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1) Heterosis performance and combining ability in soybeans.

Before hybrid soybeans can become a reality, two requirements should be satisfied: (i) an economical large-scale method of producing hybrid seed must be found, and (ii) heterosis for yield must exist. With the findings of genetic male sterility in soybeans (Brim and Young, 1971) interest has developed in the potential productivity of hybrid soybeans. A method for producing experimental quantities of hybrid soybean seed using genetic male sterility and green seed embryo was suggested by Burton and Carter (1983). Studies have shown the average high-parent heterosis for yield of hybrid soybeans to range from 8% (Paschal and Wilcox, 1975) to 25% (Chaudhary and Singh, 1974). The objective of this study was to determine the magnitude of heterosis and combining ability for agronomic characters in soybeans adapted to Oklahoma.

Materials and methods: The study was conducted at the Agronomy Research Station, Perkins, Oklahoma, in the summers of 1982 and 1983. Six F_1 hybrids (all combinations except reciprocals) of the cultivars 'Douglas', 'Essex', 'Forrest', and 'York' were space-planted along with their parents in a randomized complete block design with four replications in 1982 and eight replications in 1983. The spacing between plants and between rows was the same ($76 \times 76 \text{ cm}^2$). Data collected were seed yield/plant (g), number of pods/plant, number of seeds/pod, seed size (weight in g of 100 random seeds), plant weight (g), harvest index, and height (cm). The statistical analyses were performed on entry-blocks means. In the analysis of variance, years, and genotypes were assumed fixed. The 1982 and 1983 tests were combined in the analyses.

Diallel analysis was obtained using Gardner and Eberhart (1966) analysis III. In this analysis, the among F_1 hybrids were partitioned into general (GCA) and specific combining ability (SCA), using Griffing's (1956) method 4 (parents excluded), model 1 (fixed model).

Results and discussion: Average midparent heterosis for yield, number of pods/plant, number of seeds/pod, seed size, plant weight, harvest index, and height were 24.6, 18.0, 0.4, 2.7, 19.5, 4.9, and 13.5%, respectively. Average high-parent heterosis for yield, number of pods/plant, number of seeds/pod, seed size, plant weight, harvest index, and height were 20.1, 6.9, -3.4, -7.5,

14.0, 1.7, and 7.6%, respectively. Five out of six hybrids were significantly ($P \leq 0.05$) higher in yield than the high-parent. The hybrid of Douglas/Essex expressed the highest heterosis response for yield with 37.1% for midparent heterosis and 32.5% for high-parent heterosis, and these were highly significant ($P \leq 0.01$). The hybrids of Douglas/Forrest expressed the lowest heterosis response for yield with 8.9% for midparent heterosis and 2.5% high-parent heterosis.

The years \times parents component from the analysis of variance was significant for yield, number of pods/plant, number of seeds/pod, seed size, harvest index. The years \times F_1 s component, however, was significant only for harvest index. These results indicate that the hybrids were more stable over both years than their parents for yield, number of pods/plant, number of seeds/pod, and seed size.

Mean squares for GCA and SCA were significant for number of pods/plant and harvest index, suggesting the presence of additive and nonadditive genetic variance in this population for these characters. Mean squares for GCA were significant for number of seeds/pod, seed size, and height, suggesting the presence of additive genetic variance in this population for these characters. Mean squares for SCA were significant for yield and plant weight, suggesting the presence of nonadditive genetic variance in this population for these characters.

The years \times GCA interaction was significant only for plant weight and harvest index. The years \times SCA interaction was not significant for any characters evaluated. These results indicate that SCA was more stable over both years than GCA for plant weight and harvest index. The other characters appeared to be equally stable for both types of combining ability.

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2) Combining ability for seed protein and oil content in soybeans.

The diallel analysis technique allows the breeder to estimate the relative importance of general and specific combining ability for important traits in terms of the nature of gene action. Information on these systems is of value in the development of soybean hybrids as well as in the development of pure-line varieties. In this study, a primary objective was to determine the relative magnitudes of general and specific combining ability estimates for protein and oil content in four soybean cultivars grown in Oklahoma.

Materials and methods: The material for this study consisted of four parents ('Douglas', 'York', 'Essex', and 'Forrest'), six F_1 s and six F_2 hybrids. The test materials were space-planted in a randomized complete block design in eight replications at the Agronomy Research Station, Perkins, Oklahoma, in the 1983 growing season. Percent seed protein and oil of each plant was estimated by the Technicon Infraanalyzer 400 (near-infrared reflectance). All diallel tests (F_1 s and F_2 s) were subjected to combining ability analysis using Model 1, Method 4 of Griffing (1956).

Results and discussion: The analysis of variance showed that significant differences are present for protein and oil content among F_1 hybrids and for protein content among F_2 hybrids indicating the presence of sufficient amounts of genetic variability for these traits in these soybean populations.

Highly significant general combining ability effects were observed for protein content in both generations and highly significant specific combining ability effects were observed for oil content in the F_1 generation. These findings are in agreement with those reported by Leffel and Weiss (1958) for oil but not for protein content.

Since general combining ability mean squares were significant only for protein content, general combining ability effects of parents were evaluated

with regard to this trait. Douglas had the greatest positive general effects in both generations, indicating that this parent tended to transmit high protein content to all progenies. Forrest had the greatest negative general combining ability effects in the F_1 generation indicating that this parent tended to transmit low protein content to all progenies. In the F_2 , both Forrest and York had significant negative general combining effects.

Since specific combining ability mean squares were significant only for oil content in the F_1 generation, estimates of specific combining ability effects associated with individual crosses were evaluated for this trait. The hybrids Douglas x Forrest and Essex x York had the greatest positive specific effects (highest in oil content). These particular crosses would be potentially valuable in a breeding program where high oil is of prime consideration. The hybrids Douglas x York and Forrest x Essex had the greatest significant negative effect (lowest in oil content). The negative specific effects of the hybrids Douglas x Essex and Forrest x York were not significant.

In conclusion, the results obtained from the combining ability study indicated that general combining ability effects were important for protein content in both generations, while specific combining ability effects were important for oil content only in the F_1 generation. The line Douglas had the most promising general effect for protein content and the hybrids Douglas x Forrest and Essex x York had the most promising specific effects for oil content. Kempthorne and Curnow (1961) pointed out that general combining ability variance is due primarily to additive genetic variance, while specific combining ability variance estimates primarily nonadditive genetic variance. In this study, Griffing's (1956) Model I, Method 4 were utilized. In this model, the genotypes in the diallel are considered a fixed population and inferences are therefore valid only for the experimental material in the study.

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3) The effect of the narrow-leaf gene in a segregating population.

A single recessive gene designated *ln* by Bernard and Weiss (1972) controls the inheritance of the lanceolate trifoliolate in soybean. They state that the narrow-leaf condition is associated with a high number of four-seeded pods, which they attributed to a pleiotropic effect of the *ln* gene.

No yield differences have been found between narrow and normal leaf types using isolines. Where the narrow-leaf isolines have a higher number of seeds per pod, they have lower 100-seed weight or lower number of pods per plant compared with the normal-leaf isolines (Hartwig and Edwards, 1970; Mandl and Buss, 1981). No previous study has tested the *ln* gene in the heterozygote state. The objectives of this study were to examine the differences for yield and yield components in the F_2 *Ln/Ln*, *Ln/ln* and *ln/ln* genotypes in a cross between a narrow and a normal leaf cultivar.

Materials and methods: The parents selected for this study were the normal-leaf cultivar 'Douglas' and narrow-leaf cultivar 'Miles'. Miles has the T109 germplasm, a narrow-leaf line in the soybean genetic collection. The plants were space-planted (76 x 76 cm) in order to minimize interplant competition. Experimental design was a randomized complete block design consisting of ten replications. Experimental units were each individual plant. The study was conducted at the Perkins Agronomy Research Station (Teller Loam soil), Perkins, Oklahoma, in 1983.

Leaf length and leaf width were taken on the center leaflet of the most recent full expanded trifoliolate. The ratio of leaf width to leaf length was used to classify each plant as narrow (*ln/ln*), intermediate (*Ln/ln*) or normal (*Ln/Ln*) leaf type. Additional measurements were taken at harvest as follows: Plant height (cm), plant biomass (g), number of pods/plant, seed size (the weight of 100 random seeds in grams), number of seeds/pod, yield (g), and harvest index.

Results and discussion: The ranges of the ratio of leaf width to leaf length were 0.32 to 0.45, 0.52 to 0.65, and 0.65 to 0.87 for Miles, F_1 , and Douglas, respectively. There was no overlap among the three genotypes. There were 70, 126, and 58 plants classified as narrow, intermediate, and normal, respectively, in the F_2 generation, using the above ratios. These numbers fit the expected 1:2:1 ratio ($P=0.5$ to 0.7).

No differences in height and harvest index were found among the three genotypes, indicating that these characters were not associated with the *ln*

gene. However, significant differences were observed among the means of the narrow, intermediate, and normal genotypes for the characters: plant biomass, number of pods/plant, seed size, number of seeds/pod, and yield. Differences for number of seeds per pod (2.30, 2.44) and seed weight (14.1 g, 13.0 g) were observed between the normal and the narrow F_2 genotypes, respectively. No differences were observed for yield (85.6 g, 80.5 g), number of pods per plant (262, 250), or plant biomass (196.8 g, 182.3 g) between the normal and narrow F_2 s, respectively. These results support conclusions of Mandl and Buss (1981) and Hartwig and Edwards (1970), who found that the *ln* gene was associated with a higher number of seeds/pod, and smaller seed size.

The intermediate (heterozygote) had significantly higher means for plant biomass (220.7 g), number of pods/plant (292) and yield (96.2 g) than either the narrow or the normal. Seed size (19.9 g) and number of seeds/pod (2.34) were not different from the normal leaf. These results suggest that there is an association between the *ln* gene and plant biomass, number of pods/plant and yield in the heterozygous condition. Thus, while there is a compensating effect in the yield components in the normal (*Ln/Ln*) and narrow (*ln/ln*) genotypes producing no yield differences, the intermediate *Ln/ln* genotype appears to be favored in the space-planting environment producing higher number of pods/plant, consequently higher yield.

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