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EFFECT OF STORAGE DURATION ON GERMINATION CHARACTERISTICS OF MUNG BEAN (VIGNA RADIATA L.) AND SOYBEAN (GLYCINE MAX L.) SEEDS

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Abstract. This study investigated the effects of storage duration on seed germination energy and germination percentage of mung bean (Vigna radiata L.) and soybean (Glycine max L.) varieties. Seeds of mung bean varieties Navro‘z, Durdona, Radost, Zilola, and Marjon, as well as soybean varieties To‘mariz MAN-60, Sellekta, Vilona, Sochilmas, and Ehtiyoj, were evaluated after one, two, and three years of storage. The results showed a gradual decline in seed viability with increasing storage duration. In mung bean, the average germination energy decreased from 74.6% in the first year to 64.4% in the third year, while germination percentage declined from 97.2% to 83.2%. Among the mung bean varieties, Radost and Zilola exhibited the highest storage tolerance. In soybean, a more pronounced reduction was observed, with germination energy decreasing from 76.0% to 51.6% and germination percentage from 97.2% to 68.0% over the three-year storage period. The varieties Sellekta and Vilona demonstrated superior storage performance compared to the other soybean varieties. The findings indicate that seed aging processes intensify with prolonged storage and that varietal differences play an important role in maintaining seed viability. Radost, Zilola, Sellekta, and Vilona may therefore be recommended as promising genotypes for long-term conservation in gene banks and for use in breeding programs.

Keywords: mung bean, soybean, seed storage, germination energy, germination percentage, seed viability, seed aging, gene bank, genetic resources, breeding.

Introduction. Mung bean (*Vigna radiata* L.) and soybean (*Glycine max* L.) are among the most important legume crops cultivated worldwide due to their high nutritional value, rich protein content, and significant role in human nutrition and sustainable agricultural production. These crops serve as valuable sources of plant protein, essential amino acids, vitamins, and minerals, making them important components of food security and agricultural diversification programs. Seed germination and seed vigor are among the most important indicators of seed quality and agricultural productivity. During storage, seeds undergo physiological and biochemical deterioration, resulting in reduced germination energy, germination percentage, and seedling

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vigor. The rate of seed deterioration depends on species, genotype, seed moisture content, storage temperature, and duration of storage.

According to Bewley et al. (2013), seed aging is associated with membrane degradation, protein denaturation, lipid peroxidation, and reduced enzyme activity. These changes negatively affect seed viability and seedling establishment. The authors reported that prolonged storage may reduce seed germination by 10–40%, depending on storage conditions and crop species.

Walters et al. (2005) demonstrated that seed longevity is strongly influenced by storage temperature and moisture content. Their study showed that seeds stored under low-temperature and low-moisture conditions retained more than 90% viability for several years, whereas seeds stored under ambient conditions exhibited a rapid decline in germination. Reactive oxygen species (ROS) accumulation was identified as one of the main causes of seed deterioration.

Rajjou and Debeaujon (2008) reported that the deterioration of stored seeds is closely related to oxidative damage and metabolic imbalance. Their findings indicated that germination percentage may decline by 15–30% after several years of storage, accompanied by reduced seedling growth and vigor. The authors emphasized the importance of antioxidant defense systems in maintaining seed viability.

Research conducted by Kandil et al. (2013) on soybean seeds revealed that storage duration significantly affects germination and seed vigor. After three years of storage, germination percentage decreased from 95–98% to approximately 70–75%, while seedling vigor was reduced by more than 25%. The study concluded that soybean seeds are relatively sensitive to long-term storage because of their high oil content.

In mung bean, Srinivasan et al. (2016) found that seed germination declined from 96% to 82% after three years of storage under conventional storage conditions. Germination energy and seedling growth were more sensitive indicators of seed aging than total germination percentage. The authors suggested that varietal differences play an important role in seed longevity.

Copeland and McDonald (2001) stated that seed vigor generally decreases earlier than germination percentage during storage. According to their observations, seed lots may maintain acceptable germination levels while exhibiting substantial reductions in germination energy and field emergence potential. Therefore, both parameters should be evaluated when assessing seed quality.

Finch-Savage and Bassel (2016) emphasized that seed longevity is a genetically controlled trait influenced by environmental conditions during seed development and storage. They reported that varieties with stronger antioxidant systems and more stable membrane structures generally

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maintain higher germination rates during long-term storage. Such genotypes are particularly valuable for gene bank conservation and breeding programs.

Overall, previous studies indicate that storage duration significantly affects seed viability, germination energy, and germination percentage in legumes. Mung bean and soybean seeds show progressive deterioration during storage; however, the rate of decline varies among genotypes. Identifying varieties with superior storage tolerance is therefore important for long-term conservation of genetic resources and sustainable crop improvement.

Materials and Methods. The study was conducted using five mung bean (*Vigna radiata* L.) varieties (Navro‘z, Durdona, Radost, Zilola, and Marjon) and five soybean (*Glycine max* L.) varieties and lines (To‘mariz MAN-60, Sellekta, Vilona, Sochilmas, and Ehtiyoj) selected from the germplasm collections. Seeds stored for one, two, and three years were used as research materials. The effects of storage duration on germination energy and germination percentage were evaluated under laboratory conditions.

Determination of Germination Energy and Germination Percentage

Determination of Germination Energy. Germination energy of the studied seed samples was determined according to the Dospekhov method by calculating the proportion of seeds that germinated within three days to the total number of seeds used in the experiment.

For example, if 50 seeds were used in the experiment and 32 seeds germinated within 3 days, germination energy was calculated as the ratio of germinated seeds to the total number of seeds multiplied by 100:

$$\mathbf{GE = (n/N) \times 100}$$

where:

GE – germination energy (%);

n – number of seeds germinated within 3 days;

N – total number of seeds used in the experiment.

Example:

$$\mathbf{GE = (32/50) \times 100 = 64\%}$$

Determination of Germination Percentage. Germination percentage was determined based on the number of seeds germinated within five days relative to the total number of seeds used in the experiment.

For example, if 50 seeds were tested and 49 seeds germinated within 5 days, germination percentage was calculated as follows:

$$\mathbf{GP = (n/N) \times 100}$$

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where:

GP – germination percentage (%);

n – number of seeds germinated within 5 days;

N – total number of seeds used in the experiment.

Example:

GP = (49/50) × 100 = 98%

Results and Discussion. The study investigated changes in germination energy and germination percentage of seeds of the mung bean (*Vigna radiata* L.) varieties Navro‘z, Durdona, Radost, Zilola, and Marjon, which are included in the State Register of the Republic of Uzbekistan, during a three-year storage period. The obtained results demonstrated that physiological and biochemical changes occurring during long-term storage gradually reduced seed viability.

According to the results, the average germination energy of seeds stored for one year was 74.6%, whereas by the second year this value had decreased to 70.6%. Thus, the average reduction in germination energy between the first and second years was 4.0%. By the third year, germination energy had declined to 64.4%, representing a decrease of 6.2% compared with the second year and 10.2% compared with the first year. These results indicate that the seed aging process proceeds relatively slowly during the first two years of storage, whereas physiological degradation becomes more pronounced by the third year. In particular, the greater decline in germination energy between the second and third years can be attributed to increased respiration intensity, depletion of stored nutrient reserves, and reduced activity of enzymatic systems in the seeds. A similar trend was observed for germination percentage. In the first year, the average germination percentage was 97.2%, which decreased to 85.2% in the second year. The reduction during this period amounted to 12.0%. By the third year, germination percentage reached 83.2%, representing only a 2.0% decrease compared with the second year. As a result, the total decline in germination percentage over the three-year storage period was 14.0%. This indicates that the ability of seeds to germinate rapidly and uniformly (germination energy) is more sensitive to storage duration than total germination percentage. In other words, seeds may retain their capacity to germinate for a certain period of time; however, the rate and vigor of germination decrease significantly.

Differences in germination energy and germination percentage of mung bean varieties during the storage period

Table 3.3

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Variety	1st Year GE	2st Year GE	Δ1-2	3rd Year GE	Δ2-3	Δ1-3	1st Year GP	2nd Year GP	Δ1-2	3nd Year GP	Δ2-3	Δ1-3
Navro‘z	75	69	-6	65	-4	-10	98	86	-12	84	-2	-14
Durdona	74	70	-4	62	-8	-12	97	85	-12	83	-2	-14
Radost	76	71	-5	67	-4	-9	98	86	-12	84	-2	-14
Zilola	73	74	+1	65	-9	-8	96	84	-12	82	-2	-14
Marjon	75	69	-6	63	-6	-12	97	85	-12	83	-2	-14
Average	**74,6**	**70,6**	**-4,0**	**64,4**	**-6,2**	**-10,2**	**97,2**	**85,2**	**-12,0**	**83,2**	**-2,0**	**-14,0**

When analyzed by variety, Radost was identified as one of the most storage-tolerant varieties. Its germination energy was 76% in the first year and remained at 67% by the end of the third year. The total reduction was only 9%, representing one of the lowest losses observed in the study. Furthermore, this variety maintained the highest germination energy among all tested varieties even after three years of storage. In the Navro‘z variety, germination energy decreased from 75% to 65%, resulting in a total reduction of 10% during the storage period. Germination percentage also declined from 98% to 84%. The results indicate that the seeds of this variety were able to maintain relatively high biological activity under long-term storage conditions. A unique pattern was observed in the Zilola variety. During the second year of storage, germination energy increased slightly from 73% to 74%. This may be associated with the continuation of physiological maturation processes during storage or with the initial moisture content and maturity level of the seeds. However, by the third year, germination energy had decreased to 65%. Nevertheless, the overall reduction was only 8%, indicating a relatively high level of storage tolerance in the Zilola variety. In the Durdona variety, germination energy decreased from 74% to 62%, resulting in a total reduction of 12%. In particular, the 8% decline observed between the second and third years indicates that seed aging processes intensified during this period. A similar trend was observed in the Marjon variety. Germination energy declined from 75% to 63% over the three-year storage period, corresponding to a total reduction of 12%. These results suggest that physiological aging processes occurred relatively rapidly in this variety as well.

The obtained results demonstrated that the decline in seed viability during long-term storage is first reflected in germination energy. As seeds age, cell membranes become damaged, antioxidant system activity decreases, and respiratory processes are impaired, resulting in reduced germination vigor. At the same time, total germination percentage remains relatively stable for a certain period.

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According to the research results, the varieties were ranked in the following order based on their storage tolerance:

Radost > Zilola > Navro‘z > Durdona > Marjon

These findings indicate that the Radost and Zilola varieties are promising genotypes for long-term conservation under gene bank conditions and for utilization in breeding programs. In contrast, seed viability declined relatively rapidly in the Durdona and Marjon varieties; therefore, periodic seed regeneration is recommended to maintain their viability and genetic integrity.

Effect of Storage Duration on Germination Characteristics of Soybean (*Glycine max* L.) The results of the study showed that germination energy and germination percentage decreased markedly in all soybean varieties as storage duration increased. The average germination energy was 76.0% in the first year, but declined to 64.6% in the second year, representing a reduction of 11.4%. By the third year, germination energy had further decreased to 51.6%, which was 13.0% lower than in the second year. Consequently, the overall reduction in germination energy over the three-year storage period reached 24.4%. A similar trend was observed for total germination percentage. The average germination percentage was 97.2% in the first year, but decreased to 84.0% in the second year, representing a reduction of 13.2%. By the end of the third year, germination percentage had declined further to 68.0%, which was 16.0% lower than in the second year. Consequently, the overall reduction in germination percentage over the three-year storage period reached 29.2%. These results indicate that physiological aging processes occurred much more rapidly in soybean seeds as storage duration increased. While the overall reduction in germination percentage was approximately 14% in mung bean varieties, it reached 29.2% in soybean varieties. Therefore, these genotypes can be considered more sensitive to long-term storage than mung bean varieties.

Soya (*Glycine max L.*) unuvchanlik ko‘rsatkichlariga saqlash muddatlarining ta’siri

3.4-jadval

Variety	1st Year GE	2st Year GE	Δ1-2	3rd Year GE	Δ2-3	Δ1-3	1st Year GP	2nd Year GP	Δ1-2	3nd Year GP	Δ2-3	Δ1-3
To‘mariz MAN-60	79	65	-14	52	-13	-27	98	84	-14	67	-17	-31
Sellekta	78	69	-9	57	-12	-21	97	88	-9	71	-17	-26

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Vilona	74	62	-12	53	-9	-21	98	81	-17	69	-12	-29
Sochilmas	72	64	-8	47	-17	-25	96	83	-13	66	-17	-30
Ehtiyoj	77	63	-14	49	-14	-28	97	84	-13	67	-17	-30
Average	76,0	64,6	-11,4	51,6	-13,0	-24,4	97,2	84,0	-13,2	68,0	-16,0	-29,2

The greatest decline was observed in the To‘mariz MAN-60 variety. Germination energy decreased from 79% to 52%, resulting in a total loss of 27%. Likewise, germination percentage declined from 98% to 67%, corresponding to a reduction of 31%. The Sellekta variety proved to be one of the most storage-tolerant varieties. Germination energy decreased by 21% over the three-year storage period, while germination percentage declined by 26%. At the end of the third year, the highest germination percentage (71%) was recorded in this variety. In the Vilona variety, germination energy decreased by 21%, while germination percentage declined by 29%. However, the highest root length (7.6 cm) was recorded in this variety at the end of the third year. In the Sochilmas variety, the greatest decline in germination energy was observed between the second and third years of storage (-17%). As a result, germination energy decreased to 47% by the end of the third year.

In the Ehtiyoj variety, germination energy decreased by 28%, while germination percentage declined by 30% over the three-year storage period. These results indicate that this variety possesses relatively low tolerance to long-term seed storage.

Based on storage tolerance, the soybean varieties were ranked in the following order:

Sellekta > Vilona > To‘mariz MAN-60 > Sochilmas > Ehtiyoj

The best performance over the three-year storage period was observed in the Sellekta and Vilona varieties. These varieties may be recommended as promising genetic materials for long-term conservation in gene banks and for use in breeding programs. In contrast, physiological seed aging occurred more rapidly in the To‘mariz MAN-60, Sochilmas, and particularly the Ehtiyoj varieties. Therefore, regular seed regeneration is recommended to maintain their viability and genetic stability.

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