30.7, 30.2, 30.2 and 28 days, respectively.

Results revealed that the averages of 50 and 100 % podding were 93.9 and 105.3 days, respectively. Plants of PKVL-1 were the earliest to start podding with an average of 74.2 days for 50 % podding and 81.8 days for 100 % podding followed by FLIP 96-52L and FLIP 97-30L, respectively.

The overall mean of days to 95 % maturity was 141.2 days with a range of 124 -156.5 days. Six genotypes: FLIP 88-42L, PKVL-1, Sinai I, FLIP 97-30L, FLIP 97-33L and FLIP 96-52L were the earliest in maturity as they matured at 124, 124.8, 125, 126, 126 and 129 days, respectively, after sowing. Moreover, these promising genotypes were significantly earlier than local check Giza 9 by 20.0, 19.2, 19.0, 18.0, 18.0 and 15.0 days, respectively. It is worth noting that these genotypes were among the earliest flowering genotypes and hence they deserve further testing.

Regarding the relationships among earliness characters, there were strong positive correlations between 95 % maturity and each of days to first, 50 and 100 % flowering, 50 and 100 % podding (r ranged from 0.81** to 0.85**). These results indicate that in future studies in lentil, selection for earliness, recording number of days to maturity, is sufficient to identify earliness in flowering and podding. Ibrahim (2001) also mentioned that measuring only one earliness trait which is strongly

correlated with other earliness characters is sufficient for indicating earliness and saves time and cost.

2- Yield and yield components:

The combined results of yield and its components over seasons are shown in Table 3: The results revealed significant differences among genotypes for all studied characters.

Results showed wide variation in plant height from 24.6 to 51.5 cm. Plants of the highest yielding genotypes were significantly taller than those of the check cultivar Giza 9. Therefore, these genotypes appear more suitable for mechanical harvesting. There was a significant variation among studied genotypes in total number of branches/plant from 6.87 to 15.20. Plant height and number of branches/plant are important characters since they reflect plant vigor, which leads to high yield and their variability would be helpful for selecting parents to be used in crossing programs. These results are in harmony with those reported by Hamdi and Ezzat 1998, Ezzat and Ashmawy (1999), Selim (2000), Ibrahim (2001) and Hamdi *et al.* (2003) who observed wide variability in plant height and number of branches/plant in lentil.

Results in Table 3 also show that both number of pods and seeds/plant varied widely among the tested genotypes. Averages of both characters were 28.5 and 38.4, respectively. Number of pods/plant ranged from 9.7 to 73.5 and number of seeds/plant ranged from 12.9 to 87.7. FLIP 88-34L produced the highest number of pods and seeds/plant being 73.5 and 87.7 followed by Line (Family 300 X precoz) (70.0 and 83.7), XG 98-13 (69.6 and 84.0) and Family 29 (55.7 and 70.4). These genotypes surpassed the local check Giza 9 which produced 45.0 and 57.0, pods and seeds/plant, respectively.

Results indicated also that there was wide variation in seed weight/plant. Three genotypes: FLIP 88-34L, Line (Family 300 X precoz) and XG 98-13 gave the maximum seed weight/plant recording 2.56, 2.38 and 2.25 g, respectively. These genotypes outyielded the check cultivar Giza 9 by 100.02, 87.40 and 77.17 %, respectively.

Weight of 100 seeds was ranging between 1.47- 4.92 g with an overall average of 2.82 g, indicating that most of the tested genotypes are small seeded. In comparison, the average 100-seed weight of international lentil germplasm at ICARDA is 3.4 g, Hamdi *et al.* (1991). Large seeded lentil is more favoured in the Egyptian market. Therefore, large seeded lentil genotypes should be introduced to Egypt and more attention should be given for selection of large seeded types. Also, results in Table 3 indicate that FLIP 95-11L had the heaviest weight of 100 seeds being 4.92 g and ranked the first followed by PKVL-1 (4.20 g) and FLIP 88-42L (4.00 g).

Consequently, these three large seeded genotypes would be used in the lentil improvement program.

Seed yield averaged 2 ardab/feddan (1 ardab = 160 kg) and had a range of 0.36 to 4.10 ard/fed. Results in Table 3 show a wide variation in seed yield among the tested genotypes. FLIP 88-34L, produced the highest seed yield/fed recording 4.10 ard/fed followed by Line (Family 300 X precoz) (3.89), XG 98-13 (3.85), Family 29 (3.60), Giza 51 (3.20) and FLIP 97-30L (3.15). These genotypes outyielded the check cultivar Giza 9 by 35, 28, 27, 19, and 3 %, respectively. In addition, some of these genotypes matured earlier than Giza 9 particularly FLIP 97-30L and Line (Family 300 X precoz) which matured 18 and 8 days earlier than Giza 9, respectively. The superiority of these six genotypes in seed yield could be attributed to their higher number of pods, seeds and seed weight/plant compared to other genotypes. These promising genotypes will be re-tested in advanced yield trials compared to other genotypes.

Data in Table 3 show also that crop efficiency (yield/day) was significantly affected by genotypes with large variability among tested genotypes. FLIP 88-34L was the most efficient in seed production (4.58 kg/day) followed by Line (Fam 300 X precoz) (4.54 kg/day), XG 98-13 (4.19), Family 29 (4.03 kg/day), FLIP 97-30L (4.00 kg/day), respectively.

3- Seed quality:

Mean values of seed quality characters as affected by lentil genotypes (combined over 2001/2002 and 2002/2003 seasons) are presented in Table 4. Results revealed that the tested genotypes significantly differed with respect to the studied characters.

Range of seed protein content found in the present study was 18.5 - 25.5 %, which is close to the range of seed protein previously reported by Hamdi and El-Emery (1996), El-Bagoury *et al.* (2000) and Selim (2000). Results indicated that FLIP 93-1L had the highest content of seed protein, being 25.5 % followed by Giza 51 (25.0 %) and FLIP 88-34L (24.5 %). The lowest seed protein content was produced by FLIP 86-2L being 18.5 %.

Hydration coefficient before cooking (H.C.B) for all genotypes ranged from 101 % for FLIP 86-2L to 131 % for FLIP 98-7L, while the local check Giza 9 averaged 122 %. The wide range of H.C.B indicates that the tested genotypes differed in potential to imbibe water. A high capacity to absorb water indicates good seed quality. Same results were found by Selim (2000).

The percentage amount of water uptake by cooked seeds as represented by hydration coefficient after cooking (H.C.A) ranged from 105 for FLIP 87-21L to 124 for FLIP 93-1L. Local check Giza 9 had value of 111 %. Although the range of the H.C.A value is small, the differences among genotypes allow for selection among them. In

fact, during the soaking process which water imbibition is greatly dependent on the inherent physio-chemical composition of the seed. Sathe and Salunkhe (1981) reported that the polar amino groups of protein molecules are the primary water binding sites.

For the total soluble solids (T.S.S.%), data in Table 4 clearly showed significant wide variation among the tested genotypes. FLIP 92-48L gave the highest value of T.S.S., being 1.95 while FLIP 87-70L recorded the lowest value of T. S. S. being 0.94.

On the other hand, there was a significant variation among the tested genotypes in the percentage of cookability. Most genotypes gave high percentage of cookability which was above 85 %. FLIP 2001-5L genotype gave the lowest percentage of cookability (75 %).

Correlation analysis:

The matrix of simple correlation coefficients among seed weight/plant and each of days to 50 % flowering and maturity, plant height, number of branches, pods and seeds/plant and weight of 100 seeds is presented in Table 5.

Results showed that the most important relationships to lentil breeder are those between seed weight/plant and each of plant height ($r = 0.499^{**}$), number of branches/plant ($r = 0.792^{**}$), number of pods/plant ($r = 0.887^{**}$), number of seeds/plant ($r = 0.919^{**}$) and weight of 100 seeds ($r = 0.278^*$).

Significant positive correlation was found between number of days to 50 % flowering and each of number of days to maturity ($r = 0.852^{**}$) and number of pods/plant ($r = 0.217^*$). However, number of days to 50 % flowering was highly significantly negatively correlated with weight of 100 seeds ($r = -0.432^{**}$). Number of days to maturity was found to be highly significantly negatively associated with 100-seed weight ($r = -0.369^{**}$). Positive highly significant correlation was detected between plant height and each of number of branches/plant ($r = 0.556^{**}$), number of pods/plant ($r = 0.521^{**}$) and number of seeds/plant ($r = 0.472^{**}$). Correlation between number of branches/plant and each of number of pods and seeds/plant and weight of 100 seeds was found to be positive highly significant with r values being 0.676^{**} , 0.682^{**} and 0.429^{**} , respectively. Highly significant positive correlation was observed between number of pods/plant and number of seeds/plant with r value of 0.934^{**} . The previous results indicate that selection for these characters would improve the productivity of lentil crop because of their highly significant correlation with yield. These results are similar to those reported by Ezzat and Ashmawy (1999).

Correlation analysis showed that the relationships among seed weight/plant and seed quality characters were found to be non-significant and showed very small contribution to the seed yield variation. So, they were discarded from the results.

Table 2. Mean values of earliness as affected by lentil genotypes over 2001/2002 and 2002/2003 seasons.

Genotype	1 st flower	50 % flowering	100 % flowering	50 % podding	100 % podding	95 % maturity	
1- FLIP 86 – 2L	52.5 ^l	56.8 ^g	63.3 ^{ij}	79.8 ^l	90.3 ^{kl}	141.7 ^f	
2- FLIP 87 – 21L	51.2 ^l	56.3 ^{gh}	64.5 ^l	76.8 ^{mn}	88.5 ^l	136.0 ^h	
3- Pant L 406	78.7 ^b	82.5 ^c	90.0 ^{cde}	101.0 ^{def}	114.0 ^{cd}	151.8 ^{bc}	
4- FLIP 87 – 70L	77.0 ^{bcd}	82.7 ^c	89.8 ^{cde}	101.3 ^{cde}	117.5 ^b	146.5 ^{de}	
5- FLIP 88 – 7L	71.5 ^{hi}	78.7 ^{de}	84.8 ^{gh}	95.0 ^{hi}	105.5 ^l	138.0 ^h	
6- FLIP 88 - 42L	47.5 ^{mn}	50.0 ^j	57.5 ^l	84.0 ^k	92.8 ^k	124.0 ^j	
7- L E N 8830	75.5 ^{c-g}	81.3 ^{cd}	87.7 ^{d-g}	98.5 ^{fg}	111.2 ^{def}	151.7 ^{bc}	
8- XG 88 – 16	65.7 ^k	74.7 ^f	82.3 ^h	99.5 ^{efg}	108.2 ^{fgh}	149.0 ^{cd}	
9- FLIP 97 – 13L	78.7 ^b	87.7 ^b	93.5 ^b	100.0 ^{def}	117.0 ^b	156.5 ^a	
10- FLIP 98 – 7 L	82.0 ^a	92.2 ^a	101.0 ^a	112.0 ^a	124.0 ^a	152.0 ^{bc}	
11- PKVL –1	41.5 ^o	50.0 ^j	57.0 ^l	74.2 ^o	81.8 ⁿ	124.8 ^j	
12- FLIP 92 – 48L	74.3 ^{d-h}	81.3 ^{cd}	89.5 ^{de}	105.0 ^b	122.8 ^a	146.7 ^{de}	
13- FLIP 93 – 1L	72.0 ^{hi}	82.3 ^c	89.7 ^{cde}	98.5 ^{fg}	108.5 ^{fgh}	143.5 ^f	
14- FLIP 95 – 1L	73.3 ^{fgh}	82.0 ^c	88.5 ^{def}	104.5 ^b	123.2 ^a	154.3 ^{ab}	
15- FLIP 95 – 11L	70.0 ^j	80.7 ^{cde}	87.7 ^{d-g}	99.5 ^{efg}	114.3 ^c	150.0 ^c	
16- FLIP 96 – 18L	68.5 ^j	79.8 ^{cde}	85.8 ^{fg}	99.5 ^{efg}	113.5 ^{cd}	143.5 ^f	
17- FLIP 96 – 52L	45.0 ⁿ	51.5 ^j	58.7 ^{kl}	76.0 ^{no}	84.8 ^m	129.0 ^l	
18- FLIP 2001 – 3L	78.0 ^{bc}	86.0 ^b	90.8 ^{bcd}	101.0 ^{def}	112.0 ^{cde}	138.3 ^{gh}	
19- FLIP 97 – 30L	46.5 ⁿ	52.0 ^{ij}	58.8 ^{kl}	75.8 ^{no}	85.0 ^m	126.0 ^j	
20- FLIP 97 – 33L	50.0 ^{lm}	54.2 ^{hi}	60.8 ^{jk}	77.0 ^{mn}	83.5 ^{mn}	126.0 ^j	
21- XG98 – 13	76.5 ^{b-e}	82.7 ^c	90.3 ^{cde}	101.0 ^{def}	113.3 ^{cde}	147.0 ^{de}	
22- FLIP 2000 – 4L	51.5 ^l	57.5 ^g	64.3 ^l	79.0 ^{lm}	90.0 ^l	137.7 ^h	
23- FLIP 2001 – 5L	76.0 ^{b-f}	82.0 ^c	92.8 ^{bc}	102.5 ^{bcd}	113.0 ^{cde}	143.5 ^f	
24- FLIP 88 – 34L	75.0 ^{d-g}	80.8 ^{cde}	87.3 ^{efg}	104.2 ^d	113.2 ^{cde}	143.0 ^f	
25-Line (Fam.300 Xprecoz)	77.0 ^{ij}	80.7 ^{cde}	90.5 ^{b-e}	103.2 ^{bc}	114.3 ^c	136.8 ^h	
26- Family 29	74.0 ^{e-h}	78.7 ^{de}	89.3 ^{de}	97.0 ^{gh}	107.8 ^{ghi}	141.0 ^{fg}	
27- ILL 590	73.0 ^{gm}	78.3 ^e	90.8 ^{bcd}	104.0 ^b	110.5 ^{efg}	147.0 ^{de}	
28- Giza 9	71.8 ^{hi}	82.2 ^c	87.8 ^{d-g}	94.5 ⁱ	107.0 ^{hi}	144.0 ^{ef}	
29- Giza 51	68.7 ^j	73.2 ^f	82.2 ^h	91.7 ^j	102.5 ^j	142.5 ^f	
30- Sinai 1	45.3 ⁿ	51.2 ^j	58.7 ^{kl}	79.5 ^l	88.5 ^l	125.0 ^j	
Mean	66.0	73.0	80.5	93.9	105.3	141.2	
Range	Minimum	41.5	50.0	57.0	74.2	81.8	124.0
	Maximum	82.0	92.2	101.0	105.0	124.0	156.5

* Means followed with same letters are not significantly different.

Table 3. Mean values of morphological, yield and related characters as affected by lentil genotypes over 2001/2002 and 2002/2003 seasons.

Genotypes	Plant Height (cm.)	Number of branches /plant	Number of pods /plant	Number of seeds /plant	Seed weight /plant (g)	100 seed weight (g)	Seed yield ardeb/fed	Seed yield (kg/day)
1- FLIP 86 – 2L	38.23 ^{fj}	8.50 ^{fg}	12.2 ^{ij}	20.20 ^{kl}	0.50 ^{dp}	2.80 ^{e-i}	0.85 ⁱ	0.96 ⁿ
2- FLIP 87 – 21L	45.06 ^{a-f}	12.53 ^{a-d}	20.2 ^{g-j}	35.00 ^{ghi}	1.11 ^{g-j}	3.52 ^{cd}	2.52 ^d	2.96 ^{fg}
3- Pant L 406	47.20 ^{abc}	11.00 ^{b-f}	25.0 ^{e-h}	43.00 ^{efg}	1.20 ^{f-i}	2.73 ^{f-j}	2.48 ^d	2.61 ^{gh}
4- FLIP 87 – 70L	33.20 ^j	11.20 ^{b-f}	39.8 ^{cd}	46.57 ^{def}	0.96 ^{f-i}	2.25 ^{i-l}	1.82 ^{efg}	1.98 ^{jk}
5- FLIP 88 – 7L	24.57 ^k	8.40 ^{fg}	14.2 ^{ij}	16.87 ^{kl}	0.58 ^{no}	3.55 ^{cd}	1.23 ^h	1.43 ^m
6- FLIP 88 – 42L	39.50 ^{d-j}	12.10 ^{a-e}	32.1 ^{def}	37.00 ^{fgh}	1.39 ^{def}	4.00 ^{bc}	2.70 ^d	3.48 ^{de}
7- L E N 8830	48.37 ^{ab}	9.30 ^{d-g}	31.8 ^{def}	41.60 ^{efg}	0.91 ^{j-m}	2.20 ^{kl}	1.78 ^{efg}	1.88 ^{kl}
8- XG 88 – 16	35.02 ^{ij}	12.45 ^{a-e}	20.1 ^{g-j}	25.10 ^{kl}	0.73 ^{l-o}	2.50 ^{h-k}	1.85 ^{ef}	1.98 ^{jk}
9- FLIP 97 – 13L	43.98 ^{b-g}	9.30 ^{d-g}	16.6 ^{hij}	21.30 ^{kl}	0.31 ^{pq}	1.75 ^{lmn}	0.75 ^{ij}	0.76 ^{no}
10- FLIP 98 – 7 L	41.82 ^{b-i}	8.20 ^{fg}	14.9 ^{hij}	16.05 ^{kl}	0.22 ^q	1.47 ⁿ	0.59 ^{ijk}	0.62 ^{no}
11- PKVL –1	44.28 ^{a-g}	15.20 ^a	22.3 ^{f-i}	35.00 ^{ghi}	1.32 ^{d-g}	4.20 ^b	2.60 ^d	3.11 ^{def}
12- FLIP 92 – 48L	35.83 ^{hij}	10.20 ^{c-f}	15.9 ^{hij}	19.32 ^{kl}	0.66 ^{mno}	3.35 ^{de}	0.82 ^{ij}	0.89 ⁿ
13- FLIP 93 – 1L	40.97 ^{b-i}	8.35 ^{fg}	12.3 ^{ij}	18.30 ^{kl}	0.49 ^{op}	2.55 ^{h-k}	0.79 ^{ij}	0.88 ⁿ
14- FLIP 95 – 1L	43.03 ^{b-h}	10.70 ^{b-f}	29.0 ^{efg}	34.85 ^{ghi}	0.65 ^{mno}	1.75 ^{lmn}	1.50 ^{gh}	1.55 ^{lm}
15- FLIP 95 – 11L	40.20 ^{c-j}	11.20 ^{b-f}	9.7 ^j	13.42 ^l	0.61 ^{no}	4.92 ^a	0.89 ⁱ	0.95 ⁿ
16- FLIP 96 – 18L	37.02 ^{g-j}	9.13 ^{efg}	14.2 ^{ij}	21.63 ^{kl}	0.76 ^{l-o}	2.80 ^{e-i}	1.20 ^h	1.33 ^m
17- FLIP 96 – 52L	36.25 ^{hij}	10.20 ^{c-f}	11.0 ^j	20.10 ^{kl}	0.84 ^{k-n}	3.30 ^{def}	1.62 ^{fg}	2.00 ^{jk}
18- FLIP 2001 – 3L	41.90 ^{b-i}	8.30 ^{fg}	32.2 ^{def}	39.22 ^{efg}	0.61 ^{no}	1.57 ^{mn}	1.78 ^{efg}	2.06 ^{ijk}
19- FLIP 97 – 30L	48.02 ^{ab}	13.47 ^{abc}	34.0 ^{de}	48.40 ^{cde}	1.50 ^{cde}	3.18 ^{d-g}	3.15 ^c	4.00 ^c
20- FLIP 97 – 33L	35.87 ^{hij}	10.80 ^{b-f}	17.2 ^{hij}	28.20 ^{hij}	0.74 ^{l-o}	2.87 ^{e-h}	1.91 ^{ef}	2.42 ^{hi}
21- XG98 – 13	41.67 ^{b-i}	14.60 ^a	69.6 ^a	84.00 ^a	2.25 ^b	2.50 ^{h-k}	3.85 ^{ab}	4.19 ^{bc}
22- FLIP 2000 – 4L	39.98 ^{c-i}	6.87 ^g	13.1 ^{ij}	17.00 ^{kl}	0.50 ^{op}	2.62 ^{g-k}	0.50 ^{jk}	0.58 ^{no}
23- FLIP 2001 – 5L	46.35 ^{a-d}	10.10 ^{c-g}	10.5 ^j	12.90 ^l	0.28 ^{pq}	2.07 ^{klm}	0.36 ^k	0.40 ^o
24- FLIP 88 – 34L	46.77 ^{a-d}	13.45 ^{abc}	73.5 ^a	87.70 ^a	2.56 ^a	2.98 ^{d-h}	4.10 ^a	4.58 ^a
25- Line (Fam300Xprecoz)	51.52 ^a	13.30 ^{abc}	70.0 ^a	83.65 ^a	2.38 ^{ab}	2.77 ^{f-j}	3.89 ^{ab}	4.54 ^{ab}
26- Family 29	47.35 ^{abc}	13.93 ^{ab}	55.7 ^b	70.35 ^b	1.72 ^c	2.45 ^{h-k}	3.60 ^b	4.03 ^c
27- ILL 590	33.13 ^l	10.62 ^{b-f}	18.2 ^{hij}	56.93 ^c	1.05 ^{n-k}	3.50 ^{cd}	2.10 ^e	2.27 ^{hij}
28- Giza 9	40.53 ^{c-j}	12.13 ^{a-e}	45.0 ^c	57.00 ^c	1.27 ^{e-h}	2.15 ^{kl}	3.03 ^c	3.36 ^{de}
29- Giza 51	46.15 ^{a-e}	13.0 ^{abc}	45.0 ^c	55.90 ^{cd}	1.56 ^{cd}	2.80 ^{e-i}	3.20 ^c	3.59 ^d
30- Sinai 1	38.78 ^{e-j}	10.3 ^{c-f}	31.0 ^{def}	43.00 ^{efg}	1.12 ^{g-j}	3.48 ^{cd}	2.50 ^d	3.20 ^{ef}
Mean	41.09	10.96	28.5	38.42	1.03	2.82	2.00	2.15
Range	Minimum	24.57	6.87	9.7	12.90	0.22	1.47	0.40
	Maximum	51.52	15.2	73.5	87.70	2.56	4.92	4.58

* Means followed with same letters are not significantly different.

** 1 ardeb = 160 kg

Table 4. Mean values of seed quality characters as affected by lentil genotypes over 2001/2002 and 2002/2003 seasons.

Genotypes	Seed protein %	H. C. B %	H. C. A %	T. S. S %	Cook %	
1- FLIP 86 – 2L	18.5 ⁱ	101.0 ^m	111.5 ^{ei}	1.14 ^{kl}	92.5 ^a	
2- FLIP 87 – 21L	21.5 ^{d-h}	121.5 ^{d-g}	105.0 ^l	0.97 ^{mn}	97.5 ^a	
3- Pant L 406	23.5 ^{a-d}	103.5 ^{lm}	110.0 ^{ghi}	1.02 ^{k-n}	95.0 ^a	
4- FLIP 87 – 70L	18.5 ⁱ	102.5 ^m	105.5 ^{hi}	0.94 ⁿ	95.0 ^a	
5- FLIP 88 – 7L	22.0 ^{d-g}	123.0 ^{c-f}	106.0 ^{lu}	1.00 ^{lmn}	85.0 ^{ab}	
6- FLIP 88 – 42L	23.5 ^{a-d}	114.0 ^{jk}	113.0 ^{d-g}	1.20 ^j	97.5 ^a	
7- L E N 8830	22.0 ^{d-g}	119.5 ^{ei}	120.0 ^{abc}	1.85 ^{ab}	92.5 ^a	
8- XG 88 – 16	22.5 ^{c-f}	120.5 ^{e-h}	114.5 ^{c-g}	1.18 ^j	97.5 ^a	
9- FLIP 97 – 13L	22.5 ^{c-f}	125.0 ^{b-e}	122.0 ^{ab}	1.57 ^d	85.0 ^{ab}	
10- FLIP 98 – 7 L	21.0 ^{e-h}	131.0 ^a	114.0 ^{c-g}	1.77 ^b	87.5 ^{ab}	
11- PKVL –1	23.5 ^{a-d}	127.0 ^{a-d}	111.5 ^{ei}	1.58 ^d	97.5 ^a	
12- FLIP 92 – 48L	23.0 ^{b-e}	108.5 ^{kl}	119.0 ^{a-d}	1.95 ^a	90.0 ^{ab}	
13- FLIP 93 – 1L	25.5 ^a	129.0 ^{ab}	124.0 ^a	1.10 ^{j-m}	92.5 ^a	
14- FLIP 95 – 1L	22.0 ^{d-g}	121.5 ^{d-g}	119.5 ^{a-d}	1.40 ^{efg}	95.0 ^a	
15- FLIP 95 – 11L	21.0 ^{e-h}	129.0 ^{ab}	116.5 ^{b-g}	1.38 ^{fgh}	87.5 ^{ab}	
16- FLIP 96 – 18L	22.0 ^{d-g}	127.5 ^{abc}	116.0 ^{b-g}	1.23 ^{ij}	95.0 ^a	
17- FLIP 96 – 52L	19.5 ^{hi}	120.5 ^{e-h}	111.0 ^{fi}	1.25 ^{hij}	95.0 ^a	
18- FLIP 2001 – 3L	20.5 ^{fi}	115.0 ^{hij}	113.5 ^{c-g}	1.15 ^{jk}	87.5 ^{ab}	
19- FLIP 97 – 30L	22.0 ^{d-g}	122.5 ^{c-g}	120.0 ^{abc}	1.23 ^{ij}	95.0 ^a	
20- FLIP 97 – 33L	23.0 ^{b-e}	119.0 ^{ei}	112.0 ^{e-h}	1.21 ^j	92.5 ^a	
21- XG98 – 13	21.0 ^{e-h}	116.5 ^{g-j}	113.0 ^{d-g}	1.01 ^{k-n}	97.5 ^a	
22- FLIP 2000 – 4L	20.0 ^{ghi}	122.0 ^{c-g}	119.0 ^{a-d}	1.57 ^d	97.5 ^a	
23- FLIP 2001 – 5L	19.5 ^{hi}	114.0 ^{ijk}	111.0 ^{fi}	1.52 ^{def}	75.0 ^b	
24- FLIP 88 – 34L	24.5 ^{abc}	118.5 ^{fj}	115.5 ^{b-g}	1.61 ^{cd}	97.5 ^a	
25-Line (Fam.300 X precoz)	23.5 ^{a-d}	118.5 ^{fj}	119.0 ^{a-d}	1.72 ^{bc}	95.0 ^a	
26- Family 29	25.0 ^{ab}	113.0 ^{jk}	117.5 ^{a-f}	1.10 ^{j-m}	95.0 ^a	
27- ILL 590	20.5 ^{fi}	117.0 ^{fj}	113.0 ^{d-g}	1.36 ^{ghi}	95.0 ^a	
28- Giza 9	22.5 ^{c-f}	122.0 ^{c-g}	111.0 ^{fi}	1.53 ^{de}	97.5 ^a	
29- Giza 51	25.0 ^{ab}	125.0 ^{b-e}	111.5 ^{ei}	1.48 ^{d-g}	90.0 ^{ab}	
30- Sinai 1	23.0 ^{b-e}	119.5 ^{ei}	118.0 ^{a-e}	1.16 ^{jk}	92.5 ^a	
Average	22.10	118.9	114.4	1.34	93.5	
Range	Minimum	18.5	101.0	105.0	0.94	75.0
	Maximum	25.5	131.0	124.0	1.95	97.5

* Means followed with same letters are not significantly different.

Table 5: Matrix of simple correlation coefficients among seed weight/plant and its components in lentil over 2001/2002 and 2002/2003 seasons.

Characters	X1	X2	X3	X4	X5	X6	X7	
50 % flowering	X1	1.000						
Maturity	X2	0.852**	1.000					
Plant height	X3	0.130	0.130	1.000				
Branches/plant	X4	-0.040	-0.073	0.556**	1.000			
No.of pods/plant	X5	0.217*	0.035	0.521**	0.676**	1.000		
No.of seeds/plant	X6	0.162	0.009	0.472**	0.682**	0.934**	1.000	
100-seed weight	X7	-0.432**	-0.369**	-0.007	0.429**	-0.046	0.034	1.000
Weight of seeds/plant	Y	0.027	-0.163	0.499**	0.792**	0.887**	0.919**	0.278*

* Significant at 5 % level of significant.

** Significant at 1% level of significant.

Factor analysis:

Results of factor analysis are shown in Tables 6 and 7. Factors were constructed by applying the principal factor analysis approach to establish the dependent relationship between yield components in lentil. Factor analysis grouped the studied seven characters into two main factors. Factor loadings greater than 0.5 were considered important. Table 7 presents the composition of variables of the two factors with loadings.

Table 6: Principal factor matrix after orthogonal rotation for seven characters of lentil

Variables	Factors		Communality (h ²)
	Factor I	Factor II	
Days to 50 % flowering.	0.167	0.913	0.861
Days to maturity.	0.052	0.889	0.793
Plant height.	0.711	0.099	0.515
Number of branches/plant.	0.862	-0.258	0.810
Number of pods/plant.	0.922	0.096	0.859
Number of seeds/plant.	0.913	0.033	0.835
Weight of 100 seeds.	0.153	-0.702	0.516
Latent roots	2.986	2.203	5.19
Factor variance ratio %	42.66	31.47	74.13

Table 7: Summary of factor loading for seven variables of lentil.

Variables	Loading	% of total communality	Suggested factor name
Factor I:			
1- Plant height.	0.711	42.66	Seed
2- Number of branches/plant.	0.862		
3- Number of pods/plant.	0.922		
4- Number of seeds/plant.	0.913		
Factor II:			
1- Days to 50 % flowering.	0.913	31.47	Maturity
2- Days to maturity.	0.889		
3- Weight of 100 seeds.	-0.702		
Commulative variance		74.13	

The results indicate that the two obtained factors explained 74.13 % of the total variation in the dependent structure. Factor I accounted for 42.66 % of the total variability and included four variables, *i.e.* plant height, number of branches/plant,

number of pods and seeds/plant. The four variables positively correlated with the factor. These variables had equal importance and high communality with factor I. Therefore, this factor may be called seed factor.

Factor II could be regarded as maturity factor because it contained number of days to 50 % flowering, number of days to maturity and weight of 100 seeds. This factor was responsible for 31.47 % of the total variation in the dependent structure (Table 7). Two variables of factor II which were days to 50 % flowering and maturity had positive loading while weight of 100 seeds had negative loading. The sign of the loading indicates the direction of the relationship between the factor and the variable.

The results of the current study indicated that the estimated communalities (Table 6) were adequate for conclusion since both obtained factors contributed 74.13 % to the total variability of the dependent structure.

Factor I (seed factor) had high loadings for the included variables (Table 6). The correlation between these variables and factor I is given by the suitable factor loading. Based on the studied genotypes, selection for plant height, number of branches, pods and seeds/plant will enable plant breeders to obtain higher yield.

From the previous results, it could be concluded that factor analysis indicates both grouping and percentage contribution to the total variability in the dependent structure. Using factor analysis by plant breeders has the potential of increasing the comprehension of causal relationship of variables and can help to determine the nature and sequence of traits to be selected in a breeding program. This may be helpful in planning an appropriate selection strategy to improve lentil crop.

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تقييم بعض التراكيب الوراثية للعدس للتبكير فى النضج والمحصول ومكوناته و صفات جودة البذور

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أقيمت تجربة حقلية فى محطة الجيزة للبحوث الزراعية موسمى ٢٠٠٢/٢٠٠١ و ٢٠٠٢/٢٠٠٣ تضمنت ثلاثين تركيباً وراثياً من العدس بعضها مستورد من المركز الدولى للبحوث الزراعية فى المناطق الجافة (إيكاردا) والبعض الآخر من مصر بهدف تقييم التبكير والمحصول ومكوناته وصفات الجودة بالإضافة إلى تحديد العوامل المساهمة فى تباين المحصول حيث استخدم لذلك طريقتى الارتباط البسيط وتحليل العامل .

أوضحت النتائج أن التراكيب الوراثية FLIP 88-42L ، PKVL - 1 ، FLIP 96-52L ، FLIP 97-30L ، FLIP 97-33L ، Saini 1 كانت الأبر فى التزهير و النضج. سجل التركيب الوراثى (Family 300 X Precoz) Line أعلى القيم لارتفاع النبات (٥١,٥ سم) متفوقاً على جيزة ٩ بحوالى ١٠,٩٩ سم و أحتل PKVL-1 المرتبة الأولى من حيث عدد أفرع النبات بينما أعطى FLIP 88-34L أعلى قيمة لكل من عدد قرون وبذور النبات. وكذلك أعطت التراكيب الوراثية FLIP 88-34L ، (Family 300 X Precoz) Line و الهجين (XG 98-13) أعلى محصول بذور للنبات ، بينما كان أكبر وزن ١٠٠ بذرة ناتجاً من FLIP95-11L (٤,٩٢ جم) يليه PKVL-1 (٤,٢٠ جم) ثم FLIP 88-42L (٤ جم). سجل التركيب الوراثى FLIP 88-34L أعلى القيم لمحصول البذور للفدان (٤,١٠ أردب / ف) متفوقاً على جيزة ٩ بحوالى ٣٥ % وايضا أعلى كفاءة فى استخدام الأرض (محصول بذور فى اليوم) (٤,٥٨ كجم / يوم).

أظهرت النتائج أيضاً أن التراكيب الوراثية FLIP 93-1L ، Family 29 ، FLIP 88-34L ، جيزة ٥١ سجلت أعلى نسبة للبروتين فى البذرة. تراوح معامل الامتصاص للبذور بعد الطهى بين ١٠٥ للتركيب الوراثى FLIP 87-21L إلى ١٢٤ للتركيب الوراثى FLIP 93-1L بينما تراوح معامل الامتصاص للبذور قبل الطهى من ١٠١ (FLIP 86-2L) إلى ١٣١ (FLIP 98-7L). و أعطى التركيب الوراثى فيليب FLIP 92-48L أعلى القيم لنسبة المواد الصلبة الذائبة وسجلت معظم التراكيب الوراثية نسب عالية لصفة الطبخ (أعلى من ٨٥ %).

أوضحت النتائج وجود ارتباط معنوى موجب بين محصول بذورالنبات وكل من ارتفاع النبات وعدد أفرع النبات وعدد قرون النبات وعدد بذور النبات ووزن ١٠٠ بذرة. وأظهرت نتائج تحليل العامل أن الصفات تحت الدراسة تجمعت فى عاملين فقط ساهما بحوالى ٧٤,١٣ % فى التباين الكلى لمحصول البذور وضم العامل الاول صفات ارتفاع النبات وعدد أفرع النبات وعدد قرون النبات وعدد بذور النبات وقد ساهم هذا العامل بحوالى ٤٢,٦٦ % فى التباين الكلى لمحصول البذور أما العامل الثانى فقد ساهم بحوالى ٣١,٤٧ % فى التباين الكلى للمحصول وضم صفات عدد الايام حتى ٥٠ % تزهير وعدد الايام حتى النضج ووزن ١٠٠ بذرة.