PRODUCTION—Round table discussions

Germplasm Availability

EDGAR E. HARTWIG,
AR/SEA USDA, PO Box 196, Stoneville, MS 38776

Soybean germplasm from Eastern Asia obtained over an 80-year period has been the basis of the present soybean industry in the U.S.

One major requirement for adapting the soybean plant from the hand culturing of Asia to the mechanized culturing of the U.S. was to develop types less subject to shattering as they reached harvestable maturity. While many germplasm lines will shatter 50% of their seed before complete maturity, we have cultivars that will hold their seed for at least six weeks after reaching harvestable maturity.

Soybean germplasm adapted for higher latitudes is maintained by R.L. Bernard, University of Illinois at Urbana. Soybean germplasm adapted to lower latitudes is maintained at Stoneville, Mississippi. Publications are available giving the origin of each strain and its maturity classification as well as many other characteristics. At present, we have 6,500 strains.

Maturity covers a range of those which will mature at 60° latitude to those which will make excellent growth at equatorial latitudes at sea level.

A major use of germplasm lines in U.S. breeding programs is to identify sources of pest resistance and then attempt to transfer this resistance to highly productive cultivars. We have been able to identify sources of resistance to most disease and nematode problems which can cause economic injury. We have identified sources of resistance to foliar-feeding insects and are making progress in transferring these characteristics to productive types.

Protein content of germplasm lines will range from 36 to 48% and oil content from 16 to 23%. There is a very high inverse correlation between oil and protein content of the seed. Weight/100 seeds will range from 4 to 35 g.

An impermeable seed coat characteristic has been transferred from a wild-type to a good agronomic type. This characteristic should improve seed quality for cultivars maturing in warm, humid regions. This characteristic also should aid in preserving seed quality during storage in tropical and subtropical regions.

We have identified sources of resistance to soybean rust, a serious disease of soybeans in Southeast Asia and Australia. We have also identified a source of resistance to mung bean virus which damages soybeans in India.

I believe we have germplasm available to assist research workers in any part of the world that are interested in developing production soybean cultivars for their areas.

A New Soybean for Human Consumption in the Tropics

N.M.S. BANAFUNZI, A. MENA B., I. RANGEL D., A.A. MASTACHE L., M.L. MOLINA M., V.M.H. GANTES., S.R. MÁRQUEZ B., Instituto Superior Agropecuario Autonomo del Estado de Guerrero, Unidad de Investigacion y Divulgacion, Iguala, Guerrero, Mexico

ABSTRACT

Modern technology, especially in animal husbandry, has made remarkable progress. Even with all recent advances in animal reproduction (animal protein), we have not been able to keep pace with the rapid population growth rate in order to meet the demand for protein. This discrepancy in demand and supply for animal protein is even more severe in the tropics. The tradition of producing cereals and legumes to feed animals for conversion to meat (protein) is no longer feasible. Usually, animal proteins have complete profiles of essential amino acids, whereas those of plant origin are deficient in one or more of them. Soybean proteins, however, have about the same nutritional value as those of animals, and it is available for direct consumption by humans at a low cost. Because of the "off" or painty flavor, soybeans were not used for direct human consumption for a long time, except in areas such as China, Japan, Korea and Indonesia. Two major limiting factors for production of soybeans in the tropics are (a) lack of varieties adapted to low latitude and shorter days of the cool season, or to high altitude and low temperatures of the tropics, and (b) lack of varieties that are mild in beany flavor and appropriate for direct human consumption. A cross of the selected soybeans Kahala X Lee 68" was made at Iguala ISAAEG Research Station. Several lines were selected in the F_4 generation with good agronomic and organoleptic properties. The resulting variety has been evaluated from 0 to 40° latitude and in the short growing season of low latitude; results were good. The ISAAEG-BM_2 variety of soybean is mild in flavor, and the heat treatment commonly applied to denature antinutritional factors is sufficient to completely eliminate the painty flavor. Details for the synthesis of ISAAEG-BM_2 variety and the recommended cultural practices for its maximal yield is discussed.

INTRODUCTION

Although the potential of raising soybeans in tropical and subtropical climates is enormous (2-3 vs 1 harvest/year in temperate zones), the majority of soybeans are produced in temperate regions. Lack of adapted varieties and cultural practices in lower latitudes are preventing its increased production.

The world supply of 100 million tons of soybeans or 40 million tons of protein in crop year 1980 would supply 680,000 million people with recommended daily allowance of .56 g protein/70-kg man if used directly for food. Because of its high oil content, soybean develops a painty flavor during processing, which reduces its use in human consumption to a small fraction of these enormous quantities.

The total demand for soybeans in Mexico (as grain, meal or oil) for 1980 is estimated at 1.5 million tons. Last year, production averaged 700,000 tons (1) and this year national production decreased to less than 250,000 tons. The majority of soybeans (80%) is produced in the northwest regions of Mexico (Sonora, Sinaloa, Chihuahua and Tamaulipas) where the development of varieties and technological packages are well established.

In order to meet the local demand for soybeans, it is essential that the majority of southern regions of the country potentially adapted to this legume crop be brought under cultivation. The climatic conditions such as day length and temperatures at high elevation in the North are completely different from those of the South.

Studies on varietal development for low latitudes are few and limited in scope. This paper summarizes part of 6 years' research work on synthesis of a new genotype of soybean for human consumption in the tropics and its cultural practices for maximal yield.

SYNTHESIS OF ISAAEG–BM$_2$ SOYBEAN

Origin and Development

In the summer (rainy season) of 1975, a Kahala (2) variety from the University of Hawaii yielded highly in a trial performance at ISAAEG Research Station in Iguala Gro., Mexico. Unlike in Hawaii, the weather in Iguala at the end of maturation for winter planting (April to May) is hot and dry; the Kahala variety, under these climatic conditions, becomes extremely susceptible to shattering.

A selected and adapted line from Kahala (Group V) with high pod-set, good eating qualities both as vegetable and dry bean, but susceptible to shattering, was crossed to Lee 68 (Group VI), which is resistant to shattering, to produce 6 combinations (Table I), some of which have good eating qualities as vegetable and dry bean, are resistant to shattering and have higher yields than both parents (Table II). The cross was made during Summer 1975 at the Instituto Superior Agropecuario (lat. 18° 20′; alt. 635 m) in Iguala. New lines have been produced from selection made in the fourth and fifth generations.

The Iguala cross selection in F$_5$ was tested in Pedro Escobedo Qro., Delicias Chih., Miacatlán Yautepec, Jiutepec and Alpuyeca, Mor., Obregón Son., Cotaxtla, Ver., Cuesta Blanca, Xamaje, Xuchitlán, Hgo., Cd. Mante Tamps., Mexico; Arkansas, USA; Venezuela; Nicaragua; Ecuador; Cuba; Rezife Pernambuco in Brazil; and Bulgaria.

TABLE I

Historical Genetic Background of Newly Synthesized Soybean Genotypes

Selected line from Kahala	X	Lee 68
Big seed Good quality for human consumption Resistant to root-knot nematodes Good pod-set Susceptible to shattering		Resistant to shattering
F$_1$		
F$_4$: BB, BM, BM$_2$	BM$_2$N	CB, CM

The variety Banafunzi-Mena designated as BM$_2$ and recently renamed ISAAEG-BM$_2$ leads in yield for pods, fodder and especially in dry beans under both long and short photoperiod growing conditions. Our lines are selected for human consumption as vegetable, sprouts and dry beans for preparation of milk, fish analog and other products. Each variety fulfills one of these requirements as well as some multiple purposes, as is the case of BM$_2$ (except that it does not give good yield of high quality sprouts).

Description

The ISAAEG-BM$_2$ is a determinate erect variety of medium height compacted type. It has purple flowers, tawny or brown at pubescence. During maturation, under-leaves and petioles start to turn purple in color. This symptom is more intensified at high altitudes. The leaves appear to have a self-regulating mechanism, as they are reduced in size under water stress. Seeds are medium-sized, yellow in color with black-colored hilium and round in shape. The ISAAEG-BM$_2$ at green pod stage has a protein content in the seed that compares favorably with other vegetable soybean varieties and has more than peas and lima beans (3).

Disease Resistance

In area of its best adaptation, such as Iguala Gro. Yautepec and Miacatlán, Mor., in Mexico the ISAAEG-BM$_2$ soybean is resistant to bacterial postule and root-knot nematodes. This new variety also has shown resistance to bacterial postule in Stuttgart, Arkansas (US) (C. Williams, personal communication) and resistance to purple seed stain (*Cercospore kikuchii*) in Managua and Rivas in Nicaragua (4).

Cultural Recommendation

The ISAAEG-BM$_2$ variety is photoperiod-insensitive but flowering is delayed under low temperature conditions of high altitude of the subtropical and tropical climates. It has shown resistance to shattering in Managua and Rivas in Nicaragua. For green pod, BM$_2$ can be grown year-round, but for combining, a planting date of June 15-July 20 is best in Iguala Valley; a date of July 1-20 is preferable for the coast of Guerrero during the rainy season. For seed production, planting must be done such that harvesting date coincides with dry weather and low temperatures. Harvest of early planting generally coincides with the rainy season and high humidity, and with high temperatures of summer in storage.

Recommended row width is 82 cm and the seeds should be planted on the bed in double rows with 15 cm between them. Recommended population densities for the rainy season (long days in summer) and under irrigation (short days of winter) are 350,000 and 600,000 plants/ha, respectively.

The ISAAEG-BM$_2$ variety has a wide range of adaptability (from 0 to 40° latitude and from 0 to 2,000 m altitude) and with high yields when planting date (day length), recommended population densities and cultural practices are followed.

Selection Index for Soybean High Yielders

Banafunzi et al. (5) report that the lengthy periods from flowering until the pods are filled and from flowering to

TABLE II

Agronomic Characteristics of ISAAEG-BM_2 Variety and Its Ancestors

Characteristics	Kahala	×	Lee 68	=	BM_2
	Genotype				
Color					
Seed	Yellow		Yellow		Yellow
Hilium	Brown		Brown		Black
Hepycotyl	Green		Purple		Purple
Pubescence	White		Brown		Brown
Flower	White		Purple		Purple
Growing habit	Indeterminate		Determinate		Determinate
Days to					
Flowering (50%)	33		40		39
Maturity for processing	79		78		78
Maturity for combining	99		121		103
Height					
Plant (cm)	69		49		52
First pod (cm)	16		9		14
Number					
Nodes/main stem	12		8		9
Branches/plant	2		3		3
Pods/plant	23		20		30
Weight (g) of 100					
Pods	43		60		59
Seeds	17		16		18
Diameter of main stem (mm)	4		6		5
Lodging (%)	20		0		15
Yield in kg/ha					
Immature beans	9,900		9,000		11,500
Seed	3,000		2,320		3,500

physiological maturity are good indexes for selection of high yielding soybean varieties for immature (pod) and mature (grain) soybean, respectively. More recently, it was found that the time duration of pod filling to maturity over length of days from flowering to maturity × 100 is a better selection index for high yielding soybean (Banafunzi and Mastache, unpublished data).

GOOD CULTURAL PRACTICES FOR YIELD IMPROVEMENT

Planting Date at Low Latitude and Low Altitude

Temperatures of low latitude (to 20°) and altitude (up to 1,500 m) permit the planting of soybeans year-round in the subtropical and tropical climate. Ten genotypes (Banafunzi et al., unpublished data) of soybean were studied at 5 different planting dates at ISAAEG (latitude 18 N, altitude 635 m) Research Experimental Station. The peak of delayed flowering and harvest was reached when planting was done on March 12. These results are in agreement with those reported by Minor in 1976. Delayed flowering was more pronounced in Júpiter than in Tropicana and BM_2. The reason for the extended life cycle is attributed to the sharp increase in the amount of light after the equinox. When flowering occurred at a declining light curve, days until harvest were gradually reduced; perhaps the shortest life cycle might take place at the equinox of September 21st flowering. Across all planting dates, BM_2 had the shortest life cycle. The corresponding yields of the 3 varieties of soybeans for the 5 planting dates given are presented in Table III. The BM_2 produced higher yields of beans than the other 2 varieties at each planting date. The highest yields for the 3 varieties were produced when plantings were done in June. The sharpest discrepancy in yields were observed when planting was done on July 17. It is notable that, in Iguala Valley and along the 2 coasts of Guerrero, rains are well established in July. For its short life cycle and for the highest yields produced with July planting, the ISAAEG-BM_2 seems to be the best choice for commercial production of soybeans in Guerrero and many other regions of Mexico in rainy seasons. The lengthened harvesting days and reduced yields from March planting mean that no soybean of the BM_2 variety should be planted after February 10 in order to prevent the coincidence of bean harvest with the rainy season. For these reasons, 2 crops of soybeans can be grown in Guerrero during one calendar year.

Planting Date at Low Latitude and High Altitude

The days before flowering represent the number of days from planting (in wet soil) until 50% of the plants have flowered. This evaluation system is different from that established (6) in temperate regions, where counting is made from emergence and not from planting. This standard type of evaluation in temperate regions is made to take into account delays in emergence of 5-15 days, but in tropical regions, emergence is uniform throughout the year. Days until flowering of 11 genotypes of soybeans at 2 different altitudes are presented in Table IV. The difference in the increased altitude from Iguala to Pedro Escobedo of 1,275 m was accompanied with decreased temperatures of 8.4 C (1 C for each increase of 154 m elevation) and, consequently, the delayed days to flowering was almost doubled for both early and late varieties relative to its interval at low

TABLE III

Effect of Planting Date on Yield of Beans in Three Genotypes of Soybean[a]

Variety	1/25	3/12	6/13	7/17	7/27
	Planting date (yield in kg/ha)				
Tropicana	938	862	2,081	1,420	1,180
Jupiter	1,411	1,431	3,516	1,680	1,948
BM_2	1,564	1,495	3,932	3,090	1,832

[a]ISAAEG Guerrero (Iguala), Mexico, 18° latitude.

TABLE IV

Effect of Temperature (Altitude) on Days to Flowering in Eleven Genotypes of Soybeans

State	Guerrero	Queretaro
Locality	Iguala	Pedro Escobedo
Latitude	18° N	20° N
Altitude	635 m	1,910 m
	Planting date	
Genotype	6/13/80	6/12/79
	Days to flowering	
BB	32	65
BM	34	66
BM_2	39	69
CB	37	68
CM	36	67
Hill	–	68
Jupiter	54	112
Kahala	33	63
Kailua	28	63
Mokapu	31	63
Tropicana	54	112
Total	378.0	816.0
Mean ($\bar{X}$)	37.8	74.2

altitudes. These results differ from those found by Whigham and Minor (7), who reported that early varieties respond more to changes in temperature than to day length and late maturing cultivars respond more to change in day length than to temperature.

Unlike regions of low latitude where late planting of at least 45 days is required for flowering and to obtain sufficient plant growth for acceptable machine harvest (8), high altitudes require a choice of earlier flowering beans over late genotypes in order to escape the early frosts of subtropical climates.

Predicting Days to Flowering in High Altitudes

Based on the assumption that for each increase of 152 m in altitude there is a decrease in temperature of ca. 1 C and that the temperature below 24 C retards the flowering 2-3.5 days for each 0.5 C in early and late varieties, it is possible to predict days to flowering of a given variety planted at a high altitude in reference to the known data of low latitude. Example:

Pedro Escobedo 1,910 m (altitude) Queretaro unknown zone
Iguala 635 m (altitude) Guerrero zone of reference
Difference 1,275 m (1275:152) = 8.4 C
8.4 C:0.5 C = 16.73 days
16.73 days × 2 = 33 days retardation for early varieties
16.72 days × 3.5 = 59 days retardation for late varieties

These differences of delayed days due to low temperatures summed up to days to flowering of known zones of low altitude can predict days to flowering of the varieties for regions of high elevation (Table V).

Population Densities for Two Different Planting Dates and Ideal Distance between Rows for BM_2 Soybean

Banafunzi et al. (9), in a study of 5 population densities with ISAAEG-BM_2 during both rainy (long day length) and dry (short day length) seasons, found that 350,000 and 600,000 plants/ha were ideal for maximal dry grain production, respectively.

Soybeans, like all crops, convert sunlight into chemical energy (dry matter). If efficient conversion is to occur, it is important to intercept as much light as possible. The critical time for high light interception occurs once the plant becomes reproductive and starts to make beans. The BM_2 is a compact variety and when planted at 82 cm between rows at flowering time, the plants are small, and much of the light is not intercepted by the leaves, but strikes the soil. If top yields are to be achieved, the leaf canopy should close the rows as the reproductive stage is reached. Banafunzi et al. (unpublished) studied BM_2 in 5 distances between rows at 5 population densities, and found that 40.5 cm between rows with 45.3 plants/m^2 controlled weeds better with less lodging and higher yields than with 82 cm rows between planting.

Low yields of soybeans obtained at latitude N below 20° grown under short photoperiod conditions and in zones above 50° latitude N grown under long days (10) are compensated by higher population densities.

In order to follow the method established for planting soybeans in double rows 20 cm apart, the tractor front and rear wheels have to be opened at 160 cm. Furrowing and fertilizing can be done simultaneously, mounting three furrow openers on the tool bar, one at the center of the tractor and the other two 82 cm apart from the center. The point of the side furrow openers will align with the wheel centers. The furrow openers must be specially made for soybeans which open furrows deep and narrow.

The fertilizer should be adjusted in order to apply the fertilizer at the bed center, 41 cm apart from the tractor center or from the rear wheel center.

Planting can be done with conventional planters by adjusting seed openers 10 cm apart from bed centers. In order to plant 2 seed rows 20 cm apart on top of the bed, the tractor has to make 2 trips on the same row. In the first trip, seed is planted at one side of the bed, and on the way back, the second row is planted on the other side of the bed, 20 cm apart from the other row and 10 cm from the bed center, place where fertilizer was deposited.

The ideal planter for planting 4 or 8 rows simultaneously has to be made or adapted, installing 4 or 8 seed hoppers in tandem.

Once this implement is obtained, the rows will be planted equidistant and cultivating will be easier and faster.

TABLE V

Computing Days to Flowering of Three Genotypes of Soya in Three Unknown Localities of High Altitude (Low Temperature) and Using As Reference Point Iguala, Gro., Mexico

		P. Escobedo, Qro. (8.4 C) 1,910 m			Chapingo Max. (10.6 C) 2,225 m		Toluca Mex. (13.4 C 2,675 m)	
Genotype	Iguala Gro. 635 m	Delayed	cal.	obs.	Delayed	cal.	Delayed	cal.
				Days				
Kailua	28	33	61	63	42	70	54	82
BM_2	39	33	72	69	42	81	54	93
Jupiter	54	59	113	112	74	128	94	148

RECOMMENDATIONS

1. For maximal yield of BM_2 in subtropical, tropical and temperate climates, seeds must be treated with fungicide against phytophthera.
2. Although maximal yields are produced when planting is done in June, subsequent wet weather at harvest time means July planting is more suitable.
3. For summer and winter planting, 350,000 and 600,000 plant/ha are recommended.
4. Double-row planting at 82 cm between rows and 15 cm between plants on the bed is ideal. This makes the plants close up at 15-days-old and facilitates weed control with 3 mechanical cultivations at intervals of 10 days.
5. Fertilization can be done at planting or 14 days afterward when the inoculant is ineffective. The fertilizer must be placed in a band 10 cm deep and at the center of the bed between the rows of plants. In calcareous soils with high pH, iron-deficiency can easily be corrected by spraying ferrous sulfate mixed with spreader stickers in the rainy season (0.5-1 cm^3/ℓ of water) at a rate of 2.0%.
6. Frequent irrigation and reduced volume of water at each interval would reduce the hazards often encountered with red spider in dry seasons.
7. Insecticide could be applied (10 and 20 days after planting) as a preventive measure within the first 3 weeks at intervals of 10 days.
8. Timely harvesting, especially during the dry season, will avoid high loss of grain by shattering.
9. Following the technological package of Unidad de Investigación y Divulgación del ISAAEG, yields up to 3 tons/ha of BM_2 were obtained in the rainy season.
10. The BM_2 variety has shown a wide range of adaptability to high and low latitudes, and high and low altitudes. It has early maturity, withstands droughts, is tolerant to hail, frost, excessive humidity for short times, is resistant to bacterial postule and nematodes and is a high yielding pod and grain plant. The novelty of BM_2 is the direct use for human consumption of either immature or mature beans.

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