important for the selection of soybeans for dense planting.

The F_2 is grown at 40 X 11 cm; this is about 23 plants per m^2 and is comparable with the spacing of 20 X 20 cm. To reach the yield target of 3000 kg/ha (45 bu/ac), the F_1 has to yield 27 g per single plant and the F_2 has to yield 13.2 g per single plant.

Deduction of the spacing problem: The trials will be continued; from investigations with different other crops it is concluded that the tendency to more plants per area will continue. It is necessary to grow soybeans with different spacings for screening new varieties or own breedings. Breeders have to consider the requirements of closer spacings.

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1) A spontaneous mutant at the st_2 locus.

In 1971, Detroy Green, Department of Agronomy, Iowa State University, found sterile plants in an F_4 single-plant progeny row from a cross of Hark X Harosoy Dt_2Dt_2. This family segregated 66 fertile to 21 sterile plants. Microspore mother cells of the sterile plants were examined, and a low level of chromosome pairing was observed, indicating that the sterile was either an asynaptic or desynaptic mutant. We designated this new mutant the ISU sterile.

Among F_2 families, we found 18 segregating and 9 nonsegregating families which fit a 2:1 ratio. Furthermore, a ratio of 3 fertile : 1 sterile plants was observed in the 18 segregating families (Table 1, 1972 data).

Segregation for the ISU sterile was observed in other genetic backgrounds as well (Table 1, 1976 data). Crosses were made using plants heterozygous for the ISU sterile and homozygous fertile plants of T241, T242, and T258, respectively. We observed a total of 3284 fertile : 1119 sterile plants (a 3:1 ratio). On the basis of these data, we concluded that sterility in the ISU sterile is controlled by a single gene in the homozygous recessive condition.

Three nonallelic asynaptic or desynaptic mutants have been previously reported in soybeans. Hadley and Starnes (1964) reported $\underline{st}_2$ (T241) and $\underline{st}_3$ (T242). Palmer (1974) later described $\underline{st}_4$ (T258).

The purpose of this study was to determine if this new asynaptic or desynaptic mutant, the ISU sterile, $\underline{st}_?$, is allelic to either $\underline{st}_2$, $\underline{st}_3$, or $\underline{st}_4$. This was done by crossing known heterozygotes, i.e., $\underline{St_2st_2}^X\underline{St_?st_?}$, $\underline{St_3st_3}^X\underline{St_?st_?}$, and $\underline{St_4st_4}^X\underline{St_?st_?}$. F_1 and F_2 populations of each cross were observed. If two lines were allelic with regard to their sterility, then one out of four F_1 plants would be sterile; in the F_2 generation nonsegregating families and families segregating 3 fertile : 1 sterile plants would be observed. If different genes were controlling sterility in the two lines, however, no sterile plants would be observed in the F_1 generation. Moreover, the F_2 generation would include nonsegregating families, families segregating 3 fertile : 1 sterile plants, and families segregating 9 fertile : 7 sterile plants.

In conducting an allelism test with T241H and the ISU sterile, 94 F_1 plants were obtained from 30 different parental combinations. Among these, 66 fertile and 28 sterile plants were observed which fit a 3:1 ratio. Of the 62 F_2 families, 15 were nonsegregating and 47 segregated 3384 fertile : 1197 sterile plants (a 3:1 ratio). No F_2 families segregated 9:7 (Table 2). The F_1 and F_2 data show that T241 and the ISU sterile are genetically alike with regard to their sterility.

Since $\underline{st}_2$, $\underline{st}_3$, and $\underline{st}_4$ previously have been reported to be nonallelic, and $\underline{st}_?$ was found to be allelic to $\underline{st}_2$, it must then be nonallelic to $\underline{st}_3$ and $\underline{st}_4$. To be certain of this we simultaneously conducted allelism tests for $\underline{st}_3$ and $\underline{st}_4$ with $\underline{st}_?$. When crosses were made between T242H and the ISU

Table 1

Ratios of fertile to sterile plants in segregating families of the ISU sterile (1972) and in segregating families of the ISU sterile crosses (1976)

Year	Fertile plants	Sterile plants	χ^2(3:1)	P
1972	434	167	2.49	<.250
1976†	1676	564	0.04	<.900
1976††	633	200	0.44	<.750
1976†††	541	188	0.24	<.750
Totals	3284	1119	3.21	<.750
Pooled χ^2 (1 df)			0.40	<.750
Homogeneity χ^2 (3 df)			2.81	<.500

†, ††, †††Segregating F_2 families from crosses between heterozygous plants of the ISU sterile and homozygous fertile plants of T241, T242, and T258, respectively.

Table 2

Ratios of fertile to sterile plants in the F_1 population and 47 segregating F_2 families from crosses between heterozygous plants of T241 and heterozygous plants of the ISU sterile

Generation	Fertile plants	Sterile plants	df	χ^2(3:1)	P
F_1 Totals	66	28	1	1.15	<.500
F_2 Totals	3384	1197	47	33.72	<.950
Pooled χ^2			1	3.12	<.100
Homogeneity χ^2			46	30.60	<.975

sterile, 38 F_1 plants were obtained from 14 different parental combinations. All 38 F_1 plants were fertile. In the F_2 population, 15 families were all fertile, 13 families segregated 868:310 (3:1), and the remaining 10 families segregated 666:505 (9:7) (Table 3). These observations support the hypothesis

Table 3

Ratio of fertile to sterile plants in segregating[a] F_2 families from crosses between heterozygous plants of T242 and heterozygous plants of the ISU sterile

	Fertile plants	Sterile plants	df	χ^2(3:1)	P	Fertile plants	Sterile plants	df	χ^2(9:7)	P
Totals	868	310	13	13.40	<.500	666	505	10	6.94	<.750
Pooled χ^2			1	1.09	<.500			1	0.19	<.750
Homogeneity χ^2			12	12.31	<.500			9	6.76	<.750

[a]13 families appeared to segregate 3:1 and 10 families 9:7.

Table 4

Ratio of fertile to sterile plants in segregating[a] F_2 families from crosses between heterozygous plants of T258 and heterozygous plants of the ISU sterile

	Fertile plants	Sterile plants	df	χ^2(3:1)	P	Fertile plants	Sterile plants	df	χ^2(9:7)	P
Totals	1166	411	17	14.52	<.750	721	575	12	8.06	<.900
Pooled χ^2			1	0.95	<.500			1	0.20	<.750
Homogeneity χ^2			16	13.57	<.750			11	7.86	<.750

[a]17 families appeared to segregate 3:1 and 12 families 9:7.

that sterility in T242 and the ISU sterile are controlled by two different genes.

In the allelism test between T258H and the ISU sterile, we obtained 38 F_1 plants from 15 different parental combinations. We found no sterile plants among the F_1 plants. The F_2 population included 9 families that did not segregate, 17 families that segregated 1166:411 (3:1), and 12 families that segregated 721:575 (9:7) (Table 4). We, therefore, concluded that sterility in T258 and the ISU sterile are controlled by two different genes.

Three nonallelic asynaptic or desynaptic mutants have previously been reported in soybeans, $\underline{st}_2$(T241), $\underline{st}_3$(T242), and $\underline{st}_4$(T258). The sterile found by Detroy Green was also an asynaptic or desynaptic mutant. It was shown to be allelic with $\underline{st}_2$ on the basis of sterile plants in the F_1 and no 9:7 ratios in the F_2 populations. On the other hand, it was found to be nonallelic to $\underline{st}_3$ and $\underline{st}_4$ because there were no sterile F_1 plants, and there were 9:7 ratios in the F_2 population.

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2) Soybean linkage tests.

In 1969, Walter Fehr of Iowa State University found a dwarf soybean plant (T263) in an early elite breeding population. Allelism tests have not been conducted with the other dwarfs, $\underline{df}_2$, $\underline{df}_3$, and $\underline{df}_4$. We have used this early elite dwarf mutant in crosses with our trisomics.

Segregation ratios were determined for the F_2 progenies from disomic and trisomic plants (Table 1). Previous tests indicated that genes controlling pubescence color ($\underline{T}_1\underline{t}_1$) and flower color ($\underline{W}_1\underline{w}_1$) were not on trisomics A, B, or C. In crosses with trisomics A and B, we classified F_2 progenies for plant height, flower color and pubescence color (Table 2). F_2 linkage results are presented with a = XY, b = Xy, c = xY and d = xy for the gene pairs listed in the form of Xx and Yy. Percentage recombination was obtained from the ratio of

Table 1

Segregation ratios of F_2 disomic and trisomic progenies for tall and dwarf plants

Chromosome type	Number of plants		Ratio
	Tall	Dwarf	
Disomic A	262	92	2.85:1
Trisomic A	358	97	3.69:1
Disomic B	323	120	2.69:1
Trisomic B	345	103	3.35:1
Disomic C	112	34	3.29:1
Trisomic C	327	116	2.82:1

Table 2

F_2 linkage tests

Genes	General phenotypic classes					%R ± SE	Linkage phase
	a	b	c	d	Sum		
T263 ($\underline{W}_1\underline{t}_1$ dwarf) X ($\underline{w}_1\underline{T}_1$ tall)†							
$\underline{W}_1\underline{w}_1$ $\underline{T}_1\underline{t}_1$	950	301	320	129	1700	53.4 ± 1.8	repulsion
$\underline{W}_1\underline{w}_1$ tall dwarf	952	299	336	113	1700	51.0 ± 1.8	repulsion
$\underline{T}_1\underline{t}_1$ tall dwarf	1158	112	130	300	1700	15.4 ± 1.0	coupling
T266 ($\underline{ms}_1\underline{W}_1$) X ($\underline{Ms}_1\underline{w}_1$)†							
$\underline{W}_1\underline{w}_1$ $\underline{Ms}_1\underline{ms}_1$	1268	557	583	60	2468	30.4 ± 1.8	repulsion
T260 ($\underline{ms}_1\underline{w}_1$) X ($\underline{Ms}_1\underline{W}_1$)††							
$\underline{W}_1\underline{w}_1$ $\underline{Ms}_1\underline{ms}_1$	451	91	87	100	729	27.9 ± 2.0	coupling

†Includes disomics and trisomics A and B.

††Includes disomic and trisomic C.

products following the method of Immer and Henderson (1943).

The dwarf trait is not located on trisomics A, B or C, nor is it linked to $\underline{W}_1\underline{w}_1$. It is linked to $\underline{T}_1\underline{t}_1$ of Linkage Group 1, with 15.4% recombination.

Additional tests are underway with the other mutants of Linkage Group 1.

In another linkage study, involving flower color ($\underline{W_1}\underline{w_1}$) and male sterility ($\underline{Ms_1}\underline{ms_1}$), we noticed linkage of $\underline{Ms_1}\underline{ms_1}$ and $\underline{W_1}\underline{w_1}$ and the results show 27.9% and 30.4% recombination for coupling and repulsion phase, respectively (Table 2).

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1) Observation on cross-pollination of soybeans after gamma irradiation of seeds.

Seeds of 'Sansai' variety, line No. 34-9-1 (white flower, as a female parent) were irradiated with gamma rays of a cesium^{137} source; 5 and 15 krad were used. After treatment, Sansai seeds were grown in alternate rows with S.J. 1 line No. 56-12 and S.J. 2 line No. 27-9 (both purple flowers, as male parents). The experiments were carried out in replications on Kasetsart campus and at Suwan Farm, Pakchong. M_1 plants of Sansai were singly harvested and threshed separately. M_2 seeds of Sansai were then sown in rows (plant-to-row). Observations on flower color of M_2 plants were carefully made. Sansai plants with purple flowers were found in both experiments as shown in Table 1.

In a combination of Sansai and S.J.1, on Kasetsart campus, 1 plant was found among 2741 M_2 plants derived from 15 krad treatment. None was found among M_2 plants derived from either control or 5 krad treatment. In a combination of Sansai and S.J.2, on Kasetsart campus, 2 plants were found among 2412 M_2 plants derived from 15 krad treatment. None was found among M_2 plants derived from either control or 5 krad treatment.

In a combination of Sansai and S.J.1 at Suwan Farm, Pakchong, 1 plant was found among 2385 M_2 plants derived from 15 krad treatment. None was found among M_2 plants derived from either control or 5 krad treatment. In a combination of Sansai and S.J.2 at Suwan Farm, 2 and 6 plants were found among 3226 and 3252 M_2 plants derived from 5 and 15 krad treatments, respectively.