Breeding Vegetable Soybeans in the Midwest

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I would like to broaden the topic somewhat to include breeding for all food-type soybeans. I will also include other parts of the country and Canada, although most breeding for food types in the U.S. has been in the Midwest. My talk will concentrate on work at public institutions although especially in the case of the small-seeded natto or sprout type, private breeding has been very successful.

The distinction between edamame, dry vegetable soybeans, tofu type, and other large-seeded soybeans is not clearcut but is overlapping, and so I have not attempted to separate them. A variety bred for edamame may very well be useful for tofu and find acceptance in that market and vice versa.

For a report for the 1999 annual soybean breeder's conference in St. Louis I conducted a mail survey among all public soybean breeders in the U.S. and Canada to find out who was working on food-type soybeans. My talk today derives largely from that report with some update.

I am giving you a 5-page handout, which includes as Table 1 a list with addresses of the 22 breeders who report that they work on specialty varieties for food use. All of them are breeders working on commercial grain types with food types as a sideline except perhaps Dr. Lumpkin and myself. With my partial retirement and his administrative duties and other research interests, we are also only part-timers on food-type soybeans.

The 22 breeders are at 17 locations in 8 north central states, 4 southeastern states, Washington, and Canada. Only a few of them mentioned edamame or green vegetable soybeans in their responses. Most of them were aiming at the export market (to Japan) for tofu and natto, and there was little mention of a potential domestic market. Soybeans in the U.S. are being increasingly recognized as an important nutritious and healthful food source, but almost all of the publicity and increased sales are directed toward processed foods (tofu, soy milk, protein-fortified foods, etc.) with the tacit assumption by most (including my colleagues in nutrition and food science research) that soybeans are not to be eaten directly.

Nevertheless there is increasing interest by many, including home gardeners and commercial vegetable producers, in edamame. In the spring of 2000 at the University of Illinois we released 6 vegetable-type cultivars, and with a little (largely unsolicited) newspaper publicity we received over 1500 requests for seed packets for garden planting, much more than we had anticipated. This past spring Rupp Seed Co. of Wauseon, Ohio, took over seed distribution of these 6 varieties and has had quite satisfactory sales.

I would like to look at the history of food-type soybeans in North America by looking at the varieties that have been imported or developed for food use. Table 2 covers such varieties released up to 1949. These are all varieties presently maintained in the USDA soybean germplasm collection at Urbana. While there were other food-type varieties in the U.S. that were lost or discarded before the Collection was established in 1949, these I think are representative and include a majority of all such cultivars. There are 47 of them, all introduced from Asia, 31 from Japan, 10 from Korea, 5 from China, and 1 unknown (but appears to be an east Asian type).

Five are very early (group O), 7 are late (VI-VIII), and the majority (35) are I to IV and therefore adapted across the major Midwest soybean-growing belt.

I have used a liberal interpretation of what to include. If an early publication called a variety a food type I included it on the list regardless of seed size. Most (32) were released directly by the USDA, 8 by 4 state experiment stations and Canada, and 7 by private sources. Two were released prior to 1920, 30 in the 1930's, and 15 in the 1940's. To what extent they were grown is not recorded, but there was a fair amount of publicity from the USDA and state experiment stations on growing and eating soybeans during the 1930's and during World War II (partly due to the wartime effort to compensate for food shortages). I have seen some of them such as Bansei and Jogun listed for sale in garden vegetable seed catalogs up until recent years, and all are available for research and breeding from the USDA Collection.

There is an interesting 3-page mimeographed list from the Department of Agronomy of the University of Illinois dated January 1945 entitled Sources of Edible Soybeans, which gives a picture of the extent of the interest in these specialty soybeans at that time. It lists 17 of the varieties of Table 2 and 38 growers, with a total of about 16,000 bushels (435,000 kg) enough to plant over 10,000 acres (4,000 ha). Bansei was by far the most popular with over 11,000 bushels and 28 growers. Etum was second with 1143 bushels from 3 growers. Eight other cultivars had over 100 bushels each (Aoda, Easycook, Funk Delicious, Giant Green, Hokkaido, Jogun, Rokusun, and Sac). The remaining 7 (Chusei, Higan, Imperial, Kanro, Mendota, Sanga, and Sousei) ranged from 10 bushels up.

The problem with growing most of these introduced cultivars is that they are not well adapted to the climate, diseases, and insects of North America and do not grow and yield as well as the grain-type varieties, which had been highly selected and bred for adaptation to North American conditions. So breeding work was begun to combine the growth performance of the grain types (largely from ancestors from northeast and east central China) with the seed characteristics of the food types (largely from Japan and Korea).

Table 3 shows the results of this breeding effort from 1950 to 1990, a 40-year period. There were 25 cultivars released, all maturity group O to IV, 14 from Iowa, 4 from the University of Hawaii, 2 from Delaware, 2 from Minnesota, and 1 each from Indiana, New Hampshire, and Canada. Some (Protana, Provar, and Proto) are simply high-protein types and perhaps should not be on this list. It seemed to the breeders at that time that since protein was the more scarce and more valuable component, these high-protein types should have greater economic value and so they were released to test the market. However the processors preferred high oil and these varieties were not a commercial success. Some of the varieties on this table have been successfully used in the tofu market and for export and others have found their way into home gardens.

The initial releases of the 1950`s and 1960`s were combinations of successful grain types such as Richland and Mandarin (Ottawa) from China with vegetable types such as Kanro and Jogun from Korea and Sac and Aoda from Japan. One of the most successful of these, Vinton (released in 1978 by Iowa State University) comes from a later cycle of breeding combining the grain variety Hark with the high protein Provar and the 1967 large-seeded releases Disoy and Magna.

Vinton was converted to Phytophthora resistant as Vinton 81 by backcrossing but because of linkage of this resistance with gene <u>hm</u> for metribuzin sensitivity (a common soybean herbicide) Vinton 81 was sometimes damaged by herbicide. This problem was solved with the cultivar Harovinton derived at Harrow, Ontario, by Richard Buzzell from a crossover with both desirable genes from the cross of Vinton x Vinton 81. With these 3 versions of Vinton and 4 subsequent releases closely related to Vinton, there is a rather narrow germplasm base among the 1978-90 releases.

The Iowa program was the major large-seeded breeding program in the U.S. during this period. It was initiated by Martin Weiss and conducted during most of this period by Robert Weber, both of the USDA. It was considered by the USDA soybean research unit, which dominated U.S. soybean breeding at that time that food type was not a major objective and that one program was enough. The Iowa program has been continued and greatly expanded under the direction of Walter Fehr of Iowa State University.

On the bottom of Table 3 we see the beginning of small-seeded variety development, with 12 public cultivars released during the 10 years 1981-90, 4 from Canada and 2 each from Iowa, Minnesota, Illinois, and Virginia. Most derive the small-seed trait from wild soybeans but some from Korean or other sprout or natto types. Most of this work is aimed at the Japanese natto market with some interest expressed in possible domestic sprout use as a replacement for mung beans. Some Japanese natto varieties have been grown in the U.S., but none has been "released" or publicized for general use as was done with the large-seeded vegetable types. They have the seed traits that the natto maker wants but often don't yield well and shatter in our climate and sometimes the seed traits don't develop well here either.

Table 4 lists by location the public small-seeded cultivars developed and released in the past 10 years, chiefly for the natto market. They total 34, 15 from Iowa, 5 from Canada, 5 from Virginia, 4 from North Carolina, and the remaining 5 from 4 north central states. Seven are early (OO-O), 18 are II-IV, and 9 are late (V-VIII). These varieties are better adapted and higher yielding in their area of development than the introduced cultivars, but a major problem has been to find ones that are acceptable to the Japanese natto maker. Some efforts are under way to get them accepted in the domestic sprout market as a more nutritious replacement for mung beans.

In the past 10 years there has been increased efforts toward breeding for tofu, edamame, and other large-seed food uses. Table 5 lists such varieties and includes some that are primarily for high protein or contain lipoxygenase nulls and are more suitable for tofu or identity-preserved processing rather than edamame. There are 63 varieties with most of them from the Iowa State-Puerto Rico program: 44 from Iowa, 6 from Illinois, and 2 each from Minnesota, Nebraska, North Dakota, and Ohio in the Midwest and Virginia and North Carolina in the Southeast (1 from Ohio just announced this year will bring their total to 3). Two of these are very early (O), 5 are late (IV-VI), and all the rest (56) are I-III.

These varieties give us a diversity of better performing large-seeded varieties and will help in encouraging the adoption of the soybean by the home gardener and perhaps by the commercial vegetable industry as well, in addition to providing types for identity-preserved markets for tofu and other special purposes both domestic and for export.

The main overall breeding objective for the American edamame breeder is to combine the desirable yield and plant traits of our commercial grain types with the desirable seed traits of the east Asian edamame types. Yield is less important than seed qualities for the small-scale gardener but becomes important in large-scale production. It is an important consideration for the breeder because of the strong negative correlation between yield and seed size larger than the common grain types.

Seed size is an important consideration with 20 cg considered to be a minimum and 25 cg a more desirable goal and 30 cg as our long-range goal. Much greater increase appears impractical now because of the likelihood of low yield. Forty cg is the largest that I have grown but I have seen seeds produced in Japan that are twice that size. Seed size appears to be controlled by many genes. In segregating generations from edamame x grain type crosses the frequency of segregates as large as the large-seeded parent is very low, indicating a very large number of genes. It is significant that among the successful large-seeded varieties developed in the U.S. many were from backcrosses to the large-seeded type.

Seed pigment is important and eliminating the black and brown pigment from our food soybeans is a major objective. A majority of American grain varieties have black or brown pigment in the hilum. The main desirable genes for the breeder to consider are:

t the gene for gray pubescence color rather than tawny(T) lightens seed color from brown to buff or from black to imperfect black

r gives brown or buff seed pigment rather than black(R)

w for white flower color (rather than purple, W) changes imperfect black (R t) to buff and also eliminates unwanted anthocyanin from the green pod

I lightens buff to yellow (also black to gray and brown to tan) but may be associated with more seed coat mottling than the dark hilum allele (i-i)

Even with all of the above genes, buff mottling can occur on the seed coat caused by the several races of soybean mosaic virus or perhaps also by bean pod mottle virus. This has been a major problem in the Midwest in recent years especially for natto beans, (causing the complete rejection of the cultivar KS-2 in its first year of commercial production) and so virus resistance has become an important objective.

Some of the edamame cultivars, both North American and Asian, have the stay-green trait in the seed coat or seed embryo. The genes involved are G1 or G2 for green seed coat and d1 plus d2 for green embryo (d1 d2 also affect green leaf, stem, and pod).
Some consider it a desirable trait but it makes it more difficult to judge the proper time for edamame harvest and does not appear to make timely harvested edamame pods and seeds any greener. Because of this we have favored the yellow-seed genes g1 g2 D1 D2 in our selection at Urbana.

Seed composition is another very important trait. Increasing protein and decreasing oil are changes that would improve the soybean for human nutrition, but care must be taken that there is no adverse effect on taste. Increasing sugar content may improve taste, and other factors affecting taste should be looked for, but at present we are dependent on taste panel results. The lipoxygenase nulls have a major effect on the taste of ripe soybeans, but their effect if any on the taste of properly prepared edamame is not well understood. Other soybean constituents that may be desirable for nutritional or health reasons such as increased isoflavone, increased linolenic acid in the oil, increased fiber, etc. may become important objectives in the future.

Certain plant and pod traits are of special importance in vegetable-type breeding. Time of maturity is of concern in grain types mainly in determining where a variety is adapted, but in the case of soybeans to be harvested at the green immature stage there is the added consideration of using multiple varieties with a range of maturities to lengthen the time of harvest. For example the 6 ‘Gardensoy’ varieties that University of Illinois released a year ago range from maturity group I to IV. With a planting of any one of these the home gardener has less than a week to harvest, but by planting all 6 there is over a month of ideal harvest time. Obtaining early and late harvest from the garden may be more important than maximizing yield.

Desirable plant type for the garden may be a small, compact, non-lodging plant with uniformly ripening pods. This may favor the determinate stem type but not necessarily since some short indeterminate types also fit this description. For obtaining a seed crop or to harvest ripe seeds for eating, a non-shattering type is preferred. Most of the Asian edamame varieties have a strong tendency to shatter at maturity in our climate, necessitating considerable effort by the breeder to recover the non-shattering of the grain parent. Another pod trait, which we are just beginning to look at, is what might be called "shellability" or the ability to easily and cleanly shell the cooked seeds out of the pod. I have had a very annoying problem with some lots of edamame where the highly inedible endocarp comes out of the pod with the seeds, requiring a separate operation to pick it off (or pick it out of the soup or salad or whatever). We are trying to find out if it is a varietal trait or because of growing conditions, harvest time, or cooking or storage conditions.

We can see that there is a fair effort on breeding for edamame and other food type soybeans in North America, but at present there is very little market production. Judging from personal observation what little edamame is marketed in this country is mostly imported (from China). The widespread success of edamame will depend in part on the availability of suitable varieties but to a larger degree on the successful marketing of it and its acceptance by the American consumer. It seems to most of us here that it is a highly desirable food and should be rapidly adopted, but the failure of this to happen 50 years ago after considerable promotion should lead us to be cautious in predicting the results of our current efforts.

TABLE 1 PUBLIC SOYBEAN BREEDERS IN THE U.S. AND CANADA FOR EDIBLE TYPE SOYBEAN (EDAMAME, TOFU, NATTO)

Name	Address	Phone/Fax	email
Allen, LeRoy	Purdue University Dept. of Agronomy 1150 Lilly Hall West Lafayette, IN 47907-1150	765-496-3756	
Anand, S.C.	Univ. of Missouri Dept. of Agronomy 210 Waters Hall Columbia, MO 65211	573-882-0318 FAX: 573-882-1467	anands@missouri.edu
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Fehr, W.R.	Iowa State University Dept. of Agronomy Ames, IA 50011	515-294-6865 FAX: 515-294-6514	wfehr@iastate.edu
Fioritto, R.J.	OARDC, OSU Dept. of Hort. & Crop Science 1680 Madison Ave. Wooster, OH 44691-4096	330-263-3851 FAX: 330-263-3887	fioritto.1@osu.edu
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Helms, T.C.	North Dakota State Univ. Dept. of Plant Science Fargo, ND 58105-5051	701-231-8136 FAX: 701-231-8474	helms@badlands.nodak.edu
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Mebrahtu, T.	Virginia State University Agricultural Research Station Box 9061 Petersburg, VA 23806	804-524-5953 FAX: 804-524-5186	tmebraht@vsu.edu
Orf, J. H.	Univ. of Minnesota Dept. of Agronomy & Plant Genetics	612-625-8275 FAX: 612-625-1268	orfxx001@tc.umn.edu

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Poysa, V.	Agriculture & Agri-Food Canada Greenhouse & Processing Crops Res. Centre Harrow, Ontario CANADA NOR 1GO	519-738-2251 ext.467 FAX: 519-738-2929	poysav@em.agr.ca
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TABLE 2 USDA SOYBEAN GERMPLASM COLLECTION
INTRODUCED VEGETABLE CULTIVARS TO 1949

Variety	Maturity	Seed Size	Origin	Year Introduced	Year Released	Agency
Agate	OO	28	Japan	1929	1937	USDA
Aoda	IV	25	Japan	1929	1939	USDA
Bansei	II	19	Japan	1929	1936	USDA
Burwell	I	23	unk.		1933	private
Cherokee	VIII	20	China	1931	1944-	USDA
Chusei	III	26	Japan	1929	1936	USDA
Delsoy	VI	13	Korea	1930	1943-	USDA
Easycook	VI	17	China	1894	1919	USDA
Emperor	IV	25	Korea	1932	1939	Illinois
Etum	II	22	Japan	1930	1941-	USDA
Fuji	III	16	Japan	1929	1936	USDA
FunkDelicious	IV	25	Japan	1932-	1932	private
GiantGreen	I	25	Japan	1935	1938	Illinois
Goku	II	15	Japan	1929	1936	USDA
GreenandBlack	IV	24	Korea	1930	1941	private
Hahto	VI	30	Japan	1915	1918	USDA
Hahto[Michigan]	IV	22	Japan		1940-	private
Hakote	II	28	Japan	1929	1936	USDA
Hidatsa	OOO	18	Japan	1929	1941	private
Higan	IV	24	Japan	1929	1936	USDA
Hokkaido	IV	21	Japan	1930	1936	USDA
Illington	III	17	Japan	1938-	1938	Illinois
Imperial	IV	32	Japan	1929	1939	USDA
Jefferson	IV	33	Korea	1929	1941	private
Jogun	III	25	Korea	1930	1936	USDA
Kabott (black)	O	27	China	1933	1939	AgCanada
Kanro	II	22	Korea	1930	1936	USDA
Kanum	II	19	Korea	1930	1941-	USDA
Kura	III	31	Japan	1929	1936	USDA
Mendota	I	17	Korea	1930	1944-	Wisconsin
Nanda	VIII	18	Korea	1932	1936	USDA
Osaya	III	26	Japan	1929	1936	USDA
Pando	OOO	18	Korea	1947	1949	NewHamp shire
Rokusun	VI	45	Japan	1929	1936	USDA
Sac	I	26	Japan	1929	1941	Iowa
Sanga	IV	28	China	1926	1944-	private
Sato	IV	24	Japan	1929	1936	USDA
Seminole	VIII	10	China	1931	1943-	USDA
Shiro	IV	27	Japan	1929	1936	USDA

Sioux	OOO	20	Japan	1929	1939	USDA
Sousei	II	17	Japan	1929	1936	USDA
Tastee	II	22	Japan	1930	1941-	USDA
Toku	II	20	Japan	1930	1936	USDA
Tortoise Egg	I	25	Japan	1938-	1938	Illinois
Waseda	II	20	Japan	1929	1936	USDA
Willomi	III	25	Japan	1929	1939	USDA
Wolverine	III	26	Japan	1929	1941	USDA

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TABLE 3 HISTORICAL LIST OF PUBLICLY DEVELOPED NORTH AMERICAN SPECIALTY SOYBEAN CULTIVARS TO 1990

Year Released	Institute	Cultivar	Maturity	Parentage
		LARGE SEEDED (vegetables, edamame, tofu, etc.)		
1956	Iowa, USDA	Kanrich	III	Kanro^2 x Richland
“	”	Kim	III	Sac^2 x Richland
1967	Iowa, USDA	Disoy	I	(Mandarin Ott x Kanro) x (Richland x Jogun)
“	”	Magna	II	(Mandarin Ott x Jogun) x (Mandarin Ott x Kanro)
“	”	Prize	III	(Mandarin Ott x Jogun) x (Mandarin Ott x Kanro)
“	Delaware	Verde	III	Aoda x A50-7445 (Richland x Jogun)
1969	Purdue, USDA	Protana	II	(Mukden x C1069) x (PI65388 x C1079)
“	Iowa, USDA	Provar	II	Harosoy x Clark
1970	Hawaii	Kahala, Kaikoo, Kailua, & Mokapu Summer	IV	UD288 (Hawkeye x FC33243) x C1079)
1975	Delaware	Emerald	IV	Aoda x (Hahto x Kent)
1976	Minnesota	Grande	0	Anoka x Magna
1978	Iowa, P. Rico	Vinton	1	Hark x [Provar x (Disoy x Magna)]
1981	“ ”	Vinton 81	1	(Harosy x Higan) x Vinton^5
1986	New Hampshire	Merrimax	0	Prize x A100
1989	Ontario, Harrow	Harovinton	1	Hm Rpsl-c from Vinton x Vinton 81
“	Minnesota	Proto	0	[(Chippewa 64 x PI261.475) x PI189.880] x [(PI261.475 x Pridesoy II) x Provar]
1990	Iowa	HP201	1	Vinton 81 x Hardin
“	”	HP202	1	Vinton 81^2 x Pride B216 (Corsoy x Wayne)
“	”	HP203	1	Vinton 81^2 x Pride B216
“	”	HP204	1	Vinton 81^2 x Hardin
“	“	LS201	II	(GrowMark Hisoy HS235 x A79-24088) x A79-240002
“	”	LS301	III	A79-140022 x A79140011
		SMALL SEEDED (sprout, natto)		
1981	Ottawa, Ontario	Nattawa	0	(M62-173 x PI101.404, wild) x Acme
1983	Minnesota	Chico	00	[Evans x (Merit x Lee)] x [M65-89 x (057-2921 x Kogane Jiro)]
1985	Ottawa, Ontario	Canatto	00	[BD22115 x (M62-173 x PI101.404)] x Evans-e_3
1986	Virginia	Vance	V	Esex x wild soybean
1989	Illinois	IL1	II	Hobbit x T208, Yu Tae, S. Korea
“	”	Il2	III	Hobbit x PI408.016B S. Korea
“	Iowa	SS201	II	NKS1346^3 x PI81.762, wild
“	”	SS202	II	Migro HP20-20^3 x PI135.624, wild
“	Minnesota	Minnatto	0	Evans x PI437.267, Dobruzanca I
“	Virginia	Camp	V	from Vance
“	Ottawa, Ont.	Nattosan	0	[BD22115 x (M62-173 x PI101.404)] x [(PI194.654 x OX27-8) x P71-39]
“	” “	TNS	0	OX611 x [Altona x (PI194.654 x M62-173)]

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TABLE 4 SMALL SEEDED CULTIVARS 1991 - 2000

Variety	Year Released	Maturity	Seed Size	Parentage
AgCanada, Ottawa - Cober, Voldeng				
AC Pinson	1995	O	8	{[Harcor x (SRF200 x Harosoy-Dt2)]x[Altona x (T106 x M62-173)]}x(H24 x Nattawa)
AC Colibri	1995	O	8	TNS x (H24 x Nattawa)
Micron	1995	O	9	TNS x (H24 x Nattawa)
T2653	1995	O	8	TNS x (H24 x Nattawa)
AC Colombe	1996	OO	10	[(H24 x X390)x(OX611 x X393)] x X390
Illinois, University of - Bernard				
KS-2	1998	III	8	IL2 x L87-626(Hobbit x PI 157.404)
Minnesota, University of - Orf				
UM3	1998	O	7	Natto x (Chico x PI 437.396 from Russia)
Nebraska, University of - Graef				
Mercury	1994	III	8	T208 x Hobbit
NE3496SS	1996	III	10	U431082 x A87-102102
North Dakota State University - Helms				
Danatto	1996	O	10	Natto King 86 x unknown
North Carolina State University, USDA - Carter				
Pearl	1994	VI	8	Vance x G80-515(Pickett 71 x Bedford)
N7101	2000	VIII	7	Vance x Jizuka from Japan
N7102	2000	VIII	8	Vance x Jizuka from Japan
N7103	2000	VII	8	NTCPR90-143(Gasoy 17 x Vance) x Pearl
Virginia Polytechnical Institute - Buss				
MFS-551	1993	V	9	Essex x wild soybean; Camp sib
MFS-552	1993	V	9	Essex x Camp sib V81-1335
MFS-553	1997	V	8	Essex x Camp
MFS-591	1997	V	8	Camp x Rocky
Camp-Ix2	1996	V		Camp BC
Iowa and Puerto Rico AES - Fehr				
IA2005	1991	II		Migro HP20-20(Rampage x Hark)(3) x PI 135.624
IA4001	1993	IV		(Asgrow A3205 x SS202) x SS201
IA2023	1995	II		(Asgrow A3205 x SS202) x SS201
IA2024	1995	II		(NKS23-03 x SS202) x SS201
IA3007	1995	III		Asgrow A3205 x SS202) x SS201
IA2035	1997	II		[NKS23-03(Pride B216 x Hodgson) x SS202] x unknown
IA3008	1997	III		(NKS23-03 x SS202) x SS201
IA2055 to 2060	2000	II		
IA3013	2000	III		
IA4002	2000	IV		

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TABLE 5 **LARGE SEEDED CULTIVARS 1991 - 2000**

Variety	Year Released	Maturity	Seed Size*	Parentage
Ag Canada, Harrow - Poysa				
AC Onrei	1997	II	28	Vinton x Enrei (from Japan)
OX 756	1997	II	21	Century-lx2 x Harovinton
Illinois, University of - Bernard				
Gardensoy 11	2000	I	27	Century-lx2 x Disoy
Gardensoy 21	2000	II	27	Disoy x Verde
Gardensoy 22	2000	II	24	Century-lx2 x Disoy
Gardensoy 31	2000	III	25	Disoy x Miyagi Shirome A
Gardensoy 41	2000	IV	33	Disoy x yagi Shirome B Miyagi Shirome B
Gardensoy 42	2000	IV	24	Disoy x Miyagi Shirome A
Minnesota, University of - Orf				
Black Kato	1995	I	19	mutant from Kato
Toyopro	1995	O	17 p	{Dawson x {Provar x [(Lincoln(2) x Richland) x PI 180.501)}} x {(Sioux x Harosoy)(2) x [(PI 261.475 x Pridesoy II) x Provar]}
Nebraska, University of - Graef				
Saturn	1994	III	26	Hobbit x Jogun
NE2696LS	1996	II	24	Hobbit 87 x LS201
North Carolina State University - Burton, Carter Burton				
Prolina	1996	VI	16 p	from population of 10 high protein lines x 3 commercial cultivars
N6201	2000	VI	23	Nakasennari x Young
North Dakota State University - Helms				
Norpro	1997	O	16 p	Ozzie x Proto
Ohio State University - St. Martin, Fioritto				
Ohio FG 1	1994	III	24	LS301 x (Zane(3) x HW79149)
Ohio FG 2	1994	III	25	LS301 x (Zane(3) x HW79149)
Ohio FG 3	2001	II	22 p	HS89-8843(Hayes x LS301) x Ohio FG1
Virginia Polytechnical Institute - Buss				
MFL-552	1997	V	23	unknown
Iowa and Puerto Rico Ag Exp Sta				
IA----	1991-2000	I-III	44 cvs with large seed, high protein,or lipoxygenase null	

* p = also high protein

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