Agronomic Performance of *G. max* x *G. soja* Hybrid Progenies for Crop Improvement in Soybean

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ABSTRACT

Genetic improvement of the cultivated soybean [*Glycine max* (L.) Merr] may be possible through hybridization with its wild progenitor, *G. soja* Sieb. & Zucc. Interspecific cross between *G. max* (Hwangkeumkong) and *G. soja* (IT.182932) was made in the summer of 1997. In F_2 the percentage of plant height, nodes per plant, and pods per plant were high but gradually reduced from F_2 to F_4. In contrast pod length, seeds per pod, and 100-seeds weight were increased gradually through generations advanced. Wild variation as evident in F_2 in plant height, number of branches, pods per plant, and 100-seeds weight. Twenty six percent of the F_2, 44 % of the F_3 and 60% of the F_4 segregants showed more *G. max* traits. The combination of useful traits from both species is possible through interspecific hybridization. The characters that could be transferred from wild species to cultivated species are more pod number, better capacity, and resistance to disease and insects. The interspecific derivatives offer scope for selection for high grain yield. Therefore, introducing genes from *G. soja* to *G. max* could be contribute to greater genetic diversity of future cultivars. And semicultivated soybean had some desired characteristics including tolerance to adverse environments and multi-seed characters. It means the infusing of semicultivated germplasm to the cultivated soybean could increase number of seeds and pods per plant significantly, and consequently could enhance selecting potential on yield.

Key Words : soybean, wild species, interspecific hybridization, semicultivated soybean

INTRODUCTION

Genetic variation is the basis of crop improvement. Limited genetic diversity in a crop species may restrict the amount of genetic improvement that can be achieved through plant breeding. Soybean is one of the world' s most important crops. For a crop of such international significance, it' s future of breeding still depends upon a relatively narrow base of genetic resources. In such a situation, the wild soybeans were of great interest as a potential genetic resource(Hadley and Hymowitz, 1973; Brown and Grant, 1985). Wild species have been used most frequently as sources of pest resistance, although they also have provided genes for improved yields of some crops[2,4,7,10)].

A potential source of genetic variability for the cultivated soybean is the wild species *G. soja* Sieb. & Zucc. The genus *Glycine* Willd. subgenus Soja includes *G. soja* Sieb. & Zucc. and *G. max* (L.) Merr[3,5)]. *G. soja*

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Table 1. Comparison of characters in F_1 hybrids and parents

Character	*G. max*	*G.max* x *G.soja*	*G. soja*
Habit	erect	viny	viny
Lateral branches	few,short,stout	many,long,slender	many,long,slender
Stem hairiness	profuse	moderate	sparse
Petiole length	short	intermediate	long
Leaf size	large,wide	intermediate	small,narrow
Pod color	tawny	intermediate	black
Pod arrangement	usually erect	semi-erect	appressed
Seed color	yellow	black or tan (more rarely yellow)	black
100-seeds weight	22.0	8.3	3.1

is a twining or procumbent annual vine bearing small-black seeds. It is found in fields, thickets, and hedgerows, and along roadsides and riverbanks throughout the Korean peninsula, Japan, and on the east Asian mainland from the Amur river region of Siberia into south China (Hermann, 1962). *G. max*, the domesticated soybean, is an erect annual herb grown extensively as a source of protein and vegetable oil. And a third species, *G. gracilis* Skvortz., has been described. The *gracilis* form of this species bears many more and longer lateral branches, smaller leaflets, and smaller, often black or tan seeds. Wild soybean consistently shows a higher level of variation than domestic cultivars (Kiang & Gorman, 1983; Kiang et al., 1987).

The objective of this study was to assess the breeding behavior in soybean hybrid progenies which crossed between cultivated species and wild species for crop improvement.

MATERIALS AND METHODS

Interspecific hybrids were obtained between variety of cultivated soybean(*G. max*) and wild species(*G. soja*). In one set the cultivar Hwangkeumkong(*G. max*) and IT 182932(*G. soja*) were utilized for hybridization for detailed studies in 1997. The harvested seeds were sown in a pot and the F_1 plants were grown to maturity. The F_1 seeds were raised as progeny rows in the F_2 generation. Similarly, individual F_2 and F_3 progenies were evaluated in F_3 and F_4 generations, respectively. In 1999, 320 F_2s were studied, and subsequently, in 2000 and 2001, 320 F_3 and F_4 families were studied. F_3 and F_4 seeds were harvested from F_3 and F_4 individuals through SSD(Single Seed Descent) method.

In F_2, F_3, and F_4 plant progenies of *G. max* x *G. soja*, 9 morphological characters that are distinct between parents were selected (Table 1). A morphological scoring index to discriminate segregants was constructed and the methodology of classification is detailed hereunder. Three classes, namely, (1) segregants having cultivated soybean(*G. max*)-like phenotype (0 score); (2) segregants having intermediate phenotype (score 1); and (3) segregants having wild soybean(*G. soja*)-like phenotype (score 2) were formed for each of the characters and respective scores were assigned. These scores of the 9 characters were summed and those segregants which obtained a final score of 0 to 18 were classified, respectively, as cultivated soybean or wild species-like progenies(Table 4). In addition, data on several quantitative characters were also recorded for individual segregants.

RESULTS AND DISCUSSION

Table 2. Mean values for the quantitative characters in the F1 hybrid between *G. max* x *G. soja*

	Plant height (cm)	Nodes per plant (no.)	Pods per plant (no.)	Pod length (cm)	Seeds per pod (no.)	100-seeds weight (g)
Hwangkeumkong	81.5	12.5	69.8	3.1	2.4	22.0
F_1	168.4	14.1	73.4	2.6	2.3	8.3
IT 182932	198.5	21.8	211.6	1.9	2.7	3.1

Quantitative characters

The interspecific hybrids between *G. max* x *G. soja* were characterized by moderate hairiness of stem, petiole length, leaf size, pod color, pod arrangement, and seed color which are, generally features of cultivated soybean(*G. max*)(Table 1). But the hybrids showed significant variations among themselves for all the characters except for pod length and seed per plant.

The F_1 hybrids were later than cultivated soybean in attaining 50 % bloom. The hybrids were taller, produced more branches and more pods than cultivated variety Hwangkeumkong.

The nodes per plant and pods per plant were drastically reduced in the F_1s. But 100-seeds weight showed a increase as compared with the wild species. A comparison of the data for the parents and hybrids on the six quantitative characters studied in given in Table 2.

The F_2 progenies showed wide variation for most of the observed quantitative characters. In subsequent generations, the variation among the segregants for all

Table 3. Mean, range, and coefficient of variation for quantitative characters of interspecific hybrids in the F_2, F_3, and F_4 generations

Character		Mean	Range	CV(%)
Plant height (cm)	a	172.9	105.1~202,4	68.2
	b	165.5	93.7~195.4	59.4
	c	156.6	91.5~188.7	57.8
Nodes per plant (no.)	a	14.2	11.0~18.5	35.2
	b	14.0	11.2~17.0	26.5
	c	13.6	12.0~16.3	24.3
Pods per plant (no.)	a	81.0	63.7~110,3	73.5
	b	75.1	60.1~90.4	51.7
	c	74.7	61.4~89.2	37.6
Pod length (cm)	a	2.7	1.9~3.7	28.8
	b	2.9	1.9~3.6	21.1
	c	3.2	2.2~3.4	20.1
Seeds per pod (no.)	a	2.9	2.4~4.0	57.2
	b	3.4	2.4~3.9	35.5
	c	3.3	2.8~3.9	29.1
100-seeds weight (g)	a	8.5	3.5~14.7	81.0
	b	9.2	3.1~13.9	72.6
	c	11.1	5.2~18.1	65.5

Superscripts a, b, and c represent the values for F_2, F_3, and F_4 segregants, respectively

Table 4. Frequency in percentage of segregants in F_2, F_3, and F_4 generations based on morphological score for 9 characters

Index score *	F_2	F_3	F_4
0	-	-	-
1	-	-	2.5
3	-	3.8	12.5
5	10.1	16.6	15.9
7	16.3	24.1	29.4
9	46.5	33.8	23.1
11	24.0	14.7	6.6
13	17.0	7.5	-
15	7.0	-	-
17	-	-	-
18	-	-	-

* Index score for *G. max* = 0 and *G. soja* = 2

the characters decreased to a considerable extent resulting in stabilization of the genotypes(Table 3). There was also a positive shift and increase in the mean expression of all the quantitative characters from the F_2 to the F_4 generations.

In the F_4 progenies exhibited higher expression than that of the midparental value for all the characters except for pod length and seeds per pod. While some of the F_2 segregants fell below the range of expression of F_1s, the rest showed a higher expression than the F_1s, although not equal in expression as that of wild species. Most of the F_3 progenies were found scattered between F_1 and wild species and a small percentage of them exhibited higher expression than wild species. These segregants showed positive deviation from the F_2 population. The bulk of the segregants in F_4 were intermediate between the parents and only a small percentage of them had a higher level of expression than wild species.

Segregation

The phenotypic expression in the hybrids was intermediate for hairiness on the stem and pod. It is inferred that the F_1 resembled the paternal parent(*G. max*) for most of the quantitative characters(Table 4).

The F_2 segregants showed wide variation in morphological characters. None of the segregants completely resembled *G. max* or *G. soja* in the F_2 generations. There was recombination for the morphological characters of both the parents.

Among the F_2 segregants, 48% showed more wild species, while in the F_3, only 22% of the population showed pronounced wild species expression. Almost all the segregants in the F_4 generation were cultivated soybean-like in their expression of quantitative characters.

Ahmad et al.(1979) reported that the chromosomes of the two species differed by two or more paracentric inversions. They found a meiotic irregularities and partial sterility in the hybrid between two species. This was adequately demonstrated by the index scores that consistently indicated the decreasing frequency of segregants with higher scores owing to the elimination of wild species features. The segregating plants in F_2, F_3, and F_4 evidenced the gradual elimination of wild species characters in the cytoplasmic and genotypic background of cultivated soybean.

The breeding behavior of the derivatives of *G. max* x

Table 5. Performance of cultivars or lines of different types of soybean

Variety	Type	Plant height(cm)	Flower color	Seed coat color	100-seeds weight(g)
Hwangkeumkong	cultivated (determinated)	81.5	purple	yellow	22.0
IT. 105296	semi-cultivated (semi-determinated)	85.9	purple	black	8.3
IT. 184225	semi-cultivated (semi-determinated)	92.7	purple	black	7.9
IT. 188359	semi-cultivated (semi-determinated)	86.8	purple	black	8.5
IT. 188417	semi-cultivated (semi-determinated)	90.5	purple	black	8.3
IT. 188418	semi-cultivated (semi-determinated)	83.7	purple	black	6.9
IT. 182932	wild (indeterminated)	198.5	purple	black	3.1
IT. 183014	wild (indeterminated)	202.7	white	yellow	3.8

G. soja indicated recombination of the characters of the parents. Although most of the wild species traits have been lost in the later generation progenies, a few of the characters of wild species were retained by the further recombinants. So, nowadays breeding objective to abandon those undesired characters of the wild soybean such as viny stem, black seed color, and small seeds is essential. Eral and Fehr(1984) demonstrated that backcrossing to the cultivated species probably would be necessary to transfer the desired genes from *G. soja* into a genotype that is free of the numerous unacceptable traits of the wild species.

The evaluation and utilization of genetic potential of semicultivated soybeans

Glycine gracilis that shows semi-cultivated growth habit was described originally as a weed growing in mung bean fields throughout northeast China(Skavortzoy,1927). It has been considered as the progenitor of *G. max* (Fukuda,1933) or as a hybridization product of *G. max* and *G. soja* (Hymowitz,1970). Some researchers were convinced that these 'gracilis' phenotypes merit some sort of recognition. Broich and Palmer(1980) demonstrated that (1) a distinct difference exists between the typical *G. max* phenotype and the 'gracilis' form and (2) selection for the latter phenotypes from among the many Plant Introduction of *G. max* is possible.

Table 5 shows semicultivated soybean had promoting effect on plant height, number of nodes, number of branches, number of pods and seeds while wild soybeans had reducing effect on agronomic characters(data not shown). So, we think crosses including semicultivated germplasm will be had greatest genetic potential. The infusing of semicultivated germplasm to the cultivated soybean could increase number of seeds and pods per plant significantly, and consequently could enhance selecting potential on yield.

And we could seperate two types of plants among IT.183014 individuals. They had all wild type growth, but one plant showed different characters that flower color was white , seed color was yellow, and seed shape was round whereas generally *G. soja* shows purple flower color, black seed color, and plated seed shape.

There is little doubt that the subgenus *Soja* represents the primary gene pool available to soybean breeders. But the application of the biological species concept to plants, in general, presents many nomenclatural problems(Hawkes, 1970; Cronquist, 1978).

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REFERENCES

Ahmad, Q.N., E.J. Britten, and D.E. Byth. 1979. Inversion heterozygosity in the hybrid soybean x *Glycine soja*. The J. of Heredity 70:358-364

Broich ,S.L. and R.D. Palmer. 1981. Evolutionary studies of the soybean : The frequency and distribution of alleles among collections of *Glycine max* and *G. soja* of various origin. Euphytica 30:55-64

Broich ,S.L. and R.D. Palmer. 1980. A cluster analysis of wild and domesticated soybean phenotypes. Euphytica 29:23-32

Erickson, L.R., W.D. Beversdorf, and S.T. Ball. 1982. Genotypic x environment interactions for protein in *Glycine max* x *Glycine soja* crosses

Ertl, D.S. and W.R. Fehr. 1984. Agronomic performance of soybean genotypes from *Glycine max* x *Glycine soja* crosses. Crop Science 25:589-5925.

Fukuda, Y. 1933. Cytogenetical studies on the wild and cultivated Manchurian soybeans. Jap. J. Bot. 6:489-506

Harlan, J.R. 1976. Genetic resources in wild relatives of crops. Crop Science 16:329-333

Hymowitz, T. 1970. On the domestication of the soybean. Econ. Bot. 24:408-421

Kiang, Y.T. & M.B. Gorman. 1983. Soybean. In : S.D. Tanksley & T.J. Orton(Eds.), Isozymes in plant genetics and breeding, Part B. pp. 295-328. Elsevier Science Publishing, Amsterdam

Yu, H and Y, Kang. 1993. Genetic variation in south Korean natural populations of wild soybean(*Glycine soja*). Euphytica 68:213-221

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