INHERITANCE OF HEAT TOLERANCE IN COMMON BEAN

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INTRODUCTION: Ability to yield well under high temperatures is a complex trait affected by many genes throughout plant development. Heat tolerance at a particular growth stage, however, may be under simpler genetic control.

INHERITANCE STUDY: The genetics of heat tolerance were studied at two reproductive growth stages. Bud abortion (BA), scored on a visual scale, and pod fill (PF), calculated as the percentage of mature seeds per pod, were evaluated on individual plants. For each growth stage, two tolerant (T) and two susceptible (S) lines, were chosen as parents and crossed in a complete diallel including reciprocals. In 1988, the parents, F1's, F2's, and six cultivars representing California market classes were planted in a RCBD with two reps of 40 plants each (15 for F1's).

ANALYSIS OF VARIANCE: The ANOVAs for BA and PF (Table 1) show highly significant differences among generations and among entries within generations.

GENERATION MEANS ANALYSIS: Generation means analyses (Mather & Jinks, 1977), were conducted for BA or PF for each combination of T x S parents (data not shown). The failure of a simple additive dominance model to fit the data for some of the crosses could be due to interactions or to lack of simple Mendelian inheritance (maternal effects, preferential fertilization...).

DIALLEL ANALYSIS: A diallel analysis was conducted according to Griffing's (1956) Method 1 Model I for both traits (Table 2). Both the general combining ability (GCA), containing additive effects and A x A interactions, and the self effects, were highly significant for both traits. Specific combining ability (SCA), containing dominance effects and A x D and D x D interactions were highly significant for BA only. (The "Self" df and SS come out of the "SCA" components and the "Maternal" df and SS come out of the "Reciprocal" components.) Neither maternal nor reciprocal effects were significant for either trait. Since parents represent a fixed sample, it was valid to estimate GCA effects ($\hat{g}_i$) and SCA ($\hat{s}_{ij}$) or self ($\hat{s}_{ii}$) effects (Table 3, Hallauer & Miranda, 1981). For both traits, $\hat{g}_i$ values indicated that the tolerant parents transmitted heat tolerance to their F1 progeny, while the susceptible parents resulted in more susceptible F1's (Table 3). Several self effects ($\hat{s}_{ii}$) were significant, and thus it appears that heterosis for heat tolerance is important at both BA and PF.

DISCUSSION: Significant GCA for both traits indicates opportunity for gain from selection, since both additive effects and A x A interactions are maintained upon selfing. Significant self effects for both traits, with inbred parents less tolerant than F1 hybrids indicate that materials must be tested for heat tolerance in advanced generations.

LITERATURE CITED:

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

Hallauer, Arnel A. and J. B. Miranda, FO. 1981. Quantitative Genetics in Maize Breeding. Iowa State University Press, Ames, IA. 468p.

Mather, Kennneth and John J. Jinks. 1977. Introduction to Biometrical Genetics. Cornell University Press, Ithaca, NY. 231p.

Table 1. Analysis of variance for BA and PF. Model - reps random, generations and entries fixed; MS_e is denominator for all F tests.

Source	BUD ABORTION df	BUD ABORTION F	POD FILL df	POD FILL F
Rep	1	2.13^{NS}	1	5.29^{NS}
Gen	3	58.10**	3	15.50**
Rep x Gen	3	$.91^{NS}$	3	$.89^{NS}$
Ent / Gen	30	55.86**	35	5.16**
Among Cultivars	5	18.62**	5	3.17*
Among Parents	3	101.41**	4	15.00**
Among F1	11	65.06**	11	1.76^{NS}
Among F2	11	51.17**	15	5.69**
Rep x Ent / Gen	30		35	
CV		7.24%		9.26%

Table 2. Diallel analysis according to Griffing's (1956) Method 1 Model I for bud abortion (BA) and pod fill (PF).

Source	df	BA F	PF F
Mean	1		
Reps	1	1.16^{NS}	$.94^{NS}$
GCA	3	427.24**	10.33**
Self	4	42.26**	5.52**
SCA	2	13.35**	$.22^{NS}$
Maternal	3	$.34^{NS}$	$.82^{NS}$
Reciprocal	3	$.19^{NS}$	2.58^{NS}
Error	15		

**Significant at P=.01   NSNonsignificant.

Table 3. Estimates of GCA and SCA effects (and standard errors) for two diallel analyses (BA and PF).

BUD ABORTION - negative values indicate tolerance

	$\hat{g}_i$	$\hat{s}_{ii}$, $\hat{s}_{ij}$ P1	P2	P3	P4
P1	- .40	- .38	- .13	- .05	.56
P2	-1.75		1.76	- .55	-1.08
P3	.81			.28	.32
P4	1.34				.20

$SE(\hat{g}_i)$ = .82 $SE(\hat{s}_{ii})$ = .20 $SE(\hat{s}_{ij})$ = .15

POD FILL - positive values indicate tolerance

	$\hat{g}_i$	$\hat{s}_{ii}$, $\hat{s}_{ij}$ P1	P5	P6	P7
P1	.044	-.025	-.003	.007	.020
P5	.026		-.085	.021	.067
P6	-.012			-.065	.037
P7	-.058				-.124

$SE(\hat{g}_i)$ = .017 $SE(\hat{s}_{ii})$ = .042 $SE(\hat{s}_{ij})$ = .032