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STUDIES CONCERNING WATER UPTAKE DURING GERMINATION PROCESS AT CEREALS

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Abstract

Seed germination is a complex physiological process through which the embryo is passing from the latent to active life. The germination process starts with water uptake by imbibition of seeds, the water been necessary for enzyme system activation in view to breakdown the complex substances stored within the seed, as well as for translocation and use by the embryo of the substances resulted from the enzyme activity. After this first germination stage, the germination process continues with embryo growth, and finishes with the radicle emergency from the seed, during these stages the water continuing to be uptake by the seed after a specific curve. The main aim of the present study is to determine the water uptake by different cereal seeds (wheat, durum wheat, triticale, barley, and maize) during the germination process, this been expressed through the seed water content and water absorbed by seeds reported to their dry matter content in different germination stages. Also the study is aiming to find out the time needed for the germination process, as well as how the process of water uptake is going on from the begging up to the end of the germination process.

Key words**:** *germination, water uptake, seeds, cereals.*

INTRODUCTION

Seeds have a reproductive role, meaning the assurance of survival of the plant species. Seed germination is a complex physiological process through which the embryo is passing from the latent to active life and starts a new life cycle. Thus, it can be assumed that the germination process makes the seeds to accomplish their reproductive role.

Seed germination incorporates those events that commence with the uptake of water [1, 3] through the imbibition process. Imbibition is the uptake of water determined by the very low water potential of the dry seeds. Imbibition process is a physical phenomenon which is not connected with any living process but which has essential consequences for all the physiological processes within the seed.

Water uptake by imbibition process is followed by embryo growth. Radicle protrusion through all seed covering layers is considered as the completion of germination process [2]. Thus, the germination process finishes with the radicle emergency from the seed.

During all the germination stages, the water continues to be uptake by the seeds after a specific curve, with different intensity and in different quantities.

Water is a basic requirement for germination process. This is essential for enzyme system activation in view to breakdown the complex substances stored within the seed, as well as for translocation and use by the embryo of the substances resulted from the enzyme activity.

A good understanding of germination process and its basic requirements (especially water) with practical applications in agriculture remains an essential issue for a modern crop production.

The present study is aiming at determining the water uptake by different cereal seeds (wheat, durum wheat, triticale, barley, and maize) during the germination process, this been expressed through the seed water content and water absorbed by seeds reported to their dry matter content in different germination stages. Also, this is aimed at establishing the time needed for the germination process, as well as at establishing the performing of the process of

water uptake from the begging up to the end of the germination process on a constant temperature of 20°C.

MATERIAL AND METHOD

Studies concerning water uptake during germination process at cereals were carried out at the following species: wheat (*Triticum aestivum* L.), durum wheat (*Triticum durum* Desf.), triticale (*Triticosecale* Wittm.), barley (*Hordeum vulgare* L.), and maize (*Zea mays* L.).

The water content of the seeds from all the five cereal species were determined by the help of a moisture analyser. Three samples of twenty-five intact seeds (caryopses) from each species were counted paying attention the seeds not to be affected anyhow (broken seed, seed with coat layer affected, seeds affected by pathogens et al.). Each sample was weighted with an analytic balance and put on a germination seedbed of moist filter paper.

The filter paper was used as envelope with two layers of papers below the seeds and two layers above the seeds (method BP = Between Papers, according to the standard SR 1634:1999, equivalent with the ISTA standard Seeds for Sowing. Determination of Germination). The paper envelops were of 14 cm of length and 7 cm of width (98 cm^2) for all the analysed species except maize which has much bigger seeds and for which the paper envelops were double as surface, respectively 14 x 14 cm (196 cm^2). Seeds were placed on the germination seedbed in such a manner not to touch each other.

Each moist germination seedbed with the twenty-five seeds was introduced in a plastic bag and then it was put in an incubator at a constant temperature of 20°C.

Each hour the seeds were weighted at an analytic balance up to the moment when the seeds were germinated in a proportion of 50% out of the twenty-five seeds. A single seed were considered germinated when the radicle protruded through the seed coat was of 2 mm.

The obtained data were statistically processed by analyses of variance (Anova-single factor).

RESULTS AND DISCUSSIONS

The average weight of one dry seed at the analysed cereal species was the following: 39.3 mg for wheat, 41.9 mg for durum wheat, 47.2 mg for triticale, 53.8 mg for barley (Fig. 1), and 338 mg for maize (Fig. 2).

The end of germination process, respectively the moment when the seeds were germinated (the radicle protruded through the seed coat of 2 mm) under conditions of moisture and constant temperature of 20°C, were reached at 14 hours for barley, 20 hours for wheat and durum wheat, 22 hours for triticale, and 54 hours for maize (Fig. 1 and 2).

It has to be emphasised the very short germination period registered at barley, with six days shorter than those of wheat and durum wheat. For reaching the end of the germination process, triticale needed two days more than the wheat and durum wheat. Maize is a thermophile plant with high requirements for temperature starting from the germination. That is why, for reaching the end of the germination process, the maize needed 54 hours, which means 2.7 times more than the period required by wheat and durum wheat. Wheat and durum wheat reached the end of the germination process in 20 days both of them, even there are some differences between the seeds of these two species concerning their weight and chemical composition.

Compared to the average weight of one dry seed, the average seed weight at the end of the germination process was 1.45 times bigger at wheat, durum wheat and maize, 1.4 times bigger at barley, and 1.7 times bigger at triticale. It can be assumed that the increased average seed weight at the end of the germination process is due mainly to the water absorbed by the seeds. It is interesting to notice that from all the analysed cereal species, barley has absorbed the smallest amount of water and triticale has absorbed the highest amount of water, while wheat, durum wheat and maize have absorbed quite similar quantities of water.

The average weight of all seeds at the analysed cereal species has the most important increasing in the first hour after the seeds were put under germination conditions, respectively moisture and temperature of 20°C. Thus, after

the first hour, the seed weight has increased because of the imbibition process with 2.4 mg for wheat seeds, 3.6 mg for durum wheat seeds, 3.7 mg for triticale seeds, 8.0 mg for barley seeds and 14.9 mg for maize seeds (Fig. 3).

Compared to the average increasing rate (mg per hour) of the seed weight during the whole germination process, the average increasing seed weight after the first hour of the germination process was 2.7 times bigger for wheat seeds, 3.6 times bigger for durum wheat seeds, 2.5 times bigger for triticale seeds, 5 times bigger for barley seeds and 5.3 times bigger for maize seeds.

Compared to the other analysed cereal species, maize seeds absorb the largest quantity of water through the imbibition process in the first hour of the germination process, this been due to the fact that the maize has the largest seeds. Among other cereal species except maize, barley seeds absorb the largest quantity of water, while the wheat seeds absorb the smallest quantity of water through the imbibition process in the first hour of the germination process.

After the first hour of the germination process, the seed water content of the analysed cereal species was in average of 17.3%. The highest value was registered at barley with 22.1% (distinct significant difference compared to average for the analysed cereal species), while the smallest value was registered at maize with 14.1% (negative significant difference compared to average for the analysed cereal species). The wheat, durum wheat and triticale have registered comparable values, respectively 16.1% for wheat, 17.6% for durum wheat and 16.8% for triticale (Fig. 4). It has to be emphasised the rapid imbibition capacity of barley seeds. In the case of maize, although the average increasing seed weight after the first hour of the germination process was the biggest among the analysed cereal species, the quantity of water absorbed by seeds was not so important reported to the whole seed weight. This led to the smallest value of the seed water content at maize after the first hour of the germination process.

After two hours of germination, for all the analysed cereal species the seed water content increased in average with another 3% compared to the value registered after one hour. The average seed water content of the analysed cereal species was of 20.4% (Fig. 4). After two hours of germination process, as in the case after one hour, maize registered the smallest increase in the seed water content, respectively from 14.1 to 15.7%. Also, barley registered the highest value (24.6%), while wheat, durum wheat and triticale registered comparable values, respectively 20.0% for wheat, 21.0% for durum wheat, and 20.7% for triticale.

At the end of the germination process, the seed water content was in average for all the analysed cereal species of about 40% (39.9%). In this moment, triticale has registered the highest value, with 47% (very significant difference compared to average for the analysed cereal species), while barley has registered the smallest value, with 36.8% (negative distinct significant difference compared to average for the analysed cereal species). This time, the wheat, durum wheat and maize have comparable values, respectively 38.6% for wheat and durum wheat, and 38.3% for maize (Fig. 4). It has to be emphasised the triticale seeds capacity to absorb important quantities of water in the second period of the germination process.

Water uptake by seeds reported to their dry matter content at all analysed cereal species after the first hour of germination was in average about 21% (21.1%). The highest value was registered at barley seeds with 28.4% (distinct significant difference compared to average for the analysed cereal species), while the smallest value was registered at maize seeds with 16.4% (negative significant difference compared to average for the analysed cereal species). The values registered by the other analysed cereal seeds were the following: 19.1% for wheat, 21.4% for durum wheat, and 20.4% for triticale (Fig. 5). The proportions between species are similar to those registered at seed water content.

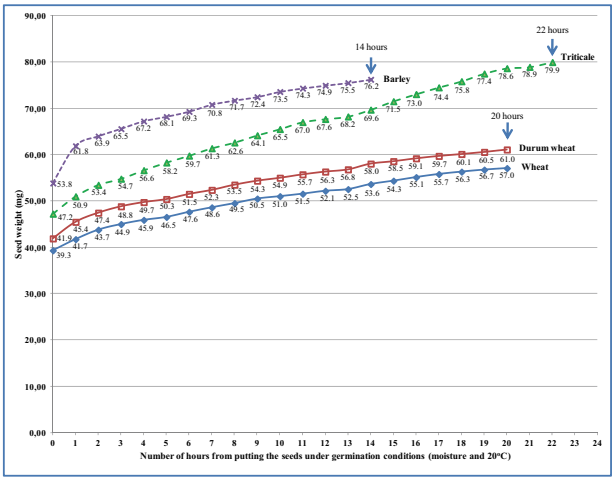

Fig. 1. Seed weight during the germination process at the analysed cereals

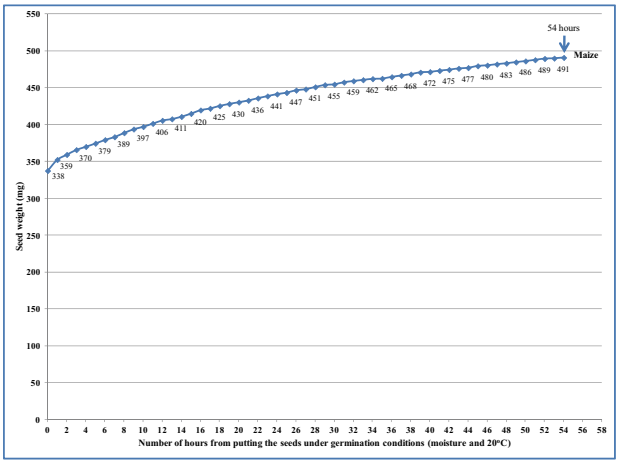

Fig. 2. Seed weight during the germination process at maize

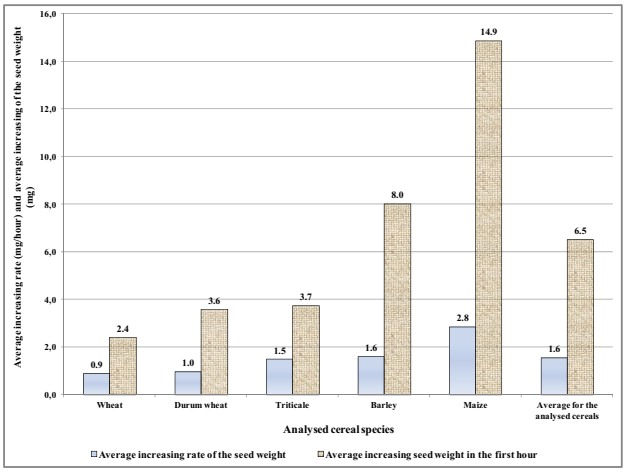

Fig. 3. Average increasing rate of the seed weight during the whole germination process and average increasing seed weight after the first hour of the germination process at the analysed cereals

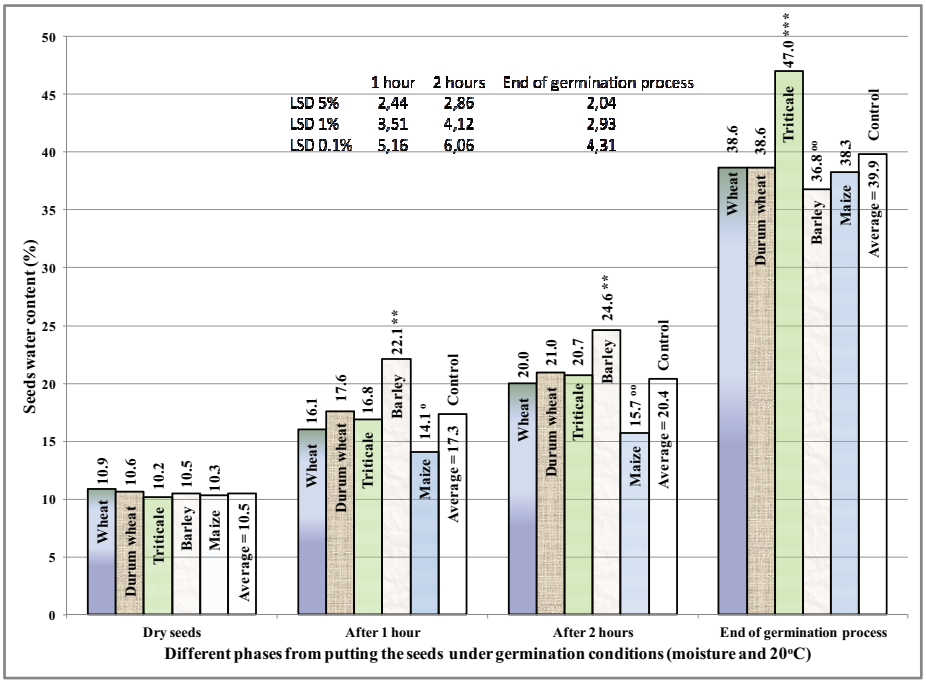

Fig. 4. Water content of seeds at the analysed cereals in different phases of the germination process

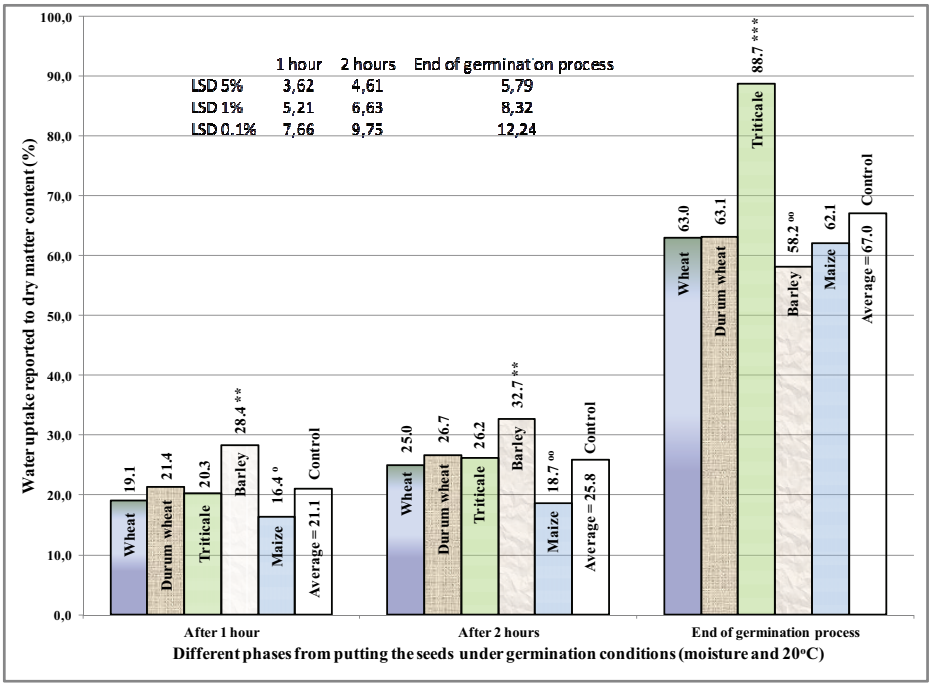

Fig. 5. Water uptake by seeds reported to their dry matter content at the analysed cereals in different phases of the germination process

After two hours of germination, the water uptake by seeds reported to their dry matter content at all the analysed cereals was in average about 26% (25.8%). As in the case of after the first hour of germination, the highest value was registered at barley with 32.7%, while the smallest value was registered at maize with 18.7%. The values registered by the other analysed cereal seeds were the following: 25% for wheat, 26.7% for durum wheat, and 26.2% for triticale (Fig. 5).

At the end of the germination process, the water uptake of seeds reported to their dry matter content at all the analysed cereals was in average 67%. The highest value was registered at triticale with 88.7% (very significant difference compared to average for the analysed cereal species), while the smallest value was registered at barley with 58.2% (negative distinct significant difference compared to average for the analysed cereal species). The wheat, durum wheat and maize seeds have registered comparable values, respectively 63% for wheat, 63.1% for durum wheat, and 62.1% for maize (Fig. 5).

CONCLUSIONS

At a constant temperature of 20^{o}C, the germination process takes 14 hours for barley, 20 hours for wheat and durum wheat, 22 hours for triticale, and 54 hours for maize.

After the first hour of the germination process, the seed water content of the analysed cereal species was in average about 17%, while the water uptake by seeds reported to their dry matter content was in average about 21%.

At the end of the germination process, the seed water content at the analysed cereal species was in average about 40%, while the water uptake by seeds reported to their dry matter content was in average about 67%.

The seed water content registered the following values:

- for wheat, 16.1% after one hour and 38.6% at the end of germination;
- for durum wheat, 17.6% after one hour and 38.6% at the end of germination;
- for triticale, 16.8% after one hour and 47% at the end of germination;
- for barley, 22.1% after one hour and 36.8% at the end of germination;
- for maize, 14.1% after one hour and 38.3% at the end of germination.

The water uptake by seeds reported to their dry matter content registered the following values:

- for wheat, 19.1% after one hour and 63% at the end of germination;
- for durum wheat, 21.4% after one hour and 63.1% at the end of germination;
- for triticale, 20.3% after one hour and 88.7% at the end of germination;
- for barley, 28.4% after one hour and 58.2% at the end of germination;
- for maize, 16.4% after one hour and 62.1% at the end of germination.

Wheat, durum wheat and triticale have a comparable behaviour concerning the water uptake in the first hour of germination.

Wheat, durum wheat and maize have a comparable behaviour concerning the water uptake at the end of the germination process.

Barley seeds absorb very rapidly water in the first hour of germination, but at the end of germination process, they have the smallest water content and the smallest water uptake by seeds reported to their dry matter content among all analysed cereals.

Triticale has the highest values for water seed content and water uptake by seeds reported to their dry matter content at the end of germination process.

Maize has the smallest values for water seed content and water uptake by seeds reported to their dry matter content after the first hour of germination.

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