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Ohio FG1 and Ohio FG2 Soybean Varieties

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Ohio Agricultural Research and Development Center
Wooster, Ohio

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Ohio FG1 and Ohio FG2 Soybean Varieties

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Introduction

'Ohio FG1' and 'Ohio FG2' are new soybean varieties released August 1, 1994, by the Ohio Agricultural Research and Development Center of The Ohio State University. These two varieties were developed specifically for the production of tofu and other soyfoods. The purpose of this publication is to describe these varieties and to provide performance data relative to other varieties.

History and Characteristics of Food-Grade Soybean Varieties

Most of the world's soybean production is processed ("crushed") to produce both oil, chiefly for human consumption, and meal, an important source of protein for livestock. A small portion of the crop, however, is used to produce traditional soyfoods, such as soymilk, tofu, miso, tempeh, eda mame, and natto. Tofu, or soybean curd, is one of the most important of these foods. Produced by coagulation of soymilk, it is a major source of protein in the diet, particularly in the East Asian countries. The term 'food-grade' is applied to varieties intended for production of soyfoods.

Although any soybean variety can be used to make soyfoods, certain varieties are preferred. Seed (grain) characters believed to be important for production of tofu and other soyfoods include high content of protein, especially soluble protein; large seed weight; acceptable color; and high sugar content. Of these characteristics, high protein content is probably the most important. In the production of soymilk and tofu, high soluble protein leads to higher yield of food product, i.e., more weight of product per pound of soybeans. Ability of tofu to form a satisfactory gel is also believed to be related to the protein content of the soybeans. Also, the protein content of the soybeans is strongly related to the protein content (and therefore the nutritional quality) of the food product.

Soymilk solids content is a strong indicator of tofu yield (the number of pounds of tofu that can be obtained from a pound of soybeans). Soymilk protein content reflects the concentration of soluble protein in the soybean grain. High values are desirable for both measurements.

Identification of varieties for particular food uses was a feature of traditional soybean production in its Asian homeland (China, Japan, and Korea). As the North American soybean industry developed, the U.S. Department of Agriculture, from 1936 to 1941, named and released several Asian introductions as food-grade varieties. Two of these varieties, 'Willomi' and 'Wolverine,' were known to have been produced in Japan and used for making tofu there. None of the USDA releases was ever widely grown in the United States. Later, varieties such as 'Hawkeye' (released in 1947), 'Kanrich' (1956), and 'Beeson' (1968) were used for production of soyfoods, particularly tofu. Interestingly, 'Hawkeye' and 'Beeson' were originally selected and widely grown as grain-type varieties; their suitability for tofu production was discovered only after their release.

Numerous food-grade soybean varieties are currently on the market, including varieties developed by at least five state experiment stations, several private companies, and Agriculture and Agri-Food Canada. The varieties 'Beeson 80' and 'Vinton 81,' which possess resistance to phytophthora rot [caused by *Phytophthora sojae* (Kaufmann and Gerdemann)], are the most widely grown food-grade varieties in Ohio. Ohio FG1 and Ohio FG2 were developed to replace 'Beeson 80' and 'Vinton 81.'

Origin of Ohio FG1 and Ohio FG2

Ohio FG1 and Ohio FG2 were derived from the cross 'LS301' x HS84-6247, which was made in the summer 1987 at Columbus, Ohio. The parent variety LS301 is a large-seeded variety released by the Iowa Agriculture and Home Economics Experiment Station. The parent line HS84-6247 was derived from 'Zane' [3] x HW79149. The germplasm line HW79149 is a source of phytophthora resistance derived by backcrossing with A72-507 ('Amsoy' x 'Wayne') as recurrent parent.

The F_1 and F_2 plants from LS301 x HS84-6247 were produced during the winter of 1987–88 at Mayaguez, Puerto Rico. The F_2-derived line, HS88-8318, from which both Ohio FG1 and Ohio FG2 were selected, was tested in Ohio from 1988 to 1990. Individual F_4 plants from HS88-8318 were harvested in 1989. Two of the resulting F_4-derived lines, designated HS90-3508 and HS90-3513, were tested in Ohio from 1991 to 1994. When released, HS90-3508 was named Ohio FG1 (FG for Food Grade), and HS90-3513 was named Ohio FG2. Breeder seed of the two varieties was shared with foundation seed organizations in interested states. As a result, Ohio FG1 was released cooperatively between Ohio and Nebraska, and Ohio FG2 between Ohio and Missouri.

Characteristics of Ohio FG1 and Ohio FG2

Both Ohio FG1 and Ohio FG2 have purple flowers and gray pubescence. Pods are brown at maturity. Seedcoats are dull yellow. Seed of Ohio FG1 has a yellow (clear) hilum, although buff- and gray-hilum variants have been observed. Such variants are permitted to constitute a maximum of 1.0% of the variety. Seed of Ohio FG2 has a gray hilum, but variants having imperfect black or buff hila may be observed at a frequency of up to 0.1%.

Both varieties have a relatively bushy, indeterminate plant habit. Leaflets are large and dark green. Seedcoats of both varieties are characterized by high peroxidase activity.

Both varieties have larger seed than any public varieties currently produced in Ohio. Data on seed weight are provided in the next section. Mature plant height of Ohio FG1 and Ohio FG2 is similar to that of 'Chapman' and

Table 1. Performance of Selected Entries from the Ohio Large-Seeded Test, 1991–1994.

Entry	Date Mature	Lodging (score)[1]	Seed Wt.[2]	Yield (bu/a)[3] Lakeview	S. Charleston	Hoytville	Columbus	Mean
Conrad	9/13	1.6	16.3	51.3	58.7	53.2	21.3	51.1
Beeson 80	9/13	2.0	19.2	43.7	50.4	45.8	17.2	43.7
Vinton 81	9/13	2.2	23.5	42.5	52.1	47.4	17.4	44.2
Chapman	9/14	1.6	19.3	53.7	61.8	54.3	24.7	52.6
Burlison	9/18	1.6	19.5	46.3	64.6	52.4	26.4	51.1
Ohio FG2	**9/20**	**2.0**	**26.0**	**47.3**	**63.6**	**52.2**	**21.0**	**50.7**
Ohio FG1	**9/21**	**1.8**	**24.4**	**46.7**	**60.7**	**55.5**	**22.7**	**50.8**
Resnik	9/21	1.4	16.3	52.2	67.8	56.4	23.7	55.0
Thorne	9/23	1.6	19.1	53.8	66.3	55.5	20.9	54.7
Flyer	9/27	1.5	15.9	52.0	69.0	60.3	21.1	56.1
Approximate LSD (0.30)	1	0.2	0.5	3.7	4.7	2.9	2.6	2.6

[1]Rated from 1 (erect) to 5 (prostrate).
[2]Grams per 100 seeds; to convert to seeds/lb., divide 45360 by figure given (for example, 19.2 g/100 seeds equals 2269 seeds/lb.).
[3]Lakeview data from 1991–94; South Charleston and Hoytville from 1992–94; Columbus from 1991 only.

'Resnik.' Shattering resistance of Ohio FG1 and Ohio FG2 is good, similar to that of 'Beeson 80.'

Agronomic Performance

Agronomic performance of selected entries in the Ohio Large-Seeded Test for 1991 to 1994 is shown in Table 1. This test was conducted at two or three Ohio locations each year in order to evaluate released and potential food-grade varieties. Grain-type varieties were included in the test for further comparisons. These tests were conducted in a 15-inch row spacing beginning in 1992. Row spacing was 30 inches in 1991.

In these tests, Ohio FG1 and Ohio FG2 matured later than 'Burlison' (late maturity group II) and at the same date as 'Resnik' (mid-maturity group III) or slightly earlier (Table 1). Both new varieties were somewhat more susceptible to lodging than the best grain-type varieties, but both showed less lodging than 'Vinton 81.' Ohio FG1 had more lodging resistance than Ohio FG2 and 'Beeson 80.' Ohio FG2 had the largest seed of any entry, with Ohio FG1 ranked second.

Yields of Ohio FG1 and Ohio FG2 averaged about 15% greater than those of 'Beeson 80' and 'Vinton 81' but about 9% less than the maturity-group III grain-type varieties 'Resnik,' 'Thorne,' and 'Flyer' (Table 1). The yield advantage of the new food-grade varieties over 'Beeson 80' and 'Vinton 81' was 3 to 5 bushels per acre at Lakeview (Auglaize County), 8 to 14 bushels per acre at South Charleston (Clark County), and 5 to 10 bushels per acre at Hoytville (Wood County). In the test at Columbus in 1991, under severe drought stress, the yield advantage was 4 to 5 bushels per acre. Mean yields of Ohio FG1 and Ohio FG2 were similar to or slightly less than those of maturity-group II grain-type varieties 'Conrad' and 'Chapman' and the high-protein variety 'Burlison.'

Table 2. Performance of Ohio FG2 in Ohio Advanced Line Test B, 1993.

				Yield (bu/a)					
Entry	Date mature[1]	Lodging[2]	Height (in.)	Wooster	Hoytville	Lakeview	Plain City	Mt. Orab	Mean
Chapman	12	1.3	29	27.6	39.6	55.5	49.3	50.1	44.4
Pella 86	16	1.2	28	25.0	35.5	49.4	43.7	45.4	39.8
Ohio FG2	**16**	**1.6**	**30**	**26.7**	**41.5**	**51.1**	**51.0**	**43.7**	**42.8**
Resnik	20	1.2	28	25.6	35.2	53.7	42.7	52.9	42.0
Thorne	20	1.2	28	23.6	34.9	54.5	49.3	53.2	43.1
Charleston	20	1.1	24	28.2	41.9	65.9	46.7	46.9	45.9
Shurgrow SG351	21	1.2	29	24.7	41.3	54.7	43.4	54.0	43.6
Williams 82	23	1.4	33	22.9	39.9	46.9	46.8	46.4	40.6
Probst	23	1.4	30	27.1	40.0	58.8	44.8	57.9	45.7
Edison	24	1.1	27	24.0	33.5	49.1	45.8	50.3	40.5
Flyer	25	1.2	30	24.3	36.8	53.6	52.1	51.9	43.7
Ripley	32	1.4	27	25.0	44.6	49.2	49.9	58.5	45.4
KS 4390	32	1.6	31	27.9	25.1	48.1	38.7	43.2	36.6
LSD (0.30)	1	0.2	1	2.2	3.5	3.9	ns	4.0	2.2

[1]Days after August 31.
[2]Rated from 1 (erect) to 5 (prostrate).

In the Ohio Advanced Line Test B in 1993, Ohio FG2 matured at the same time as 'Pella 86' (Table 2). It was more susceptible to lodging than most other entries and slightly taller than entries of similar maturity. The mean yield of Ohio FG2 in this test was similar to that of 'Resnik' and 'Thorne,' showing a significant advantage at Hoytville but a disadvantage at Mt. Orab (Brown County). Overall, Ohio FG2 outyielded 'Pella 86,' 'Williams 82,' and 'Edison' in this one-year test, but was outranked by 'Charleston,' 'Probst,' and 'Ripley.' Row spacings in this test were 30 inches at Wooster and Hoytville, 15 inches at the remaining sites.

The performance of Ohio FG2 in a regional test is shown in Table 3. This test was conducted at nine locations in Iowa, Illinois, Indiana, Missouri, Nebraska, and Ohio in 1993. In this test, Ohio FG2 matured two days later than 'Resnik' and five days earlier than 'Flyer.' It was more susceptible to lodging than the grain-type check varieties but intermediate in plant height and visual seed quality score. Seed weight of Ohio FG2 was much greater than the checks. In yield, 'Resnik' and 'Flyer' had a 2 to 4 bushels per acre advantage over the food-grade variety, but Ohio FG2 yielded 1.2 bushels per acre more than 'IA2007,' the group II check. Ohio FG2 was similar to 'Resnik' and 'Flyer' in protein content and slightly higher in oil content (Table 3).

Seedlings of a few varieties, such as 'Zane,' develop a short hypocotyl at 25° C (77° F), which may result in poor emergence when planted deep. Results of a deep-planted emergence test are shown in Table 4. Ohio FG2 had a good emergence (78%), but Ohio FG1's emergence was low (15%), similar to 'Vinton 81' and 'Beeson 80.' It should be noted that this deep-planted emergence test measures only hypocotyl elongation and that other factors, such as germination percentage, seedling vigor, and the ability to emerge from a crusted soil, are probably more important than hypocotyl elongation in obtaining a satisfactory stand. In general, emergence problems are more likely to occur with large-seeded varieties than with other varieties. Use of high-quality seed and management of the seedbed to avoid crusting should reduce the probability of stand problems.

Food Quality Performance

The most extensive data on protein content of Ohio FG1 and Ohio FG2 derive from the Ohio Large Seeded Test (Table 5), for which both protein and oil content were determined for four years, 1991–1994. The effect of production environment, chiefly weather, is shown in the year-to-year differences. Previous studies indicated that heat and drought stress during grain filling tend to reduce protein content. The data from Table 5 conform to this, because,

Table 3. Performance of Ohio FG2 in Uniform Preliminary Test IIIA, 1993.

Entry	Date mature	Lodging (score)[1]	Plant height (in.)	Seed quality (score)[2]	Seed weight[3]	Yield (bu/a)	Protein[4]	Oil[4]
IA2007	9/19	1.5	30	2.0	16.8	49.0	39.9	21.8
Resnik	9/24	1.5	33	1.5	14.6	52.2	42.1	20.8
Ohio FG2	**9/26**	**2.3**	**34**	**1.8**	**23.7**	**50.2**	**41.8**	**21.4**
Flyer	10/1	1.6	35	1.6	13.4	53.9	42.1	20.3

[1]Rated from 1 (erect) to 5 (prostrate).
[2]Visual rating considering degree of wrinkling, defective seedcoat, greenishness, and moldy or rotten seeds, rated from 1 (very good) to 5 (very poor).
[3]Grams per 100 seeds; to convert to seeds/lb., divide 45360 by figure given.
[4]Percentage on a moisture-free basis; to convert to 13% moisture basis, multiply by 0.87.

generally, the lowest protein contents occurred during the unusually dry 1991 season, while the highest protein contents occurred in 1994, when there was adequate moisture. Despite year-to-year differences in absolute protein content, the relative ranks of varieties were similar in all years. 'Vinton 81' had the highest mean protein content overall, 0.8 to 1.0% greater than Ohio FG1 and Ohio FG2. Of the grain-type soybeans, only 'Century 84' and 'Burlison' had higher protein contents than Ohio FG1 and Ohio FG2.

Table 4. Comparison of Emergence of Soybean Varieties (At 25°C When Planted 4 Inches Deep in Sand)

Variety	% Emergence
Chapman	100 a[1]
Pella 86	93 ab
Ohio FG2	**78 cb**
Vinton 81	22 c
Ohio FG1	**15 c**
Beeson 80	6 c
Zane	1 c

[1]Means followed by the same letter are not significantly different according to the LSD (0.05) applied to transformed data.

Table 5. Protein and Oil Content of Selected Entries in the Ohio Large-Seeded Test, 1991–1994.

	Protein/Oil[1]					
Entry	1991[2]	1992[2]	1993[3]	1994[2]	3-Year Mean	4-Year Mean
Beeson 80	38.9	42.9	41.2	42.6	41.0	41.4
	21.9	20.0	21.5	19.5	21.2	20.8
Vinton 81	41.0	43.3	44.1	44.4	43.0	43.3
	21.5	20.1	20.8	19.5	20.8	20.5
Ohio FG1	**40.3**	**42.8**	**42.6**	**43.5**	**42.0**	**42.3**
	21.8	**20.6**	**21.3**	**20.1**	**21.2**	**21.0**
Ohio FG2	**41.4**	**42.8**	**42.5**	**43.1**	**42.2**	**42.5**
	21.4	**20.3**	**21.4**	**19.7**	**21.1**	**20.8**
Chapman	40.3	41.8	41.0	42.4	41.0	41.3
	22.1	21.0	23.0	20.8	22.2	21.9
Conrad	39.4	40.7	40.2	40.9	40.1	40.3
	21.9	20.4	22.4	20.1	21.7	21.3
Flyer	41.4	41.6	42.4	42.8	41.9	42.1
	21.4	20.7	20.8	20.1	20.9	20.8
Resnik	40.1	41.4	42.1	42.9	41.3	41.7
	21.5	20.7	21.0	20.7	21.1	21.0
Thorne	39.8	42.1	42.4	42.9	41.6	41.9
	22.2	20.8	21.2	20.1	21.4	21.1
Burlison	42.4	43.6	42.2	—	42.7	—
	20.3	19.3	20.7	—	20.2	—
Century 84	41.1	44.3	43.1	—	42.9	—
	21.1	19.6	20.8	—	20.5	—
Keller	39.1	42.7	41.1	—	41.0	—
	22.0	20.0	21.5	—	21.2	—
LSD (0.30)					0.4	0.4
					0.3	0.3

[1]Protein on upper line, oil on lower line; both expressed on dry-weight basis (multiply by 0.87 to convert to 13% moisture basis).
[2]Mean of two locations.
[3]Mean of three locations.

Table 6. Soymilk Solids Content of Soybean Varieties, 1992–1993.

	Soymilk Solids Content					
	1992 Hoytville	1992 S. Charleston	1993 Hoytville	1993 Lakeview	1993 S. Charleston	Mean
	%	%	%	%	%	%
Beeson 80	6.86	6.72	—	—	—	—
Vinton 81	6.88	6.78	7.18	6.92	6.88	6.93
Ohio FG1	**6.95**	**6.69**	**7.04**	**6.84**	**7.08**	**6.92**
Ohio FG2	**6.85**	**6.70**	**7.10**	**7.20**	**7.01**	**6.97**
Sandusky	—	—	—	—	6.82	—
LSD (0.30)	0.04	0.04	0.04	0.04	0.04	ns

Table 7. Soymilk Protein Content of Soybean Varieties, 1992–1993.

	Soymilk Protein Content					
	1992 Hoytville	1992 S. Charleston	1993 Hoytville	1993 Lakeview	1993 S. Charleston	Mean
	%	%	%	%	%	%
Beeson 80	3.34	3.51	—	—	—	—
Vinton 81	3.37	3.45	3.62	3.65	3.63	3.54
Ohio FG1	**3.39**	**3.35**	**3.26**	**3.48**	**3.65**	**3.42**
Ohio FG2	**3.36**	**3.33**	**3.39**	**3.57**	**3.56**	**3.44**
Sandusky	—	—	—	—	3.19	—
LSD (0.30)	0.05	0.05	0.05	0.05	0.05	0.04

Generally, the varieties highest in protein are lowest in oil content, and vice versa. This trend was apparent in the 1991–1994 data (Table 5), but exceptions occurred. Mean oil content of Ohio FG1 and Ohio FG2 was similar to that of most grain-type varieties.

Seed samples of several varieties were obtained from two test locations in 1992 and three in 1993 for production and analysis of experimental quantities of soymilk. Both soymilk solids content and soymilk protein content were measured on these samples.

Soymilk solids content was strongly influenced by the environment in which the soybeans were produced (Table 6). The poorest values were obtained at South Charleston in 1992, the best values at Hoytville in 1993. It is not known which specific environmental factors were responsible for these differences.

Table 6 also reveals that the relative rank of varieties for soymilk solids content varied with the production environment. 'Vinton 81' was significantly better than Ohio FG1 and Ohio FG2 at South Charleston in 1992 and at Hoytville in 1993, but one or both of the new varieties outperformed 'Vinton 81' in the other three environments. Ohio FG2 had substantially greater solids content than Ohio FG1 at Lakeview in 1993, but this large advantage did not appear at other sites. The grain-type variety 'Sandusky' had a low solids content in the one test where it was included. Averaged over all environments, the soymilk solids contents of Ohio FG1, Ohio FG2, 'Vinton 81,' and 'Beeson 80' (included in 1992 only) were similar.

Environmental influences also occurred for soymilk protein content (Table 7). 'Vinton 81' had a greater soymilk protein content than Ohio FG1 and Ohio FG2 in three of the five test environments. The two new varieties were similar to 'Beeson 80' in one 1992 test but inferior in the other. 'Sandusky' again had the lowest recorded value. Overall, Ohio FG1 and Ohio FG2 had similar mean soymilk protein contents, both less than the mean of 'Vinton 81.'

Disease and Insect Resistance

Ohio FG1 and Ohio FG2 both carry the *Rps3* gene for resistance to phytophthora rot. Also found in the variety 'Chapman,' this gene confers resistance to races 1, 3, 4, 16, and 25, but not to race 7. In tests of tolerance to race 7, Ohio FG1 was rated moderately intolerant and Ohio FG2 highly tolerant. In four years of testing in Ohio, no symptoms of phytophthora rot have been observed on either variety.

Both Ohio FG1 and Ohio FG2 are susceptible to brown stem rot [caused by *Phialophora gregata* (Allington and Chamberlain) W. Gams]. Observations in Michigan and Ohio in 1994 suggested that, when the disease occurs, symptoms of brown stem rot are more severe on Ohio FG1 and Ohio FG2 than on most other varieties. Growers should avoid fields where this disease is known to be a problem, such as fields where soybeans were grown the previous year and brown stem rot symptoms were observed.

Ohio FG2 is susceptible to purple seed stain [caused by *Cercospora kikuchii* (T. Masu. & Tomoyasan)] and to pod and stem blight [caused by *Diaporthe phaseolorum* (Cke. & Ell.) Sacc. var. *sojae* (Lehman) Wehm]. The reaction of Ohio FG1 to these diseases has not been evaluated.

Assays using Mexican bean beetle [*Epilachna varivestis* Mulsant] indicated that Ohio FG1 and Ohio FG2 incurred greater loss of leaf area than the variety Williams when attacked by foliar-feeding insects. Ohio FG1 and Ohio FG2 have larger leaves than most grain-type cultivars, and it is not known whether this loss of leaf area would lead to reduced yields. Although economic damage from leaf-feeding insects is rare in Ohio, growers of these new varieties should be prepared to scout fields carefully if leaf-feeding insects are a threat.

Availability

Ohio FG1 and Ohio FG2 are available for planting only as a class of certified seed. Foundation seed was first produced in 1994. In addition to Ohio, foundation seed of Ohio FG1 was produced in Nebraska, and foundation seed of Ohio FG2 was produced in Missouri. A very limited amount of certified seed will be available for 1996 planting.

Breeder seed of Ohio FG1 and Ohio FG2 will be maintained by the Ohio Agricultural Research and Development Center with the cooperation of Ohio Foundation Seeds, Inc. Application for Plant Variety Protection for both varieties was made in 1994.

Production of Food-Grade Soybeans

Ohio FG1 and Ohio FG2 differ from grain-type varieties of similar maturity by having lower yields but better quality for the specialized soyfood market. As a result, producers of the new food-grade varieties should expect to receive a premium for their crop. Producers should secure a contract with a buyer of food-grade soybeans prior to producing the crop.

As the data in Tables 5 to 7 show, genetic differences are not the only factors that influence the quality of soybeans for soyfood production. The production environment is also important. Quality is undoubtedly influenced by many environmental factors that cannot be controlled by the producer, such as temperature and precipitation. There are specific practices, however, that producers should employ in order to obtain maximum quality, and therefore the best price.

Appearance of the grain is perhaps the most important criterion for determining marketability and price. The most important production practices are timely harvest and proper adjustment of combines and augers to avoid splits and excessive foreign matter. Timely harvest also reduces the effects of weathering of mature seed. Because the presence of weeds at harvest can stain seed, poor weed control can reduce grain quality as well.

Maintenance of varietal identity and purity is more important for food-grade varieties than for varieties intended for processing into oil and meal. In Ohio, production of food-grade soybeans can be arranged under a third-party identity-preserved quality control program to ensure varietal and physical purity.

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