Dorman	PI 82.588	Lexington
PI 60.273	PI 157.470	PI 371.611
PI 81.780-S	PI 274.442	FC 30.265
PI 157.451	PI 371.610	PI 79.832
PI 238.928	Arlington	PI 95.959
PI 342.003	PI 71.465	PI 235.347
Dortchsoy 67	PI 83.942	PI 339.998
PI 62.203	PI 200.450	PI 381.670

Twenty-four cultivars/PI's were found to have field resistance to both of these pests.

The use of diversified germplasm with multiple pest resistance in developing cultivars resistant to various pests will greatly reduce the need of chemical control measures.

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References

Athow, K. L. 1973. In Soybeans: Improvement, Production and Uses. B. E. Caldwell, Ed. ASA, Incorporated, Madison, WI. pp. 462-464.

Turnipseed, S. G. 1973. In Soybeans: Improvement, Production and Uses. B. E. Caldwell, Ed. ASA, Incorporated, Madison, WI. pp. 545-572.

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1) Evaluation of some soybean isolines in irrigation culture.*

About 9% of the total soybean acreage and about 50% of the total corn acreage in Nebraska was irrigated at least once during the growing season in 1975. The 1975 state averages for irrigated soybeans and irrigated corn were

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2220 and 7605 kg/ha respectively. Obviously, this yield differential (in relation to the price and production cost differentials) accounts for the reason most farmers utilize their irrigated acreage for corn rather than soybeans. It seems reasonable to assume that if irrigated soybean yields of 3500-4000 kg/ha or greater could be consistently obtained, soybeans could become an effective competitor with corn for irrigated land resources. This yield range is certainly not unobtainable as some cultivars in irrigated variety trials often reach the 3500-4000 kg/ha level (Dreier *et al*., 1975).

Soybean cultivars with a somewhat shorter stature would seem to be the solution to the problem of utilizing irrigation to maintain optimum soil moisture levels throughout the growing season and yet still avoid the lush vegetative growth and the subsequent severe lodging which limits the substantial yield potential often inherent under these conditions (Cooper, 1971). In recent years, there have been several studies on the potential of the dt_1 (determinate) and Dt_2 (semi-determinate) genes with respect to reducing lodging (Cooper, 1976; Chang *et al*., 1976). Cultivars carrying either one of these genes were shorter in height and consequently, lodging was reduced, but particularly with dt_1. An earlier report (Hicks *et al*., 1969) also indicated that the gene Dt_2 may confer a slight yield advantage in narrow and conventional row spacings in dryland production even though the lodging scores of the Dt_2 and normal types were not very different.

We are currently interested in evaluating soybean genetic morphological variants in irrigation culture to determine their yield potential and lodging resistance. In 1976, we selected several 'Clark' and 'Harosoy' isolines for a preliminary test under irrigation (original seed provided by R. L. Bernard, USDA-ARS, Urbana, IL). A randomized complete block design with four replications was used. Individual plots consisted of 3 rows, 6.1 m in length, from which a 3.05 m section of the center row was ultimately harvested for yield. The test was irrigated three times during the growing season, July 12, July 29 and August 13. A planned fourth irrigation during the last week in August was not accomplished because of other demands on the water resources during this rather dry year. The isolines used are listed in Table 1. The gene e_2 in Clark was included to provide isolines with a maturity more adapted to the Lincoln area. The gene E_1 in Harosoy was selected because in previous tests it had been extremely sensitive to lodging when grown under irrigation.

The agronomic data shown in Table 1 reveal that the leaf shape genes

Table 1

Agronomic data for some Clark and Harosoy isolines grown under irrigation

Isoline	Line designation	Yield (kg/ha)	Maturity	Lodging	Height (cm)
Clark - +	(L1)	2102 b	10/5	1.5 a	116 a
Clark - $\underline{Dt_2}$	(L62-1251)	2154 b	10/4	1.6 a	84 c
Clark - $\underline{e_2}$	(L62-1932)	2494 a	9/18	1.1 b	100 b
Clark - $\underline{Dt_2e_2}$	(L67-3232)	2845 a	9/18	1.0 b	73 d
Clark - $\underline{ln}$	(L62-1579)	2019 b	10/4	1.5 a	114 a
Harosoy - +	(L2)	2470 a	9/14	1.6 b	104 b
Harosoy - $\underline{Dt_2}$	(L62-361)	2731 a	9/15	1.0 d	77 c
Harosoy - $\underline{E_1}$	(L68-694)	1558 b	10/9	5.0 a	133 a
Harosoy - $\underline{ln}$	(L63-1212)	2473 a	9/14	1.1 cd	105 b
Harosoy - $\underline{lo}$	(L65-372)	2455 a	9/16	1.4 bc	103 b

C.V. = 10.4%

(_ln_ and _lo_) were similar to the normal Harosoy isoline in most respects. The Harosoy-E_1 isoline, however, lodged almost completely within a day or two after the second irrigation and its yield was only 60% of the normal isoline. While one cannot ignore the substantial maturity difference between the E_1 and normal Harosoy isolines, the early lodging resulting from the 28% increase in height was probably the primary factor in the yield reduction (compare, for example, the Harosoy-E_1 isoline and the normal Clark isoline which are somewhat more similar in maturity). Although the Harosoy-Dt_2 isoline was shorter (26%) in height, which resulted in significantly less lodging, the 10% yield advantage over the normal isoline was not statistically significant.

Surprisingly, the Clark-Dt_2 isoline did not differ significantly from the normal isoline (or the _ln_ isoline) in either yield or lodging, even though it was significantly shorter (28%) in height. This may have been due to the absence of the planned fourth irrigation which for the later-maturing Clark might have masked a potential lodging and yield differential. The Clark-e_2 isoline, which was about two weeks earlier and 14% shorter than the normal isoline, showed significantly greater yield (about 400 kg/ha), probably because of the better maturity 'fit' with the irrigation schedule. Interestingly, the Clark-Dt_2e_2 isoline was 27% shorter and had a nearly significant 14% yield advantage over Clark-e_2, indicating a synergistic effect of Dt_2 and e_2 on yield under the irrigation schedule imposed. Although the lodging scores of the Dt_2 and normal isolines were similar, the corresponding earlier Dt_2e_2 and e_2 isolines were shorter and, consequently, had significantly less lodging.

While we recognize the limitations in the isoline approach to evaluating contrasting alleles (Cooper, 1976), these preliminary data indicate that the reported slight yield advantage of the Dt_2 gene (Hicks _et al_., 1969) can be enhanced in irrigation culture when present in a genetic background of an appropriate maturity that 'fits' the irrigation schedule imposed. In addition, these data indicate the critical importance of the timing of irrigation with respect to reproductive differentiation and development. In this regard, isolines differing in flowering and maturity dates (i.e., the major maturity genes) may be of significant use in identifying those critical, perhaps relatively short, periods in reproductive ontogeny when supplemental water is most beneficial for enhancing yield.

Although the yields of the late Clark isolines were comparable to that of

'Clark 63' (2136 kg/ha) grown in an adjacent variety trial (irrigation on July 13 and August 12 only), some indeterminate cultivars of similar maturity to Harosoy and early (e_2) Clark isolines yielded 3000-3300 kg/ha with lodging scores of 2.0-3.0. However, it seems reasonable to assume that the Dt_2 gene, when incorporated into possibly more complementary genetic backgrounds, could have some potential in reducing lodging in irrigated soybean culture and could well provide the necessary yield enhancement to allow soybeans to effectively compete with corn for grower-directed allocations of irrigated land resources.

References

Chang, J. F., R. Shibles and D. E. Green. 1976. Performance of semi-determinate and indeterminate soybean isolines. Agron. Abstr., p. 47.

Cooper, R. L. 1971. Influence of soybean production practices on lodging and seed yield in highly productive environments. Agron. J. 63: 490-493.

Cooper, R. L. 1976. Modifying morphological and physiological characteristics of soybeans to maximize yields. pp. 230-236. In L. D. Hill (ed.), World Soybean Research. Interstate Printers and Publishers, Inc., Danville, IL.

Dreier, A. F., J. H. Williams, R. S. Moomaw, P. H. Grabouski and J. E. Specht. 1975. Performance of soybean varieties in Nebraska—1975. Outstate Testing Circular 171.

Hicks, D. R., J. W. Pendleton, R. L. Bernard and T. J. Johnston. 1969. Response of soybean plant types to planting patterns. Agron. J. 61: 290-293.

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2) Heterosis and additive X additive epistasis.*

Abstract: A model is shown which has no dominance or dominance types of epistasis but which can result in heterosis of a hybrid over the best parent. The heterosis is due, in this case, entirely to additive X additive epistasis. The fact that dominance affects inbreeding depression but that additive X additive epistasis does not suggests that the amount of inbreeding depression is a better criterion for deciding whether or not to breed for hybrids in a particular crop.

Much has been said in recent years about heterosis in self-pollinated

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crops as a theoretical reason for going into hybrid breeding programs. I wish to show a model that contains no dominance whatsoever and still shows heterosis of the hybrid over the best parent. This is not a new idea but has been previously alluded to by Matzinger (1963), among others.

Assume a model with the following genetic values:

	bb	Bb	BB
aa	1	3	5
Aa	2	6	10
AA	3	9	15

This model contains only additive and additive X additive epistasis effects. If one crosses two lines, AAbb (value of 3), and aaBB (value of 5), one gets the genotype AaBb with a value of 6, thus exhibiting "hybrid vigor" or heterosis.

If one starts with the double heterozygote and self-pollinates to homozygosity without natural or artificial selection, one should end up with equal proportions of aabb, aaBB, AAbb, and AABB. The mean value of these four genotypes would be 6 and is equal to the value of the double heterozygote. Thus there is no inbreeding depression with this model. Therefore, the notions of "heterosis" and "inbreeding depression" should be considered separately. Inbreeding depression information should be better evidence for the presence or absence of large dominance effects or dominance types of epistasis. If no inbreeding effects are exhibited, one might conclude that the major genetic effects present are additive and additive X additive epistasis. This, in turn, would suggest the use of line per se recurrent selection programs as the best investment of breeding time and money, as suggested by Hanson et al. (1967).

One final point may be worth making. Suppose we change the model to the following genetic effects:

	bb	Bb	BB
aa	1	3	5
Aa	2	5	8
AA	3	7	11

Again, if we cross aaBB and AAbb the resulting hybrid would have the value of 5. One sometimes sees references to crosses being closer in measurement to one or the other of two parents, and this is sometimes called dominance.

The fact that this is not necessarily so is evident from this model, which again has only additive and additive X additive epistasis effects in it.

References

Hanson, W. D., A. H. Probst and B. E. Caldwell. 1967. Evaluation of a population of soybean genotypes with implications for improving self-pollinated crops. Crop Sci. 7: 99-103.

Matzinger, D. F. 1963. Experimental estimates of genetic parameters and their applications in self-fertilizing plants. In Statistical Genetics and Plant Breeding, pub. 982, Natl. Acad. of Sci. - Natl. Res. Council. Hanson, W. D. and H. F. Robinson (eds.).

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1) Soybean breeding research in India.

Introduction: Soybean (*Glycine max* (L.) Merrill) is the miracle crop of the twentieth century. It is a new introduction to Indian agriculture. In view of chronic shortage of protein and oil in this country, soybean should be welcome introduction to provide the much needed stability and boost to the production of these two essential items of food (Saxena, 1975). Its high nutritive value makes it ideally suited for its versatile industrial uses. Its increasing industrial exploitation has, also, led to the manufacture of a large number of antibiotics in this country (Singh and Bajaj, 1969).

There is an immediate demand for soybean of 10,000 to 12,000 tons from the antibiotic industries of India, which utilize soybean as culture media. A demand for equal quantum is from the high protein food units. There is also a substantial demand from the poultry and animal feed industry (Jayswal, 1969).

Keeping in view the rising trend of demand for soybean from every corner of the country's economy, an overall improvement has to be undertaken in different agro-ecological conditions of India, to derive the fullest advantage from this wonder crop.

Floral biology: The knowledge of floral biology serves as a guideline to frame the various steps in proper execution of hybridization programs. The various aspects of floral biology, like bud development, time of blooming,