

ORIGINAL ARTICLES

Seed Reserve Utilization and Electrical Conductivity of Deteriorated Soybean Seeds (*Glycine max* L.)

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ABSTRACT

Internal changes in soybean seeds (*Glycine max* L.) which occur during aging show a subsequent loss of vigour and increase in leakage of electrolytes. So, an experiment was conducted as completely randomized design with 4 replications to evaluate deterioration effect on electrical conductivity, seedling growth and seed reserves utilization from cotyledons. High moisture Seeds (15-16%) of DPX cultivar of soybean were incubated at temperature of 40°C for 0 (as control), 3, 7 and 10 days. Results showed that, with increasing deterioration time electrical conductivity of leakage increased mainly. In this study some growth indexes of seeds such as germination present (GP), seedling length (SL) and seedling dry weight (SLDW) had a significant difference with control. Also, in evaluation of heterotrophic seedlings growth, seed reserves utilization rate (SRUR) and seed reserve use efficiency (SRUE) decreased significantly with deterioration intensity. Thus efforts to improve seed germination and growth in plant breeding should focus on improvement of fraction of mobilized seed reserves.

Key words: Aging, Electrical conductivity, Germination, Seed reserve, Soybean

Introduction

According to the explanation of international seed testing association (ISTA), seed vigour is sum of seed characteristics that determine activity level of one seed or seed lot function during germination and seedling emergence (Hampton and Tekrony., 1995). The performance capability of seeds in general and particularly in soybean declines during storage. This aging or loss of vigour is evidenced by delayed germination and emergence, slower growth, susceptibility to environmental stresses, and ultimately, a decline in germinability (Byrd and Delouche., 1971). Seed deterioration can be defined as the loss of quality, viability and vigour either due to aging or effect of adverse environmental factors. The rate of deterioration rapidly increases with increase in either seed moisture content and or temperature of storage (Ellis *et al.*, 1992). Seed deterioration associated with loss of viability during storage results in decreasing early growth of roots and shoots and increasing variability of growth between plants (Kapoor *et al.*, 2010). Vigorous seeds germinate rapidly in a wide range of environmental conditions and uniform and healthy seedlings provide good stand in direct-seeded crop. Mobilization of nutrient reserves may be associated with the changes in seed vigour (Walters *et al.*, 2005). The heterotrophic seedling growth could be quantitatively described as the product of two components, weight of mobilized seed reserve and conversion efficiency of mobilized seed reserve to seedling tissues (Soltani *et al.*, 2006).

The electrical conductivity (EC) has been recommended to evaluate seed vigour for peas. It has also been suggested for soybean seeds (Hampton and TeKrony., 1995). EC test in soybean is more efficient indicator of field emergency than germination test (Salinas *et al.*, 2010). This test is an index for seed leakage amount. When low vigour seeds put in distilled water, some of their materials leaks out. There is a negative correlation between EC and seed vigour and membrane integrity (Egli, 2001). Vieira *et al.* (2008) showed that the temperature at which soybean seeds remain during storage may affect the amount of electrolytes in the soaked water and consequently the results of the electrical conductivity test. Ruzrokh *et al.* (2002) in their studies on chickpea reported that electrical conductivity test is the most suitable test for chickpeas vigour evaluation. Also Rizzatti *et al.* (2005) reported that accelerated aging test, electrical conductivity and first count of germination were so useful in field germination assessments. Borji *et al.* (2007) in their experiments on chickpea indicated that, there is a negative relation between electrical conductivity and seed vigour, and negative and non-significant relation between electrical conductivity and germination, too.

Deterioration development with time and storage longevity is predictable. Because seed aging and deterioration are the most important affecting factors to decline seed vigour and germination, the present study was conducted to analyse the effect of seed aging on different growth characteristics. In this way, different levels of aged soybean seed were used to find a relationship between EC test result and reserve utilization. On the best of our knowledge there is no published data reporting quantitative effects of seed aging on the indexes of seedling growth in soybean. Determining which trait affects seedling growth could help agronomists and plant breeders to improve crop yield.

Materials and Methods

Soybean seeds (cv. DPX) were obtained from Institute of Oil Seed Cultivation, Gorgan, Iran. The experimental design was a completely randomized design with 4 replications. For seed deterioration considering to primary humidity (15-16%) seeds were incubated for 0 (as a control), 3, 7 and 10 days in sealed containers at 40°C. After aging for vigour test, 25 seeds were placed between moistened Whatman filter papers, and held in dark for 8 days at 25±1°C with occasional additions of distilled water. The number of seeds germinated (embryonic axis longer than 2mm) and seedling dry weight (measured by removing cotyledons and weighting the remaining seedling and cotyledon) were recorded. According to the method described by Soltani *et al.* (2006) and Sedghi *et al.* (2010), to determine seed dry weight and seed moisture content, four replicates of 50 seeds were weighed (W1), dried at 104°C for 24 h and then reweighed (W2). Seed water content was calculated as [(W1-W2)/W2]. The initial seed dry weight was calculated using the data for seed water content and W1. After seven days, oven dried weight of seedlings was determined. The weight of utilized (mobilized) seed reserve was calculated as the dry weight of the original seed minus the dry weight of the seed remnant. Conversion efficiency of mobilized seed reserve into plant tissue was estimated dividing seedling dry weight by the utilized seed reserve. The ration of utilized seed reserve to initial seed dry weight was considered as seed reserve depletion percentage. The procedure for electrical conductivity consisted of weighing four samples of 50 unbroken and intact seeds and then each sample was placed in 250ml of deionised water in a 500 ml Beaker for 24 hours at a constant temperature of 20°C. The bulk electrical conductivity of solution was determined through reading in a conductivity meter and the average values obtained for each lot were expressed as $\mu\text{scm}^{-1}\text{g}^{-1}$ (Hampton and Tekrony., 1995). The obtained experimental data were statistically processed (ANOVA and LSD test) using SAS (Statistical Analysis System version 9.1) computer program.

Results and Discussion

Table 1 represents a summary of the analysis of variance for seedling vigour characteristics and electrical conductivity test. The results indicated that different levels of deterioration had a significant ($P < 0.01$) effect on germination present (GP), seedling length (SL) and seedling dry weight (SLDW). Also deterioration affected seed reserves utilization efficiency (SRUE) and seed reserves utilization rate (SRUR) significantly ($P < 0.01$). Decreasing seedling dry weight with increasing aging can be the result of decrease in seed reserves mobilization amount, and reducing seed germination following seed aging treatments might have been resulted from the increased solute leakage following imbibitions (Soltani *et al.*, 2006).

Table 1: Analysis of variance for deterioration effect on soybean seeds germination growth indexes and seed reserve utilization.

S.O.V	DF	GP	SL	SLDW	SRUR	SRUE	EC
Treatment	3	0.44**	8.4**	0.17**	3.72**	0.08**	978.2**
Error	9	0.004	475.8	0.018	0.05	0.008	6.08
CV(%)		16.14	9.7	17.5	7.07	17.5	6.4

* and ** significant difference at $P < 0.05$ and 0.01 , respectively.

Germination percent (GP), seedling length (SL), seedling dry weight (SLDW), seedling reserve utilization rate (SRUR), seedling reserve utilization efficiency (SRUE) and Electrical Conductivity (EC).

Seedling growth, fraction of seed reserve utilization and weight of mobilized seed reserve, decreased by increasing deterioration levels (Table 2). Percentage of seed viability is an excellent indicator of the growth potential of the surviving seeds that is associated with seed deterioration and decreasing early growth of roots and shoots (Abdalla and Roberts., 1969). Comparison of means showed that increasing seed aging caused decrease in seedling reserve utilization rate. Control treatment has the highest value for SRUR. Soltani *et al.* (2006) indicated that seedling growth and weight of mobilized seed reserves decreased mainly with increasing salt intensity. GP was sharply decreased by increasing seed deterioration (Table 2). Sedghi *et al.* (2010) reported that GP is a susceptible criterion of seeds to environmental stresses.

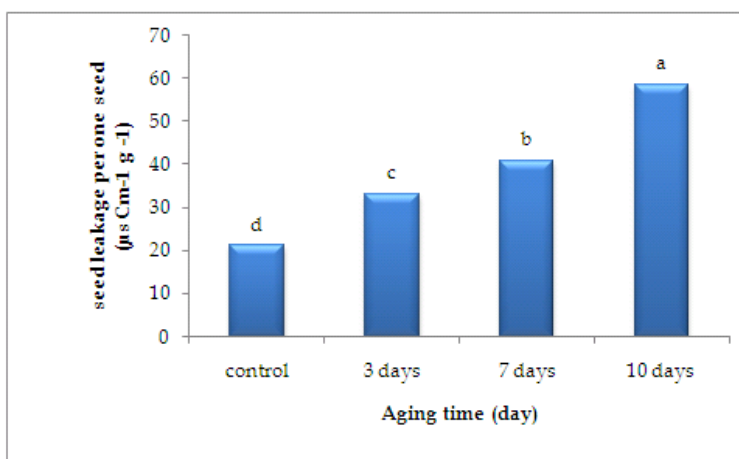
Table 2: Means comparison of seeds germination growth indexes and seed reserve utilization as affected by deterioration time in soybean seeds

S.O.V	GP (%)	SL (mm)	SLDW (mg)	SRUR	SRUE (mg)
Control	83 ^a	24.4 ^{ab}	0.92 ^a	4.47 ^a	0.63 ^a
3 days	58 ^b	26.8 ^a	14.9 ^b	3.91 ^b	0.64 ^a
7 days	27 ^c	21.8 ^b	15.9 ^b	3.1 ^c	0.5 ^a
10 days	7 ^d	16.1 ^c	5.7 ^c	2.25 ^d	0.33 ^b

Means in each column with the same letter are not different significantly.

Germination percent (GP), seedling length (SL), seedling dry weight (SLDW), seedling reserve utilization rate (SRUR), seedling reserve utilization efficiency (SRUE).

According to Table 1 seed aging had a significant effect on electrical conductivity of seed leakage. Also Figure 1 confirms that, after 10 days of seed aging EC obtains to the highest value and control treatment was the lowest one. Increasing aging time caused an increase in electrical conductivity. This evidence provided here indicates that aging treatments caused a marked increasing in the initial leakage of electrolytes.

**Fig. 1:** Increasing seed leakage per one seed by increasing aging time in soybean seeds.

Salinas *et al.* (2010) showed that naturally and/or artificially aged or mechanically damaged seeds have more conductivity than normal and healthy seeds. Also, Verma *et al.* (2001) stated that high quality seeds have low electrical conductivity and increase in electrical leakage can be the result of membrane permeability and seed senescence during aging. It is in agreement with our results.

Conclusions:

In conclusions, each of these aged-induced changes is consistent with the interpretation that there is deterioration in the membrane systems of the seed with aging, and the suggestion is offered that a basic mechanism of aging in soybean seeds is a deterioration of the membrane's ability to reform the function upon hydration (Parrish and Leopold., 1978).

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