

## Inheritance of Superior Seed Longevity in Tropical Soyabeans (*Glycine Max* (L) Merr)

D.K. Ojo, Ariyo O.J., Adebisi M.A. and Kehinde O.B.

Department of Plant Breeding and Seed Technology, University of Agriculture, Abeokuta, Ogun State, Nigeria

**ABSTRACT:** Heritability of seed longevity was determined in a cross between an improved tropical soyabean genotype (TGx 1448-2E) and an exotic parent (TGm 737p) from the view point of standard laboratory germination tests. Specified number of seeds from the parentals, F<sub>1</sub>, F<sub>2</sub>, F<sub>3</sub>, the backcross and the respective reciprocal populations of the hybrids were used for the evaluation of inherent seed longevity. Considerable variation in variance estimates was observed in the parental, the F<sub>1</sub>, F<sub>3</sub> and the backcross populations. However, large pooled variance estimates in the F<sub>2</sub> compared with the parental suggested that crop genotype had a significant effect on seed longevity. A good fit of 3high:1low storability ratio in the F<sub>2</sub> populations also confirmed the assumption of one dominant gene for superior seed longevity in tropical soyabeans. Absence of significant reciprocal differences in the F<sub>1</sub> generation showed that there was no maternal influence and therefore, the expression of genetic segregation and selection is possible in the early generations. Relatively high narrow-sense heritability estimates (48-51%) observed in the study suggested that genetic resistance to seed deterioration is conditioned by additive gene action and consequently, superior seed longevity characteristic is highly heritable in tropical soyabeans.

**Key words:** Heritability, Seed longevity, Storability, Tropical glycine cross (TGx)

### INTRODUCTION

Soyabean seed quality is highly variable from one location to another and environmental conditions during seed development and maturation have been reported to have significant effects on subsequent seed quality (Green *et al.*, 1966, Tekrony *et al.*, 1987). High temperature, relative humidities and precipitation have been shown to enhance field deterioration in soyabeans (Tekrony *et al.*, 1980).

One of the many known problems encountered in soyabean production in the humid tropical environments of West Africa is the wide fluctuations in field germination and emergence of soyabean seed from year to year even when appropriate seed rates are used (IITA, 1974; Nangju *et al.*, 1975). Reason for these fluctuation can be traced either to the use of seed of very poor quality obtained from poor harvesting, careless post-harvest handling or planting of seeds when environmental conditions are not favourable for germination and seedling emergence (Nangju, 1977; Martins *et al.*, 1988).

Green *et al.*, (1965) have observed earlier that soyabean plants which mature during hot and dry weather conditions produced seeds with lower laboratory germination and field emergence. Small seed size was, however, observed to be associated with high laboratory germination and high field emergence under similar field conditions.

In 1978, a breeding programme was initiated by the International Institute of Tropical Agriculture (IITA) to incorporate promiscuous nodulation and good seed storability into soyabean lines with good agronomic characters and high yield potential (IITA, 1983). Substantial progress has been made. Good longevity characteristics is now available in some of the soyabean varieties released for cultivation in the West African sub-region. However, a lot of questions have been raised as regards the desirability (in terms of actual gene transfer) of longevity trait in the offspring of the original cross (Zanakis *et al.*, 1994). Assuming that the moisture content of a seedlot going into store can be monitored and controlled by hermetic storage, temperature remains a single environmental factor which is quite variable depending on the field location. There is need, therefore, to exploit this factor with some genetic control measures to improve and predict soyabean seed longevity in West Africa because soyabean varieties that will consistently produce high quality seeds with superior storability under hot-humid tropical field conditions are desirable.

The objective of this experiment was to determine the heritability of seed storability in a cross between an elite soyabean variety of West Africa origin and an exotic parent, from the point of view of standard laboratory germination tests.



## MATERIALS AND METHODS

Crosses were made by artificial hybridization in the IITA greenhouse between cultivar TGx 1448-2E (female) and TGM 737p (male) to obtain the first ( $F_1$ ), second ( $F_2$ ), third ( $F_3$ ) and the two backcross ( $BC_1$  and  $BC_2$ ) populations. TGx 1448-2E was chosen as female parent because it is an improved vigorous high yielding soyabean cultivar with relatively good seed storability characteristic.

It has been observed to be of below average stability and it is adapted to poor field conditions as far as seed yield and storability is concerned (Ojo, 2000). TGM 737p on the other hand is a plant introduction with excellent seed longevity characteristics. However, it has black seed coat which is not acceptable for commercial soyabean production in Nigeria.

The specific purpose was to investigate whether the choice of cultivar TGx 1448-2E as a female parent could result in superior seed longevity as opposed to an initial cross made (IITA, 1983). Advancement of filial generations was by selfing. Two backcrosses were obtained by making crosses between the  $F_1$ s and each of the parents. Reciprocal crosses were also made to determine maternal effects or any possible sex linkage. Seeds from parental,  $F_1$ ,  $F_2$ ,  $F_3$ , the backcrosses and the reciprocal populations were planted by carefully adjusting date of planting in an attempt to bring the different populations to maturity at about the same time. The long-duration parent was planted ten days before the short-duration parent and the F-lines. For the evaluation of inherent seed storability in the main cross, 20, 20, 126 and 883 individual plants were selected at random from each of the parental,  $F_1$ ,  $F_2$ , and  $F_3$  generations respectively. Seeds were harvested, threshed separately by hand and dried artificially. However, 20, 20, 504 and 2670 plants were selected at random from the parental,  $F_1$ ,  $F_2$  and  $F_3$  generations of the reciprocal cross. However, ten (10) plants were selected from each of the backcross generations, due to low plant populations.

Moisture content was adjusted to 10% and seeds from each plant were stored hermetically in a cold store until needed. Each seedlot was used for the standard rolled-paper laboratory germination tests. Each test was carried out in an incubator maintained at 30°C/20°C (8h. 16h). Normal seedlings were counted 5 days after, and a final count was made 2 days later. Seedling with well developed primary roots (radicle about 2-5cm long) were considered to have normal germination. The laboratory germination percentage of each test was taken as an index of seed storability (Wien and Kueneman, 1981).

The  $F_2$  and  $F_3$  data were subjected to mendelian genetic analysis with an assumption that seeds having a percentage germination of 90 and above had the

superior storability quality while anything short of this was poor. The cut off line was arrived at because the mean performance of either of the parent plants and their  $F_1$  offsprings was never less than 90%.

Broad-sense heritability ( $H_B$ ) was estimated on a single-plant basis in the  $F_2$  generations to measure the degree of genetic determination according to Mahmud and Kramer (1951). Thus,

$$H_B = V_{F_2} - \frac{V_{P_1} + V_{P_2}}{V_{F_2}}$$

Where  $V_{F_2}$  = phenotypic variance among  $F_2$  plants

$V_{P_1}$  &  $V_{P_2}$  = phenotypic variances among plants of parent 1 and 2 respectively.

The difference between the variance estimates among the  $F_2$  plants and the geometric mean of the variances of the parents ( $P_1$  and  $P_2$ ) was considered an estimate of the genetic variance ( $V_g$ ) (Fehr, 1987). Since the genetic variance among the randomly chosen genotypes in each population was considered a valid estimate of the true genetic variance of the population, heritability estimate was therefore a valid estimate of true heritability.

A breeding method proposed by Warner (1952) for estimating the narrow-sense heritability ( $H_N$ ) on a single-plant basis used in this study involved measurement of the variances of plants in the  $F_2$  and backcross populations. The formula is given as  $H_N = \frac{V_{F_2} - (V_{BC_1} + V_{BC_2})}{V_{F_2}}$  where  $V_{BC_1}$  and  $V_{BC_2}$  are the variances of plants from the backcross generations. The numerator of the equation represents additive genetic variance and the  $V_{F_2}$  in the denominator represents the phenotypic variance among the chosen plants.

Seeds (at 10% moisture content) were assessed for germination according to the standard laboratory germination criteria (ISTA, 1985). Components of genotypic variance was analyzed using the variances in the  $F_2$  and later generations of backcrossing (Mather, 1949; Borojevic, 1990) to determine the additive, dominance and environmental effects. Chi-square ( $X^2$ ) analysis was used to assess the conformity or otherwise of observed data to the Mendelian genetic ratios.

## RESULTS

The frequency distribution of germination percentages is represented in Table 1. There was a trend towards high percentages in the parent plants and their hybrid generations as the mean of distribution was never less than 89.8% in any of the populations. The table also showed the survival of more plants in the reciprocal than in the main cross. However, a comparison of the mean performance of the two  $F_1$ s did not reveal any significant difference between the main and reciprocal crosses i.e. the relative contribution of either parent to the subsequent offspring was similar.

Chi-square ( $X^2$ ) analysis in the  $F_2$  of the main and reciprocal populations is represented in Table 2. The



**Table 1:** Frequency distribution of germination percentages used as a measure of seed storability in soyabean crosses

Generation	Class Intervals										n	$\delta^2$	S.D.
	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100			
P <sub>1</sub> (TGx 1448-2E)						2		1	1	14	20	94.45	2.00
P <sub>2</sub> (TGm 737p)						0	0	1	1	18	20	97.95	1.73
<u>Main cross</u>													
F <sub>1</sub> (P <sub>1</sub> xP <sub>2</sub> )						2	0	0	1	7	10	94.70	1.66
F <sub>2</sub> (F <sub>1</sub> xF <sub>1</sub> )				2	1	3	0	12	11	97	126	94.92	1.04
F <sub>3</sub> (F <sub>2</sub> xF <sub>2</sub> )	1	2	6	14	10	26	22	82	120	601	883	90.24	0.51
BC <sub>1</sub> (F <sub>1</sub> xP <sub>2</sub> )						0	0	1	1	8	10	95.00	4.01
<u>Reciprocal cross</u>													
F <sub>1</sub> (P <sub>2</sub> xP <sub>1</sub> )						0	0	0	1	9	10	96.00	1.33
F <sub>2</sub> (F <sub>1</sub> xF <sub>1</sub> )						11	16	17	55	396	504	95.30	0.53
F <sub>3</sub> (F <sub>2</sub> xF <sub>2</sub> )	8	19	14	15	11	92	66	266	287	1852	2670	89.80	0.31
BC <sub>2</sub> (F <sub>1</sub> xP <sub>1</sub> )						0	0	0	2	7	10	97.00	2.14
LSD (5%)												5.18	

n = number of plants tested

0 = mean germination percent of all plants tested

analysis revealed dominance of superior storability over poor storability and a good fit to the mendelian ratio of 3 high: 1 low storability type whereas there was lack of good fit to the ratio 5:3 in the selected F<sub>3</sub> bulk populations.

Broad-sense heritability estimates of percentage germination were high but there was no significant difference between the main (91.4%) and the reciprocal (91.6%) crosses as shown in Table 3. Narrow-sense heritability also showed relatively high estimates (48-51%). Although, main and reciprocal crosses gave near-similar variance and heritability estimates in the F<sub>2</sub> populations, a considerable variation was observed between parents, F<sub>1</sub>, F<sub>3</sub> and the backcross populations. For instance, variance estimates in the two F<sub>1</sub> populations were larger than those of their respective maternal parents. Also, the pooled variances in the F<sub>2</sub> generation were larger than the pooled parental variance estimates.

Components of variance in the F<sub>2</sub> and backcross generations showed that environmental variance accounted for only 14.1% whereas the genetic variance for seed storability accounted for 85.9% of total variability. This analysis also revealed that 49.4% of the variability was due to additive gene action while the portion due to the dominant gene action was 36.5% of total variability.

## DISCUSSION

High germination percentages among the selected plants in the backcross, the F<sub>1</sub>, F<sub>2</sub> and F<sub>3</sub> populations and their reciprocals were indicative of excellent seed storability

**Table 2:** Chi-square (X<sup>2</sup>) test for segregation of germinability of seeds used as an index of storability in cross TGx 1448-2E x 737p and its reciprocal.

Phenotype	Observed frequency	Expected frequency	Chi-square value	P-value
(TGx 1448-2E x 737p)				
F <sub>2</sub> generation		3:1		
Superior storability	97.0	94.5	0.264	0.50-0.05 (good fit)
Poor storability	29.0	31.5		
F <sub>3</sub> bulk		5:3		
Superior storability	600.0	551.9	11.162	0.50-0.10
Poor storability	283.0	331.1		
(737p x TGx 1448-2E)				
F <sub>2</sub> generation		3:1		
Superior storability	396.0	378.0	3.428	0.50-0.05 (good fit)
Poor storability	108.0	126.0		
F <sub>3</sub> bulk		5:3		
Superior storability	1852.0	1669.0	53.662	0.50-0.10
Poor storability	818.0	1001.0		

attributes available in the two plant parents which continued to feature as the generations were advanced. Although both parents contributed the much needed superior seed storability trait, the black seeded cultivar 737p with smaller seed size, superior germination and low variance estimate (5.50) was preferred to the



**Table 3:** Mean values ( $\bar{O}$ ), variances ( $\delta^2$ ) and heritability estimates of seed germination in the parent and hybrid generations of two soyabean cultivars

Parents and hybrid	No. of plants analysed	Percent Germination		Heritability (%)	
		$\bar{O}$	$\delta^2$	$H_B$	$H_N$
P <sub>1</sub>	20	94.5	25.2		
P <sub>2</sub>	20	98.0	5.5		
F <sub>1</sub>	20	94.7	27.6		
F <sub>1</sub> (R)	20	96.0	17.8		
BC <sub>1</sub>	10	95.0	161.1 (103.3)*		
BC <sub>2</sub>	10	97.0	45.6		
F <sub>2</sub>	126	94.9	137.2	91.4	50.1
F <sub>2</sub> (R)	504	95.3	139.1	91.6	48.6
F <sub>3</sub>	883	90.2	224.7		
F <sub>3</sub> (R)	2670	89.8	260.2		

$H_B$  = Broad-sense heritability

$H_N$  = Narrow-sense heritability

- Mean of variances of the two backcross populations

improved high-yielding variety TGx 1448-2E (with creamy seed coat colour) because small seed size and seed coat characteristics appeared to play a major role in conditioning genetic resistance to seed deterioration. Superior seed storability according to Paschal and Ellis (1978), is associated with small seed size – a fact that was corroborated by high laboratory germination and better field emergence in soyabeans.

It has also been suggested that the black seed in soyabean may offer advantages in terms of better storability (Starzinger *et al.*, 1982) because soyabean with black or brown seed coats tend to imbibe water slowly and maintain viability longer than rapid imbibers (Dassou and Kueneman, 1984). Coloured seeds of many crops have often been shown to be more resistant to mechanical damage (Dickson and Boettger, 1976) and more resistant to organisms that incite rootrot and seedrot diseases (Dickson and Boettger, 1977). Reduced mechanical damage to the seed presumably results in less nutrient leakage from the germinating seed, less attack by soil-borne fungi and consequently, an improved germination (York *et al.*, 1977).

A good fit of 3 high: 1 low storability ratio observed in the F<sub>2</sub> generations conformed to the assumption of one dominant gene for superior storability (Singh and Ram, 1986), whereas lack of fit in the selected F<sub>3</sub> bulk population was suggestive of the fact that the F<sub>3</sub> variances were probably not homogenous due to sampling errors.

High broad-sense heritability estimates for seed storability in the main (91.4%) and the reciprocal (91.6%) crosses in the F<sub>2</sub> generations suggested the possibility that either soyabean parent could provide a good genetic base for seed longevity improvement through hybridization and selection (Lanyon, 1970).

This observation is substantiated by the moderately high narrow-sense heritability estimates (48-51%) which actually showed the breeding value or the proportion of the total variation due to additive genetic variance. Hence, there is good chance that the superior seed storability characteristic can be transmitted to the offspring from either parent because heritability estimates are a tool in the prediction of genetic gain expected from selection of a character (Fehr, 1987).

Absence of significant reciprocal differences observed in the F<sub>1</sub> generations showed that the maternal plant genome *per se* did not influence seed longevity in soyabeans. Thus, selection for superior seed storability is possible in the early generations. As superior seed storability characteristic in soyabean is governed by one major gene, (Singh and Ram, 1986) larger additive genetic variance compared with dominance variance observed here, suggested an additive gene action.

Genotype TGx 1448-2E which is a product of a 3-way hybridization has been able to combine the superior seed storability characteristic from a number of tropically adapted landrace and improved soyabean varieties into excellent characteristics similar to those of the original parents. Thus, TGx 1448-2E is a soyabean genotype that combines high yield with superior seed storability.

Since the environmental variance was fairly low (14.1%) compared to the actual value of the genotype (85.9%), it would be possible and faster for the breeder to select soyabean genotype modifications which will produce a superior progeny with good seed storability in subsequent generations.

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