Table 2 (cont'd)

Label no. of collection	Latitude of collection	Daylength (hr) 10*	12	13.5	15	Natural daylength	18	Continuous light
7	43°30'	48	54 (118)	58 (106)	65 (129)	87 (not)	94 (not)	NB
17	31°54'	48	62 (114)	91 (not)	NB	NB	NB	NB
16	30°32'	49	65 (118)	84 (not)	NB	NB	NB	NB
20	28°12'	49	60 (138)	91 (not)	NB	NB	NB	NB

*Results of 1965.

†Figures within parentheses are days from seeding to maturity; outside of them are days to flowering.

††Not mature.

†††NB = no blooming.

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1) Seed acid phosphatase genotypes of cultivars in the USDA soybean collection.

Soybeans have three cultivar-specific electrophoretic forms of a seed acid phosphatase (Gorman and Kiang, 1977). Hildebrand et al. (1980) reported that the three acid phosphatase forms are inherited as codominant alleles at a single locus. The symbol Ap^a was assigned to the slow form, Ap^b to the intermediate and Ap^c to the fast form.

Seed of the cultivars screened for acid phosphatase forms were obtained from R. L. Bernard, USDA, Urbana, IL 61801 and E. E. Hartwig, USDA, Stoneville, MS 38776. The acid phosphatase genotypes of the soybean cultivars (Tables 1 and 2) were determined by a polyacrylamide gel electrophoretic procedure described by Hildebrand et al. (1980).

Table 1

Acid phosphatase form of named cultivars of the Northern U.S.
(Maturity Group 00 through IV)

Cultivar	Maturity group	Ap*	Cultivar	Maturity group	Ap*
Acme	00	B	Clark	IV	B
Ada	00	B	Clark 63	IV	B
Adams	III	B	Clay	0	B
Adelphia	III	B	Cloud	III	B
Agate	00	B	Columbia	III	B
AK (FC 30 761)	IV	B	Columbus	IV	B
AK Harrow	III	B	Comet	0	B
AK Kansas	IV	B	Corsoy	II	B
Aksarben	II	B	Crest	00	B
Altona	00	B	Custer	IV	B
Amsoy	II	B	Cutler	IV	B
Amsoy 71	II	B	Cutler 71	IV	B
Anoka	I	B	Cypress No. 1	IV	B
Aoda	IV	B	Delmar	IV	B
A-100	I	B	Disoy	I	B
Bansei Ames	II	B	Dunfield	III	C
Bavender Special A	III	C	Dunn	I	B
Bavender Special B	III	C	Early White Eyebrow	0	B
Bavender Special C	III	C	Earlyana	I	B
Beeson	II	B	Ebony	IV	A
Bethel	IV	B	Elton	I	B
Black Eyebrow	II	B	Emperor	IV	B
Blackhawk	I	B	Ennis I	III	B
Bonus	IV	B	Etum	II	B
Boone	IV	B	Evans	0	B
Burwell	I	B	Fabulin	IV	B
Calland	III	B	Flambeau	00	B
Capital	0	B	Ford	III	B
Carlin	IV	B	Fuji	III	B
Cayuga	I	B	Funk Delicious	IV	B
Chestnut	III	B	Funman	II	C
Chief	IV	B	Giant Green	I	B
Chippewa	I	B	Gibson	IV	B
Chippewa 64	I	B	Goku	II	B
Chusei	III	B	Goldsoy	0	B

Table 1 (cont'd)

Cultivar	Maturity group	Ap*	Cultivar	Maturity group	Ap*
Granger	III	B	Kingwa	IV	B
Grant	0	B	Kura	III	B
Green and Black	IV	B	Lincoln	III	B
Guelph	III	B	Lindarin	II	B
Habaro	I	B	Lindarin 63	II	B
Hahto Michigan	IV	C	Linman 553	II	C
Hakote	II	B	Little Wonder	III	B
Harbinsoy	IV	B	Macoupin	IV	B
Harcor	II	B	Madison	II	B
Hardome	0	B	Magna	II	B
Hark	I	B	Manchu	III	C
Harly	I	B	Manchu Lafayette	III	C
Harman	III	B	Manchu Lafayette B	III	C
Harosoy	II	B	Manchu Madison	II	C
Harosoy 63	II	B	Manchu Hudson	II	C
Hawkeye	II	B	Manchu Montreal	I	C
Hawkeye 63	II	B	Manchu 3 Wisc	II	C
Henry	II	B	Manchu 606 Wisc	II	C
Hidatsa	00	B	Manchukota	II	C
Higan	IV	B	Manchuria	I	B
Hodgson	I	B	Manchuria 13177	III	B
Hokkaido	IV	B	Manchuria 20173	III	B
Hongkong	IV	B	Mandarin	I	B
Hoosier	I	C	Mandarin Ottawa	0	B
HP-963	IV	B	Mandarin 507	I	B
Hurrelbrink	IV	B	Mandell	III	C
Illington	IV	B	Manitoba Brown	00	B
Illini	III	B	Mansoy	III	C
Ilsoy	III	B	Medium Green	I	B
Imperial	IV	B	Mendota	I	B
Jefferson	IV	B	Merit	0	B
Jogun	III	B	Midwest	IV	B
Jogun Ames	III	B	Miller 67	III	B
Kabott	0	B	Mingo	III	C
Kagon	I	B	Minsoy	00	B
Kanrich	III	B	Monroe	I	B
Kanro	II	B	Morse	IV	B
Kanum	II	B	Morsoy	00	B
Kent	IV	B	Mukden	II	B
Kingston	IV	B	Norchief	0	B

Table 1 (cont'd)

Cultivar	Maturity group	Ap*	Cultivar	Maturity group	Ap*
Norman	00	B	Sooty	IV	B
Norredo	IV	B	Sousei	II	B
Norsoy	I	B	Soysota	I	B
Ogemaw	00	B	Steele	I	B
Oksoy	IV	B	Swift	0	B
Ontario	I	B	Tastee	II	B
Osaya	III	B	Toku	II	A
Ottawa	I	B	Tortoise Egg	I	B
Pagoda	00	B	Traverse	0	B
Pando	00	B	Union	IV	B
Patoka	IV	B	Vansoy	0	C
Patterson	IV	C	Verde	III	B
Peking	IV	B	Viking	III	B
Pennsoy	III	C	Wabash	IV	B
Perry	IV	B	Wayne	III	B
Poland Yellow	0	B	Wea	II	B
Polysoy	IV	B	Wells	II	B
Portage	00	B	Wilkin	0	B
Portugal	I	B	Williams	III	B
Pridesoy 57	I	B	Willomi	III	B
Prize	II	B	Willomi B	III	B
Protana	II	B	Wilson	IV	B
Provar	II	B	Wilson B	III	B
Rampage	I	B	Wilson 5	IV	B
Renville	I	B	Wilson 5B	IV	B
Richland	II	B	Wilson 6	IV	B
Ross	III	B	Wing Jet	III	B
Sac	I	B	Wirth	I	B
Sanga	IV	B	Wisconsin Black	I	C
Sato-3	IV	B	Wolverine	III	B
Scioto	IV	C	Woodworth	III	B
Seneca	II	B	Wye	IV	B
Shelby	III	B	Yellow Marvel	II	B
Shingto	III	B			
Shiro	IV	B			

*A = $\underline{Ap}^a$ electrophoretic form at Rf 0.38; B = $\underline{Ap}^b$ electrophoretic form at Rf 0.42; C = $\underline{Ap}^c$ electrophoretic form at Rf 0.47. The Rf values of the three electrophoretic forms of acid phosphatase are relative to the Kunitz trypsin inhibitor ($\underline{Ti}^a$) in a 10% polyacrylamide gel anodic system using pH 7.0 gel and bath buffers.

Table 2

Acid phosphatase form of named cultivars of the Southern U.S. (Maturity Group V through IX)

Cultivar	Maturity group	Ap*	Cultivar	Maturity group	Ap*
Acadian	VIII	B	Hollybrook	V	B
Armredo	VI	B	Hood	VI	B
Arisoy	VIII	B	Hutton	VIII	B
Arksoy	VIII	B	Improved Pelican	VIII	B
Avoyelles	VIII	B	Jackson	VII	B
Barchet	VIII	B	JEW 45	VIII	B
Biloxi	VIII	B	Jupiter	IX	B
Bossier	VII	B	Kino	VI	B
Bragg	VII	B	La Green	VIII	B
Charlee	VII	B	Laredo	VI	B
Cherokee	VIII	B	Lee	VI	B
Clemson	VII	B	Lee	VI	B
Cobb	VIII	B	Lee 68	VI	B
Coker 338	VIII	B	Lee 74	VI	B
Coker Hampton	VIII	B	Luthy	V	C
Creole	VII	B	Mack	V	B
Dare	V	B	Magnolia	VI	B
Davis	VI	B	Majos	VIII	B
Delsoy	VI	B	Mammoth Yellow	VII	B
Delsta	VIII	B	Mamloxi	VIII	B
Dixie	V	B	Mamredo	VI	B
Dortchsoy 67	VII	B	Manotan 6640	VIII	B
Dyer	V	B	Missoy	VII	B
Easycook	VI	B	Monetta	VII	B
Essex	V	B	Nanda	VIII	B
Forrest	V	B	Nansemond	V	B
Gatan	VII	B	Nela	VIII	B
Georgian	VII	B	Old Dominion	VI	B
Haberlandt	VI	A	Otootan	VIII	B
Hampton 262	VIII	B	Palmetto	VII	B
Hampton 266A	VIII	B	Peking	IV	B
Hardee	VIII	B	Pickett	VI	B
Harrel	V	B	Pickett 71	VI	B
Hayseed	VI	B	Pine Dell Perfection	VI	B
Hinn	VI	B	Pluto	VII	B

Table 2 (cont'd)

Cultivar	Maturity group	Ap*	Cultivar	Maturity group	Ap*
Pochahontas	VII	B	Tarheel Black	VII	B
Ralsoy	VI	B	Tenn Non-Pop	VII	B
Roanoke	VII	B	Tokyo	VII	B
Rokuson	VI	B	Tracy	VI	B
Rose Non-Pop	VI	B	Virginia-S	V	B
S-100	V	B	Volstate	VII	B
Semmes	VII	B	White Biloxi	VIII	B
Seminole	VIII	B	Woods Yellow	VII	B
Stuart	VIII	B	Yelrarda	VIII	B
Tanner	VII	B	Yelredo	VIII	B
			York	V	B

*A = $\underline{Ap}^a$ electrophoretic form at Rf 0.38; B = $\underline{Ap}^b$ electrophoretic form at Rf 0.42; C = $\underline{Ap}^c$ electrophoretic form at Rf 0.47. The Rf values of the three electrophoretic forms of acid phosphatase are relative to the Kunitz trypsin inhibitor ($\underline{Ti}^a$) in a 10% polyacrylamide gel anodic system using pH 7.0 gel and bath buffers.

A note of caution: From a plant breeder's viewpoint the cultivar seed obtained from Drs. Bernard and Hartwig generally are pure. That is, the flower color, pod color, hilum color, etc., of each cultivar is uniform. However, from a biochemist's viewpoint the seed may be mixed. There are three possible sources for the mixtures: (1) The original parental lines may have had different allelic forms. By the time a cultivar is released it has been selfed for several generations and hence very few, if any, heterozygous seed can be found in a sample seed lot. (2) Natural outcrossing or mutations may have taken place during the multiplication process. And (3) during the harvesting and cleaning process alien seed may have been mixed in accidentally with the cultivar. Most frequently, the first two sources are the causes of a cultivar mixture. Therefore, we suggest that, when a new cultivar is to be categorized for a particular biochemical allele, at least 100 seed be tested. The seed tested should be breeders or foundation seed. In addition, the parental lines should be tested. It is important to determine whether the mixture is inherent in the cultivar or whether the mixture is due to some other cause. There is nothing intrinsically wrong with a cultivar that contains an inherent

mixture or mixtures of biochemical alleles; e.g., 'Cutler 71' and 'Williams 79' are mixtures of Ep and ep. Common sense must prevail and such cultivars should not be disqualified by either seed standard or certification agencies because they are "mixed".

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2) Screening the USDA soybean germplasm collections for lines lacking the 120,000 dalton seed lectin.

Pull et al. (1978b) screened 102 lines of soybeans [Glycine max (L.) Merr.] and found 5 lines lacking the 120,000 dalton seed lectin ('Columbia', 'Norredo', 'Sooty', 'T102', and 'Wilson-5'). The amount of soybean lectin (SBL) per g defatted meal and the amount of SBL content in soybean protein for the 102 lines tested also was published by Pull et al. (1978a). Orf et al. (1978) demonstrated, using polyacrylamide gel electrophoresis, that the presence of SBL is controlled by a single dominant gene designated Le. The homozygous recessive le le results in the lack of SBL.

The conventional Ouchterlony (1948) double diffusion technique was used in this study to screen for the presence or absence of SBL. Anti-serum with antibodies specific to SBL was obtained by immunizing adult male New Zealand white rabbits with purified soybean lectin and Freund's complete adjuvant emulsion (Orf, 1979). Twenty-four lines simultaneously were screened in each Ouchterlony plate (1% agar in 0.1 M pH 8.0 phosphate buffer). Ten µl of seed extract (one seed ground in 2 ml of 0.092 M Tris and 0.023 M $CaCl_2 \cdot 2H_2O$ plus 1 ml of 0.4 g of sucrose per ml adjusted to pH 8.1) was pipetted into a well surrounding a central well containing 10 µl of antiserum. Failure of a precipitin band to form indicated no detectable SBL present. Lines of G. max not showing lectin by this procedure were checked using polyacrylamide gel electrophoresis (Orf et al., 1978). In all cases the two procedures were in agreement.

The seed used in this study were obtained from R. L. Bernard, USDA, Urbana, IL 61801 and E. E. Hartwig, USDA, Stoneville, MS 38776. The collection is divided into 4 categories: Plant Introductions, T lines (genetic mutants), named cultivars, and G. gracilis. Glycine gracilis Skvortz. has been described as a species morphologically intermediate between G. max and G. soja Sieb. and Zucc. (Skvortzow, 1927), but Hermann (1962) placed it under synonymy with G. max. For this study G. gracilis has been separated from G. max.

The results of the screening data are presented in Table 1. Of the 2137 soybean plant introductions (PI) screened, the following 13 lacked SBL: PI 81,764, PI 82,278, PI 89,772, PI 89,773, PI 90,490, PI 90,763, PI 90,768, PI 96,786, PI 123,587, PI 157,492, PI 171,428, PI 171,431 and PI 291,310C. Of the 107 lines tested in the type collection,

Table 1

Distribution of alleles of the Le locus in the USDA soybean germplasm collection

Collection	Le	le	Total
Plant Introductions			
Japan	500	0	500
China	811	10	821
Korea	436	3	439
India	245	0	245
USSR	16	0	16
Vietnam	5	0	5
Pakistan	4	0	4
Burma	2	0	2
Afghanistan	4	0	4
Indonesia	33	0	33
Malaya	14	0	14
Philippines	20	0	20
Thailand	34	0	34
Type collection	106	1	107
Named cultivars			
Southern	110	0	110
Northern	266	4	270
Glycine gracilis	40	0	40

only T102 was found to be lacking SBL. T102 is the source for y_4, a chlorophyll-deficient gene. It was selected out of Wilson-5, a cultivar lacking SBL. All 110 of the named cultivars in the southern collection had SBL. Of the 270 named cultivars tested from the northern collection, only 4, which were previously reported by Pull et al. (1978b), lacked lectin. All of the Glycine gracilis accessions contained lectin.

The absence of lectin in seed does not appear to be associated with flower color, pubescence color, pod color, seed coat luster, seed coat color or hilum color. Most of the accessions without lectin are in Maturity Groups III or IV. All of the accessions without lectin come from either China or Korea.

In summation, 2664 lines in the USDA soybean collection were screened for the absence or presence of the 120,000 dalton seed lectin. A total of 18 accessions were found to be lacking the lectin.

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3) Relay intercropping of soybeans and small grains.

During the past two years we have been comparing several cropping systems: relay intercropping of soybeans with wheat, relay intercropping of soybeans with oats, and soybean monoculture. The purpose of the study was to determine if a need for separate breeding programs for these specialized cultural practices exists. Last year McBroom et al. (1979) reported a significant cultivar x cropping system interaction that would seem to indicate that such a need did exist. Further investigation of this cultivar x system interaction was carried out at two locations in Illinois, Urbana and DeKalb, during the summer of 1979.

At Urbana we planted 12 cultivars representing Maturity Groups I-IV in wheat, in oats, and also in monoculture. We used experimental designs that would allow comparisons of soybean yields in the intercropping and monoculture systems. The wheat and oats were planted in 41 cm rows to allow for interplanting of the soybeans. The planting dates of the soybeans were chosen to coincide with heading dates of the small grains. The soybeans in wheat and the associated monoculture were planted on May 29; the intercropped and monoculture soybeans with oats were planted on June 14. Those with oats, however, because of lack of moisture, did not start to germinate until June 22. The wheat was harvested July 2 and the oats were harvested July 19. The soybeans were harvested as they matured from October 6 through October 20.

Similar experiments were conducted at DeKalb, using seven of the same cultivars, those in Maturity Groups I-III. The soybeans were planted in wheat and monoculture June 12, and in oats and monoculture June 25. The wheat was harvested July 17 and the oats were harvested August 2. The soybeans at DeKalb were harvested November 11 and 12. At both Urbana and DeKalb in 1979 two rows 41 cm apart and 4.88 meters long were harvested for yield data. Notes were also taken on lodging, plant height, and number of branches per plant just prior to harvest. An analysis of variance of soybean yields was made for each experiment separately and then on the combined data over years and locations. Since we would like to make inferences over years and locations the data presented here will be the combined data. One way of looking at the combined data is to calculate a mean value for each cultivar intercropped and a mean value for each cultivar in monoculture over years and locations. An analysis of variance can be performed on these mean values using a pooled estimate of error from the various experiments to perform F-tests.

When such an analysis is done the intercrop and monoculture systems are significantly different, and the cultivars are significantly different, but the cultivar x system interaction is non-significant. Another way to analyze the data is to include sources of variation due to years and locations and various interactions with these terms. In such an analysis there are significant year x cultivar and location x cultivar interactions of sufficient magnitude that cultivars, when tested against these, are not considered significantly different. These two interactions cause complications in evaluation of the cultivar x system interaction and seem to be of a much greater magnitude, i.e., differences between years and locations seem to have a greater effect on cultivar evaluation than differences between cropping systems.

Table 1 contains the mean values for the seven cultivars grown over both years and at both locations. These are the means over all intercrop and monoculture plots grown. The pooled estimate of experimental error was used to calculate a lsd value and those yields not followed by the same letter are considered significantly different. It is noteworthy that the correlation ($r = .8877$) between these mean yields (intercrop vs. monoculture) is highly significant. Seven values are really not enough for a good estimate of the correlation coefficient. But if we calculate the correlation between yield in intercrop and yield in monoculture within each experiment using means, we have a total of 51 pairs of means correlated. Such a correlation coefficient ($r = .6164$) is highly significant. Furthermore, an overall correlation ($r = .6161$) of rankings of means within each experiment was highly significant. It is interesting that, over all cultivars, years, and locations, the

Table 1

Mean yields of soybeans intercropped and grown in monoculture

Cultivar	Intercrop yield (kg/ha)	Monoculture yield (kg/ha)
Cumberland	1826 a	3253 c
Oakland	1833 a	3008 a
Hark	1864 a	3035 a b
Wells	1906 a b	3238 b c
Beeson	2104 b c	3436 c d
Corsoy	2174 c	3371 c
Harcor	2309 c	3602 d

intercropped soybean yields averaged 61% of monoculture yields. The range of this percentage for individual experiments was from 42 to 80%. 'Williams' soybeans intercropped in wheat at Urbana, 1979, gave the best overall productivity with 4955 kg/ha of wheat and 3552 kg/ha of soybeans being produced.

On the basis of these means the extra effort and money required for a separate breeding program for intercropping apparently is not justified. However, a word of caution should be added. We worked with a rather small sample of cultivars, whose parentages are not very diverse, and which were all selected for their performance in a monoculture system. It could well be that a more diverse group of germplasm would give different results.

Reference

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H. H. Hadley
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4) Inheritance of hard seeds in soybeans.

During the past three years we have studied the inheritance of hard seeds in soybeans. These studies have been supported in part by INTSOY and in part by the Rockefeller Foundation. They were begun with the help of Dr. H. C. Minor and Dr. E. H. Paschal III who had evaluated potential parental material for the hard-seed characteristic and who continued to help through advice, handling plant materials in Puerto Rico, and providing certain facilities.

Parental materials were classified as high, medium, and low in respect to hard-seed percentage. 'Barchet' and PI 326,578 with 70% and 93% hard seeds, respectively, were considered to be high, PI 240,672 and PI 32,566 with 33% and 37% were considered medium, and 'Hardee' and SJ2, each with less than 1%, were considered low in hard-seed percentage.

Seeds were obtained from individual parental, F_1, and F_2 plants grown in Puerto Rico. In March, 1979, hand-threshed seed were shipped to Urbana. All undamaged seed were placed in a germinator and hard-seed counts were made five days later.

Frequency distributions of hard-seed percentage classes shown in Table 1 are examples of the type of data obtained. Barchet x Hardee and Hardee x

Table 1

Frequency distributions and mean percentages of hard seeds in parental, F_1, and F_2 generations of four soybean crosses

Generation	Class											No. of plants	Hard seed X (%)
	0	0.01-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100		
						Barchet (P_1) x Hardee (P_2)							
P_1						1	8	9	4	3	2	27	68.2 ± 1.92
P_2	26	2										28	0.1 ± 0.07
F_1	6	1										7	1.0 ± 1.14
F_2	53	18	2	0	4	2						79	4.4 ± 1.24
						Hardee (P_1) x PI 326,578 (P_2)							
P_1	30											30	0.0 ± 0.00
P_2								4	7	12	4	27	81.5 ± 1.36
F_1	16	4	2									22	1.3 ± 0.83
F_2	53	28	2	2	5	4	1					75	6.3 ± 1.47
						Hardee (P_1) x PI 323,566 (P_2)							
P_1	27	3										30	0.2 ± 0.10
P_2	9	11	3	1	1							25	4.9 ± 1.65
F_1	3	4	4	3	1	1	2					18	18.3 ± 2.61
F_2	32	10	12	9	8	7	2	4	3	0	1	88	19.5 ± 2.62
						PI 326,578 (P_1) x Barchet (P_2)							
P_1							1	6	4	7	8	26	81.4 ± 1.24
P_2						2	3	4	5	7	1	22	73.3 ± 1.40
F_1						1	1	1	2	3	2	10	77.0 ± 3.88
F_2							5	7	18	28	14	72	79.0 ± 1.04

PI 326,578 represent high x low (or low x high) crosses. Normal (soft) seed appears to be dominant. No evidence of transgressive segregation is obvious. Chi-square tests for goodness of fit on the basis of an assumed difference between the parents of three major genes, with complete dominance at each locus and only the completely recessive genotype being as high as the high parent, gave small values with probabilities of 20-50%. A similar hypothesis, except with an assumption of a difference of four major genes, was even more acceptable for the cross, Hardee x PI 326,578, but unacceptable for the cross, Barchet x Hardee.

The cross, Hardee x PI 323,566 (low and medium) showed evidence of "hybrid vigor" for hard-seed percentage with the mean values of F_1 and F_2 being almost four times as high as that of the high parent (18.3% or 19.5% vs. 4.9%). Another medium x low cross involving different lines, however, did not show heterotic-like behavior.

The high x high cross (PI 326,578 x Barchet) showed overlapping among samples of the four generations tested for hard-seed percentage. Both F_1 and F_2 means (77.0% and 79.0%) fell between those of the parents (73.3% and 81.4%). A quantitative genetic model (Mather and Jinks, 1971) was used to estimate gene effects. Only additive effects were significant. We have assumed that these high hard-seed parents differ only in minor or modifier genes.

Results of our studies appear to be similar to those reported by other soybean workers including Woodworth (1933), Kilen and Hartwig (1978), and Green and Pinnell (1968).

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Peerasak Srinives
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