COMBINING ABILITY, RECIPROCAL EFFECTS AND GENE ACTION IN F$_1$ DIALLEL CROSSES OF WHITE LUPIN (*LUPINUS ALBUS* L.)

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Abstract

The present investigation was carried out at Giza Research Station during 2003/2004 and 2004/2005 growing seasons. All F$_1$ crosses, including reciprocals, in a diallel mating design among five parents of white lupin differing in origin (Dijon-2, Giza-2, Kereskedelmi, Mutant-23 and Butter Cup) were studied to estimate the genetic components along with combining ability for earliness, seed yield and its components. Significant genotypes mean squares were detected for all traits, indicating genetic variability for all variables. The mean squares of general and specific combining ability were significant for all traits indicating the role of additive and non-additive gene action in the inheritance of these traits. Reciprocal effects were significant for all traits, suggesting maternal effects . Heterosis percentages of F$_1$ crosses relative to their respective mid and better parents were significantly positive in several crosses for plant height, number of branches, pods, seeds/plant, 100-seed weight and seed yield/plant. Negative heterosis percentage relative to mid and better parents were significant in some crosses for days to maturity. Both parents Butter Cup and Mutant-23 were good combiners for earliness. Dijon-2, Giza-2, Kereskedelmi and Mutant-23 could be superior combiners for number of pods, seed index and seed yield per plant. Moreover, its F$_1$ crosses recorded high SCA estimates for those traits. The additive component of genetic variability (D) was significant for all traits, except number of branches per plant. H$_1$ values were greater than D for number of branches, pods, seeds/plant, 100-seed weight and seed yield/plant, indicating the important role of dominance of genetic variance. Overall degree of dominance $(H_1/D)^{1/2}$ was less than unity for days to maturity and plant height, indicating partial dominance for these traits. The estimates of K_D/K_R were greater than one for plant height and seed index, which indicated an excess of dominant genes in the parents. The heritability values in broad sense were moderate for number of branches per plant and high for the other traits. However, narrow sense heritability estimates were relatively high for days to maturity and plant height, moderate for number of pods, seeds/plant, seed index and seed yield/plant, and low for number of branches per plant.

INTRODUCTION

White lupin (*Lupinus albus* L.) is considered one of the leguminous crops with a great potential because of its high seed protein content (between 35 – 45 % according to the genotype) and its adaptation to poor soils and dry climates. Nevertheless, white lupin makes a minor contribution to Egypt grain legumes production as its exploitation has been restricted due to several factors including late maturity and low yield of the commercial varieties. Therefore, improvement of earliness and high yield potential are primary objectives of white lupin breeders. An

understanding of the fundamental nature of the actions and interactions of genes involved in the inheritance of quantitative characters is very helpful to plant breeders in their choice of various selection and breeding procedures. The diallel analysis is a method for identifying those parents and hybrids that have superior combinations of the characters of interest. The estimation of the additive and dominance components of genetic variance is very important in evaluating the potential of any heterotic response.

Combining ability initially is a general concept considered collectively for classifying an inbred line relative to its cross performance as well as helps the breeder to identify the best combiners which may be hybridized either to exploit heterosis or to build up the favorable fixable genes. Several investigators reported that the manifestations of heterotic and combining ability effects in lupins ranged from significantly negative to significantly positive estimates for number of days to maturity, seed yield and its components (Lukashevich, 1981, Okaz *et al.*, 1986, Bushueva, 1988, Sech and Huyghe, 1991, Agarkova *et al.*, 1991 and El-Sayad *et al.*, 2002).

The present study was undertaken to estimate the magnitude of heterosis and combining ability as well as understanding the nature of gene action and estimating heritability of some quantative characters in white lupin hybrids.

MATERIALS AND METHODS

The experiments of the present study were carried out at Giza Research Station, Agricultural Research Center, during 2003/2004 and 2004/2005 growing seasons using the diallel mating design including reciprocals among five widely diverse white lupin genotypes. Four varieties: Dijon-2 (P_1), Giza 2 (P_2), Kereskedelmi (P_3) and Butter Cup (P_5) along with the promising M_8 mutant line: Mutant-23 (P_4), which was assessed and selected from a previous study (El-Sayad and El-Barougy, 2002), were used as parents in the current investigation. They are briefly described in Table 1. All possible cross combinations among these five lupin genotypes were made during 2003/2004 season. In the second season (2004/2005), an evaluationtrial was carried out involving the five Parents and the derived 20 F_1 hybrids using a randomized complete block design with three replications. Each plot consisted of one ridge 3 m long and 60 cm width. Hills were spaced 20 cm with one seed per hill on one side of the ridge. Sowing dates took place at early November. The normal recommended cultural practices were followed. Ten guarded individual plants were taken at random from each experimental plot and the following characters were recorded: days to maturity (90 % of plants reached maturity), plant height (cm), number of branches per plant, number of pods per plant, number of seeds per plant, 100-seed weight (g) and seed yield per plant (g).

Table 1. Origin, pedigree and some characteristics of the five white lupin genotypes.

Genotype	Origin	Pedigree	Maturity	Crowth habit	Alkaloid content
P_1 (Digon-2)	France	French variety	Late	Indeterminate	High alkaloid (bitter lupin)
P_2 (Giza-2)	Egypt	Local variety select from land race	Late	Indeterminate	High alkaloid (bitter lupin)
P_3 (Kereskedelemi)	Hungaria	Hungarian variety	Late	Indeterminate	High alkaloid (bitter lupin)
P_4 (Mutant-23)	Egypt	M_8-induced mutant line derived from cv. Giza-1 by 2.5 KR*	Moderate	Indeterminate	Moderate alkaloid (bitter lupin)
P_5 (Butter Cup)	Australia	Australian variety	Early	Determinate	Free alkaloid (sweet lupin)

*KR is a dosage of gamma-rays.

Regular analysis of variance of RCBD on plot mean basis was conducted to test the differences among genotypes. The heterotic effect of F_1 crosses was estimated as percentage over mid and better parents. An appropriate "t" test was made for the significance of the F_1 crosses means from mid and better parents values (Wynne *et al.*, 1970). Combining ability analysis was conducted according to method 1, Model 1 of Griffing (1956) and genetic ratios were estimated according to Jinks (1954), Hayman (1954 a) and Mather and Jinks (1971).

RESULTS AND DISCUSSION

Significance of variance:

The significance of observed mean squares in F_1 generation due to genotypes, GCA, SCA and reciprocals are shown in Table 2. Highly significant differences among genotypes were detected for all the studied characters indicating genetic diversity between parental genotypes along with F_1 hybrids. The mean squares of GCA and SCA were highly significant for all the studied characters. These results pointed to the role of both additive and non-additive effects in the inheritance of these traits. The mean squares of reciprocals were highly significant for all the studied characters suggesting that these traits were additionally affected by non-chromosomal inherited factors in the female parents. The ratio of GCA/SCA exceeded the unity for all the

studied characters indicating that the additive gene action was more important than dominance for these characters. These findings are in accordance with those obtained by Sech and Huyghe (1991).

Mean Performance:

The mean performance of the five parents and their F_1 crosses including reciprocals for different characters are presented in Table 3. Mutant-23 recorded the highest value of seed yield, number of branches, pods and seeds per plant followed by Dijon-2, which was the latest parent and gave the highest value of plant height. Meanwhile, the sweet lupin variety Butter Cup was the earliest parent in maturity and had the lowest values of plant height, number of branches, pods, seeds and seed yield per plant but it had the highest value of 100-seed weight. Regarding the tested crosses in F_1 generation, three crosses: $(P_3 \times P_1)$, $(P_2 \times P_3)$ and reciprocal $(P_3 \times P_2)$ exhibited significantly fewer number of days to maturity compared to the earliest parent. The cross $(P_2 \times P_3)$ exceeded significantly the tallest parent, while the cross $(P_4 \times P_1)$ decreased significantly the shortest parent. Six crosses: $(P_1 \times P_2)$, $(P_1 \times P_4)$: $(P_2 \times P_4)$, $(P_3 \times P_4)$, $(P_5 \times P_1)$ and $(P_5 \times P_2)$ gave higher number of branches per plant. The crosses $(P_4 \times P_1)$ and $(P_5 \times P_1)$ showed higher estimates for 100 seed weight. Most of the crosses exceeded significantly the best parent in number of pods, seeds and seed yield per plant. Moreover, the crosses $(P_1 \times P_3)$, reciprocal $(P_3 \times P_1)$, $(P_1 \times P_4)$, $(P_2 \times P_3)$, $(P_2 \times P_4)$, and $(P_3 \times P_4)$ recorded the highest values for these traits. It could be concluded that the above mentioned parents and crosses would be interesting and prospective for the future in white lupin breeding for improving the maturity date and productivity.

Table 2. Significance of mean squares due to genotypes, general GCA and specific SCA combining ability and reciprocal in F_1 generation for the studied characters.

Source of variation	d.f.	No. of days to maturity	Plant height (cm)	No. of branches/ plant	No. of pods /plant	No. of seeds /plant	100-seed weight (g)	Seed yield/plant (g)
Genotypes	24	203.56**	651.91**	1.84**	247.34**	2792.75**	68.47**	520.46**
GCA	4	266.77**	905.81**	1.05**	192.10**	2778.21**	55.94**	489.48**
SCA	10	22.46**	121.20**	0.43**	57.97**	756.72**	18.44**	142.15**
Reciprocal	10	33.68**	38.01**	0.62**	63.06**	366.20**	13.96**	78.43**
Error	48	3.77	14.09	0.21	4.59	32.58	1.85	5.33
GCA/SCA			7.47	2.44	3.31	3.67		

** significant differences at 0.01 level of probability.

Table 3. Mean performance of the parents and their F1 diallel crosses for the studied characters.

Genotype	No.of days to maturity	Plant height (cm)	No. of branches/ plant	No.of Pods/ plant	No.of Seeds/ plant	100-seed weight (g)	Seed yield /plant (g)
Dijon-2 (P₁)	173	111.3	4	18.3	72.3	44	31.9
Giza-2 (P₂)	167.7	97.3	4	14.7	40.3	45.3	20.1
Kereskedelemi (P₃)	167	87.3	3.7	17.7	61.0	30.7	19.6
Mutant-23 (P₄)	156.7	105.0	4.7	19.7	78.3	43.8	35.8
Butter Cup (P₅)	151.3	58.3	3	8.3	30.3	45.8	13.0
P₁ × P₂	166.3	103.7	5	23.7	92.0	44.2	39.7
P₁ × P₃	170.3	108.3	4.7	29.7	111.3	40.6	45.3
P₁ × P₄	180.0	93	5.7	32.0	112.0	40.6	45.3
P₁ × P₅	159.7	87	4	14.7	44.0	44.0	20.3
P₂ × P₁	164.7	96	4.3	28.7	99.7	37.5	36.7
P₂ × P₃	161.0	103.7	4.7	35.7	112.0	39.3	44.3
P₂ × P₄	158.3	105.3	6.7	34.3	117.7	47.7	56.3
P₂ × P₅	155.0	92.7	4.3	18.0	54.7	38.7	22.0
P₃ × P₁	163.7	110	4.7	32.0	127.7	42.9	54.3
P₃ × P₂	159.7	101.7	4.7	28.0	107.3	39.0	40.0
P₃ × P₄	156.7	94.7	6	44.7	124.3	43.1	53.0
P₃ × P₅	153.3	64.3	4	16.7	57.7	33.8	20.3
P₄ × P₁	159.7	97	4.5	20.3	76.0	47.0	35.0
P₄ × P₂	158.3	101.3	4.3	29.3	93.7	44.0	42.7
P₄ × P₃	160.7	83	4	14.0	57.7	36.7	21.3
P₄ × P₅	150.3	60	3.5	11.0	35.3	38.0	13.8
P₅ × P₁	148.3	91.7	5	18.3	46.0	51.0	24.7
P₅ × P₂	148.3	98.3	5	22.0	65.3	42.4	27.7
P₅ × P₃	148.7	84.7	4	21.7	76.0	36.2	27.7
P₅ × P₄	149.7	72.7	4	12.3	45.0	41.8	18.7
LSD at 0.05 LSD at 0.01	3.19 4.25	6.16 8.21	0.74 0.98	3.52 4.69	9.37 12.49	2.23 2.98	3.79 5.05

Heterotic effects:

Heterosis percentages relatives to mid (MP) and better (BP) parents are presented in Table 4 . Concerning the number of days to maturity, data showed that seventeen crosses were significantly earlier than the means of mid-parents with heterotic effects ranged from --1.5 to -8.6 %. Moreover, heterosis percentages relative to mid-parents were significantly positive in eight, thirteen, fifteen, fourteen, seven and fourteen crosses with a range of 8.1 - 26.3, 17.6 - 52.3, 28.5 - 139.0, 26.3 - 120.9, 7.0 - 15.5 and 24.5 - 122.6% for plant height, number of branches, pods, seeds, 100-seed weight and seed yield per plant, respectively.

However, heterosis percentages relative to better parents were significant with negative values in three crosses and ranged from −2.0 to −4.4 % for number of days to maturity. Meanwhile, heterosis percentages relative to better parents were significant with positive values in one cross for plant height (6.6 %), in six crosses for number of branches per plant (21.3 - 42.6 %), in twelve crosses for number of pods per plant (22.6 - 126.9 %), in thirteen crosses for number of seeds per plant (19.7 - 83.6 %), in three crosses for 100-seed weight (5.3 - 11.4 %) and in thirteen crosses for seed yield per plant (15.0-120.4%). The high magnitudes of heterotic values found in these materials were expected due to the diversity of the parents.Therefore, improvement would be expected from selection in the advanced segregating generations. These results are in general agreement with those reported by Agarkova *et al.* (1991), Sech and Huyghhe (1991) and El-Sayad *et al.* (2002).

General combining ability effects:

The estimated effects of general combining ability (gi) for each trait of the five parents are included in Table 5. High positive estimates were found for all traits except number of days to maturity where also the high negative estimates of this effect would be useful from the breeder's point of view. Therefore, the results suggested that both parents Butter Cup and Mutant-23 were good combiners for earliness. They gave highly significant negative GCA effects for number of days to maturity. Both parents Dijon-2 and Giza-2 seemed to be better combiners for plant height. Moreover, Dijon-2, Giza-2 and Mutant-23 showed to be good combiners for number of branches per plant and 100-seed weight. Additionally, Dijon-2, Giza-2, Kereskedelmi and Mutant-23 could be superior combiners for number of pods, seeds and seed yield per plant. They exhibited highly significant and positive GCA effects for these traits. The detection of the combining ability of the parental genotypes provides better information not only for selecting the parents for hybridization but also in choosing the proper breeding scheme.   Agarkova *et al.* (1991) reported that the use of phenotypically similar mutants with multiple allelism in hybridization appeared promising for breeding work.

Table 4. Percentage of heterosis over mid parents (MP) and better parents (BP) for various studied characters.

Cross	Days to maturity		Plant height (cm)		No. of branches/plant		No. of pods/plant		No. of seeds/plant		100-seed weight (g)		Seed yield/plant (g)	
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
P1 × P2	-2.4**	-0.8	-0.6	-6.8*	25.0**	25.0**	43.6**	29.5**	63.4**	27.3**	-1.1	-2.4	52.7**	24.5*
P1 × P3	0.2	2.0*	9.1**	-2.7	20.5**	17.5	65.0**	62.3**	66.9**	53.3***	8.6**	-	75.6**	42.0*
P1 × P4	9.2**	14.9*	-	-16.4**	29.5**	21.3**	68.4**	62.4**	48.7**	43.0**	15.3*	-	33.6**	26.5*
P1 × P5	-1.5*	5.6**	2.6	-21.4**	14.3	0.0	10.5	-19.7*	-14.2*	-	-2.0	-3.0	-9.8	-
P2 × P1	-3.3**	-1.8	-	-13.7**	7.5	7.5	73.9**	56.8***	77.1**	37.9***	-	-	41.2**	15.0*
P2 × P3	-3.8**	-3.6**	12.4*	6.6*	20.5**	17.5	120.4*	101.7*	120.9*	83.6**	3.4	-	122.6**	120.4
P2 × P4	-2.4**	1.0	4.1	0.3	52.3**	42.6**	99.4**	74.1**	98.5**	50.3**	7.0**	5.3*	101.5**	57.3*
P2 × P5	-2.8**	2.4*	19.2**	-4.7	22.9**	7.5	56.5**	22.4	52.1**	35.7**	-	-	32.5**	9.5
P3 × P1	-3.7**	-2.0*	10.8*	-1.2	20.5**	17.5	77.8**	74.9**	95.5**	76.6**	14.7*	-2.5	110.5**	70.2*
P3 × P2	-4.6**	-4.4**	10.2*	4.5	20.5**	17.5	72.8**	58.2**	111.6*	75.9**	2.6	-	101.0**	99.0*
P3 × P4	-3.2**	0.0	-1.7	-9.8**	42.9**	27.7**	139.0*	126.9*	78.3**	58.7**	15.5*	-1.6	91.3**	48.0*
P3 × P5	-3.7**	1.3	-	-26.3**	17.6*	8.1	28.5**	-5.6	26.3**	-5.4	-	-	24.5**	3.6
P4 × P1	-3.1**	1.9	-	-12.8**	2.3	-4.3	6.8	3.0	0.9	-2.9	7.1**	6.8**	3.2	-2.2
P4 × P2	-2.4**	1.0	0.1	-3.5	-2.3	-8.6	70.3**	48.7**	58.0**	19.7**	-1.3	-2.9	58.2**	19.3*
P4 × P3	-0.7	2.6*	-	-20.9**	-4.8	-14.9	-	-	-	-	-1.6	-	-23.1**	-
P4 × P5	-2.4**	-0.7	-	-42.9**	-10.3	-	-21.4*	-	-	-	-	-	-43.4**	-
P5 × P1	-8.6**	-2.0	8.1**	-17.6**	42.9**	25.0**	37.6**	0.0	-10.3	-	13.6*	11.4*	9.8	22.6*
P5 × P2	-7.0**	-2.0	26.3*	1.0	42.9**	25.0**	91.3**	49.7**	85.0**	62.0**	-	-	66.8**	37.8*
P5 × P3	-6.6**	-1.7	16.3*	-3.0	17.6*	8.1	66.0*	22.6*	66.3**	24.6**	-5.5*	-	69.9**	41.3*
P5 × P4	-7.5**	-1.1	-	-30.8**	2.6	-14.9	-12.1	-	-17.1*	-	-	-	-23.4**	-

* and ** significant differences at 0.05 and 0.01 level of probability, respectively.

Specific combining ability effects:

The estimated effects of specific combining ability (Sij) are presented in Table 6. The crosses: (P_1 x P_2), (P_1 x P_5), (P_2 x P_3), (P_2 x P_5), (P3 x P4) and (P_3 x P_5) exhibited negative significant SCA effects for days to maturity. Concerning plant height, four crosses: (P_1 x P_3), (P_1 x P_5), (P_2 x P_4) and (P_2 x P_5) expressed positive significant SCA effects. On the other hand, because sometimes it is useful to breed for short plants, three crosses (P_1 x P_2), (P_1 x P_4) and (P_4 x P_5) showed negative significant SCA effects for this trait. Most of crosses had positive significant SCA effects for number of branches per plan

Table 5. Estimates of general combining ability effects (gi) of the parental genotypes in F1 generation for the studied characters.

Parent	No. of days to maturity	Plant height (cm)	No. of branches /plant	No. of pods /plant	No.of seeds /plant	100-seed weight (g)	Seed yield /plant (g)
P1 (Dijon-2)	6.33**	8.49**	0.09**	1.08**	8.03**	2.17**	4.25**
P2 (Giza-2)	1.17**	7.29**	0.19**	2.38**	4.89**	0.93**	2.72**
P3 (Kereskedelemi)	1.27**	0.33	-0.11**	3.25**	12.19**	-4.00**	2.29**
P4 (Mutant-23)	-0.83**	-0.74	0.33**	0.95**	4.16**	0.90**	3.19**
P5 (Butter Cup)	-7.93**	15.37**	-0.51**	-7.65**	29.27**	0.00	-12.45**
S. E. (gi)	0.32	0.61	0.07	0.35	0.93	0.22	0.38
S. E. (gi-gj)	0.50	0.97	0.12	0.55	1.47	0.35	0.60

*and ** significant differences at 0.05 and 0.01 level of probability, respectively.

The crosses (P_1 x P_3), (P_2 x P_3) and (P_2 x P_4) had positive significant SCA effects for number of pods, seeds, 100-seed weight and seed yield per plant. Moreover, the two crosses: (P_2 x P_5) and (P_3 x P_5) exhibited positive significant SCA effects for number of pods and seed yield per plant. The two crosses (P_1 x P_4) and (P_3 x P_4) showed positive significant SCA effects for number of pods per plant. Also, the two crosses (P_1 x P_5) and (P_3 x P_4) showed positive significant SCA effects for 100-seed weight. From the breeding point of view, parents characterized by good GCA for yield and its components along with high estimates of SCA effects are obiviously essential. A great deal of interest has been given to select crosses that contain both good general combining parents and crosses involving one good and one poor combining parents with SCA effects. This conclusion is in agreement with those obtained by Bushueva (1988) and Sech and Huyghe (1991).

Reciprocal effects:

Regarding to reciprocal effects (rij) in Table 7, only one cross Mutant-23 x Kereskedelmi (P_4 x P_3) showed negative significant reciprocal effects for days to maturity as well as positive significant reciprocal effects for the other studied traits. Moreover, the cross Giza-2 x Dijon-2 (P_2 x P_1) expressed positive significant reciprocal effects for both number of branches per plant and 100-seed weight, the cross Mutant 23 x Dijon-2 (P_4 x P_1) for number of branches, pods, seeds and seed yield per plant, the cross Kereskedelmi x Giza-2 (P_3 x P_2) for both number of pods and seed yield per plant; and the cross Mutant-23 x Giza-2 (P_4 x P_2) for number of branches, pods, seeds, 100-seed weight and seed yield per. Results suggested that earliness of maturity, seed yield and its components appeared to be influenced by the female parent. Reciprocal differences may result from maternal differences and plasmon- gene interactions. Sech and Huyghe (1991) and El-Sayad *et al.* (2002) found reciprocal cross differences occurring among white lupin reciprocal F_1 hybrids.

Gene action:

Data were subjected to the diallel analysis proposed by Hayman (1954 a), Mather and Jinks (1971) to obtain more information about the genetic behavior of the studied traits. The computed parameters presented in Table 8 showed that the additive components of genetic variability (D) were significant or highly significant for all traits except number of branches per plant, indicating that the additive gene action was more important than the non-additive in controlling the inheritance of these traits. Whereas, dominance gene action played an important role in the inheritance of number of branches per plant, which had insignificant D value inspite of obtained significant GCA mean square for it. Dominance may play a role in GCA estimates as emphasized by Jinks (1954).

In each case H_1 and H_2 (dominance components of genetic variance) were significantly different from zero and H_1 was greater than H_2 in all cases except number of branches per plant, indicating that the positive and negative alleles at the loci for these traits were not equal in proportion in the parents. Theoretically, H_2 should be equal to or less than H_1 (Hayman, 1954 b). Since D was greater than H_1 for days to maturity and plant height, suggesting that additive genetic variance was more important. However, number of branches, pods, seeds, 100-seed weight and seed yield per plant showed high values of H_1 than D, indicating the important role of dominance of genetic variance. These results are in accordance with those obtained by Khotyljova *et al.* (1996) and El-Sayad *et al.* (2002).

Table 6. Estimates of specific combining ability effects (Sij) of different crosses in F₁ generation for the studied characters.

Cross	No.of days to maturity	Plant height (cm)	No. of branches/ plant	No.of pods /plant	No.of seeds /plant	100-seed weight (g)	Seed yield /plant (g)
P1 × P2	-1.53**	-8.39**	-1.13**	0.19	5.61	-3.67**	-1.09
P1 × P3	-0.13	7.91**	0.17**	3.99**	21.97**	2.27**	11.01**
P1 × P4	4.80**	-5.19**	0.24**	1.62**	4.51	-0.80**	0.45
P1 × P5	-3.93**	3.77*	0.41**	0.55	-11.06**	3.93**	-1.59*
P2 × P3	-1.63**	2.61	0.07**	3.69**	14.77**	0.83**	4.88**
P2 × P4	-1.53**	4.34**	0.47**	5.99**	19.31**	2.60**	11.31**
P2 × P5	-1.10*	11.14**	0.47**	2.75**	7.07	-1.83**	2.28**
P3 × P4	-1.30**	-3.19	0.27**	2.62**	-2.66	1.87**	-0.59
P3 × P5	-1.87**	-1.56	0.11**	1.05*	6.61	-2.23**	1.88**
P4 × P5	-0.77	-9.99**	-0.49**	-5.48**	-14.19**	-4.47**	-8.19**
S. E. (gi)	0.65	1.26	0.15	0.72	1.91	0.46	0.78
S. E. (gi - gi)	1.00	1.94	0.23	1.11	2.95	0.70	1.19

*and ** significant differences at 0.05 and 0.01 level of probability, respectively.

Table 7. Estimates of reciprocal effects (rij) of different crosses in F1 generation for the studied characters.

Cross	No.of days to maturity	Plant height (cm)	No. of branches/plant	No.of pods /plant	No.of seeds /plant	100-seed weight (g)	Seed yield /plant (g)
P2 × P1	0.83	3.83	0.33**	-2.50**	-3.83	3.50**	1.50
P3 × P1	3.33**	-0.83	0.00	-1.17	-8.17	-1.17**	-4.50**
P4 × P1	10.17**	-2.00	0.50**	5.83**	18.00**	-3.33**	5.17**
P5 × P1	5.67**	-2.33	-0.50**	-1.83*	-1.00	-3.50**	-2.17*
P3 × P2	0.67	1.00	0.00	3.83**	2.83	0.17	2.17*
P4 × P2	0.00	2.00	1.17**	2.50**	12.00*	1.83**	6.83**
P5 × P2	3.33**	-2.83	-0.33**	-2.00*	-5.33	-1.83**	-2.83**
P4 × P3	-2.00**	5.83*	1.00**	15.33**	33.33**	3.17**	15.83**
P5 × P3	2.33**	-8.83**	0.00	-2.50**	-9.17	-1.17**	-3.67**
P5 × P4	0.33	-6.33**	- 0.17**	-2.00*	-7.00	-3.83**	-3.83**
S. E. (sij)	0.79	1.53	0.19	0.89	2.33	0.56	0.94
(S. E. sij- sik)	1.12	2.17	0.26	1.24	3.30	0.79	1.33

*and ** significant differences at 0.05 and 0.01 level of probability, respectively.

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Table 8. Estimates of genetic and environmental components with mean of genetic estimates and heritability values for the studied characters in F1's diallel crosses.

Components of variance	No.of days to maturity	Plant height (cm)	No. of branches /plant	No.of pods /plant	No.of seeds /plant	100-seed weight (g)	Seed yield /plant (g)
D	74.71** ± 3.87	418.32**± 13.08	0.183 ± 0.074	15.87* ± 4.67	394.56 ± 45.90	38.58** ± 1.99	83.77** ± 9.02
F	-19.24 ± 9.68	127.57* ± 32.66	-0.223 ± 0.184	-31.48 ± 11.68	-144.73 ± 114.66	23.27* ± 4.97	-15.93 ± 22.54
H1	48.64* ± 10.46	292.38**± 35.31	0.429 ± 0.199	134.39**± 12.62	2016.76** ± 123.96	39.54** ± 5.37	369.20** ± 24.37
H2	37.68* ± 9.49	219.05**± 32.03	0.519 ± 0.180	107.11** ± 11.45	1456.96**± 112.43	32.53** ± 4.87	276.04** ± 22.11
E	3.77 ± 1.58	13.27 ± 5.34	0.184** ± 0.030	4.59 ± 1.91	32.53 ± 18.74	1.82 ± 0.81	5.45 ± 3.68
h2	81.01	1.36	2.45	287.86	2707.02	2.01	419.03
(H1/D)½	0.807	0.836	1.532	2.910	2.261	1.012	2.099
H2/4H1	0.194	0.187	0.303	0.199	0.181	0.206	0.187
KD/KR	0.725	1.446	0.412	0.492	0.850	1.849	0.913
h2/H2	2.150	0.006	4.727	2.688	1.858	0.062	1.518
eritability: Broad sense Narrow sense	0.943 0.799	0.945 0.728	0.614 0.341	0.933 0.543	0.966 0.581	0.914 0.529	0.968 0.564

*and ** significant differences at 0.05 and 0.01 level of probability, respectively.

The covariance of additive and dominance effects (F) were negative for days to maturity as well as number of branches, pods, seeds and seed yield per plant, but they were positive for plant height and 100-seed weight. Negative estimates of F indicates an excess of recessive alleles, while the positive estimates of F indicates an excess of dominant ones. All estimates of the environmental variance (E) were insignificant for all studied traits except number of branches per plant, indicating that this trait has been affected by environmental factors. The overall dominance effects of heterozygous loci (h^2) were positive in all traits, indicating that the effect of dominance was due to heterozygosity and that direction of dominance was positive. Overall degree of dominance estimated by $(H_1/D)½$ was less than unity for days to maturity and plant height, indicating partial dominance for these traits, while the over

dominance was important in the inheritance of the other traits. Yassen (1988), Klochko *et al.* (1996) and El-Sayad *et al.* (2002) reported that both additive and dominance gene action were the most important components controlling variation for days to maturity, seed yield and its components.

The proportion ($H_2/4H_1$) was lower than 0.25 for all traits except number of branches per plant, indicating that positive and negative alleles were not equally distributed among the parents. The estimates of K_D/K_R were greater than one for plant height and weight of 100-seed, indicating an excess of dominant genes in the parents for these traits. Meanwhile, K_D/K_R were less than one for days to maturity, number of branches, pods, seeds and seed yield per plant, indicating an excess of recessive genes in the parents for these traits.

The heritability values in broad sense were moderate for number of branches per plant and high for the other traits. However, narrow sense heritability estimates were relatively high for days to maturity and plant height, moderate for number of pods, seeds, 100-seed weight and seed yield per plant and low for number of branches per plant. These results indicated that dominant genetic variance was more important for number of branches per plant. However, days to maturity, plant height, number of seeds and seed yield per plant are mostly controlled by additive gene action and it is possible to breed for improving these traits. These findings are in general agreement with those obtained by Sech and Huyghe (1991), Klochko *et al.* (1996) and El-Sayad *et al.* (2002).

In general , pedigree selection program for all studied traits, except number of branches per plant could be more efficient for obtaining desirable improvement in these traits in the advanced segregating generations.

REFERENCES

1. Agarkova, S. N., N. F. Pukhal and M. P. Miroshnikova. 1991. Study of genetic aspects of heterosis in pea and *Lupinus angustifolius*. Genetika Moskva, 27 (10): 1799 - 1800.

2. Bushueva, V. I. 1988. Using combining ability in breeding narrow-leaved lupin. Plant Breed. Abst. 58 (6): 5154.

3. El-Sayad, Z. S. and Ebtehag El-Barougy. 2002. Development of some white lupin mutant lines high yielding, early maturing and resistant to fusarium wilt. Annals of Agric. Sci., Ain Shams Univ., Cairo 47 (2): 641 – 657.

4. El-Sayad, Z. S., R. E. El-Lithy, Saba M. Attia, M. S. Said and Samia A. Mahmoud. 2002. Heterosis, inbreeding depression and gene action of some quantitative characters in diallel cross among five white lupin genotypes. Annals of Agric. Sci., Ain Shams Univ., Cairo 47 (2): 659 - 679.

5. Griffing, J. B. 1956. Concept of general specific combining ability in relations to diallel crossing system. Aust. J. Biol. Sci., 9: 463 - 493.

6. Hayman, B. I. 1954 a. The analysis of variance of diallel tables. Biometrics, 10: 235 - 244.

7. Hayman, B.I. 1954 b. The theory and analysis of diallel crosses. Genetics, 42 : 336 – 355.

8. Jinks. J. L. 1954. The analysis of continuous variation in a diallel cross of *Nicrotiona rustica* varieties. Genetics, 39 : 767 – 788.

9. Khotyljova, L. V., L. A. Tarutina, V.N. Kavtsevich and A. P. Savchenko. 1996. Genetic control of quantitative characters in yellow lupin. Abst. Book of 8th Int. Lupin Conf., Pacific, California, USA.

10. Klochko, N. A., L.Narvaes and N. F. Anikeeva. 1996. combining ability of *L. angostifolius* varieties in a diallel crossing scheme. Plant Breed. Abst., 66 (4): 3808.

11. Lukashevich, M. I. 1981. Breeding and genetical study of intervarietal hybrids of yellow fodder lupin. Plant Breed. Abst., 51 (5) : 4306.

12. Mather, K. and J. K. Jinks. 1971. Diallel. In Biometrical Genetics. Chapman and Hall, London, 249 – 284.

13. Okaz, A. M., E. A. El-Gharib, A. F. Abdalla, S. B. Mourad and H. E. Yassen. 1986. Heterosis in some crosses of the genus *Lupinus.* Al-Azhar J. Agric Res., 5 : 296 - 306.

14. Sech, L. and C. Huyghe. 1991. Diallel analysis in white lupin: consequences for breeding. Agronomie. 11: 719 - 726.

15. Wynee, J. C., D. A. Emery and P. W. Rice. 1970. Combining ability estimates in *Arachis hypogaea* L. II. Field performance of F_1 hybrids. Crop. Sci., 10: 713 - 715.

16. Yassen, H. E. 1988. Breeding studied on lupin for high yield and quality. Ph.D. Thesis, Fac. Agric., Al-Azhar Univ., Cairo, Egypt.

القدرة على التآلف ، التأثيرات العكسية وفعل الجين

للهجن التبادلية فى الترمس

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– مصر

أجريت هذه الدراسة بمحطة البحوث الزراعية بالجيزة على خمسة آباء (Dijon-2 ، جيزة-٢
Kereskedelmi, ، الطفرة-٢٣ ، Butter Cup) من الترمس وجميع الهجن التبادلية بينهـا متضـمنة
الهجن العكسية فى الجيل الأول خلال الموسمين ٢٠٠٤/٢٠٠٣، ٢٠٠٥/٢٠٠٤ بهدف تقـدير قـوة
الهجين والقدرة العامة والخاصة على الائتلاف وتأثيرات الهجن العكسية وكذلك لدراسة فعل الجـين
وتقدير درجة التوريث بمعناها الواسع والضيق وذلك لصفات التبكير فى النضج، طول النبات ، عدد
الأفرع للنبات، عدد القرون للنبات، عدد البذور للنبات، وزن ١٠٠ بذرة ووزن محصول النبات وتـم
تحليل النتائج حسب ما أقترحه العالم جريفنج (١٩٥٦) والعالم هايمان (١٩٥٤) ويمكن تلخيص النتائج
كما يلى:

كان التباين الراجع للتراكيب الوراثية وكذلك التباين الراجع للقدرة العامة والخاصة على الائتلاف كان
معنويا لكل الصفات تحت الدراسة مما يشير الى أهمية كل من التأثير المضيف وغير المضيف للفعل
الجينى على توريث هذه الصفات.

أوضحت النتائج تفوق بعض هجن الجيل الأول تفوقاً معنوياً مقارنة بمتوسط الأبوين والأب
الأحسن لجميع الصفات المدروسة.

أظهرت الآباء Butter Cup، الطفرة-٢٣ قدرة عامة على التآلف مرغوبة لصفة التبكير فى
النضج كما تفوقت الآباء Dijon-2، جيزة-٢، Kereskedelmi والطفرة-٢٣ فى قدرتها العامة على
التآلف لصفات عدد القرون للنبات، عدد البذور للنبات وكذلك وزن محصول النبات هذا وقد سجلت
الهجن الناتجة من تلك الآباء قيم مرتفعة للقدرة الخاصة على التآلف للصفات المذكورة، كما
كان هناك تأثيرات معنوية لبعض الهجن العكسية لجميع الصفات تحت الدراسة مما يوضح أهمية
التأثيرات الأمية فى وراثة هذه الصفات.

أظهر تحليل النتائج أن تأثير العوامل ذات الأثر المضيف كان معنويا واكثر أهمية من دور
العوامل ذات الأثر غير المضيف فى وراثة الصفات تحت الدراسة ماعدا صفة عدد الأفرع للنبات مما
يؤكد جدوى الانتخاب لهذه الصفات خلال الأجيال الانعزالية المبكرة.

كما أظهرت النتائج أن درجة التوريث بمعناها الواسع كانت متوسطة لصفة عدد الأفرع
للنبات وعالية لباقي الصفات تحت الدراسة، بينما كانت درجة التوريث بالمعنى الضيق مرتفعة
لصفات التبكير فى النضج وطول النبات بينما كانت متوسطة لصفات عدد القرون للنبات، عدد
البذور للنبات، وزن ١٠٠ بذرة ووزن محصول النبات ومنخفضة لصفة عدد الأفرع للنبات.