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DIRECT AND INDIRECT RELATIONSHIPS AMONG LENTIL CHARACTERS

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Abstract

Correlation and path analysis were carried out for 24 lentil genotypes grown in three environments in Egypt (Sids research station in 1997/98 and 1998/99, and Giza research station in 1998/99 season). Season and location showed major effects on the performance of genotypes. Seed yield was positively and significantly correlated with pod and seed numbers, plant height and number of branches/plant, and negatively with flowering duration. Days to 50% flowering was significantly correlated with days to100% flowering, 50 and 100% podding and days to maturity, indicating that selection for early flowering (50% flowering) is sufficient to identify the earliness in podding and maturity and no need to measure other earliness traits to save time and cost. Path analysis revealed that number of seeds/plant had the highest direct and indirect effects on seed yield followed by pods/plant. But as yield component selection has been unsuccessful in the past, probably because of yield component compensation, and measuring yield is much less time-consuming than counting/measuring components, selection for yield components is not justified.

INTRODUCTION

Lentil (*Lens* culinaris Medikus) is an important crop grown for both seeds for human consumption and straw for livestock feed. The crop grows in old lands in both North and South Egypt, in new reclaimed lands outside the Nile Valley and in rainfed areas in North-West coastal region. Early maturing (short duration) and high yielding lentil varieties should be available for these three regions (Hamdi, 1998). Consequently, seed yield and earliness are primary economic traits.

Knowledge of the magnitude and type of relationships between economic traits in a crop profoundly affect the approach to be taken in plant improvement. With genetic variance and covariance it is possible to predict the expected response to selection for one trait and expected correlated response in other traits (Hamdi *et al.*, 1991). In addition, path analysis separate the direct effects from the indirect effects through other related characters by partitioning the correlation coefficient and bring out the relative importance of different characters as selection criteria (Dewey and Lu, 1959).

There are several reports of the associations among yield and its components, morphological and phenological characters in lentil (Rajput and Sarwar, 1989; Luthra and Sharma, 1990; Hamdi *et al.*, 1991; Jain *et al.*, 1991; Kumar-Sanjai and Bajpai, 1993; Khattab, 1995; Hamdi and Ezatt 1998; Ezatt and Ashmawy, 1999; Selim, 2000)

The present study aimed to estimate the coefficient of correlation and path analysis among seed yield, yield components, morphological and penological characters in lentil.

MATERIALS AND METHODS

Twenty-four lentil genotypes randomly selected from the germplasm collection in Lentil Breeding Program at ARC, including the four Egyptian genotypes Giza 9, Giza 370, Sinai 1 and Family 29, 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 traits were recorded on 10 randomly and 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% podding, podding duration, and days to 90% maturity were recorded on 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 phenotypic correlation was calculated according to Gomez and Gomez (1984). Path analysis was done following the procedure of Dewey and Lu (1959).

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 (Table 2).

Phenotypic correlation among the studied characters:

Seed yield/plant was positively and significantly correlated with number of pods/plant (0.86), number of seeds/plant (0.95), plant height (0.66) and number of branches/plant (0.46), while it correlated negatively with flowering duration (- 0. 51) as present in Table (3). No correlation between seed yield and other earliness characters was observed, revealing that the yield performance of tested genotypes was not influenced by their earliness traits. Luthra and Sharma (1990) also reported positive correlation between yield and each of pods and seeds/plant in lentil. The strong positive correlation among seed yield and each of pods and seeds/plant suggest the use of any one of them in indirect selection for seed yield.

Number of pods/plant was strongly correlated with number of seeds/plant (0.87) and positively correlated with plant height, branches/plant, days to 50% flowering and days to 50% and 100% podding, while it correlated negatively with flowering duration. The positive and significant correlation between pods and seeds/plant with plant height indicate that tall plants may have more bud bearing nodes and hence produce more pods, seeds, and yield. Therefore selection based on taller plants may be effective in improving seed yield. Similar results were reported by Saraf *et al.* (1985) in lentil.

Regarding the relationships among earliness traits, the data show that early flowering (50% flowering) was related to termination of flowering (100% flowering). There were also strong positive correlations between 50% flowering and each of 50% and 100% podding, and between 50 and 100% flowering and 50 and 100% podding with days to maturity (Table 3). These results indicate that in future studies in lentil selection for early flowering (50% flowering) is sufficient to identify the earliness in podding and maturity without need to measure other earliness traits to save time and cost. The insignificant correlation between 100-seed weight and seed yield was due to that all tested genotypes characterized as small seeded type and had narrow range of 100-seed weight ranging from 1.9 to 2.98 g, except the genotype Sinai 1, which had medium seed size of 3.13 g/100 seeds.

Path coefficient analysis:

The results of partitioning the correlation coefficient by path analysis technique for seed yield/plant as the resultant variable and number of pods/plant, number of seeds/plant, 100-seed weight, plant height and number of branches/plant as causal variables were made. In addition the direct and indirect effects of the earliness characters, 50% flowering, 50% poding and days to 90% maturity on seed yield were also calculated and presented in Table 4.

Seed yield/plant vs. pods/plant:

The direct effect of number of pods/plant on seed yield/plant was positive and recorded 0.2661. The indirect effect via number of seeds/plant was positive and high (0.5481), indicating that the major indirect effect of pods/plant on seed yield was through seeds/plant. Indirect effects through plant height, branches/plant and days to 50% flowering were negative and negligible. The indirect effects via other traits were positive but low in magnitude. Table 4.

Seed yield/plant vs. seeds/plant:

The direct effect of seeds/plant on seed yield was positive and very high (0.6300). The highest value of indirect effect was through number of pods/plant (0.2515), while those through plant height, branches/plant, 50% flowering and maturity were negative and negligible. The other indirect effects via 100-seed and 50% poding were positive but low.

Seed yield/plant vs. 100-seed weight:

Seed weight had moderate and positive direct effect on seed yield (0.1413). The indirect effects were low in general, and positive except via plant height and maturity, which were negative and negligible. Although the correlation between seed yield and 100-seed weight was insignificant, the direct effect of 100-seed weight on seed yield showed the relatively highest value among both direct and indirect effects. Kumar *et al.* (1983) also found positive direct effect between both traits, and Dixit and Dubey (1984) reported insignificant correlation between seed yield and 100-seed weight in lentil, which agrees with our results.

Seed yield/plant vs. plant height:

The correlation between plant height and seed yield was positive (0.66). The direct effect of plant height on seed yield was positive and recorded 0.1253. The indirect effects via number of seeds and pods/plant were positive and high and recorded 0.3995 and 0.1764, respectively. These data indicate that the major indirect effect of plant height on seed yield was via seeds and pods/plant.

Seed yield/plant vs. number of branches/plant:

The direct effect of number of branches on seed yield was negative and small. The indirect effects were mainly via seeds/plant (0.3503) and pods/plant (0.1216). Other indirect effects were small and /or negative.

Seed yield/plant vs. days to 50% flowering:

The direct effect of days to 50% flowering on seed yield was negative and small and hence negligible. The data show that the largest indirect effect was via number of seeds/plant. Kumar *et al.* (1983) reported also negative direct effect of days to flowering on seed yield in lentil, which agrees with the present results.

Seed yield/plant vs. days to 50% poding:

The correlation between 50% poding and seed yield was very low and insignificant (0.016). The direct effect of days to 50% flowering on seed yield was negative and small and hence negligible. The highest indirect effect was clearly via number of seeds/plant.

Seed yield/plant vs. days to 90% maturity:

The direct effect of days to 90% maturity on seed yield was positive but small. Again the highest indirect effect was clearly via number of seeds/plant. Khattab (1992) also reported negligible direct and indirect effects of days to maturity on seed yield in lentil.

There are several reports of the correlations among yield, yield components and phenological characters in lentil based on few, relatively similar lines grown in single environments. But as heritability and genetic correlation are affected by the materials studied, the results have often been inconsistent because of inadequate sampling of genotypes and environments. Therefore, this study was planned to examine associations within genetically varied genotypes over three varied environments to get reliable results.

Comparison of the correlation and path analyses indicated that number of pods and seeds/plant were strongly positively correlated with seed yield, which in turn was insignificantly correlated with 100-seed weight. Path analyses confirmed the importance of direct and indirect relations among these two traits and seed yield. But as yield component selection has been unsuccessful in the past, probably because of yield compensation (Adams, 1967), and measuring yield is much less time-consuming than counting/measuring components, selection for yield components is not justified.

There are some additional interesting observations, while the correlation study showed weak association between seed yield and 100-seed weight (0.223), the path analysis indicated the importance of the direct effect of 100-seed weight on seed yield. On the other hand, path analysis revealed negligible direct effect between branches/plant and seed yield, but the correlation value between both traits was significant and recorded 0.46. It is therefore, suggested that in addition to correlation analysis, path analysis should also be conducted in order to develop a clearer picture of the interrelationship among characters.

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. Mean squares from combined analysis of variance over three environments at Sids (1997/98 and 1998/99) and Giza (1998/99) for 13 lentil characters.

Source of variance	D.F.	Seed Yield/ Plant (g)	No. of Pods/ Plant	No. of Seeds/ Plant	100-Seed weight (g)	Plant Height (cm)	No. of Branches /plant
Environments (E)	2	64.03**	44765.62**	116546.57**	19.03**	8333.67**	355.03**
Error (a)	6	0.06	19.82	84.05	0.07	105.19	2.54
Genotypes (G)	23	1.36**	1585.89**	3058.57**	1.43**	67.03**	13.27**
G x E	46	0.82**	1140.17**	1667.7**	0.54**	46.66**	7.87**
Error (b)	207	0.09	20.31	172.76	0.01	20.77	1.46

Source of variance	D.F.	Days to 50% flower.	Days to 100% flower.	Flower. Duration (day)	Days to 50% poding	Days to 100% poding	Poding Duration (day)	Dys to 90% maturity
Environments (E)	2	1726.07**	1611.73**	1333.67**	2932.46*	935.98**	1189.14**	6.98NS
Error (a)	6	2.79	2.03	2.34	5.79	3.73	20.72	2.61
Genotypes (G)	23	212.90**	342.48**	44.17**	322.50**	317.96**	72.03**	137.24**
G x E	46	43.28**	48.29**	30.59**	66.55**	78.95**	84.10**	46.31**
Error (b)	207	2.98	1.55	3.21	1.7	1.68	10.62	2.1

*,** Significant at 0.05 and 0.01 levels of probability

NS Not significant..

Table 3. Estimates of phenotypic correlation coefficients among 13 lentil characters of lentil genotypes evaluated at three environments.

Character	2	3	4	5	6	7	8	10	11	12	13
1- Seed yield/plant (g)	0.86**	0.95**	.66**	0.46**	0.19	-0.16	-0.51**	0.13	0.13	0.18	0.22
2- No. of pods/plant		0.87**	0.63**	0.56**	0.38**	0.05	-0.45**	0.25*	-0.04	0.2	0.01
3- No. of seeds/plant			0.70**	0.46**	0.31**	-0.04	-0.51**	0.2	0.02	0.2	-0.01
4- Plant height (cm)				0.53**	0.29**	-0.12	-0.57**	0.19	-0.08	0.14	-0.04
5- No. of branches/plant					0.34**	0.04	-0.42**	0.2	-0.17	0.03	-0.07
6- Days to 50% flowering						0.74**	0.18	0.77**	-0.38**	0.53**	-0.39**
7- Days to 100% flowering							0.49**	0.80**	-0.34**	0.53**	-0.46**
8- Flowering duration								0.14	0.01	0.07	-0.17
9- Days to 50% poding								0.86**	-0.49**	0.61**	-0.46**
10-Days to 100% poding									-0.2	0.72**	-0.29*
11-Poding duration										-0.14	0.40**
12-Days to 90% maturity											-0.12
13-100-seed weight (g)											-

*,** Significant at 0.05 and 0.01 levels of probability

Table 4. Direct (underlined values) and indirect effects of different studied characters on seed yield/plant and their correlation coefficients with seed yield/plant.

Character	Effects via								Correlation With SY
	1	2	3	4	5	6	7	8	
1- No. of pods/plant	0.2661	0.2515	0.0594	0.1764	0.1216	0.05	0.0043	0.0466	0.858**
2- No. of seeds/plant	0.5481	0.63	0.0044	0.3995	0.3503	0.2388	0.1443	0.1266	0.945**
3- 100-seed weight (g)	0.0795	0.0882	0.1413	-0.0172	0.0575	0.0389	0.0183	0.0249	0.223
4- Plant height (cm)	-0.0182	-0.015	-0.0011	0.1253	-0.0041	-0.0096	-0.0058	-0.0045	0.663*
5- No. of branches/plant	-0.0045	-0.0037	0.0013	-0.0035	-0.0327	-0.0941	-0.003	-0.0004	0.457*
6- Days to 50% flowering	-0.0258	-0.0164	0.0008	-0.0198	-0.0278	-0.012	0.0357	-0.06	0.188
7- Days to 50% poding	0.0118	0.0117	0.044	0.008	0.0019	0.0312	-0.1125	-0.017	0.016
8- Days to 90% maturity	0.001	-0.0013	-0.0271	-0.057	-0.0098	-0.0553	-0.0653	0.0586	0.175

*,** Significant at 0.05 and 0.01 levels of probability

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الارتباطات المباشرة وغير المباشرة بين صفات العدس

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تم دراسة معامل الارتباط وتحليل العبور على ٢٤ أصل وراثي للعدس زرعت في ثلاث بيئات في مصر (محطة البحوث الزراعية بسدس موسمي ١٩٩٧ / ٩٨ و ١٩٩٨ / ٩٩ ومحطة البحوث الزراعية في الجيزة موسم ١٩٩٨ / ٩٩).

وقد أظهرت النتائج وجود تأثير كبير لكل من موسم الزراعة والجهات على سلوك الأصناف، وأظهر تحليل الارتباط وجود ارتباط موجب ومعنوي بين محصول النبات الفردي وكل من عدد القرون وعدد البذور للنبات وطول النبات وعدد الفروع للنبات، بينما كان الارتباط بين محصول النبات وطول فترة التزهير معنوياً وسالباً، وقد ارتبط عدد الأيام من الزراعة حتى بداية التزهير (٥٠٪ تزهير) معنوياً مع كل من ١٠٠٪ تزهير، ٥٠٪ عقد القرون، و١٠٠٪ عقد القرون وعدد الأيام من الزراعة حتى ٩٠٪ نضج مما يؤكد أن الانتخاب لصفة ٥٠٪ تزهير يعتبر كافياً للتعبير عن التبكير في بداية ونهاية العقد والتبكير في النضج ولا داعي للانتخاب لكل صفات التبكير توفيراً للوقت والتكلفة. وقد أشارت نتائج تحليل العبور أن عدد البذور وعدد القرون للنبات أظهرا أعلى التأثيرات المباشرة على محصول النبات يليهما وزن الـ ١٠٠ بذرة، ولكن نظراً لأن الانتخاب للمحصول العالي من خلال الانتخاب لصفات مكونات المحصول لم يظهر نجاحاً في التجارب السابقة نظراً لأن تلك المكونات تعوض بعضها بعضاً، فإن الانتخاب المباشر لصفة محصول النبات الفردي يعتبر أكثر فائدة نظراً لسهولة وسرعة إجرائه مقارنة مع عدد القرون والبذور للنبات والتي تستغرق وقتاً وتكلفة أكثر في تجارب العدس.