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COMBINING ABILITY ESTIMATE IN F_2 FLAX POPULATIONS FOR SOME QUANTITATIVE TRAITS UNDER NORMAL AND SALINE SOIL CONDITIONS

El-Refaie, Amany M. M. and M. M. M. Hussein
Fiber Crops Res. Department, Field Crops Res .Inst., A.R.C., Giza, Egypt

ABSTRACT

The present investigation was conducted using six flax genotypes with their 15 F_2 crosses grown under two environments {normal soil (E_1= Kafr El-Hamam – Shrkia Governorate) and saline soil (E_2= Tag El-Ezz,- El Dakahlia Governorate)} to determine the combining ability and gene action of some agronomic flax characters in these entries (parents and their crosses). In 2009/10 season, the six parents { P_1= Giza 8, P_2 (S.402/1) , P_3 (S.420/140/5/11), P_4 (S.421/43/14/7), P_5 (S.533/39/5/3) and P_6 (Daniela)} as well as their 15 progenies were sown in first week of November to evaluated in a randomized complete block design with three replicates at the two above- mentioned locations.

High ratio of GCA/SCA revealed that additive played greater role than non-additive genetic effects in the inheritance of straw weight and its components as well as seed weight, 1000-seed weight and number of seeds/capsule under the two environments and combined analysis. On the other hand, both additive and non-additive types of gene action were involved in the inheritance of number of capsules/plant. Mean squares of interaction between environment and both types of combining ability for most studied traits revealed that the magnitude of both additive and non-additive types of gene action varied from environment to another. Whereas the non-additive genetic effects are more influenced by saline environment than additive effects in each of straw weight, plant height, technical stem length, seed weight, 1000-seed weight and number of seeds per capsule. While, additive gene effects were much more influenced by saline environment than non-additive effects for number of capsules per plant. P_5(S.533/39/5/3) exhibited good general combining ability effects for straw weight per plant and its two important components; plant height and technical stem length in addition P_2 for both seed weight and 1000-seed weight as well as P_1 for 1000-seed weight under the two environments and combined data. For Sij effects, one cross ($P_5 \times P_6$) which exhibited positive significant SCA effects for straw weight per plant and its components as well as seed weight per plant and number of capsules per plant in addition three crosses (P_1xP_3, P_1xP_6 and P_4xP_6) for 1000-seed weight under the two environments and combined analysis. Therefore, these crosses are suitable in breeding program for increasing the previous characters. The correlation between cross means and their SCA values was significant and positive for straw weight and its components as well as seed yield and its two important components, number of capsules per plant and 1000-seed weight indicating that high performing crosses were high specific combinations.
Keywords: Flax, Diallel analysis, Gene action, under different environments.

INTRODUCTION

Flax (*linum usitatissimum* L.) is one of the oldest plants cultivated by man for its seeds and fiber. Linseed oil has been the most important source of drying oil for the paint and varnish industry. Fibers obtained from stems of flax are widely used in the textile industry. In Egypt, flax is cultivated for fibers and oil production (dual purpose).

The variability is created either through hybridization or through mutation breeding or through polyploidy. The success of hybridization program depends on the ability of the parents entering into hybridization to yield desirable segregants/recombinants (Hallaur and Miranda, 1981). The ability of the parents to combine well depend on the complex interaction among the genes, which cannot be judged by mere yield performance and adaptation of parents. So the parents good in *per se* performance may not necessarily produce desirable progenies when used in hybridization (Allard, 1960). Combining ability analysis is an important tool for the selection of desirable parents together with the information regarding nature and magnitude of gene effects controlling quantitative traits of economic importance. Published work on the combining ability and type of gene action of flax traits under salinity-stress conditions is generally lacking i.e. Abo-Kaied *et al.,* (2007) additive genetic effects were more influenced by environmental fluctuation than non-additive effects for straw weight per plant and its two important components; plant height and technical stem length. On the other hand, many studies investigated combining ability in flax under normal conditions, i.e. Shehata and Comstock (1971), Foster *et al*., (1998), Patil and Chopde (1981), Patil, *et al.,* (1997), Abo-Kaied (2002), Abo-Kaied (2006) and Amany El-Reffaie (2007).

The extension of flax cultivation in Egypt is hampered by several factors. During the winter season, the land is occupied by wheat, berseem, faba bean …etc, which need to be cultivated in the ancient Valley lands. Therefore, the extension of the flax cultivated area in marginal soil (saline and sandy) has become essentially. For this reason, this investigation aimed to study the magnitude of gene action and combining ability effects for some quantitative traits in 15 F_2 flax crosses under normal and saline soil conditions.

MATERIALS AND METHODS

1. Materials

The material used for the present investigation consisted of 15 possible diallel crosses among six flax genotypes (the full details of these crosses in F_1 generations was reported by Amany El-Reffaie, 2007). These genotypes (Table1) included one commercial cultivars (P_1 =Giza 8), four advanced experimental strains (P_2= S.402/1, P_3= S.420/140/5/11, P_4= S.421/43/14/7 and P_5= S.533/39/5/3) and one introduced (P_6 = Daniela). The full details of these genotypes are presented in Table (1).

Table 1. Identification of parental genotypes used, pedigree, classification (dual, oil, fiber types) and origin.

Genotypes	Pedigree	Type	Origin
P_1= Giza 8	Giza 6 x Santa catalina 6 (I. Argentina)	dual	Local *cv*.
P_2= S.402/1	Giza 5 x cv. I 235 (I.USA)	oil	Local strain
P_3= S.420/140/5/11	S.162/12 x S.83/3	dual	Local strain
P_4= S.421/43/14/7	S.162/12 x S.6/2	dual	Local strain
P_5= S.533/39/5/3	S.420 x bombay (I. USA)	dual	Local strain
P_6= Daniela	An Introduction	fiber	Romania

2. Experimental procedures

In 2009/2010 season, 21 entries (6 parents and 15 F_2, s) were evaluated at two different environments viz: normal soil; Kafr El-Hamam – Shrkia Governorate (clay soil with organic matter = 1.78%, pH = 7.5 and E.C = 0.9 ds/cm) and saline soil; Tag El-Ezz,- El Dakahlia Governorate(clay soil with organic matter = 1.6, pH =7.9 and E.C = 4.9 ds/cm).

3. Layout of the experiment

Two experiments were laid out in a randomized complete block design with three replicates where each replicate consisted of 21 entries (6 parents and 15 F_2 crosses) and each entry was sown in one plot, which consisted of two rows. Each rows was 3.0 m long, spaced 20 cm apart. Single seeds were hand drilled in 5 cm spacing within rows. Normal recommended agronomic practices for maximization of yield in each specific environment were applied at individual location sampled.

At harvest, individual guarded plants were taken at random from each row; 10 plants from each parent and F_2 per replication. These plants were used for recording: straw weight (g)/plant, plant height (cm), technical stem length(cm), number of basal branches, seed weight(g)/plant, 1000-seed weight (g), number of capsules/plant, and number of seeds/capsule.

Combining ability analysis:

Plot means were used for statistical analysis. Data from each environment (combinations of location) were analyzed and Barteltt's test for heterogeneity of error variances across environments indicated that error terms were homogeneous. In the combined analysis across environmental effect was assumed to be fixed. Combining abilities, general (GCA) and specific (SCA) were calculated according to Griffing's method 2, model 1 (fixed effects). Forms of analysis for individual environments as given by Griffing (1956) and for combined analysis as suggested by Singh (1973).

RESULTS AND DISCUSSION

1-Combining ability:

1-1-Straw weight per plant and its components :

Table (2) shows mean square estimates for straw weight and its components, plant height, technical stem length and number of basal branches/plant due to 21 flax genotypes (6 parents and 15 F_2 crosses) under normal (E_1= Kafr El-Hamam – Sharkia Governorate) and saline (E_2= Tag El-Ezz,- El Dakahlia Governorate) environments and their combined data. Mean squares due to environments and genotypes were highly significant for straw weight and its components. This indicated the presence of true differences among the genotypes and the wide diversity between the parental materials used in the present study under the two environments. The significant differences among parents and crosses observed for straw weight and its two important components (plant height and technical stem length) at both environments and their combined analysis, indicated that sufficient genetic variability was existed in the population and increase the chance of isolating good new recombinations in the following generations. In this connection, significant differences between flax genotypes for straw weight and its attributes were detected by Abo El-Zahab and Abo-Kaied (2000), Abo-Kaied *et al.*, (2007) and Amany El-Reffaie, (2007).

Table 2. Mean squares of ordinary and combining ability analysis for straw weight and its components in F2 generation under normal (E1), saline (E2) environments and their combined data (C).

Source.	df		E_1	E_2	C	E_1	E_2	C
			Straw weight/plant (g)			Plant height/plant (cm)		
Environment (E)		1			601.445 **			43974.3 **
Reps/ E		4			0.173 **			9.259 * *
Genotypes(G)	20	20	16.114 **	5.251 **	14.792 **	519.173 **	190.304 **	430.824**
Parents (P)	5	5	11.523 **	4.644 **	12.178 **	611.626 **	321.120 **	700.027 **
Crosses(C.)	14	14	17.415 **	5.638 **	15.384 **	344.951 **	157.173 **	277.098 **
P.vs.C	1	1	20.851 **	2.863 **	19.583 **	2496.009**	0.049 ns	1236.968**
G x E		20			16.433 **			565.868 **
P x E		5			12.107 **			699.403 **
C x E		14			7.669 **			225.026 **
P vs C xE		1			17.18 6 **			2083.736**
GCA	5	5	7.544 **	2.044 **	6.857 **	242.662 **	111.895 **	312.738 **
SCA	15	15	4.647 **	1.652 **	4.289 **	149.856 **	47.281 **	87.231 **
GCA x E		5			2.732 **			41.818 **
SCA x E		15			2.010 **			109.906**
Error	40	80	0.718	0.097	0.407	6.491	5.416	5.953
GCA/SCA			1.623	1.238	1.599	1.619	2.367	3.585
			Technical stem length (cm)			Number of basal branches		
Environment (E)		1			33359.08 **			29.87 **
Reps/ E		4			4.168 **			0.020 ns
Genotypes(G)	20	20	259.039 **	163.309 **	318.008 **	0.406 **	0.159 **	0.481 **
Parents (P)	5	5	406.302 **	277.138 **	560.267 **	0.147 ns	0.101 ns	0.154 **
Crosses(C.)	14	14	224.097 **	134.186 **	253.370 **	0.525 **	0.172 **	0.615 **
P.vs.C	1	1	11.922 ns	1.879 ns	11.634 ns	0.031 ns	0.260 *	0.236 **
G x E		20			316.345 **			0.404 **
P x E		5			496.685 **			0.197 **
C x E		14			104.912 **			0.082 **
P vs C xE		1			9.923 ns			0.213 **
GCA	5	5	134.056 **	63.958 **	153.334 **	0.156 **	0.101 **	0.217 **
SCA	15	15	70.443 **	51.262 **	90.225 **	0.128 **	0.037 *	0.141 **
GCA x E		5			44.681 **			0.040 ns
SCA x E		15			31.480 **			0.024 ns
Error	40	80	8.891	2.135	5.513	0.034	0.016	0.025
GCA/SCA			1.903	1.248	1.699	1.214	2.738	1.534

Also, the parents vs. crosses mean squares, as an indication to average heterosis over all hybrids were significant, revealing that heterotic effect was pronounced for straw weight, plant height and number of basal branches/pant in the combined analysis. On the other hand, parents vs. crosses mean squares were insignificant for technical stem length at two environments and combined analysis in addition E_2 for plant height/plant and E_1 for number of basal branches/plant. Also, the interaction between each of parents, crosses and genotypes with environments were highly significant for straw weight and its components revealing inconsistent responses for these sources of variations from saline to normal conditions. Also, the mean squares of interaction between environment and both types of combining ability were highly significant for straw weight and its components.

GCAxE and SCAxE interaction were insignificant for only number of basal branches/plant, revealing that the magnitude of both additive and non-additive types of gene action varied from environment to another. While, concerning number of basal branches/plant both additive and non-additive genetic effects were the same influenced by the environmental conditions. These results are more or less in harmony with those obtained by Abo-Kaied *et al.*, (2007).

Mean squares due to general (GCA) and specific (SCA) combining ability were significant for straw weight and its components under normal and saline environments. These results indicate that both additive and non-additive genetic effects were involved in the inheritance of straw weight and its components. Whereas, the magnitude of mean squares due to GCA with that for SCA revealed that GCA/SCA ratio was more than unity for straw weight and its components under the two environments and combined analysis. Therefore, effective selection could be possible within F_2 and subsequent generations of the involved crosses for straw weight/plant, plant height, technical stem length and number of basal branches/plant. These results were similar to those obtained by Patil, *et al.,* (1997); Foster *et al.,* (1998); Abo-Kaied, (2002); Abo-Kaied *et al.*, (2007) and Amany El-Reffaie, (2007).

The interaction between each of genotypes, parents, crosses and parent *vs.* crosses with environment was highly significant for all traits, revealing inconsistent responses for these sources of variations from saline to normal soil conditions. Also, the mean squares of interaction between environment and both types of combining ability were highly significant for straw weight and its two important components; plant height and technical stem length except only GCAxE interaction was insignificant for number of basal branches/plant, revealing that the magnitude of both additive and non-additive types of gene action varied from environment to another. It is fairly evident that mean squares of GCAxE/GCA were lower than SCAxE/SCA ratios indicating that non-additive genetic effects were much more influenced by saline soil conditions than additive effects in both straw weight and plant height. In contrast, additive genetic effects were more influenced by environment (saline conditions) than non-additive effects for technical stem length. While, concerning number of basal branches/plant, both additive and non-additive genetic effects were the same influenced by the environmental conditions. These results are more or less in harmony with those obtained by Abo-Kaied *et al.*, (2007).

Estimates of GCA effects (g_i) for six parental genotypes as affected by normal and saline environments as well as the combined for straw weight and its components are presented in Table (3). In both environments and combined analysis P_5(S.533/39/5/3) exhibited good general combining ability effects for straw weight/plant and its two important components, plant height and technical stem length and also, P_1(Giza 8) for straw weight/plant and number of basal branches/plant. Therefore, using this parent (S.533/39/5/3) in hybridization programs may result in isolating desirable segregates for the above-mentioned characters and also, this parent was more efficient under both environments (saline and normal) as it had favourable genes for straw weight improvement which can be attained by using it in a breeding program. The simple correlation coefficient (r) between mean performance (Table 8) of parents and their GCA values (Table 3) was significant positive at both environments and combined data for plant height and technical stem length. These results indicated that the parents showing higher mean performance proved to be the highest general combiners for these traits. Therefore, high mean performance of the parents could be transferred to crosses in such cases.

Table 3. Estimates of general combining ability effects(ĝi) for six parental flax genotypes as affected by normal (E1), saline (E2) environments and their combined data (C) for straw weight and its components per plant.

Parents	E_1	E_2	C	E_1	E_2	C
	Straw weight/plant (g)			Plant height (cm)		
P_1= Giza 8	1.526 **	-0.136 ns	0.695 **	-0.070 ns	-3.717 **	-1.893 **
P_2= S.402/1	-0.528 ns	-0.075 ns	-0.301 *	-8.763 **	-3.600 **	-6.182 **
P_3=S.420/140/5/11	-0.940 **	-0.590 **	-0.765 **	-1.620 ns	0.460 ns	-0.580 ns
P_4= S.421/43/14/7	-0.715 *	-0.288 **	-0.502 **	1.772 *	-0.377 ns	0.698 ns
P_5= S.533/39/5/3	0.827 **	0.884 **	0.855 **	8.304 **	6.501 **	7.403 **
P_6= Daniela	-0.170 ns	0.205 *	0.017 ns	0.377 ns	0.733 ns	0.555 ns
LSD(gi-gi)						
0.05	0.856	0.314	0.451	2.574	2.352	1.725
0.01	1.145	0.420	0.598	3.444	3.146	2.286
r	**0.553**	**0.752***	**0.571**	**0.837****	**0.814***	**0.938****
	Technical stem length (cm)			Number of basal branches		
P_1= Giza 8	-2.302 *	-1.198 *	-1.750 **	0.148 *	0.212 **	0.180 **
P_2= S.402/1	-7.005 **	-3.252 **	-5.128 **	0.105 ns	0.011 ns	0.058 ns
P_3=S.420/140/5/11	0.802 ns	1.744 **	1.273 *	-0.155 *	-0.109 *	-0.132 **
P_4= S.421/43/14/7	3.628 **	-2.659 **	0.484 ns	-0.171 **	-0.029 ns	-0.100 **
P_5= S.533/39/5/3	3.802 **	3.998 **	3.900 **	-0.031 ns	-0.072 ns	-0.051 ns
P_6= Daniela	1.074 ns	1.367 **	1.221 *	0.103 ns	-0.013 ns	0.045 ns
LSD(gi-gi)						
0.05	3.013	1.476	1.660	0.186	0.128	0.112
0.01	4.031	1.975	2.200	0.249	0.171	0.148
r	**0.762***	**0.817***	**0.762***	**0.106**	**0.720***	**0.259**

***,** Significant at 0.05 and 0.01 levels of probability, respectively.**
r : Simple correlation coefficients between GAC values and parental means.

The specific combining ability effects (S_{ij}) for straw weight and its components under normal and saline environments and their combined data are presented in Table (4). The results indicated that there was no cross combination which was consistent good for all traits except one cross ($P_5 \times P_6$) which exhibited positive significant SCA effects for all traits under the two environments and combined analysis. Out of the 15 F_2 crosses, two crosses ($P_1 \times P_4$ and $P_1 \times P_6$) exhibited highly significant positive SCA effects for straw weight/plant at combined analysis plus one environment only. Seven crosses ($P_1 \times P_3$, $P_1 \times P_4$, $P_1 \times P_6$, $P_2 \times P_3$, $P_2 \times P_4$, and $P_3 \times P_4$) for plant height at combined analysis plus one environment only, two crosses ($P_1 \times P_6$ and $P_5 \times P_6$) for technical stem length under the two environments and combined analysis and two crosses ($P_1 \times P_3$ and $P_2 \times P_6$) for number of basal branches/plant exhibited significant positive SCA effects in the desirable direction at combined analysis plus one environment only.

In general. The cross, $P_5 x P_6$ may prove useful for simultaneous improvement for straw weight/plant and its components. The simple correlation between cross means (Table 8) and their SCA values (Table 4) was significant and positive indicating that high performing crosses were high specific combinations. Therefore, the choice of promising cross combinations would be based on SCA effects or mean performance of a cross.

1-2-Seed weight per plant and its components :

Regarding Table 5, data showed highly significant differences existed among 21 flax genotypes (6 parents and 15 F_2 crosses), parents and crosses for seed weight and its components viz., number of capsules per plant, 1000-seed weight and number of seeds/capsule. The results indicated that the parental genotypes and F_2 crosses showed reasonable degree of variability for these traits except parents mean squares at E_2 (saline environment) for only number of seeds/capsule. Significant differences were also noted for the component parents *vs*. crosses for seed weight, number of capsules/plant and number of seeds/capsule at individual environments and combined except 1000-seed weight. Also, both mean squares due to general (GCA) and specific(SCA) combining abilities were highly significant for all characters in both environments and combined except E_2 for number of seeds/capsule. In general, the magnitude of mean squares due to GCA were greater than that due to SCA for seed weight, 1000-seed weight and number of seeds/capsule except number of capsules/plant. These results revealed that additive effect played greater role than non-additive gene effects in the inheritance of seed weight/plant and its two components (1000-seed weight and number of seeds/capsule). Similar results were reported by Shehata and Comstock (1971), Patil and Chopde (1981), Abo-Kaied *et al*., (2007) and Amany El-Reffaie, (2007).

The interaction between each of genotypes, parents and crosses with environment was significant or highly significant for seed weight and its components. Also, GCAxE mean squares were highly significant or significant for seed weight, number of capsules/plant and number of seeds/capsule except 1000-seed weight. SCAxE mean squares were highly significant only for seed weight/plant and number of capsules/plant. This indicates that both additive and non-additive gene effects are influenced by saline environment. It is fairly evident that mean squares of GCAxE/GCA were lower than SCAxE/SCA ratios for number of seeds/capsule, this indicated that non-additive gene effects were much more influenced by saline environment than additive effects.

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While, additive gene effects were much more influenced by saline environment than non-additive effects for number of capsules/plant. These results are more or less in harmony with those reported by Patil and Chopde (1981) and Amany El-Reffaie, (2007).

Table 5. Mean squares of ordinary and combining ability analysis for seed weight and its components in F2 generation under normal (E1), saline (E2) environments and their combined data (C.).

Source	df S	df C	E_1	E_2	C	E_1	E_2	C
			Seed weight/plant (g)			No. of capsules/plant		
Environment (E)		1			101.231 **			21455.5**
Reps/ E		4			0.114 **			58.114**
Genotypes(G)	20	20	4.101 **	0.414 **	2.941**	862.497 **	146.604 **	629.897**
Parents (P)	5	5	1.596 *	0.140 ns	1.315 **	150.490 *	21.377 ns	125.068**
Crosses(C.)	14	14	4.199 **	0.470 **	2.873 **	764.227 **	148.110 **	472.139**
P.vs.C	1	1	15.255 *	0.993 **	12.017 **	5798.312 **	751.662 **	5362.658**
G x E		20			3.534 **			799.135**
P x E		5			1.297 **			130.178**
C x E		14			1.796 **			440.198**
P vs C xE		1			12.243 **			4762.421**
GCA	5	5	1.661 **	0.093 **	1.142 **	208.818 **	61.677 **	156.295**
SCA	15	15	1.269 **	0.153 **	0.926 **	313.726 **	44.598 **	227.856**
GCA x E		5			0.612 **			114.200**
SCA x E		15			0.496 **			130.469**
Error	40	80	0.199	0.023	0.111	42.884	12.877	27.880
GCA/SCA			1.309	0.611	1.233	0.666	1.383	0.686
			1000-seed weight (g)			No. of seeds/capsule		
Environment (E)		1			14.149 **			3.448 **
Reps/ E		4			0.035 ns			1.175 **
Genotypes(G)	20	20	8.076 **	6.924 **	14.855 **	1.575 **	1.470 **	2.496 **
Parents (P)	5	5	15.822 **	11.693 **	27.195 **	2.592 **	2.439 **	5.030 **
Crosses(C.)	14	14	5.886 **	5.705 **	11.501 **	0.864 **	0.589 ns	0.676 **
P.vs.C	1	1	0.003 ns	0.156 ns	0.102 ns	6.443 **	8.970 **	15.308 **
G x E		20			10.049 **			2.213 **
P x E		5			18.450 **			3.355 **
C x E		14			0.090 **			0.776 **
P vs C xE		1			0.125 ns			10.310 **
GCA	5	5	8.810 **	7.146**	15.891 **	1.413 **	0.295 ns	1.428 **
SCA	15	15	0.653 **	0.696**	1.305 **	0.229 **	0.555 **	0.634 **
GCA x E		5			0.066 ns			0.280 **
SCA x E		15			0.043 ns			0.151 ns
Error	40	80	0.041	0.030	0.035	0.066	0.147	0.107
GCA/SCA			13.500	10.273	12.174	6.174	0.531	2.253

ns,*, non- significant, significant at 0.05 and 0.01 levels of probability, respectively.**

Estimates of GCA effects (gi) for seed weight and its components for individual parents in both environments as well as combined data are presented in Table (6). P_2(S.402/1) showed significant positive gi effects for seed weight and 1000-seed weight in both environments as well as the combined data. Also, P_1(Giza 8) exhibited significant positive gi effects for 1000-seed weight in both environments as well as combined data. Therefore, the two parents (P_1 and P_2) could be considered as an excellent parents in breeding programs towards releasing flax varieties characterized by high value for the two above-mentioned traits. The simple correlation between GCA values (Table 6) and parental means (Table 9) were highly significant and positive in both environments as well as combined data for both 1000-seed weight and number of seeds/capsule. These results indicated that the parents showed high mean performance proved to be the high general combiners for these traits (1000-seed weight and number of seeds/capsule) under saline or normal conditions.

Table 6. Estimates of general combining ability effects(ĝi) for six parental flax genotypes as affected by normal (E1), saline (E2) environments and their combined data (C) for seed weight and its components per plant.

	E_1	E_2	C	E_1	E_2	C
Parents	**Seed weight/plant (g)**			**No. of capsules/plant**		
P_1= Giza 8	0.655 **	0.034 ns	0.344 **	4.504 *	-3.239 **	0.632 ns
P_2= S.402/1	0.468 **	0.138 **	0.303 **	5.576 *	0.257 ns	2.917 *
P_3=S.420/140/5/11	-0.518 **	-0.148 **	-0.333 **	-7.204 **	-1.390 ns	-4.297 **
P_4= S.421/43/14/7	-0.184 ns	-0.111 *	-0.148 ns	-4.806 *	-2.160 ns	-3.483 **
P_5= S.533/39/5/3	-0.207 ns	0.044 ns	-0.081 ns	-0.105 ns	3.449 **	1.672 ns
P_6= Daniela	-0.214 ns	0.043 ns	-0.085 ns	2.035 ns	3.083 *	2.559 *
LSD(gi-gi)						
0.05	0.451	0.153	0.236	6.617	3.626	3.734
0.01	0.603	0.204	0.312	8.854	4.852	4.947
r	**0.451**	**0.082**	**0.389**	**0.247**	**0.784***	**0.386**
	1000-seed weight			**No. of seeds/capsule**		
P_1= Giza 8	1.476 **	1.286 **	1.381 **	-0.436 **	-0.146 ns	-0.291 **
P_2= S.402/1	1.093 **	0.974 **	1.033 **	-0.590 **	-0.257 *	-0.424 **
P_3=S.420/140/5/11	-0.351 **	-0.278 **	-0.315 **	0.081 ns	-0.086 ns	-0.003 ns
P_4= S.421/43/14/7	-0.249 **	-0.100 ns	-0.175 **	0.355 **	0.084 ns	0.220 **
P_5= S.533/39/5/3	-0.916 **	-0.878 **	-0.897 **	0.434 **	0.205 ns	0.320 **
P_6= Daniela	-1.053 **	-1.003 **	-1.028 **	0.155 ns	0.200 ns	0.178 *
LSD(gi-gi)						
0.05	0.204	0.175	0.133	0.260	0.388	0.231
0.01	0.273	0.234	0.176	0.348	0.519	0.306
r	**0.965 ****	**0.935 ****	**0.953 ****	**0.970 ****	**0.838 ****	**0.951 ****

***,** Significant at 0.05 and 0.01 levels of probability, respectively.**
r : Simple correlation coefficients between GAC values and parental means.

SCA effects for seed weight/plant and its components for 15 F_2 crosses as affected by normal (E_1) and saline (E_2) environments as well as combined data are given in Table (7). Out of the 15 F_2 crosses, one cross ($P_5 \times P_6$) for seed weight/plant and number of capsules/plant and three crosses (P_1xP_3, P_1xP_6 and P_4xP_6) for 1000-seed weight exhibited significant positive SCA effects at the two environments and combined. Whereas, two crosses (P_1xP_4 and P_1xP_6) were significant positive SCA effects at combined data plus only one environment for both seed weight and number of capsules/plant.

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In general, the specific combining ability estimates indicated that there was no cross combination which was consistently good for all characters. Out of the previous crosses, the cross P_5xP_6 showed high SCA effects for seed weight and number of capsules/plant. Also, the cross P_5xP_6 included high x low general combiner parents for number of capsules/plant. In such case (high x low general combiners), desirable transgressive segregates might be expected in the subsequent generations if the additive genetic system was present in the good combiner and the complementary epistatic effects acted in the same direction to maximize seed weight/plant. Therefore, it could be concluded that this cross is suitable in breeding for increasing number of capsules/plant. The simple correlation between cross means (Table 9) and their SCA values (Table 7) was significantly positive for seed weight, number of capsules/plant and 1000-seed weight under the two environments and combined except E_1 for 1000-seed weight. These results, indicating that high performing crosses were high specific combinations for seed yield and its two important components, number of capsules/plant and 1000-seed weight.

2-Mean performance:

2-1-Straw weight per plant and its components :

The mean performance of 21 flax genotypes (6 parents and 15 F_2 crosses) under normal (E_1) and saline (E_2) environments and their combined data for straw yield and its components are presented in Table (8). P_5 (S.533/39/5/3) recorded the highest values for both seed weight and plant height/plant in addition P_3 (S.420/140/5/11) for technical stem length. While, P_6 (Daniela) give low value for number of basal branches. On the other hand, the best crosses P_5 x P_6 for straw, plant height and technical stem length,, P_1 x P_5, and P_3 x P_4 for plant height, in addition to P_1 x P_6 and P_3 x P_4 for technical stem length. It could be concluded that the above mentioned crosses and their parents would be interesting and prospective for the future in flax breeding program for improving straw weight/plant and its components.

2-1-Seed weight per plant and its components :

The mean performance of 21 flax genotypes (6 parents and 15 F_2 crosses) under normal (E_1) and saline (E_2) environments and their combined data are presented in Table (9). P_2 (S.402/1) recorded the highest values for seed yield, number of capsules/plant and 1000-seed weight as well as P_5(S.533/39/5/3) give high value for number of seeds/capsule. While, the highest mean values recorded by the two crosses; P_1xP_4 and P_1xP_6 for both seed weight/plant and number of capsules/plant in addition two crosses; P_1xP_2 and P_1xP_3 for 1000-seed weight and two crosses; P_1xP_2 and P_2xP_3 for number of seeds/capsule. It could be concluded that the above mentioned parents and crosses would be interesting and prospective for the future in flax breeding for improving seed weight and its components.

Table 8: Mean performance for straw weight and its components recorded under normal (E1), saline (E2) Environments and their combined data.

genotype	E_1	E_2	C.	E_1	E_2	C.	E_1	E_2	C.	E_1	E_2	C.
Parents	**Straw weight/plant (g)**			**Plant height/plant (cm)**			**Technical length (cm)**			**Number of basal branches**		
P1	8.65	2.73	5.69	110.40	76.90	93.65	93.73	55.33	74.53	2.07	1.38	1.73
P2	7.00	4.01	5.51	106.67	81.71	94.19	75.11	53.55	64.33	2.38	1.06	1.72
P3	7.67	2.30	4.99	106.07	97.76	101.91	106.03	75.60	90.81	2.17	1.03	1.60
P4	6.08	3.48	4.78	114.10	95.35	104.72	101.19	54.33	77.76	1.89	1.09	1.49
P5	9.70	5.56	7.63	143.99	102.67	123.33	100.04	71.33	85.68	2.33	1.07	1.70
P6	4.14	2.37	3.26	120.54	83.18	101.86	84.54	57.72	71.13	1.84	0.81	1.33
Mean	**7.21**	**3.41**	**5.31**	**116.96**	**89.59**	**103.28**	**93.44**	**61.31**	**77.38**	**2.11**	**1.07**	**1.59**
Crosses												
P1xP2	7.77	3.74	5.76	120.13	80.03	100.08	81.00	58.35	69.67	2.18	1.27	1.73
P1xP3	9.95	3.34	6.64	135.55	85.67	110.61	74.33	61.10	67.72	2.60	1.42	2.01
P1xP4	12.43	2.93	7.68	140.06	86.67	113.36	97.27	63.00	80.13	2.25	1.55	1.90
P1xP5	11.24	3.13	7.19	145.47	90.33	117.90	97.02	54.67	75.84	2.34	1.36	1.85
P1xP6	10.34	6.53	8.44	125.83	100.62	113.23	103.40	73.73	88.56	2.71	1.55	2.13
P2xP3	6.21	2.86	4.54	128.49	84.67	106.58	91.18	55.00	73.09	1.79	0.96	1.37
P2xP4	7.07	4.05	5.56	132.43	81.33	106.88	91.02	58.48	74.75	2.17	1.21	1.69
P2xP5	9.05	5.18	7.11	114.90	100.27	107.58	94.63	67.47	81.05	2.33	1.33	1.83
P2xP6	8.49	1.77	5.13	109.00	88.33	98.67	94.79	58.67	76.73	2.65	1.42	2.04
P3xP4	4.93	2.82	3.88	137.68	90.33	114.01	102.34	60.00	81.17	1.73	0.99	1.36
P3xP5	5.46	3.64	4.55	125.30	89.34	107.32	88.48	63.08	75.78	1.25	0.71	0.98
P3xP6	7.41	4.24	5.83	136.28	85.00	110.64	96.92	54.67	75.80	2.11	1.21	1.66
P4xP5	5.93	3.40	4.66	133.09	88.00	110.54	100.37	57.67	79.02	1.62	0.93	1.28
P4xP6	8.57	3.74	6.16	131.12	86.81	108.96	94.55	62.00	78.27	2.11	1.14	1.63
P5xP6	12.37	6.83	9.60	148.09	105.59	126.84	108.73	77.53	93.13	2.60	1.17	1.88
Mean	**8.12**	**3.75**	**5.93**	**126.91**	**89.55**	**108.23**	**94.13**	**61.58**	**77.86**	**2.15**	**1.17**	**1.66**
$LSD_{0.05}$	**1.04**	**1.40**	**0.56**	**3.96**	**4.20**	**4.20**	**3.82**	**4.92**	**2.64**	**0.26**	**0.30**	**0.23**

$=Number refer to parent codes, Table 3.
For explanation see Table 3.

Table 9: Mean performance for seed weight and its components recorded under normal (E1), saline (E2) Environments and their combined data.

genotype	E_1	E_2	C.	E_1	E_2	C.	E_1	E_2	C.	E_1	E_2	C.
Parents	Seed weight/plant (g)			No. of capsules/plant			1000-seed weight (g)			No. of seeds/capsule		
P1	2.24	1.01	1.63	30.82	17.47	24.14	10.48	8.89	9.68	6.70	6.50	6.60
P2	3.58	1.42	2.50	48.52	21.83	35.18	10.65	9.69	10.17	6.94	6.73	6.83
P3	2.46	1.19	1.82	37.15	19.44	28.29	7.90	7.53	7.72	8.40	8.15	8.27
P4	2.22	1.15	1.68	32.20	18.39	25.29	8.10	7.57	7.83	8.63	8.37	8.50
P5	2.08	1.12	1.60	40.92	24.84	32.88	5.76	5.24	5.50	8.87	8.60	8.73
P6	1.34	0.77	1.05	30.52	19.81	25.16	5.14	4.68	4.91	8.43	8.18	8.31
Mean	**2.32**	**1.11**	**1.71**	**36.69**	**20.30**	**28.49**	**8.00**	**7.27**	**7.64**	**8.00**	**7.76**	**7.88**
Crosses												
P1xP2	4.62	1.34	2.98	74.20	22.04	48.12	9.77	9.08	9.43	6.27	7.08	6.67
P1xP3	3.24	1.26	2.25	45.98	18.61	32.29	9.87	8.98	9.42	7.24	7.53	7.39
P1xP4	6.13	1.22	3.68	87.71	18.59	53.15	9.33	9.47	9.40	7.50	6.98	7.24
P1xP5	4.31	1.20	2.76	65.39	21.53	43.46	8.70	7.91	8.31	7.60	7.11	7.36
P1xP6	4.14	2.37	3.25	64.11	38.69	51.40	9.31	8.47	8.89	6.93	7.24	7.09
P2xP3	3.22	1.32	2.27	52.98	27.80	40.39	8.67	7.89	8.28	7.03	6.25	6.64
P2xP4	3.43	1.38	2.41	55.24	23.56	39.40	9.00	8.19	8.60	6.93	7.25	7.09
P2xP5	3.59	2.06	2.82	60.78	39.43	50.10	8.32	7.57	7.94	7.10	6.89	7.00
P2xP6	3.41	1.30	2.36	67.38	25.86	46.62	7.79	7.09	7.44	6.50	7.12	6.81
P3xP4	1.32	0.76	1.04	34.43	25.11	29.77	5.13	4.67	4.90	7.47	6.47	6.97
P3xP5	1.91	1.09	1.50	38.40	28.08	33.24	6.98	6.36	6.67	7.23	6.55	6.89
P3xP6	2.95	1.16	2.05	59.28	30.71	44.99	6.85	6.24	6.54	7.30	6.32	6.81
P4xP5	2.08	1.19	1.63	35.52	29.03	32.28	7.13	6.49	6.81	8.13	6.33	7.23
P4xP6	2.83	1.41	2.12	47.25	29.96	38.60	7.33	6.67	7.00	7.97	7.00	7.48
P5xP6	3.99	1.72	2.85	80.22	40.14	60.18	6.13	5.58	5.86	8.10	7.67	7.88
Mean	**3.10**	**1.31**	**2.20**	**51.86**	**25.76**	**38.81**	**8.02**	**7.35**	**7.68**	**7.49**	**7.16**	**7.32**
$LSD_{0.05}$	**0.54**	**0.74**	**0.27**	**8.58**	**10.81**	**6.48**	**0.30**	**0.33**	**0.31**	**0.53**	**0.42**	**0.69**

$=Number refer to parent codes, Table 3.
For explanation see Table 3.

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تقدير القدرة علي الائتلاف لعشائر الجيل الثاني في الكتان لبعض الصفات الكمية تحت ظروف الأراضي العادية والملحية

أماني محمد محي الدين الرفاعي و مهدى محمد مهدى حسين
قسم بحوث محاصيل الألياف – معهد بحوث المحاصيل الحقلية - مركز البحوث الزراعية- الجيزة

أجريت هذه الدراسة بهدف تقدير القدرة علي الائتلاف والفعل الجيني من خلال تقييم ١٥ هجين في الجيل الثاني مع آبائها (١= جـ٨ ، ٢= س١/٤٠٢ ، ٣= س ١١/٥/١٤٠/٤٢٠ ، ٤= س ٧/١٤/٤٣/٤٢١ ، ٥= س ٣/٥/٣٩/٥٣٣ ، ٦= دانيال) تحت بيئتين مختلفتين، الأولى بيئة عادية (كفر الحمام-م الشرقية) والثاني بيئة ملحية (تاج العز-م الدقهلية) في موسم ٢٠٠٩ /٢٠١٠ في تجربة قطاعات كاملة العشوائية ذات ثلاثة مكررات وقد زرعت في الأسبوع الأول من نوفمبر وذلك بهدف تقدير القدرة علي الائتلاف والفعل الجيني تحت الظروف البيئية المختلفة.

وتشير النتائج إلى أن تأثير العوامل الوراثية المضيفة كان أكثر أهمية في توريث صفات وزن القش ومكوناته وكذلك في توريث صفات محصول وزن البذور ووزن الألف بذرة وعدد البذور/كبسولة تحت ظروف البيئية العادية والملحية والتحليل التجميعي للبيئتين ، بينما كان تأثير كل من العوامل الوراثية المضيفة والغير مضيفة مساهمين معا في توريث صفة عدد الكبسولات/نبات. كذلك أشارت نتائج التفاعل بين القدرة العامة والخاصة علي الائتلاف مع البيئة ، أن كلا من العوامل المضيفة والغير مضيفة قد تأثرت بالظروف البيئة لكل الصفات المدروسة. وكان تأثر العوامل الغير مضيفة أكبر من المضيفة بظروف البيئة الملحية لصفات وزن القش والطول الكلي والطول الفعال ووزن البذور ووزن الألف بذرة وعدد البذور/كبسولة. بينما كان تأثر العوامل المضيفة أكبر من الغير مضيفة بالظروف البيئية لصفة وعدد الكبسولات/نبات. كما تشير النتائج إلى أن الأب س ٣/٥/٣٩/٥٣٣ أظهر قدرة عامة عالية علي الائتلاف لصفات وزن القش واهم مكونين من مكوناته (الطول الكلى والطول الفعال)، كذلك الأب س ١/٤٠٢ أظهر قدرة عامة عالية علي الائتلاف لصفات وزن البذور ووزن الألف بذرة كذلك الصنف التجاري حيزة ٨ أظهر قدرة عامة عالية علي الائتلاف لصفة ووزن الألف بذرة تحت ظروف البيئة العادية والملحية والتحليل التجميعي. كما تشير نتائج القدرة الخاصة علي الائتلاف إلى أن الهجين (٥×٦) أظهر تفوقا في القدرة الخاصة علي الائتلاف

لصـفة وزن القش/نبـات وكـل مكوناتـه تحـت الدراسـة بالإضـافة لمحصـول البـذور للنبـات وعـدد الكبسولات للنبات، كذلك الثلاثة هجن (١×١،٣×٦، ٤×٦) لوزن الألف بذرة تحت ظروف البيئـة العاديـة والملحيـة والتحليل التجميعـي. لـذلك تعتبـر الهجـن السـابقة واعدة فـي بـرامج التربيـة لزيـادة وتحسين الصفات سالفة الذكر في الكتان.

كما تشير نتائج الارتباط البسيط بين متوسطات الهجن وقيم تـأثيرات القدرة الخاصـة علـي الائتلاف لها والتي كانـت معنويـة وموجبـة لصـفات وزن القش ومكوناتـه وكذلك صـفة وزن البـذور واهم مكونين لـه (وزن الألـف بذرة وعدد الكبسولات للنبـات) ممـا يدل علـي أن الهجـن العاليـة فـي صفاتها المحصولية أظهرت قدرة خاصة علي الائتلاف عالية ، لذلك يمكن اختيار الهجن علي أسـاس متوسطاتها العالية.

قام بتحكيم البحث

أ.د / عبد الرحيم عبد الرحيم ليله	**كلية الزراعة – جامعة المنصورة**
أ.د / جمال الدين حسن الشيمى	**مركز البحوث الزراعية**

Table 4: Estimates of specific combining ability (ŝij) for 15 F2 crosses as affected by normal (E1),saline (E2) environments and their combined (C) data for straw weight and its components.

Parents	E_1	E_2	C.	E_1	E_2	C.	E_1	E_2	C.	E_1	E_2	C.
	Straw weight/plant (g)			**Plant height (cm)**			**Technical stem length/plant (cm)**			**Number of basal branches/plant**		
P1xP2$	-1.343 ns	0.203 ns	-0.570 ns	2.050 ns	-2.203 ns	-0.076 ns	-3.820 ns	1.214 ns	-1.303 ns	-0.219 ns	-0.130 ns	-0.174 ns
P1xP3	1.247 ns	0.314 ns	0.780 ns	10.323 **	-0.627 ns	4.848 **	-18.294 **	-1.031 ns	-9.663 **	0.456 **	0.145 ns	0.301 **
P1xP4	3.498 **	-0.390 ns	1.554 **	11.441 **	1.210 ns	6.325 **	1.814 ns	5.273 **	3.543 *	0.127 ns	0.190 ns	0.159 ns
P1xP5	0.770 ns	-1.361 **	-0.296 ns	10.320 **	-2.001 ns	4.160 *	1.392 ns	-9.717 **	-4.163 *	0.079 ns	0.046 ns	0.062 ns
P1xP6	0.865 ns	2.717 **	1.791 **	-1.387 ns	14.054 **	6.334 **	10.503 **	11.972 **	11.238 **	0.307 ns	0.177 ns	0.242 *
P2xP3	-0.438 ns	-0.219 ns	-0.328 ns	11.964 **	-1.743 ns	5.111 **	3.260 ns	-5.077 **	-0.909 ns	-0.312 ns	-0.119 ns	-0.216 *
P2xP4	0.201 ns	0.669 *	0.435 ns	12.508 **	-4.239 *	4.134 *	0.270 ns	2.808 *	1.539 ns	0.083 ns	0.050 ns	0.066 ns
P2xP5	0.630 ns	0.627 *	0.628 ns	-11.554 **	7.818 **	-1.868 ns	3.704 ns	5.140 **	4.422 **	0.105 ns	0.220 ns	0.162 ns
P2xP6	1.069 ns	-2.110 **	-0.521 ns	-9.527 **	1.651 ns	-3.938 *	6.596 *	-1.033 ns	2.782 ns	0.297 ns	0.251 *	0.274 *
P3xP4	-1.531 *	-0.044 ns	-0.788 ns	10.613 **	0.700 ns	5.657 **	3.779 ns	-0.669 ns	1.555 ns	-0.091 ns	-0.044 ns	-0.068 ns
P3xP5	-2.546 **	-0.401 ns	-1.473 **	-8.301 **	-7.175 **	-7.738 **	-10.253 **	-4.241 **	-7.247 **	-0.718 **	-0.281 *	-0.500 **
P3xP6	0.401 ns	0.883 **	0.642 ns	10.614 **	-5.742 **	2.436 ns	0.921 ns	-10.029 **	-4.554 **	0.014 ns	0.157 ns	0.086 ns
P4xP5	-2.300 **	-0.945 **	-1.623 **	-3.903 ns	-7.674 ns	-5.789 **	-1.189 ns	-5.256 ns	-3.222 *	-0.323 ns	-0.143 **	-0.233 *
P4xP6	1.340 ns	0.081 **	0.710 ns	2.056 ns	-3.099 ns	-0.522 ns	-4.283 ns	1.708 **	-1.287 ns	0.031 ns	0.010 ns	0.020 ns
P5xP6	3.597 **	1.997 **	2.797 **	12.498 **	8.806 **	10.652 **	9.729 **	10.577 **	10.153 **	0.378 *	0.080 **	0.229 *
LSD **5%**	2.265	0.831	1.105	6.811	6.222	4.226	7.972	3.906	4.067	0.493	0.339	0.274
(Sij-Sik)**1%**	3.030	1.112	1.464	9.113	8.324	5.600	10.666	5.226	5.388	0.660	0.453	0.363
r	**0.887 ****	**0.898 ****	**0.881 ****	**0.790 ****	**0.789 ****	**0.639 ****	**0.825 ****	**0.869 ****	**0.825 ****	**0.938 ****	**0.851 ****	**0.927 ****

Table 7: Estimates of specific combining ability (ŝij) for 15 F2 crosses as affected by normal (E1), saline (E2) environments and their combined (C) data for seed weight and its components.

Parents	E_1	E_2	C.	E_1	E_2	C.	E_1	E_2	C.	E_1	E_2	C.
	Seed weight/plant (g)			**No. of capsules/plant**			**1000-seed weight (g)**			**No. of seeds/capsule**		
P1xP2$	0.400 ns	-0.138 ns	0.131 ns	12.266 *	-0.732 ns	5.767 ns	-0.819 **	-0.522 **	-0.670 **	-0.197 ns	0.321 ns	0.062 ns
P1xP3	0.000 ns	0.068 ns	0.034 ns	-3.179 ns	-2.523 ns	-2.851 ns	0.724 **	0.624 **	0.674 **	0.105 ns	0.608 ns	0.357 ns
P1xP4	2.560 **	-0.006 ns	1.277 **	36.160 **	-1.774 ns	17.193 **	0.090 ns	0.943 **	0.517 **	0.091 ns	-0.115 ns	-0.012 ns
P1xP5	0.767 ns	-0.180 ns	0.293 ns	9.131 ns	-4.436 ns	2.348 ns	0.121 ns	0.162 ns	0.141 ns	0.112 ns	-0.107 ns	0.002 ns
P1xP6	0.598 ns	0.988 **	0.793 **	5.716 ns	13.086 **	9.401 *	0.868 **	0.841 **	0.855 **	-0.275 ns	0.028 ns	-0.124 ns
P2xP3	0.171 ns	0.022 ns	0.096 ns	2.747 ns	3.180 ns	2.964 ns	-0.084 ns	-0.148 ns	-0.116 ns	0.053 ns	-0.562 ns	-0.255 ns
P2xP4	0.045 ns	0.051 ns	0.048 ns	2.611 ns	-0.292 ns	1.160 ns	0.143 ns	-0.027 ns	0.058 ns	-0.321 ns	0.268 ns	-0.027 ns
P2xP5	0.229 ns	0.568 **	0.398 ns	3.449 ns	9.962 **	6.706 ns	0.126 ns	0.128 ns	0.127 ns	-0.234 ns	-0.214 ns	-0.224 ns
P2xP6	0.056 ns	-0.182 ns	-0.063 ns	7.909 ns	-3.242 ns	2.333 ns	-0.263 ns	-0.225 ns	-0.244 ns	-0.555 *	0.018 ns	-0.269 ns
P3xP4	-1.077 **	-0.290 *	-0.684 **	-5.420 ns	2.905 ns	-1.257 ns	-2.288 **	-2.301 **	-2.294 **	-0.459 ns	-0.690 *	-0.574 *
P3xP5	-0.467 ns	-0.109 ns	-0.288 ns	-6.145 ns	0.264 ns	-2.941 ns	0.235 ns	0.166 ns	0.200 ns	-0.771 **	-0.729 *	-0.750 **
P3xP6	0.582 ns	-0.044 ns	0.269 ns	12.591 *	3.256 ns	7.923 *	0.240 ns	0.171 ns	0.205 ns	-0.425 ns	-0.950 **	-0.688 **
P4xP5	-0.631 ns	-0.049 **	-0.340 ns	-11.427 ns	1.987 **	-4.720 ns	0.276 ns	0.118 ns	0.197 ns	-0.145 ns	-1.115 ns	-0.630 **
P4xP6	0.126 ns	0.169 ns	0.147 ns	-1.832 ns	3.276 ns	0.722 ns	0.614 **	0.425 **	0.519 **	-0.033 ns	-0.443 ns	-0.238 ns
P5xP6	1.310 **	0.324 **	0.817 **	26.437 **	7.852 **	17.144 **	0.086 ns	0.117 ns	0.101 ns	0.021 ns	0.103 ns	0.062 ns
LSD **5%**	1.193	0.404	0.577	17.508	9.594	9.146	0.540	0.462	0.326	0.688	1.026	0.566
(Sij-Sik)**1%**	1.597	0.541	0.765	23.425	12.836	12.118	0.722	0.619	0.431	0.921	1.372	0.750
r	**0.908 ****	**0.953 ***	**0.909 ****	**0.937 ****	**0.903 ****	**0.923 ****	**0.453 ns**	**0.574 ***	**0.510 ***	**0.374 ns**	**0.886 ****	**0.407 ns**

$=Number refer to parent codes, Table 3.
For explanation see Table 3.