CULTIVAR VARIATION IN STORABILITY OF SOYBEAN SEED UNDER A LOWLAND HUMID ENVIRONMENT IN SRI LANKA[1]

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ABSTRACT

Seeds of 85 soybean (*Glycine max* (L.) Merr.) genotypes of diverse origins were stored under humid tropical conditions. Seeds were germinated periodically and evaluated for viability and vigour. The seed viability and vigour of the genotypes declined at a slow rate during the first three months of storage and rapidly thereafter. However, three small seeded genotypes retained high viability and vigour for six months. Correlation coefficients indicated a tendency for long half-lives to be associated with higher initial germination percentages and smaller seed size. The results suggested that sufficient variability existed in agronomically adapted cultivars for improving seed storability to suit the humid tropical environments.

INTRODUCTION

Deterioration of seed in storage is a major constraint to the expansion of soybean production in the humid tropics. The rapid loss of seed viability, enhanced by high temperatures and high humidities in subtropical and tropical areas, results in poor stand establishment at planting (Delouche, 1975; Justice and Bass, 1978; Tenne *et al.*, 1978; Arulnandhy *et al.*, 1984). However, varietal differences exist for the period seeds can be kept with sufficiently high viability and vigour to provide good plant stand and yield, upon planting (Roberts, 1972; Kueneman and Wein, 1981; Singh and Gupta, 1982).

Many workers have investigated variability in viability maintenance among soybean genotypes. Minor and Paschal (1982) identified a number of genotypes of potential subtropical and tropical adaptation that exhibited superior

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storability under simulated tropical conditions. Meanwhile, Arulnandhy *et al.* (1984) observed a few genotypes that maintained relatively high viability for six months under subtropical conditions and Wein and Kueneman (1981) found that some soybean genotypes of southeast Asian origin maintained good germinability after eight months of adverse ambient storage in the lowland humid tropics. Several other researchers (Singh, 1976; Singh and Gunasena, 1979; Thomas, 1979; Sharma *et al.*, 1980) also reported a differential rate of viability loss among soybean genotypes during storage under tropical conditions. Most of the latter researchers have dealt with one or , at most, a few genotypes.

This work was initiated as part of an effort to upgrade seed quality in soybean which includes identification of cultivars that were able to maintain relatively high viability and vigour under the humid tropical environments prevailing in Sri Lanka. In this study, 85 entries from the advanced varietal trials with diversity in origin were compared for their seed viability and vigour while in ambient storage. This is the first report of screening these advanced breeding lines and cultivars which are good seed yielders and agronomically adapted to local conditions. Therefore, identifying superior storability in them would facilitate the development and release of superior-storing cultivars.

MATERIALS AND METHODS

On October 18, 1983, 85 soybean genotypes of diverse origins, consisting of advanced breeding lines and cultivars, were planted in non-replicated 25 m long rows at the Agricultural Research Station in Maha Illuppallama and were hand harvested when fully matured, from mid January 1984. Two of them were standard cultivars "Pb— 1" and "Bossier" , recommended for cultivation in Sri Lanka. The climate of Maha Illuppallama area (8°5'N) may be classified as humid tropical. Following harvest, seeds were well dried and kept under cold storage (10°C and 45% RH) until the commencement of the storage experiment on 21 March 1984. A completely randomized design with four replications was used for this experiment. Germination tests were performed initially and at three month intervals during storage.

Twelve 100g seed samples of each genotype were placed in paper bags and kept in open shelves under ambient conditions (typically maximum temperatures 26—36°C, minimum temperatures 18—26°C and mean relative humidity 76.2 ± 5.9%) for a period of nine months at the Agricultural Research Station in Maha Illuppallama. At each test interval, four samples of each advanced breeding line or cultivar were taken and 25 seeds of each sample were drawn at random. Seeds then were treated with Captan 80% WP (N[(Trichloromethyl) thio]-4-cyclohexane 1, 2 dicarboximide) at 3g/1 Kg of seeds and planted in moist sterilized sand contained in plastic boxes which were kept at a constant temperature of 30 ± 1°C, known approximate optimum for soybean germination (Delouche, 1952). A count of emerged seedlings was taken after five and eight days of planting. Seedlings were carefully uprooted after eight days, examined and classified in accordance with the criteria established by the Association of Official Seed Analysts (1970). Reported germination values included only normal seedlings. Seedling length was measured from the base of the cotyledons to the root tip of five random seedlings and dry weight of the same seedlings was obtained gravimetrically after drying in an oven at 60°C for 48 hours.

Germination percentage was used as a measurement of seed viability. Germination percentages were transformed to arcsine scale to compare the seed viability of the genotypes tested. To characterise the storage performance of the individual genotype, a storage half-life value was determined for each. Here, germination results of each genotype are expressed as a percentage of their initial mean germination. Using this transformation, each had an initial germination of 100. Results in subsequent period reflect changes in germination relative to the initial value rather than in absolute terms. Values from the period immediately proceeding and following a 50% loss of initial germination were used to determine parameters for the linear regression line between these two periods. Storage half-life was estimated from the resulting equation.

Seedling length and dry weight were used as a measure of seed vigour, in addition to emergence rate which was computed as follows :

$$\frac{1}{2}\left[\frac{\text{number of seedlings emerged after 5 days of planting}}{5} + \frac{\text{number of seedlings emerged after 8 days of planting}}{8}\right].$$

This is the modification of the method suggested by Maquire (1962). All data were statistically analyzed and means were compared using LSD (Snedecor and Cochran, 1967).

RESULTS AND DISCUSSION

Mean germination percentage of 85 soybean genotypes included in the experiment was 81.5 initially and approached zero at the end of nine months of storage (Table 1). The length of storage period had a drastic effect on viability. The drop in average viability of seed as measured by germination, was slow during first three months (12.1%) and rapid thereafter. A similar decline in viability has been observed earlier (Wein and Kueneman, 1981; Minor and Paschal, 1982; Arulnandhy *et al.*, 1984).

Half-life values of the genotypes ranged from 2.3 to 8.6 months with a mean of 5.1 months (Table 2). The frequency distribution of the half-lives was leptokurtotic, with 70.6% of the genotypes possessing half-lives within the range of $\pm$ 1.0 standard deviation (1.1 months) of the mean. They were included in the class "intermediate storability". The class "above average storability" (beyond + 1.0 standard deviation of the mean) and "below average storability" (beyond = 1.0 standard deviation of the mean) contained 14.1% and 15.3% of the genotypes, respectively (Table 2).

The 12 soybean genotypes possessing above average storability originated in subtropical and tropical countries (Table 3). These 12 genotypes were selected along with the standard cultivars Pb—1 and Bossier for further discussion in this paper. The seed size of the selected genotypes ranged from 8.1 to 16.4 g/100 seeds with a mean of 12.8 g/100 seeds as compared to 15.8 g/100 seeds for the balance 73 genotypes tested and 15.4 g/100 seeds for all 85 genotypes (Table 3). Half-life values were also significantly correlated with seed size and the relationship was negative (Table 4). The results indicate that genotypes with smaller seed possess longer storage half-lives which is in agreement with the observations made by Minor and Paschal (1982).

Initial germination of the selected genotypes ranged from 81.1 to 100.0% with a mean of 91.7% which was 10.2% higher than the general mean of the 85 genotypes tested. These genotypes maintained about 85.0% mean germination for a period of three months during storage (Table 1). The selected genotypes had significantly higher viability than the standard cultivar Bossier during the first six months of storage. The genotypes Nuwara Eliya local, PM 78—25, P—28, 7207—1, S.J—5, TGX 536—100C and Huites—77 were superior in viability to both standard cultivars Bossier

and Pb — 1 after nine months of storage. The first three of these genotypes maintained about 90.0% germination during the first six months of storage under the humid tropical environments (Table 1). Initial germination was found significantly correlated with half-life values (Table 4). The correlation coefficient observed indicates a tendency for longer storage half-lives to be associated with high initial germination.

The seed vigour of the genotypes, as measured by emergence rate, seedling length and seedling dry weight, was examined during storage (Tables 5 — 7). Emergence rate, seedling length and seedling dry weight decreased with storage time. The genotypes exhibited significant differences in these measurements and the differences were most noticeable during the latter part of the storage period. Emergence rate of the selected genotypes was significantly higher than the standard cultivar Bossier during the first six months of storage (Table 5). The selected genotypes, with an exception of TGX 536 — 100C, had significantly greater seedling length and dry weight than Bossier only after six months of storage (Tables 6 and 7). After nine months of storage, the genotypes Nuwara Eliya local, PM 78 — 25, P — 28, S.J — 5, TGX 536 — 100C and Huites — 77 expressed significantly better seed vigour than the standard cultivars Bossier and Pb — 1 (Tables 5 — 7). The decline in vigour of seed followed the same trend as seed viability in the genotypes studied. Germination was also significantly correlated with emergence rate, seedling length and seedling dry weight, determined at different periods during storage (Table 8). The correlation coefficients observed showed that seed viability and vigour in soybeans are closely associated. Minor and Paschal (1982) also demonstrated the variation in seed vigour among soybean genotypes under simulated tropical conditions.

CONCLUSION

Data from the study show that good quality seed of many soybean genotypes can be stored without a major loss in viability and vigour for a period of three months in the humid tropical environments. Some genotypes with superior storability are identified and these might be stored longer. Soybean genotypes with smaller seed seem to possess better storability. Results of this study also suggest that high quality seed is a prerequisite of good storability. There appears, however, to be genetic

variability in the maintenance of seed viability and vigour during storage in the humid tropical environments, a trait that should be considered during cultivar selection and development to suit the adverse situations, thus solving a major constraint in soybean production in the humid tropics.

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Table 1. Germination percentage (P) of 12 selected soybean genotypes and two standard cultivars during storage. Arcsine transformed values are in column A.

Genotype	*Initial germination*		*Storage period (months)*					
			3		*6*		*9*	
	P	*A*	*P*	*A*	*P*	*A*	*P*	*A*
Nuwara Eliya local	92.0	73.0	92.6	74.2	88.3	70.0	30.7	33.7
PM 78 — 25	100.0	90.0	97.0	80.0	90.3	71.8	12.3	20.6
P — 28	97.6	81.4	96.0	78.5	93.1	74.8	8.9	17.4
7207 — 1	89.2	70.8	81.3	64.4	53.8	46.7	30.2	33.3
S.J — 5	82.2	65.1	79.4	63.0	66.3	54.5	8.9	17.4
TGX 536 — 100C	84.2	66.6	70.5	57.1	58.0	49.6	35.9	36.8
Huites — 77	81.1	64.2	69.5	56.5	55.0	47.9	28.7	32.4
ICA — L — 128	92.5	74.1	92.8	74.5	75.2	60.1	0.0	4.1
50228 — 1 — 38 — 6	97.2	80.2	98.6	83.1	76.3	60.9	0.0	4.1
50106 — 4 — 7	94.2	76.1	94.0	75.8	72.1	58.1	0.0	4.1
UPSL 216	93.2	74.9	91.5	73.0	70.8	57.2	0.0	4.1
Guntur	95.9	78.4	88.0	69.7	74.4	59.6	0.0	4.1
Pb — 1	75.2	60.1	93.3	74.9	49.0	44.4	0.0	4.1
Bossier	69.8	56.6	52.3	46.3	5.1	13.1	0.0	4.1
Mean of 12 selected genotypes	91.7	74.8	87.6	70.8	67.8	56.2	13.0	17.7
General mean	81.5	66.9	69.1	57.2	30.1	30.6	2.7	7.4
LSD at P = 0.05		12.2		9.5		19.0		8.3

Table 2. Half-lives and classification of 85 soybean genotypes for storability.

Class	*Number of genotypes*	*Percentage of total*	*Half-life in months*	
			Range	*Mean*
Above average storability	12	14.1	6.2 — 8.6	6.8
Intermediate storability	60	70.6	4.1 — 6.1	5.1
Below average storability	13	15.3	2.3 — 4.0	3.4
Mean of 85 genotypes				5.1
Standard deviation				1.1

Table 3. Characteristics of 12 selected soybean genotypes with above average storability and two standard cultivars.

Genotype	*Origin*	*Seed size (g/100 seeds)*	*Initial germination %*	*Half-life (months)*
Nuwara Eliya local	Sri Lanka	8.1	92.0	8.6
PM 78 — 25	Sri Lanka	8.9	100.0	7.6
P — 28	Australia	15.2	97.6	6.8
7207 — 1	Indonesia	12.8	89.2	6.8
S.J — 5	Thailand	16.1	82.2	6.8
TGX 536 — 100C	Nigeria	12.5	84.2	6.5
Huites — 77	Mexico	16.4	81.1	6.5
ICA — L — 128	Colombia	12.8	92.5	6.4
50228 — 1 — 38 — 6	Taiwan	16.1	97.1	6.3
50106 — 4 — 7	Taiwan	12.1	94.2	6.3
UPSL — 216	India	11.6	93.2	6.2
Guntur	Indonesia	10.8	95.9	6.2
Pb — 1	India	12.4	75.2	6.0
Bossier	U. S. A.	17.8	69.8	4.1
Mean of 12 selected genotypes		12.8	91.7	6.8
General mean		15.4	81.5	5.1

Table 4. Correlation coefficients between half-life of seed and five characteristics of 85 soybean genotypes.

	Half-life (2.3 — 8.6 months)
Seed size (7.4 — 20.9 g / 100 seeds)	— 0.47‡
Initial germination (20.2 — 100.0%)	0.20†
Initial emergence rate (0.8 — 4.1 / day)	0.18†
Initial seedling length (18.8 — 32.6 cm)	0.11
Initial seedling dry weight (92.8 — 195.0 mg)	0.17

†, ‡ Correlation coefficient values are significant at P=0.05 and 0.01, respectively.

Table 5. Emergence rates (day^{-1}) of 12 selected soybean genotypes and two standard cultivars after three period of storage.

Genotype	*Initial emergence rate*	*Storage period (months)* 3	6	9
Nuwara Eliya local	3.8	3.7	3.2	0.8
PM 78 — 25	4.1	3.9	3.5	0.6
P — 28	3.9	3.9	3.7	0.4
7207 — 1	3.5	3.0	1.5	1.0
S. J — 5	3.3	2.9	2.5	0.4
TGX 536 — 100C	3.3	2.8	1.3	1.5
Huites	3.1	2.8	1.1	0.6
ICA — L — 128	3.6	3.7	3.0	0.0
50228 — 1 — 38 — 6	3.8	3.9	2.6	0.0
50106 — 4 — 7	3.7	3.7	2.7	0.0
UPSL — 216	3.6	3.7	2.8	0.0
Guntur	3.8	3.5	2.9	0.0
Pb — 1	2.9	3.7	2.8	0.0
Bossier	2.9	2.0	0.2	0.0
Mean of 12 selected genotypes	3.6	3.5	2.5	0.4
General mean	3.2	2.7	1.1	0.1
LSD at P=0.05	0.4	0.5	0.6	0.3

Table 6. Seedling length of 12 selected soybean genotypes and two standard cultivars during storage.

Genotype	*Initial seedling length (cm)*	*Storage period (months)* 3	6	9
Nuwara Eliya local	23.5	23.7	22.0	14.2
PM 78 — 25	23.5	30.0	28.4	6.7
P — 28	26.0	27.4	23.7	5.1
7207 — 1	23.9	26.1	23.3	17.1
S. J — 5	30.0	25.9	29.3	5.1
TGX 536 — 100C	20.4	22.9	7.5	12.5
Huites — 77	23.5	25.5	13.5	17.7
ICA — L — 128	26.1	24.8	26.1	0.0
50228 — 1 — 38 — 6	25.4	32.8	20.3	0.0
50106 — 4 — 7	25.4	24.1	23.1	0.0
UPSL — 216	25.9	26.3	26.7	0.0
Guntur	25.0	25.0	23.2	0.0
Pb — 1	27.4	31.7	27.1	0.0
Bossier	25.4	28.2	3.7	0.0
Mean of 12 selected genotypes	24.9	26.2	22.3	6.5
General mean	24.6	23.9	14.7	1.2
LSD at P=0.05	0.9	3.2	3.9	4.2

Table 7. Seedling dry weight of 12 selected genotypes and two standard cultivars during storge.

Genotype	*Initial seedling dry weight (mg)*	*Storage period (months)* 3	6	9
Nuwara Eliya local	92.8	87.6	64.2	99.6
PM 78 — 25	127.8	110.3	70.1	88.5
P — 28	115.5	162.8	76.5	59.8
7207 — 1	123.8	230.5	131.2	103.6
S. J — 5	168.8	202.2	143.7	59.5
TGX 536 — 100C	108.0	108.5	48.6	102.2
Huites — 77	127.0	147.5	110.3	118.0
ICA — L — 128	113.8	106.5	73.8	0.0
50228 — 1 — 38 — 6	116.8	187.3	177.4	0.0
50106 — 4 — 7	158.5	172.7	119.4	0.0
UPSL — 216	186.3	170.5	87.4	0.0
Guntur	169.5	101.1	80.0	0.0
Pb — 1	134.3	136.5	106.2	0.0
Bossier	154.0	161.4	36.2	0.0
Mean of 12 selected genotypes	134.1	149.0	97.7	52.6
General mean	142.2	150.4	77.4	11.6
LSD at P=0.05	11.1	34.7	27.2	29.9

Table 8. Correlation coefficients between the measurements of viability and vigour of seed of 85 soybean genotypes during storage under the humid tropical environments.

	Seedling dry weight	*Seedling length*	*Emergence rate*
Germination	0.98‡	0.97‡	0.99‡
Emergence rate	0.97‡	0.97‡	
Seedling length	0.99‡		

‡ Correlation coefficient values are significant at P=0.01.