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NEW POLISH SOYBEAN (*GLYCINE MAX* (L.) MERR.) GENOTYPES AS POTENTIAL CROSS COMPONENTS FOR SELECTING EARLY RIPENING FORMS

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Introduction

In Poland new cultivars and breeding lines of soybean (*Glycine max* (L.) Merr.) have been released during the last ten years. These soybean genotypes hold promise for the efficient yielding in the southern and central part of Poland.

Poland is stretched between 49°00′ and 54°50′ N latitude and lies near the northern limit for soybean cultivation. Therefore, the genotypes improved in Poland carry the characteristics specific to the climate; for instance, tolerance to a long daylight period and resistance to low temperature. These genotypes may be able to develop quickly and mature early when cultivated even in severe conditions. SASAKI *et al.*[4] partly confirmed this suggestion by testing Polish genotypes in collection trials at Memuro, Hokkaido.

This research was conducted to examine phenological and morphological characteristics, biomass and seed yield components of Polish soybean genotypes including breeding lines and cultivars, and to compare them with Japanese early maturing cultivars. Special emphasis was put on complementary characters of Polish and Japanese genotypes as a source of germplasm for early maturity, effective yielding, and resistance to environmental stress.

Materials and Methods

In the test, eight soybean genotypes were included. The general features of experimental material are presented in Table 1.

The experiment was carried out in 1987 at the field of Experimental Farm of Faculty of Agriculture, Hokkaido University, Sapporo. In a split-plot experimental design with three replications interrow spaces (50 and 25 cm) were assigned to the main plots, planting densities (40 and 80 seeds/m^2) to subplots, and cultivars to sub-subplots. On May 21, plots 1.5 m wide with rows 1.0 m long were sown

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TABLE 1. General characteristics of Polish and Japanese genotypes

Genotype	Abbreviation	Type	Origin	Growth type#6	Maturity
AR1	AR1	BL#1	Poland#3	SDT	very late
IHAR-NK	IHA	BL	Poland#4	INDT	late
S 23	S 23	BL	Poland#3	INDT	early
R 18	R 18	BL	Poland#3	SDT	early
Polan	POL	CV#2	Poland#4	DT	very early
Progres	PRO	CV	Poland#4	DT	very early
Suzuhime	SHI	CV	Japan#5	DT	early
Wasekogane	WKO	CV	Japan#5	SDT	early

#1—breeding line
#2—cultivar
#3—Academy of Agriculture, Poznan
#4—Plant Breeding and Acclimatization Institute, Radzikow
#5—Tokachi Agricultural Experimental Station, Hokkaido
#6—DT—determinate; SDT—semideterminate; INDT—indeterminate

manually. Conventional cultural practices were applied. Phenological data were recorded on the plot basis. Five fully matured plants were sampled from each plot for quantitative recordings.

Data presented in this paper are the means over interrow spacings and planting densities. Characteristics examined are listed in Tables 2-5. Weights were based on air-dried plant material.

Results

1) Phenological Characteristics

Phenological characteristics of genotypes are presented in Table 2. Polish cultivars 'Polan' and 'Progres' began and completed to flower much earlier than Japanese ones 'Wasekogane' and 'Suzuhime'. Polish breeding lines, when compared to Polish cultivars, were equivalent with regards to the beginning of flowering but later with the end of flowering. Polish cultivars matured earlier than Japanese ones and even slightly earlier than Polish breeding lines.

2) Morphological Characteristics

Morphological characteristics of genotypes are presented in Table 3. Plant height was greatly different among the genotypes. The Polish cultivars 'Progres' and 'Polan' had the shortest plants, though the former one was significantly shorter than the latter one. Breeding line 'IHAR-NK' was the tallest among genotypes used.

Japanese cultivars produced significantly less branches than Polish breeding

TABLE 2. Phenological characteristics of Polish and Japanese genotypes

Characteristic	Genotype								LSD	
	AR 1	IHA	S 23	R 18	POL	PRO	SHI	WKO	5%	1%
Flowering										
—begin#1	49.4	45.0	45.7	45.0	43.4	44.7	60.8	53.0	0.8	1.0
—duration#2	15.0	25.5	17.8	25.3	12.3	11.1	10.0	21.9	1.0	1.4
—end#1	64.4	70.5	63.5	70.3	55.7	55.8	70.8	4.9	0.7	1.0
Maturity#3	121.2	112.4	111.8	113.2	111.1	108.3	148.0	137.0	2.8	3.8

#1—days from planting
#2—days from begin to end of flowering
#3—days from planting to harvesting maturity

TABLE 3. Morphological characteristics of Polish and Japanese genotypes

Characteristic	Genotype								LSD	
	AR 1	IHA	S23	R 18	POL	PRO	SHI	WKO	5%	1%
Plant height [cm]	93.0	101.1	83.1	86.1	74.8	64.5	76.3	96.4	7.7	10.3
Branch no./plant	1.9	2.1	2.9	3.0	2.1	2.1	0.9	0.8	0.6	0.8
Stem diameter [mm]#1	5.4	5.0	4.4	4.6	5.1	4.7	5.7	6.2	0.4	0.5
Lodging#2	3.9	3.1	4.1	3.4	3.4	3.2	1.9	1.4	0.9	1.3
Harvest space [cm]#3	6.9	12.3	8.5	7.8	5.6	5.2	16.0	13.4	2.8	3.7
% of plant height	7.3	12.4	10.5	9.2	7.4	8.0	20.9	13.9	3.2	4.2
Pod no. below 10 cm of height	3.1	0.5	2.1	2.3	2.8	3.1	0.1	0.3	1.0	1.3
%#4	7.7	1.9	5.0	6.6	8.6	10.9	0.4	1.2	3.2	4.2
Pod no. below 15 cm of height	6.4	2.3	6.3	5.3	6.1	6.5	1.1	1.3	1.6	2.1
%#4	16.1	7.9	16.1	15.0	18.9	23.0	2.8	5.9	4.5	6.0
Pod no. below 1/2 of height	18.8	16.1	20.1	18.2	13.4	13.4	12.7	9.0	4.1	5.5
%#4	47.6	59.1	51.9	51.3	42.7	47.2	35.5	43.4	7.1	9.4

#1—measured at soil surface
#2—rated on scale 1 to 5; 1—erect plants, 5—prostrate plants
#3—distance from the soil surface to the lowest pod
#4—% of total pod number/plant

lines and cultivars. Polish breeding lines 'R18' and 'S23' appeared to be significantly more branching than other genotypes.

Polish genotypes and Japanese cultivars had thin and thick stem diameter and were susceptible and highly resistant to lodging, respectively.

Japanese cultivars had higher harvest space than Polish genotypes. When harvest space was expressed in percent of stem height, 'Suzuhime' had as much as 20.9% of the lowest part of the stem as nonproductive. The harvest space of Polish cultivars was low. Harvest space of the breeding lines was higher and more diverse than that of Polish cultivars. 'IHAR-NK' and 'Wasekogane' had the most proper harvest space.

In both spaces from the soil surface up to 10 cm and up to 15 cm, Polish genotypes produced many pods, but Japanese ones did inconsiderably. 'Progres' developed the highest number and percent of pods in above mentioned spaces.

Polish genotypes produced more pods on the lower half of stature than Japanese ones. When productivity of lower half of stature was expressed in precent of all pods produced on plant, the breeding lines developed about fifty percent of pods in this space.

3) **Biomass**

Characteristics of vegetative above ground yield are presented in Table 4. In total plant weight, excluding the most heavy 'AR1', small differences were observed among genotypes.

The most heavy stems were produced by Japanese cultivars and the most light by Polish cultivars. The breeding lines were clearly differentiated into heavy and light stem types. Weight of branches per plant was slightly different among genotypes. Only 'Wasekogane' was distinctive with significantly heavier stem and lighter branches than the other genotypes. Total weight of the stem and

TABLE 4. Characteristics of vegetative above ground yield of Polish and Japanese genotypes

Characteristic	Genotype								LSD	
	AR1	IHA	S23	R18	POL	PRO	SHI	WKO	5%	1%
Total plant weight [g][#1]	24.1	18.6	19.3	20.1	19.1	17.9	18.6	20.1	3.9	5.2
stem weight [g] (S)	4.7	4.1	2.9	3.4	2.8	2.6	4.8	6.2	0.6	0.8
stem ratio [%][#2]	87.5	88.0	80.8	84.1	85.0	83.5	89.9	98.4	6.3	8.4
branch weight [g] (B)	0.8	0.6	0.9	0.7	0.6	0.6	0.6	0.1	0.4	0.6
S+B weight [g]	5.5	4.7	3.8	4.3	3.4	3.2	5.4	6.3	0.7	1.0
Pod weight [g][#3]	4.8	4.1	4.4	4.4	4.3	3.9	3.5	3.7	0.9	1.2
stem[#3]	3.7	2.9	3.0	3.1	3.3	3.0	2.9	3.5	0.7	0.9
branch[#3]	0.9	1.0	1.2	1.1	0.8	0.8	0.5	0.2	0.5	0.6
sterile[#4]	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Weight per pod [g]	0.12	0.15	0.12	0.13	0.14	0.14	0.10	0.18	0.02	0.03
Harvest index [%]	56.0	52.7	58.9	57.6	59.4	61.0	52.1	49.4	2.5	3.3

[#1]—above ground yield without leaves and petioles taken after harvesting maturity
[#2]—% of stem and branch weight
[#3]—per plant, weighed after seed separation
[#4]—pods unfilled with seeds, taken from whole plant

branches per plant of Polish cultivars was the smallest one in the test.

The total plant pod weight and stem pod weight was slightly different among genotypes. Polish genotypes were heavier in pod weight of branches than Japanese cultivars. Japanese cultivars 'Wasekogane' and 'Suzuhime' had distinctively the heaviest and lightest weight per pod, respectively.

In the harvest index, the Japanese cultivars were low but Polish ones were high. Polish breeding lines were substantially higher than Japanese cultivars.

4) **Seed Yield and its Components**

Some characteristics which contribute to seed production are presented in Table 5. In the seed yield per plant there were small differences among genotypes. Only 'AR1' yielded significantly higher than 'IHAR-NK', 'Suzuhime', and 'Wasekogane'. The daily seed efficiency (see note in Table 5) of Japanese cultivars was significantly smaller than 'IHAR-NK' which had the least daily efficiency among Polish genotypes. 'AR1' produced the highest seed yield with the greatest daily seed efficiency.

Polish cultivars and Polish breeding lines 'S23' and 'R18' produced almost the same number of pods on the stem. Some differentiations were observed among Japanese cultivars and among Polish breeding lines. The percent of pods on the stem was higher in Japanese cultivars than in Polish genotypes. Especially 'Wasekogane' produced an unsubstantial number of pods on branches. Japanese

TABLE 5. Seed yield and its components of Polish and Japanese genotypes

Characteristic	Genotype								LSD	
	AR 1	IHA	S 23	R 18	POL	PRO	SHI	WKO	5%	1%
Yield/plant [g]	13.5	9.8	11.5	11.6	11.4	10.9	9.7	10.0	2.3	3.1
Daily efficiency#1	113.2	89.3	104.6	104.2	104.7	102.9	66.6	74.8	9.3	12.5
Pod number/plant	39.8	26.5	37.2	34.6	30.8	28.4	36.2	22.4	6.8	9.1
stem	28.6	17.9	22.1	22.2	21.5	20.0	29.0	20.4	3.9	5.2
[%]#2	80.7	76.6	70.5	71.2	80.3	77.4	85.3	95.1	7.1	9.4
branches	8.1	6.1	10.9	9.4	6.0	6.7	5.7	1.4	3.8	5.1
[%]#2	19.3	23.4	29.5	28.7	19.7	22.6	14.7	4.9	7.1	9.4
sterile#3	3.1	2.5	4.2	3.0	3.3	1.7	1.5	0.4	1.1	1.5
[%]#4	7.6	9.7	11.6	8.6	11.2	6.0	3.9	1.4	3.2	4.2
Seed no./plant	77.4	38.7	71.8	63.0	62.2	55.9	80.4	50.8	14.1	18.8
Seed no./pod	1.9	1.4	1.9	1.8	2.0	2.0	2.2	2.5	0.1	0.2
100 seed weight [g]	17.7	25.4	16.0	18.4	18.3	19.6	12.2	19.7	1.4	1.9

#1—seed yield per plant/days from sowing to maturity [mg/day]
#2—% of all fertile pod number
#3—pods unfilled with seeds, taken from whole plant
#4—% total pod number per plant

cultivars produced a relatively small number of sterile pods per plant. 'AR1' produced the highest and 'Wasekogane' the smallest total number of pods per plant.

'IHAR-NK' produced the smallest seed number per plant and per pod, but its seeds were the largest. In contrast, 'Suzuhime' produced the greatest number of seeds per plant but its seeds were the smallest. Polish genotypes produced two or less seeds per pod, and Japanese cultivars developed more than two seeds.

Discussion

From phenological recordings, it is evident that early maturing soybeans began to flower earlier than the late ones. This is consistent with the findings of JARANOWSKI *et al.*[2]. That is, there is a positive correlation between days from planting to flowering and maturity. The duration and time of completing of flowering had little or no influence on maturity. 'Suzuhime', for example, was flowering over ten days (the shortest period recorded) although it matured as the latest genotype. The duration of flowering might be more closely associated with the type of growth rather than with the maturity. Determinate type could carry a shorter flowering period than semideterminate and indeterminate.

Phenological data also pointed out that in Sapporo Polish genotypes attained to the harvest maturity with approximately four weeks shorter time than it usually lasts in Poland. As the harvesting dates in Sapporo and in Poland were similar each other, the shorter period from sowing to maturity could be the result of sowing about one month later in Sapporo. In Poland soybeans are usually planted around the 20 April[1].

Lodging resistance is of interest because of its possible association with seed yield, combine-harvesting loses, and aesthetic value to farmers[3]. Japanese cultivars produced thicker and heavier stems with less branches and were more resistant to lodging than Polish genotypes. It seems that these characteristics could contribute to the lodging resistance and therefore should be introduced to Polish soybeans.

The harvest space characterized the distribution of pods on plant and indicated potential losses of seed yield during combine-harvesting. Therefore the number, especially the percent, of pods produced in 10 cm space from the soil surface has economical importance. It seems that the improving of pod distribution throughout the canopy (shifting up) of Polish genotypes could increase their yield potential. 'Suzuhime' had distinctively the highest harvest space, produced most of its pods on the upper half of the stature and yielded low. Excessive harvest space could be also detrimental to yield potential due to the nonproductive substantial part of the plant stature as it happened to 'Suzuhime'.

Seed yield per plant and its daily rate of productivity pointed out that earlier maturing genotypes produced grain more abundantly and efficiently than later maturing ones. It seems to be associated with higher harvest index of early maturing genotypes. 'AR1' with its exceptionally high seed yield and daily efficiency appears to be promising genotype, although harvest space and lodging resistance need to be improved.

From data delivered in this study, it is evident that both Polish and Japanese soybean genotypes have strengths and weaknesses. Fortunately, the virtues of both groups are complementary. Hybridization between Japanese and Polish genotypes might be promising for producing valuable recombinats. Crossing and examining progressive generations may confirm this suggestion.

Summary

To test some of newly released Polish soybean genotypes in Sapporo and to compare them with early maturing Japanese cultivars a split-plot design experiment with three replications was conducted in 1987. Six Polish and two Japanese soybean genotypes were used. Phenological data were recorded on the plot basis. Quantitative characteristics (morphological, biomass, seed yield and its components) were taken from 5 plants per plot.

Most of the recorded characteristics were significantly different among genotypes. Polish genotypes began to flower and matured earlier than Japanese cultivars. Polish genotypes developed more branches than Japanese ones. Japanese cultivars had higher harvest space and produced less pods in lower parts of the canopy than Polish forms. Japanese cultivars had thicker and heavier stem and were more resistant to lodging than Polish genotypes. The harvest index of Polish genotypes was higher than that of Japanese ones. The daily rate of seed productivity of Polish genotypes was higher than that of Japanese cultivars. The virtues of Polish and Japanese genotypes are complementary. Hence, early maturing and efficiently yielding recombinants might be achieved through selection in the hybrid populations between Polish and Japanese genotypes.

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