# *Seed Production*

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## INFLUENCE OF ABIOTIC FACTORS ON SEED QUALITY OF MAIZE HYBRIDS IN PROCESS ITS STORAGE

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*The research results of influence of various abiotic factors on seed quality of maize hybrids during long storage were presented. The most effective of various abiotic are: temperature regime, seed moisture content and oxygen access. The storage methods (dry and cold, and controlled atmosphere storage) that have the greatest impact on the seed quality were established.*

*It was found that the optimal moisture content of seed depends on the storage duration, if for 1–2 years – 10–11 %, 3 years and more – 7–8 %. In order to stabilize the moisture content, it is recommended to store the seeds in airtight containers limiting the humidity access from the outside. During the long-term seed storage, particularly for the breeding purposes, the temperature range should advisably maintain within 8–10 °C in seed storage place. Thus, the laboratory germination of seeds increased by 3–5 %, field germination – by 6–8 %, growth rate by number of sprouts – by 5–9 % and by the weight of sprouts – by 2–5 g compared to the 18–20 °C temperature in a typical storage.*

*Methods of pre-sowing improvement of seed quality were established – it is separation and chemical treatment (seed dressing). Separation is the sifting of the seed mass through sieves with round holes in order to divide from the smallest fraction, the content of which was 15–23 % depending on the seed uniformity of maize hybrids.*

*It was found that in order to assess objectively the effectiveness of different chemicals and establish their suitability for presowing seed treatment, it is necessary to determine laboratory germination, especially the growth rate by the number of sprouts and weight of 100 sprouts. Premature chemical treatment of seed should be avoided.*

***Key words*:** *maize hybrids, storage methods, abiotic factors, seed quality, pre-sowing treatment.*

Sowing conditioned seeds is a guarantee of high yields of crops. The conditional qualities of maize seeds are provided by the DSTU 2240–93 "Seeds of agricultural crops. Varietal and sowing qualities. Specifications" [1].

It is known that the seeds before sowing are stored for some time in the seed storages and are affected by various factors. But the uncontrolled action of these factors often leads to deterioration in the seed quality. Therefore, one of the important tasks of seed production is to preserve the yield seed qualities, in particular by prolongation of longevity of seeds, because insurance, reserve and selection funds are in granaries for more than one year.

Deterioration of seed quality during storage is an objective reality and an inevitable consequence, because the seed is a living organism, which is characterized by aging. This process is associated with biochemical and physiological changes that cause a weakening of seed viability. The following processes occur such as: protein denaturation, consumption of carbohydrates, reduction of vitamins and auxins, accumulation of toxic substances. The physiological trait of aging is an increased level of respiration,

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the unusual odors in the seed mass (alcohol, stale, and sour smell). However, during storing seed funds some methods can be used that inhibit the aging process to maintain seed quality. There are optimization of the environment due to temperature, humidity and gas composition of air, light, solar radiation, using chemicals to limit and inhibit the development of harmful microorganisms, insects etc.

Many researches of influence of biotic and abiotic factors on quality of seeds of various crops during its storage and preparation for sowing are devoted [2–9]. Maize seeds differ widely by quality, and have a lower durability compared to the seeds of other crops. This must be taken into account in the storage technologies in order to obtain high quality seed [10–11].

***Aim***. To identify the influence of abiotic factors on the maize hybrid seeds during storage, and to establish the storage methods for keeping of its high sowing and yielding qualities.

***Materials and Methods.*** During 2016–2019, the experiments were carried out in the Laboratory of Grain Standardization and Storage Methods of the State Enterprise Institute of Grain Crops NAAS. The object of research is the seeds of maize hybrids selected by the State Enterprise Institute of Grain Crops of NAAS. Seeds were stored at 7–14 % moisture and 3–5 to 20 °C temperature depending on the variant of the experiment. The quality of seed was determined in laboratory and field experiments. Field experiments were established in the State Enterprise Experimental Farm "Dnipro" (Dnipropetrovsk region). The moisture, germination and seed growth rate were established in the laboratory according to current methods developed in the SE Institute of Grain Crops of NAAS [12–13]. In the field, the germination and yield qualities of seeds were studied. The obtained data were processed by statistical and mathematical method to establish their reliability [14–15].

***Results.*** Based on the literature overview and result of our previous studies, the abiotic factors (temperature, grain moisture, access of oxygen) and storage methods (dry and cold, controlled atmosphere storage) which have the greatest impact on seed quality was defined. *Dry storage* is based on the xeroanabiosis, when physiological processes in the grain mass, especially the process of respiration, are stopped or significantly slowed down. For safe storage of maize seeds, the moisture should fluctuate within 12–14 %.

*Cold storage* is based on the thermoanabiosis, i.e. weakening of vital processes of temperature-sensitive components of grain mass such as microorganisms, insects and mites. It is established that the insect activity decreases at an air temperature of 15 °C, at 10 °C – most of them fall into a state of rest, at 5 °C – mold development slows down, 0 °C – most species of insects die.

The basis of *storage in airtight conditions* is the anoxyanabiosis, i.e. the creation of a gaseous atmosphere with low oxygen content and high carbon dioxide content. Such conditions can be achieved by natural and artificial means. The change in gas composition occurs by natural means due to aerobic and anaerobic respiration, as a result, gaseous atmosphere with 3–5 % oxygen content is created; and by artificial means, due to forced filling storage with carbon dioxide or other inert gas (oxygen content does not exceed 1–3 %).

In production practice, different methods can be combined with each other. For example, dry seeds should be chilled, and stored in airtight containers, which significantly increases the seed persistence and extends viability.
Therefore, it should be noted that moisture and temperature are the most important abiotic factors that affect the seed quality of maize hybrids during storage. During our experiment, we found the effect of moisture in the range of 7–8, 10–11 and 13–14 % and temperature of 18–20 and 8–10 °C on the seed germination and growth rate.

The air temperature of a typical grainery was on average 8–20 °C, and in a climate chamber was 8–10 °C. The seeds of Orzhytsia 237 MV, Chemerovetskyi 260 SV, Solonianskyi 298 SV, Zbruch maize hybrids were used in the experiment.

It was found that laboratory germination at seed moisture of 7–8 and 11–12 % increased by 1–7 % and field germination – by 2–9 % than at 13–14 % seed moisture. The difference between these indicators increased depending on the storage duration (Table 1). The growth rate was estimated on the basis of two indicators - the number of sprouts and the weight of 100 sprouts. When storing seeds at low moisture, the

number of sprouts increased by 3–12 %, the weight of 100 sprouts – by 1.9–6.4 g or by 6.3–11.8 %, than at moisture of 13–14 %. Considering the indicators of germination and growth rate at the beginning of storage, no significant difference was found between variants in which the moisture was 7–8 and 10–11 %. The tendency to increase the field germination and seed growth rate in the variant at 7–8 % moisture was established only at the end of the third year of storage.

Naturally, the question arises how to achieve seed moisture at the level of 10–11 % or 7–8 % in order to store seeds for a long time

***1. Influence of moisture to seed sprouting of maize hybrid depending on storage duration***

| Seed moisture, % | Storage duration, years | Indicators of seed sprouting | | | |
|---|---|---|---|---|---|
| | | germination, % | | growth rate | |
| | | laboratory | field | number of sprouts, % | weight of 100 sprouts, г |
| 13–14 | 1 | 96 | 81 | 88 | 28.5 |
| | 2 | 95 | 77 | 85 | 23.1 |
| | 3 | 90 | 71 | 78 | 23.0 |
| 10–11 | 1 | 97 | 83 | 91 | 30.4 |
| | 2 | 97 | 81 | 90 | 29.0 |
| | 3 | 94 | 79 | 88 | 27.8 |
| 7–8 | 1 | 97 | 84 | 92 | 31.5 |
| | 2 | 98 | 82 | 92 | 30.0 |
| | 3 | 97 | 80 | 90 | 29.4 |

under such conditions. For this purpose it is necessary to create airtight conditions when moisture exchange between seeds and environment practically stops. This method is recommended in modern technologies for storing seed stocks, it has a double effect. Firstly, the seed moisture is stabilized by suspending the processes of sorption – desorption, and secondly, the development of harmful objects (diseases and pests) is inhibited in airtight conditions. Thus, in our experiments, the seeds were stored at moisture of 10–11 % and 7–8 % in airtight containers for 3–5 years without deterioration of quality [16].

The peculiarities of the influence of the 8–10 °C temperature, which was maintained during the storage period of seeds in the climate chamber, were also clarified. It was found that the seed quality improved on average in all variants of the experiment under such conditions: laboratory germination increased by 3.4 %, field germination – by 6.5 %, the growth rate by the number of sprouts – by 5.7 % and the weight of sprouts – by 2.8 g compared to the temperature in the seed storage.

In addition, the seed size can significantly affect to the seed quality. Classical experiments report that seeds of different sizes have different storage stability. For example, small seeds have high respiration intensity, and consume more reserve materials, so they are less stable. The effect of seed size may be more noticeable for maize. The maize seeds differ largely in this indicator due to the growing conditions, maturation dates and features of post-harvest handling. We conducted a study on the seed quality of maize hybrids for different sizes under storage for 4–5 years. Such seeds were obtained by separation and grading by sifting into 4 fractions - sifting with 9, 8, 7, 6 mm sieve size with round holes. This method is usually used in the calibration and preparation for sowing of maize hybrid seeds.

There is a significant relationship between seed quality and size (Table 2). For example, when sowing seeds of the first and second fractions, the indicators of germination and yield qualities were higher compared to the third and fourth, but the difference between them was insignificant. Small seeds of the fourth fraction were the least stable during storage, their field germination decreased by 10–15 %, and grain yield – by 1.27–1.39 t/ha (Chemerovetsky 260 SV hybrid) and by 1.05– 1.10 t/ha (Zbruch hybrid) compared to the first two fractions. At the same time varietal features play a certain role. Regarding the Zbruch hybrid seeds of the third fraction, there was an insignificant decrease in germination and yield qualities compared to the first and second fractions.

***2. Germination and yield of maize hybrid seeds depending on fractional composition and storage duration***

| Hybrid | Years | | Fraction | Germination, % | | Grain yield, t/ha |
|---|---|---|---|---|---|---|
| | yield | test | | laboratory | field | |
| Chemerovetskyi 260 SV | 2015 | 2019 | I | 92 | 83 | 8.57 |
| | | | II | 92 | 85 | 8.69 |
| | | | III | 91 | 80 | 7.95 |
| | | | IV | 92 | 70 | 7.30 |
| $LSD_{05}$, t/ha | | | | | | 0.32 |
| Zbruch | 2015 | 2020 | I | 91 | 75 | 8.30 |
| | | | II | 91 | 73 | 8.25 |
| | | | III | 90 | 72 | 7.90 |
| | | | IV | 81 | 63 | 7.20 |
| $LSD_{05}$, t/ha | | | | | | 0.40 |

It is important in the storage technology to find ways to improve seed quality, especially if its shelf life is extended. For this purpose, pre-sowing separation of individual seed fractions was carried out, which significantly reduced the seed quality during long-term storage (Table 3).

***3. Influence of pre-sowing separation to seed quality of Orzhytsia 237 MV hybrid (storage years of 2014–2019)***

| Fraction | Seed separation | Seed germination, % | | Grain yield, t/ha |
|---|---|---|---|---|
| | | laboratory | field | |
| III | Control (without separation) | 73 | 63 | 6.02 |
| | Pre-sowing | 75 | 68 | 6.61 |
| IV | Control (without separation) | 70 | 54 | 5.38 |
| | Pre-sowing | 71 | 61 | 5.90 |
| $LSD_{05}$, t/ha | | | | 0.39 |

The smallest seeds, the content of which in each fraction was 15.6–23.1 %, were removed by separation. It was determined that the field germination of seeds increased by 5–7 %, and grain yield – by 0.52–0.68 t/ha due to this method.

A chemical seed treatment also to some extent affects the quality of seeds. It is proved that the field germination and grain yield increase due to the seed treatment, especially under unfavorable conditions of the "sowing - sprouts emergence" period, but opinions differ on the terms of chemical treatment.

In our work we investigated the following terms of seed treatment: during post-harvest processing – before seed placement in storage, and pre-sowing treatment – immediately before sowing (Table 4).

***4. Quality of maize hybrid seeds depending on term of chemical treatment and storage duration (2016–2019)***

| Term of seed treatment | Storage duration, years | Germination, % | | Grain yield, t/ha |
|---|---|---|---|---|
| | | laboratory | field | |
| Control (no treatment) | 1 | 98 | 77 | 5.40 |
| | 2 | 97 | 73 | 4.95 |
| | 3 | 96 | 60 | 4.54 |
| During post-harvest processing | 1 | 97 | 81 | 5.96 |
| | 2 | 94 | 80 | 5.79 |
| | 3 | 90 | 72 | 4.90 |
| Pre-sowing treatment | 1 | 98 | 87 | 6.27 |
| | 2 | 97 | 84 | 6.03 |
| | 3 | 95 | 80 | 5.80 |
| $LSD_{0,5}$, t/ha | | | | 0.20 |

The maize hybrid seeds were treated with Vitavax 200 FF (2.5 l/t). Pre-sowing treatment compared to treatment during post-harvest processing was the most effective, given that the field germination of seeds increased by 4–8 %, and the grain yield by 0.24–0.95 t/ha. The addition of various stimulants to the seed dresser had a positive effect, and also made it possible to reduce the dresser dose by 20 %.

The laboratory germination of seeds depending on the storage duration decreased at the seed treatment during post-harvest processing. At the end of the first year of storage, a decrease in seed germination was observed by 1 %, the second – by 3 %, the third – by 6 % compared to control. According to the last indicator of germination rate, the seeds became unconditional. Therefore, the long-term storage of seed in the treated state (more than one year) is undesirable. This must be taken into account in the seed production of maize and the formation of seed stock.

***5. Germination ma growth rate of maize hybrid seeds depending on pre-sowing treatment with various chemicals***

| Dressers | Germination (standard-method), % | Growth rate | | |
|---|---|---|---|---|
| | | Number of sprouts, % | Sprouts weight, g | |
| | | | wet | dry |
| Control (no treatment) | 100 | 82 | 28.44 | 2.20 |
| Royal Flo (2.5 l/t) | 98 | 92 | 33.76 | 2.69 |
| Vitavax 200 FF (2.5 l/t) | 99 | 95 | 32.46 | 2.64 |
| Maxim XL (1.0 l/t) | 100 | 98 | 35.50 | 3.01 |
| Insure Perform (0.5 l/t) | 100 | 80 | 27.86 | 2.18 |
| Alias (1.0 l/t) | 99 | 71 | 25.60 | 2.03 |
| Vincit Minima (2.0 l/t) | 98 | 72 | 25.16 | 2.25 |
| Feuver (0.7 l/t) | 98 | 73 | 24.18 | 1.93 |

The influence of chemicals for pre-sowing treatment of maize hybrid seeds was also investigated. Royal Flo (2.5 l/t), Vitavax 200 FF (2.5 l/t), Maxim XL (1.0 l/t) were the most effective. The seed growth rate (the number of sprouts and the weight of 100 sprouts) increased due to their use (Table 5The number of sprouts increased by 10–16 %, the weight of fresh sprouts – by 4.02–7.06 g, and dry – by 0.44–0.81 g compared with the control. It should be noted that the studied chemicals had almost no effect on the laboratory germination of seeds. Thus, this indicator should not be recognized in the analysis of seed quality and assessment of chemicals.

***Conclusions***

It was found that the most influential abiotic factors on the seed quality under long-term storage are temperature, seed moisture and oxygen access. For that reason, the seed can be stored in a dry and chilled state and in airtight conditions.

The optimal level of moisture depends on the duration of seed storage: for 1–2 years – 10–11 %, 3 years and more – 7–8 %. For stabilization the moisture, it is recommended to store the seeds in an airtight container and limit the access of moisture from the outside. In the case of long-term storage of seed, the temperature should be maintained in the seed storage within 8–10 °C.

Should be to avoid beforehand chemical treatment of seed (seed dressing) at long-time storage of seeds. In order to objectively assess the effectiveness of various chemicals and establish their suitability for pre-sowing seed treatment, it is necessary to determine the laboratory germination, especially the growth rate (the number of sprouts and the weight of 100 sprouts).

A pre-sowing separation is a method which improves the seed quality at the prolongation of the storage term. This is the sifting of grain mixtures through sieves, mainly with round holes, the separation of the smallest fraction, the content of which is 15–23% depending on the uniformity of the seeds.

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