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RESPIRATION INTENSITY OF BEAN SEEDS STORED UNDER VARIOUS CONDITIONS

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Abstract: This article highlights the respiration intensity of common bean (Phaseolus vulgaris L.) seeds stored under various conditions and the effect of storage conditions on the physiological and biochemical processes occurring in seeds. The main objective of the research is to evaluate the changes in the respiration intensity of bean seeds under different storage conditions and to analyze the physiological state of seeds in relation to storage conditions.
Keywords: Common bean, Phaseolus vulgaris L., seed, respiration intensity, storage conditions, temperature, moisture, metabolism, physiological processes, seed viability.

Annotatsiya: Ushbu maqolada turli sharoitlarda saqlangan oddiy loviya (*Phaseolus vulgaris L.*) urug‘larining nafas olish intensivligi va saqlash sharoitlarining urug‘larda kechadigan fiziologik-biokimyoviy jarayonlarga ta’siri yoritiladi. Urug‘larning nafas olishi ularning hayotchanligi, unuvchanligi va saqlanish davridagi fiziologik holatini tavsiflovchi muhim ko‘rsatkichlardan biridir. Saqlash jarayonida harorat, namlik va saqlash muddati kabi omillar urug‘larda moddalar almashinuvi jadalligiga ta’sir ko‘rsatishi mumkin. Mazkur omillarni o‘rganish loviya urug‘larini uzoq muddat davomida sifatini saqlagan holda saqlash usullarini takomillashtirishga xizmat qiladi.
Kalit so‘zlar: Oddiy loviya, *Phaseolus vulgaris L.*, urug‘, nafas olish intensivligi, saqlash sharoiti, harorat, namlik, moddalar almashinuvi, fiziologik jarayonlar, urug‘ hayotchanligi.

Аннотация: В данной статье освещается интенсивность дыхания семян фасоли обыкновенной (Phaseolus vulgaris L.), хранящихся в различных условиях, и влияние условий хранения на физиолого-биохимические процессы, происходящие в семенах. Основной целью исследования является оценка изменений интенсивности дыхания семян фасоли при различных условиях хранения и анализ физиологического состояния семян в связи с условиями хранения.
Ключевые слова: Фасоль обыкновенная, Phaseolus vulgaris L., семена, интенсивность дыхания, условия хранения, температура, влажность, обмен веществ, физиологические процессы, жизнеспособность семян.

Introduction

The respiration intensity of seeds is a key physiological indicator that characterizes their physiological state, metabolic rate, and level of vital activity. During respiration, the oxidation of carbohydrates, lipids, and other reserve substances generates energy (ATP), which sustains the minimal metabolic processes essential for life within the seed tissues. However, high respiration intensity during storage leads to the rapid depletion of nutrient reserves, an increase in the production of reactive oxygen species (ROS), and an acceleration of the physiological aging process. Consequently, assessing respiration intensity serves as an important physiological criterion for determining the storability and quality of seeds.

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Research results indicate that respiration intensity is influenced by a combination of factors: seed moisture content, storage temperature, and storage duration. While a sharp increase in respiration intensity was observed at the beginning of the storage period—correlating with higher seed moisture and temperature—a gradual decline was noted across all experimental variants in the subsequent months. This trend is attributed to the aging of physiologically active tissues, a reduction in mitochondrial activity, and a slowdown in energy metabolism during the storage period. Under the optimal storage conditions—8% seed moisture content and a temperature of +5 °C—the respiration intensity was 19.9 µmol CO_2/g dry mass/hour during the first month, decreasing to 11.9 µmol CO_2/g dry mass/hour after 13 months. This represents a 40.2% reduction compared to the initial value. Due to the restricted activity of respiratory enzymes at low temperatures, reserve substances were consumed more slowly, and the physiological condition of the seeds was relatively well preserved.

When the temperature was increased to +15 °C (at the same moisture level), the respiration intensity was 25.2 µmol CO_2/g dry mass/hour in the first month, falling to 13.1 µmol CO_2/g dry mass/hour after 13 months. At +25 °C, this figure decreased from 30.5 to 15.0 µmol CO_2/g dry mass/hour. Thus, while higher temperatures intensified metabolism during the initial stage of storage, the respiratory system declined more rapidly over the course of long-term storage. An increase in seed moisture content further intensified respiration. For instance, at +25 °C during the first month, the respiration rate was 30.5 µmol CO_2/g dry mass/hour at 8% moisture, 35.5 at 10% moisture, 40.6 at 12% moisture, and 45.2 at 14% moisture. These values are linked to the fact that as seed moisture increases, the amount of free water within the cells rises, hydrolytic enzymes become activated, and metabolic processes accelerate.

Methods

Seeds of the common bean (Phaseolus vulgaris L.) were used as the research subject. The seeds were stored under laboratory conditions at varying moisture levels (8%, 10%, 12%, and 14%) and temperatures (+5 °C, +15 °C, and +25 °C) for a period of 13 months [4]. Throughout the storage period (at 1, 4, 7, 10, and 13 months), the respiration intensity of the seeds was determined using standard methodologies accepted in seed science [2, 3], with the amount of carbon dioxide released calculated in units of µmol CO_2/g dry mass/hour. Furthermore, to assess the impact of the respiration process on seed aging, the content of malondialdehyde (MDA) and the activity of the antioxidant enzymes catalase and peroxidase were analyzed in parallel [1, 6]. The obtained numerical data were subjected to statistical analysis to determine mean values and standard errors.

Results

The research findings indicated that seed moisture content, storage temperature, and storage duration collectively influenced respiration intensity [4, 5]. While a sharp increase in respiration intensity was observed at the beginning of the storage period as seed moisture content and temperature rose, a gradual decline was recorded across all experimental variants in the subsequent months (Table 1).

Table 1. Respiration intensity of bean seeds stored under various conditions (µmol CO_2/g dry mass/hour)

№	Seed moisture, %	Temperature, °C	Shelf life, months				
			1	4	7	10	13
1	8	+5	19,9±2,19	18,0±1,98	16,0±1,56	13,9±1,59	11,9±1,08
2		+15	25,2±2,21	22,2±1,89	19,2±1,73	16,0±1,53	13,1±1,45
3		+25	30,5±2,86	26,2±2,20	22,3±2,14	18,2±1,82	15,0±1,63
4	10	+5	25,3±2,43	22,4±2,30	19,0±1,97	16,1±1,64	14,1±1,38
5		+15	30,4±2,74	26,3±2,36	22,5±2,27	18,3±1,96	15,1±1,60
6		+25	35,5±3,09	30,0±3,04	25,3±2,46	20,3±1,94	17,2±1,79

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7	12	+5	30,6±2,95	26,3±2,35	21,9±2,06	18,4±1,72	16,1±1,78
8		+15	35,4±2,83	30,0±2,87	25,3±2,38	20,5±2,05	17,0±1,70
9		+25	40,6±3,66	34,4±3,15	28,2±2,64	23,2±2,15	20,5±2,03
10	14	+5	35,3±3,22	30,3±286	26,0±1,26	21,4±2,22	18,2±1,72
11		+15	40,3±3,80	34,1±3,46	28,2±2,66	23,5±2,13	20,3±2,06
12		+25	45,2±4,36	38,2±3,58	32,0±2,92	27,3±2,49	23,4±2,19

In the variant with 14% moisture content and a temperature of +25 °C—where the highest respiration intensity was recorded during the storage period—this indicator decreased from 45.2 to 23.4 µmol CO_2/g dry mass/hour, representing a relative reduction of 48.2%. Nevertheless, even after 13 months, the respiration intensity in this variant remained higher than in the others. This indicates that metabolism remained active for an extended period under high-moisture conditions, though this process occurred at the cost of a rapid depletion of energy reserves.

A slower rate of respiration under low-temperature conditions is considered physiologically optimal for seeds. For instance, in the variant with 14% moisture content and a temperature of +5 °C, respiration intensity decreased from 35.3 to 18.2 µmol CO_2/g dry mass/hour. This demonstrates a more economical consumption of energy resources compared to conditions at higher temperatures. The results obtained regarding respiration intensity were found to be closely correlated with the previously analyzed levels of malondialdehyde (MDA) and the activities of catalase and peroxidase. Under storage conditions characterized by high temperature and high humidity, respiration intensity reached its peak; simultaneously, MDA levels also reached their highest values, while the activities of catalase and peroxidase declined sharply. This indicates that the accelerated respiration process leads to an increased production of reactive oxygen species (ROS) within the mitochondria—which the antioxidant enzyme system fails to fully neutralize—thereby intensifying lipid peroxidation.

From a physiological perspective, this process can be explained as follows: as seed moisture content increases, the degree of cytoplasmic hydration rises, activating the enzymes of the respiratory chain. A rise in temperature further accelerates enzymatic reactions, intensifying electron transport within the mitochondria. Along with ATP synthesis, this also enhances the production of reactive oxygen species, such as superoxide anions and hydrogen peroxide. If the antioxidant system (comprising catalase, peroxidase, and other enzymes) is unable to completely neutralize these free radicals, lipid peroxidation within cell membranes intensifies, the selective permeability of the membranes is compromised, and the physiological aging process is accelerated. At the same time, a decrease in respiration intensity during prolonged storage is not always a positive development. This condition often arises from a decline in the functional activity of mitochondria, the inactivation of respiratory enzymes, and the disruption of energy metabolism. Consequently, a sharp drop in respiration intensity during long-term storage serves as a significant indicator of the physiological aging of seeds and a reduction in their viability.

Overall, research findings indicate that the primary factors influencing respiration intensity during the storage of bean seeds are seed moisture content, temperature, and the duration of storage. A seed moisture content of 8–10% combined with a temperature of +5°C maintains the respiration process at a physiologically optimal level; this ensures the economical consumption of reserve substances and allows for the long-term preservation of seed viability. Conversely, under conditions of 12–14% moisture and a temperature of +25°C, high respiration intensity leads to the rapid depletion of energy resources, increased oxidative stress, reduced activity of antioxidant enzymes, and accelerated lipid peroxidation—all of which hasten the physiological aging of the seeds.

Thus, when the results obtained for respiration intensity are evaluated in conjunction with indicators for catalase, peroxidase, and MDA (malondialdehyde), they provide a comprehensive characterization of the mechanisms—such as oxidative stress, energy metabolism, and physiological aging—that occur during the storage of bean seeds. Furthermore, these findings serve as an important scientific basis for improving seed storage technology.

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Conclusion

The results of the study indicate that the respiration intensity of common bean (Phaseolus vulgaris L.) seeds stored under various conditions depends on seed moisture content, storage temperature, and the duration of storage.

An increase in respiration intensity was observed as seed moisture content rose from 8% to 14% and storage temperature increased from +5 °C to +25 °C. Specifically, under conditions of 14% seed moisture and a temperature of +25 °C, respiration intensity reached its peak during the first month of storage, measuring 45.2 ± 4.36 µmol CO_2/g dry mass/hour. In contrast, for seeds with 8% moisture stored at +5 °C, this value was 19.9 ± 2.19 µmol CO_2/g dry mass/hour.

As the storage period extended from 1 month to 13 months, respiration intensity decreased across all experimental variants. For instance, in the variant with 14% moisture content and a temperature of +25 °C, this value decreased from 45.2 to 23.4 µmol CO_2/g dry mass/hour, while in the variant with 8% moisture content and a temperature of +5 °C, it dropped from 19.9 to 11.9 µmol CO_2/g dry mass/hour.

Overall, the results obtained demonstrate the importance of controlling moisture and temperature conditions when storing bean seeds. Storage at lower moisture levels and temperatures can help limit the respiration rate of the seeds. However, to fully evaluate the quality of seeds during long-term storage, it is necessary to assess indicators of germination capacity and viability, in addition to respiration intensity.

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