SUMMARY OF THE PhD THESIS

The influence of genotype, duration and storage conditions on the quality of maize seeds

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Necessity and objects of the researches

Since the beginning of agriculture, man has been preoccupied for the increases of the obtained productions and for keeping the products as grain for food and breeding. Progresses obtained in improvement begin once with Mendel alleles. After this date the plants of different species began to be crossed, followed the inbred and hybridization force first used on maize.

It was thought immediately that human living conditions are ensured to all inhabitants of the Earth, by constantly increasing production. Civilization in its modern evolution was surprised to find the continuous growth of the consumption of food, that excessive industrialization resulted in logarithmic depletion of resources left to earthlings by "mother nature" towards a wise use, and that harvests vary every year under the influence of climate change, recording drastic declines under the influence of abiotic stress factors.

Solving the world food problem, for an increasingly growing mankind and tired of the food stress depends decisively on increasing the quality and quantity of agricultural production.

Measures to reduce the impact of climate change respectively those to improve agricultural technologies to ensure clean air and food, premises of the continuity of life on earth, begins with the use of a seed of high biological and cultural value, resistant to biotic and abiotic stress factors. Maximum seed quality is achieved in a complex of conditions in which identifies a number of factors, recalling in particular those relating to environmental and genetic peculiarities of storage.

By knowing, the control of the basic parameters which influence the quality of the seed during storage as: temperature and relative humidity in the storage environment, the moisture content of the seeds subjected to storage, the quality of the seed (initial) during storage and destructive attack of microorganisms and insects, can be increased the longevity seed lot, its useful life, the inevitable closure of the circle is postponed: reproduction-aging-death of seeds, all with consequences under the economic aspect and agricultural production safety.

The theme „The influence of genotype, duration and storage conditions on the quality of maize seeds“, chosen as subject, is topical in the context in which in the recent years, the work of seed multiplication of maize in the EU is increasing from year to year, due to increased demand for seed, but the annual loss due to damage for various reasons are more than 25%. One of the main reasons for the yearly losses of seed is insufficient knowledge of the influence of storage environmental factors, on the chemical, physical, biochemical and physiological changes happening at the metabolic and structural seed levels.
Another reason, are the current climate modifications, bringing with them changes in the physiological activity of seed, as a result of increasing entropy with influences not only in the production stage in the field, but also during storage time.

In this context a first objective of the research was to study the aging of the "orthodox" seeds belonging to five hybrids created at SCDA Turda and seeds belonging to four inbred lines, stored in open space (hybrids that have different group FAO, but also the shape and size of seeds) All at once by an imposed experimental condition, in a "controlled environment" with specific parameters whose values impose a predictable negative evolution of the quality of seeds with duration of storage is testing the natural resistance of the seed of studied hybrids, namely their ability to form normal bacteria under such conditions.

Starting from fact that the most used and widely applied method of keeping for all seeds used as biological material in the world and the country is keeping dry and in open storages were, a series of specific objectives were imposed: highlighting and quantifying the action of factors, genotype, duration and conditions of storage (treatment) on the quality of the seed described by: indicators specific to viability and vigor, identifying optimum conditions during storage that would preserve the original qualities, of the genotypes studied, identifying genotypes created by SCDA Turda, showing the best stability regarding the keeping quality of seed, making available rapid methods for assessing the physiological manifestations of seeds belonging to lots, that correlate best with their performance in the field, so providing true and accurate information about the quality of each. Developing a complex equations viability for each lot, which makes possible to estimate germination at any time helping with the beneficiary to decide when, how and what conditions to use.

**Structure of the study**

The study named „The influence of genotype, duration and storage conditions on the quality of maize seeds”, is drawn-up and structures according to the effective regulations.

The first part contains two chapters and summarizes the current state of researches and knowledge of aspects concerning the storage of agricultural products for sowing, the storage environment factors (moisture content of the beans undergo storage, temperature and humidity relative to air, biotic factors, parameters of viability and vigor before storage), with influences on seed quality due to chemical, biochemical and physiological modification happening at the metabolic and structural level of the seed during storage.

The second part of the study contains the results obtained during the course experiments performed during 2012-2015, at the Agricultural Research and Development Station in Turda and Cluj Territorial Inspectorate for Seed Quality and Seedlings. It is structured in five chapters containing the scope and objectives of
researches, research methods, results and discussions regarding the viability and 
vigour of studied hybrids seeds as well as the conclusions resulted following the 
ending of researches.

**Factors and experimental design**

* **Factor A- storage conditions** hereinafter referred to as **treatment** with the 
  following graduations:
  * A₁-open room is which untreated seed is stored
  * A₂-controlled environment room is which untreated seed is stored
  * A₃-room (open space) with seed treated with fungicide Maxim XL 0,35 FS
  * A₄-room (open space) with seed treated with fungicide Maxim XL 0,35 FS + insecticide Seedoprid 600 FS.

* **Factor B – studied maize hybrids** – hybrids seed come from the homogeneous 
  maize lots under the aspect of physical (form, grain size) qualities, with initial 
  humidity of aprox. 12% and a good health status.
  * B₁-Turda 200
  * B₂-Turda 165
  * B₃-Turda 201
  * B₄-Turda Star
  * B₅-Turda Favorit
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- **Factor C – storage duration** with graduations:
  - C₁ - before sowing-2013” is the initial moment of researches
  - C₂ - after 12 months,
  - C₃ - after 24 months,
  - C₄ - after 36 months.

Repetitions: 4 (four) according to SR 1634/1999.

Considering that the experiment was developed under laboratory conditions and the variants have benefited from homogeneous conditions, basically there been no sources of heterogeneity was adopted the experimental design of the form of: **Completely Randomized Design (RCD)** of the type:

- 4x5x4 in four repetitions for the study of viability;
- 4x5x4 in three repetitions, for the study of vigour of seeds;
- 4x4 in four repetitions for the study of viability of inbred lines;
- 5x16 in four repetitions for the study of viability of hybrids in different experimental conditions;
- 4x2x4 in four repetitions for the study of the influence of form and size of seeds on the germination vigour and dynamic.

In order for the results to be repeatable, with practical and scientific value, researches were performed according to specific methods and techniques.

RESULTS AND DISCUSSIONS

Results and discussions regarding the viability of studied genotypes seed

Viability, representing the potential of the seed germination ability to generate live embryos under optimal conditions, it is practically highlighted by standard germination.

The parameters that characterize the storage conditions are: relative temperature and humidity of the air from the storage environment, the moisture content of the seeds subjected to preserve, (initial) quality of the seeds in the moment of storage, their health condition and the microorganisms and insect attack.

- appreciating the quality of seed hybrids indicator under study by standard germination were found in the initial moment of the investigations, significant differences among hybrids in terms of their viability.

- storage conditions that refer to the storage warehouse, and seed state, treated or untreated, were united under a single factor called "treatment" whose influence on germination in the stage "before sowing 2013" is insignificant.

Data recorded after a storage period of **12 months** show clearly that in fact, the ability of conservation of the initial peculiarities of studied genotypes is being a genetic characteristic influenced by the storage period and treatment factor.
Data recorded after a storage period of 24 months show obvious reductions of the germination value in case of all hybrids, significant differences of these toward those recorded in the initial moment. These results, showing that after a storage period of 24 months the seeds viability belonging to the analysed lots is being considerably reduced, are of great practical utility.

Observations registered after a storage period of 36 months indicates that the aging process of seeds, result of the enzymatic activity decline and of proteines degradation doesn’t flow with the same intensity for all hybrids during storage.

In the end of this study regarding viability conservation we can say that studied hybrids prove a different behavior opposite duration and storage conditions. Studied genotypes have different reactions under stress conditions, a better or worse adaptability regarding storage in created conditions.

Conclusions regarding the study of the initial quality stability of seeds belonging to studied hybrids

The fact that in variation analysis, double and triple interactions of the factors taken into study are significant, allow us to couple the treatment factor and storage duration factor in a new factor called environment factor ($E_{med}$) which, in fact represents the experimental condition.

We will consider as adapted genotype, one that preserves the best germination showing reduced fluctuations in all experimental conditions.

By calculating the parameters specific to the concept of stability we were able to highlight individual performance of each genotype to the environment ( experimental conditions).

Conclusions regarding the graphic profile of the aging process of seeds belonging to studied hybrids

To estimate the useful life of a seed lot, which actually means the period of time the germination average batch falls below the minimum allowed, avoiding downgrading it, using the transformation of cumulative frequency distribution of seeds survival (percentage versus time) in the distribution of scores “z” values without unit placed on a line, there were developed models of the type of regressions, called equations of viability, which allowed to determine the rate of decline of each batch of seeds depending on experimental conditions.

Assimilating the slope of the equation regression with the rate of germination decline ($d=tgw$), during storage we were able to classify and order hybrids according to its size, highlighting different reactions of these regarding initial quality conservation opposite to storage conditions.
The indicator **deterioration duration** highlights an aspect difficult to found by other methods, genotypes with a superior initial germination in certain environments record, during storage, bigger rates of decline. The method of equations **viability** makes possible the specification of lots viability after a storage period for different species and in wide storage conditions. The method can have a great practical utility, using the lots of seed in proper moment and avoiding their downgrading, with serious consequences under economical aspect.

**Conclusions regarding the viability of inbred lines stored in open warehouse**

Complexity of production of inbred lines in order to produce hybrids with a series of characteristics as: adaptability, resistance to diseases and fall, production potential, determined in practice that these were produced in quantities in order to meet the needs for several years, so that these **must undergo preservation**.

- From the recorded results we observe a weak preservation of their initial features, so that, after a storage period of 36 months these recorded very weak germinations, for example line LC 363 has the final germination $G_{36} = 33\%$.

- By using **orthogonal polynomial coefficients** was showed that, in regard of their estimation, in different storage conditions, the result cannot be estimated, in other words, the reactions of inbred lines opposite to experimental conditions are unpredictable, which means that unpredictable components are of greater importance that those predictable under the effects of factors taken into study.

**Results and discussions regarding the vigour of the studied hybrids seeds**

Evaluation and identification of seed lots with high performances is an important initiative which contributed to the success of production since the sowing phase, by using in the intended scope the seeds with an active health condition, natural resistance, able to develop normal germs and to ensure a uniform sprouting.

It is necessary to know the actual condition of a seed lot in terms of quality, to provide necessary information to the user, helping him to decide how, and when using batch conditions. Different seed lots, even if they have the same germination (sometimes almost identical), does not mean they have the same physiological potential, meaning, at the sowing in the field, they don't present the same germination and uniform sprouting.
Conclusion regarding the influence of genotype, duration and storage conditions on hybrid maize seed vigour

Evaluation and identification of seed lots with high performances is an important initiative, contributing to the success of production since the stage of sowing.

By the fact that the factor “standard germination” is compulsory to be determined, but insufficient for correlating to field sprouting, in order to express the vigour of seeds belonging to hybrids a series of complex indicators were used, which combine the final germination with the size of increases of germs essential parts, indexes that reveal the real state of batches of seed under the aspect of quality and makes possible to differentiate them in terms of physiological status and germination potential at the moment of sowing in the field.

Conclusion regarding the influence of seeds form and size on vigour

As the seed get older, germination rate decreases, the explanation being that their physiological processes resulting slower and enzymatic activity is lower, both related to the mechanism of synthesizing and mobilization of substances necessary to germination. The combined action of germination rate and slow rhythm of growth has consequences for the slow and uneven sprouting in the field, even under favorable conditions.

The seeds possessing dynamic and uniform germination, highlighted by indicators germination vigor index (GVI) and daily germination indicators (MDF), have rapid growth, with rapid development in adverse conditions. Sowing in adverse conditions, suboptimal requires avoid seeds from the category small and round.

GENERAL CONCLUSIONS AND RECOMMENDATIONS

Seed-bearing life and genetic heritage, both attributes in interaction with an constantly changing environment throughout the life from seed-plant-and again seed is an important factor of production, the first step in the improvement measures of culture technologies to increase the quality and quantity of agricultural production.

The peculiarity of “ortodoxe” seeds for sowing, is that these can be kept dry, in special warehouses, for a longer of shorter period depending the fundamental parameters characterizing the storage environment.
Deterioration of seed is a natural phenomenon, even seeds stored under normal conditions tend toward a decrease in viability and vigor, with increased shelf life.

The intensity of decline of the quality of seed may be reduced and the life of lots of seed may be extended by controlling and directing basic parameters characterizing proper storage conditions.

Starting from the importance of maize hybrid seed as a biological factor particularly important in increasing the production per unit area due to heterosis and that annual losses are over 25%, mostly due to incorrect storage, based on own results, compared to the results communicated by other researchers the following recommendations are formulated:

- the process of seed aging cannot be stopped, but this develops with an intensity depending on the genetic features of species and even genotype or variety, and the factors characterizing the storage environment. By knowledge, control and directing of storage parameters, the aging process can be influenced for the purpose of increasing the longevity of seed lot, with positive consequences under economic aspect and of the agricultural production safety.

- preserving the high maize hybrid seed seminal quality for a longer period of time can be done in practice and widely used, if seeds during storage, have humidities below 12%, and warehouse storage to be a dry construction, well insulated, without endowments with special installations, but with the possibility of aeration, even naturally, ensuring thus an average annual relative humidity below 55% and an average annual temperature below 18 °C, with a range of 0 to 35 °C, depending on the season.

- appreciating the quality of seed hybrids after the indicator standard germination, even after storage for 36 months, some hybrids have high values of germination (G36 = 96%), but taking into account the values of the indicators that characterize the seeds vigor, we recommend the use of these seeds up to 24 months of storage.

- when sowing takes place, for various reasons, under suboptimal conditions (temperature, low humidity of soil, no-tillage works system), we recommend the use of hybrids seed recommended in this regard, but to take into account the shape and size of seeds, avoiding those little and round.