SPEED OF GERMINATION AS A CRITERION OF SEED VIGOR IN SOYBEANS[1]

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ABSTRACT

The effect of germination speed on the development and seed yield of soybean [*Glycine max* (L.) Merr.] plants was investigated. Seedlings from graded 'Clark' soybean seeds were germinated in individual turf pots and grouped according to speed of germination. The pots of each group were planted in separate lots in greenhouse and field experiments.

In both experiments, foliage development, dry matter accumulation, and seed yield of the rapidly germinating plants exceeded those of the slowly germinating plants. In the field experiment, the average seed yield of the plots planted with seedlings germinating 4 and 5 days after sowing exceeded the yield of the plots planted with seedlings germinating 6, 7, and 8 days after sowing by 22%. Through tests of the progenies of the different groups it was ascertained that the differences in the speed of germination were not heritable.

Additional index words: ***Glycine max*** **(L.) Merr., Seed quality, Seed yield, Yield components.**

THE concepts of seed vigor have been reviewed by various authors (e.g., Heydecker, 1972; Woodstock, 1973). According to Heydecker (1969) " 'Vigour', in its widest sense, denotes the overall ability of seeds to perform well when sown in the field." We suggest to define the effects of seed vigor as the effects on crop performance which should be ascribed to seed characters, being beyond those which can be attributed to the effects of genotype, environment, and genotype × environment interaction.

Speed of germination has been recognized in certain cases as a useful parameter of seed quality (Heydecker, 1972). With soybean [*Glycine max* (L.) Merr.] seeds, the percentage of germination after 4 days in the standard germination test had been found successful in estimating seedling vigor (Burris et al., 1969) and was incorporated by Te Krony and Egli (1977) in a vigor index for the prediction of field emergence.

The purpose of this research was to investigate the effect of germination speed on the vegetative development and seed yield of soybean plants. This, apparently, had not been studied before.

MATERIALS AND METHODS

The seeds used in this study were taken from the medium-size fraction, comprising about half of the yield obtained on a single plot of 'Clark' soybeans grown at Rehovot, Israel in 1975. Individual seed weight was 145 to 155 mg, and germination in the standard laboratory test was 80%. Seeds were germinated in 7-cm diameter turf pots filled with sand. One seed per pot was placed on the sand and covered with a 2-cm layer of vermiculite. The day of germination was recorded for each seedling when its cotyledons had completely emerged. The seedlings were classified according to their date of germination and the pots of each group were transplanted to soil beds in the greenhouse or in the field. The greenhouse and field plots were located at Rehovot. The soil was a sandy loam, the pots were planted adjacently in furrows, the plots were sprinkler-irrigated, and the upper 60-cm soil layer was kept moist throughout the growing season. Both experiments were conducted in a randomized-block design with four replications.

In the greenhouse the pots were sown on 21 Mar. 1976 and transplanted 8 days later. Seedlings whose cotyledons had completely emerged 5 days after sowing were considered rapid; 6 days, medium; 7 or 8 days, slow. The rapid seedlings were 29% of the total seedlings classified, the medium 38%, and the slow 33%. Each plot consisted of 28 plants in two 1.2-m-long rows 50 cm apart. The greenhouse was maintained at 15 to 28 C.

In the field experiment the pots were sown on 2 July 1976 and transplanted 10 days later. Seedlings of which the cotyledons had completely emerged 4 days after sowing were considered as very rapid, 5 days as rapid, 6 days as medium, and 7 or 8 days as slow. The very rapid seedlings were 24% of the total number of seedlings classified, the rapid 28%, the medium 21%, and the slow 15% (2% earlier seedlings and 10% later seedlings were discarded). Each plot consisted of 150 plants in two 6-m-long rows 75 cm apart. The plots were separated by border rows planted with regular seeds.

The seed harvested from the different groups in the greenhouse and field experiment was tested for speed of germination in the greenhouse in four replicates of 50 seeds per plot sown 2 cm deep in sand. Large- and medium-size seeds from the greenhouse experiment were tested 60 and 188 days after harvest and large- and medium-size seeds from the field experiment were tested 75 and 140 days after harvest.

RESULTS

In the greenhouse and field the first compound leaves of the rapidly germinating plants were larger than those of the slowly germinating ones, their development was faster, and their advantage was evident throughout the growing period (Tables 1 and 2).

In the field the rapidly germinating plants matured earlier and were taller than the slow plants. Differences between any two germination groups in number of days from sowing to maturity exceeded the respective differences in days from sowing to germination (Table 2). Therefore, the periods from seedling emergence to maturity were shorter for the rapidly germinating plants than for the slow plants. A higher rate of dry matter accumulation in the rapid plants was evident from the increase in dry matter per plant from day 51 through 62 after sowing. The very rapid, rapid, medium, and slow groups increased 15.9 g/plant, 15.7 g/plant, 13.1 g/plant, and 10.4 g/plant, respectively, during this period.

In both experiments, the seed yield per plant was correlated with the speed of germination. In the greenhouse the advantage of the rapidly germinating plants was associated with a higher mean seed weight, a greater percentage of pods bearing three seeds, and a greater total number of seeds (Table 1). In the field experiment, however, the advantage in seed yield of the rapidly germinating plants could be attributed to the production of more pods per plant (Table 3). Plant survival in the field also increased with speed of germination, thus promoting the seed yield per unit area.

Germination tests conducted with large- and medium-size seeds from the harvested seed of the different groups in the greenhouse and the field, revealed no apparent differences in germination speed. It was inferred, therefore, that there were no heritable differences in speed of germination between the different groups examined in this study.

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Table 1. Vegetative development and seed yield of soybean plants grown in the greenhouse which differed in their speed of germination.†

Complete emergence of cotyledons		Length of terminal leaflet of 1st compound leaf	Compound leaves/plant 54 days after sowing	Above-ground dry wt. Days after sowing			Pods/ plant	Pods			Seed yield/ plant	Mean seed wt.
Group	Days after sowing			32	43	54		Single-seeded	With 2 seeds	With 3 seeds		
		mm	No.	g/plant			No.	%			g	mg
Rapid	5	54	9.2	0.79	2.63	6.89	22.9	4.8	20.3	74.9	10.2	165
Medium	6	50	8.3	0.70	2.55	6.94	24.4	8.9	25.5	65.6	9.7	155
Slow	7 & 8	45	8.0	0.53	2.12	5.76	22.1	8.2	24.3	67.5	8.4	147
$S_{\bar{x}}$‡		0.8	0.3	0.05	0.10	0.04	1.8	1.7	2.7	2.8	1.6	–

† Averages of seven plants per plot. ‡ Standard error of the mean.

Table 2. Vegetative development of soybean plants grown in the field which differed in their speed of germination.†

Complete emergence of cotyledons		Length of terminal leaflet of 1st compound leaf	Compound leaves/ plant 27 days after sowing	Above ground dry wt. Days after sowing			Days from sowing to maturity‡	Height at maturity
Group	Days after sowing			35	51	62		
		mm	No.	g/plant			No.	cm
Very rapid	4	76	3.9	2.9	7.6	23.5	92	69
Rapid	5	80	3.8	2.5	7.2	22.9	94	61
Medium	6	70	2.6	1.8	6.5	19.6	97	58
Slow	7 & 8	56	2.9	1.6	6.3	16.7	99	58
$S_{\bar{x}}$§		1.0	0.09	0.24	0.71	1.67	3.0	2.0

† Averages of 20 plants per plot for the dry weights and averages of 10 plants per plot for the other parameters. ‡ Date of maturity was considered the day on which 50% of the plants had shed all their leaves. § Standard error of the mean.

Table 3. Seed yield and its components of soybean plants grown in the field which differed in their speed of germination.†

Complete emergence of cotyledons							Pods				
Group	Days after sowing	Yield	Plant survival	Yield/ plant	Mean seed wt.	Pods/ plant	Seedless	Single-seeded	With 2 seeds	With 3 seeds	With 4 seeds
		g/m²	%	g	mg	No.	%				
Very rapid	4	289	98	15.5	140	40.8	1.1	3.3	21.0	73.2	1.4
Rapid	5	261	97	14.1	134	38.5	0.8	2.7	20.8	74.2	1.5
Medium	6	228	92	13.0	136	35.4	0.9	3.6	21.2	73.1	1.2
Slow	7 & 8	221	90	12.9	136	35.1	1.1	3.5	21.8	71.1	2.5
$S_{\bar{x}}$‡		–	0.92	0.45	–	0.85	–	–	–	–	–

† Averages of 70 to 80 plants/5 m² plot. ‡ Standard error of the mean.

DISCUSSION

The results indicate a close relationship between speed of germination and the subsequent development of soybean plants throughout all growth stages, including seed production. This demonstrates a case of association of the speed of germination with seed vigor, according to our definition of this concept in the Introduction. A plausible explanation of this association could be that the growth rate of the developing plants is dependent on physiological and biochemical processes similar to those which have been reported by Ching (1973) to affect germination and seedling growth; e.g., mitochondrial activity and ATP synthesis.

The differences in speed of germination and subsequent growth in our study cannot be attributed to any genetic factor because there were no differences in speed of germination between the progenies of the different groups. Seed size has been shown to affect the performance of soybean plants (Burris et al., 1973; Smith and Camper, 1975). In our study, the seeds differing in their speed of germination were of similar size. All the seeds tested had been obtained from a single plot. Therefore, it is improbable that the differences in speed of germination and subsequent growth were due to environmental effects on the seed-parent plants. These diferences may, however, be associated with differences in location of seeds on the plant (seeds within pods or pods on nodes.)

Our results call for an extensive investigation of the relationship between speed of germination and seed vigor of different seed lots within different cultivars.

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