CONSERVATION OF WHEAT SEEDS GERMINATION CAPACITY DURING STORAGE

Viorel Fătu[1,2#], Roxana Dudoiu[1], Carmen Lupu[1]

[1] Research and Development Institute for Plant Protection, Bucharest
[2] University of Agronomic Science and Veterinary Medicine, Bucharest

[#]correspondence address
Research and Development Institute for Plant Protection, 8 Ion Ionescu de la Brad
District 1, 013813, Bucharest, Romania
Phone: + 40 21269 32 31/32/34, Fax: + 40 21269 32 39
E-mail: fatu_viorel@yahoo.com

Abstract: Grain storage is a key activity in preserving the nutritional, microbiological and physiological properties of seeds. The decisive abiotic factors in the evolution of stored seed quality are temperature and humidity. These factors can be modified from the outside of the cereals warehouse through climatic variations and within through the metabolic activity of seeds and the forms of life that enter in deposit with the cereals. Temperature and humidity can increase inside the deposit as a result of starch metabolism resulting in heat, carbon dioxide and water. For each percentage of starch consumed from the seeds, the water content increases by about 0.6 percent. To reduce starch consumption during storage, a seed treatment prior to the storage period was tested with a product containing lavender vegetal debris, diatomaceous earth powder, lemongrass and thyme essential oil. After one month storage period, positive results regarding germination capacity and physical properties were reported as a result of treatment.

Key words: *wheat, deposit, germinative capacity*

INTRODUCTION

The cereal seed production activity is generally focused on breeding programs and technological seed treatment sequences prior to sowing. During the seed storage time from harvest to sowing the main concern is intended to maintain temperature and humidity in optimal parameters. During this time, high water content of the seeds favors the growth of microorganisms by air humidification while the high temperature promotes both fungal growth and insect development (Roberts, 1972). In order to keep the wheat safe for a short period, the temperature must not exceed 23ºC inside the grain store and the grain water content should not be higher than 18% at the time of entering the deposit (Friesen & Huminicki, 1986). When it is intended to keep wheat in storage for a long time at an internal variable temperature, grain moisture should be between 7.6 and 9.7% (Chai et al., 1998) while at a constant storage temperature between 21 and 26 °C, the grain water content should not exceed 12.4% (Anderson, 1970). By analyzing these parameters it can be interpreted that the viability of the seeds is conditioned by the existence of minimal respiratory activity to maintain enzyme functionality. The high water content of seed after harvesting is often caused by unfavorable weather conditions for seed dehydration and the extension of the harvest period due to the less available harvesting equipment. This study aims the possibility of intervention with a treatment based on natural products to freshly harvested seeds before storage to provide a transitional period until the seeds reach the optimum water content to be stored safely. Essential oil of *Lavandula angustifolia* Mill. is recognized as a microbial inhibitor in the medical field (Hammer et al., 1999), as a deposit pest insecticide (Germinara et al., 2017), but also as a wheat germination inhibitor (Teac et al. al., 2008). The essential oil of *Thymus vulgaris* L. is very well studied with regard to antimitotic properties (Kohiyama et al., 2015), but also with regard to the inhibitory effect on germination of annual weed seeds

(Angelini et al., 2003). The essential oil of *Cymbopogon citratus* has a strong inhibitory effect on the germination of wheat seeds (Dudai et al., 1999) and has been successfully tested as seed treatment against seed-borne diseases (Akhter et al., 2011). The insecticidal activity of the diatomaceous earth is well known (Rojht et al., 2010) ensuring protection up to 21 days (Chiriloaie et al., 2014).

MATERIALS AND METHODS

In the experiment were used wheat and corn untreated kernels from the warehouse of a commercial company. The essential oils used are of commercial origin and were extracted from the following species: *L. angustifolia* (8LOT160316), *Th. Vulgaris* (9LOT160205), and *C. citratus* (8LOT160318). The experiment was conducted in two stages. In the first stage it was analyzed the action of essential oils on maize seed germination and root growth in order to determine the optimal working dose in seed treatment. In this stage corn kernels were used instead of wheat due to the use of a larger amount of essential oil for 50 seeds and to eliminate the effect of the essential oil dilution by evaporation. The evaluation of the essential oil action on germination and root growth was performed in vented petri dishes (90 mm x 13 mm) loaded with fifty seeds covered with five layers of cellulose paper imbibed with 10 ml of water. The concentration of essential oils in the test samples ranged between 500 and 5000 ppm based on the seed weight. Essential oils were conditioned as a dispersion consisting of 5% EO (v/v), 95% water and 0.2% agar (w/v). Seed treatment was performed by adding the dispersion together with 4 ml of water required to optimal seeds soaking and homogenization. The control was treated with only 4 ml of water. At the end of the experiment germinated seeds were counted and the radicle length measured.

In the second stage of the experiment it was assessed the germination conservation capacity due to a treatment of wheat seeds with a product made from *L. angustifolia* vegetable debris, *Th. vulgaris, C. citratus* essential oils and diatomaceous earth. Based on the results obtained from the evaluation of the essential oil action on germination and root growth on maize, the required volume of essential oils to treat a 30 kg bag of seed would have been around 15 ml for each extract. Because these values are not economically advantageous it used a ten times lower concentration of essential oils and *L. angustifolia* oil has been replaced with vegetal debris of lavender. Thus, the composition of the product to treat a 30 kg bag of wheat seeds was: 1.5 milliliters essential oil of *Th. vulgaris* L., 1.5 milliliters essential oil of *C. citratus*, 10 grams lavender vegetal debris and 10 grams of diatomaceous earth. The treatment was performed in cereal bags loaded with 30 Kg of wheat seeds. At the bottom of the bag (Figure 1) was placed the product and after loading the bag were added 10 grams of diatomaceous earth (Figure 2) as an insecticide barrier. The bags were left in an open deposit for one month (Figure 3), at the end the 1000-grain weight and the germinating capacity at three days were determined.

Figure 1. Treatment at the bag bottom

Figure 2. Treatment at the cereals surface

Figure 3. Bags storage

RESULTS AND DISCUSSIONS

In the experimental stage of determining optimal doses of essential oils for seed treatments it has been shown that the essential oils of lavender (Figure 4) and thyme (Figure 6) did not have a significant effect on the number of germinated seeds at all used doses, while lemongrass essential oil inhibited germination (Figure 8) even with at first concentration of 500 µl/kg of seed. In terms of root growth, essential oils of lavender and lemongrass inhibited root growth (Figure 5, Figure 9) while essential thyme oil stimulated growth at concentrations ranging from 500 to 2000 ppm (Figure 7). With regard to the antifungal effect of essential oils, over the concentration of 1000 ppm no microbial colonies have been observed at all test variants. This effect of inhibiting microbial activity around untreated seeds could be used in future ecological seed protection treatments before sowing.

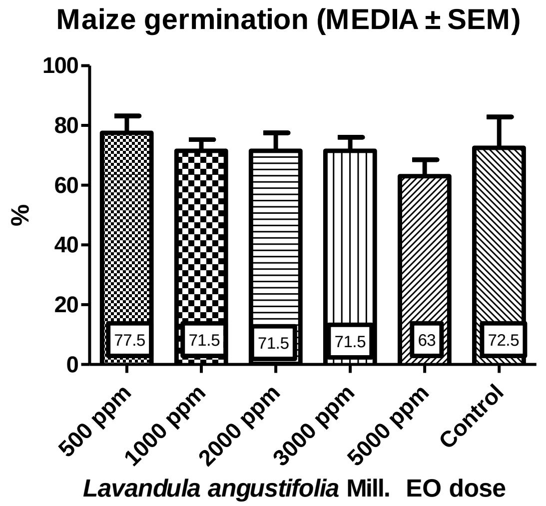


Figure 4. Maize germination at 3 days - *Lavandula angustifolia* Mill EO treatment

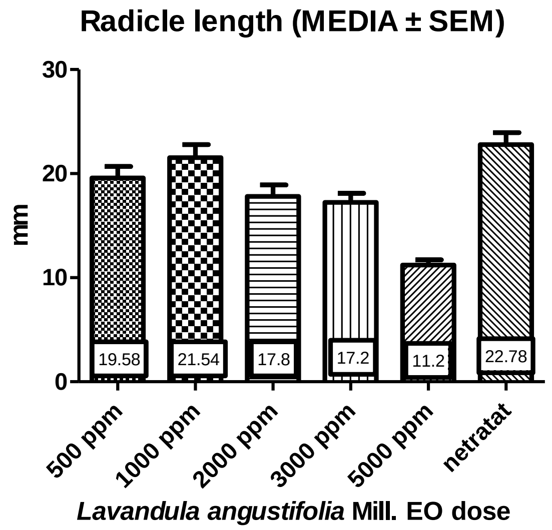


Figure 5. Radicle length at 3 days - *Lavandula angustifolia* Mill EO treatment

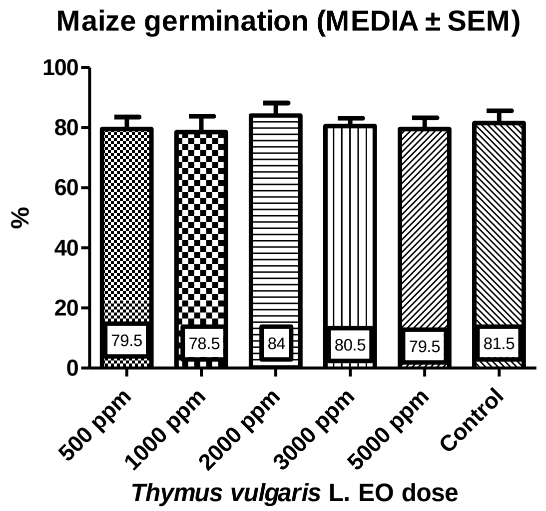


Figure 6. Maize germination at 3 days - *Thymus vulgaris L.* EO treatment

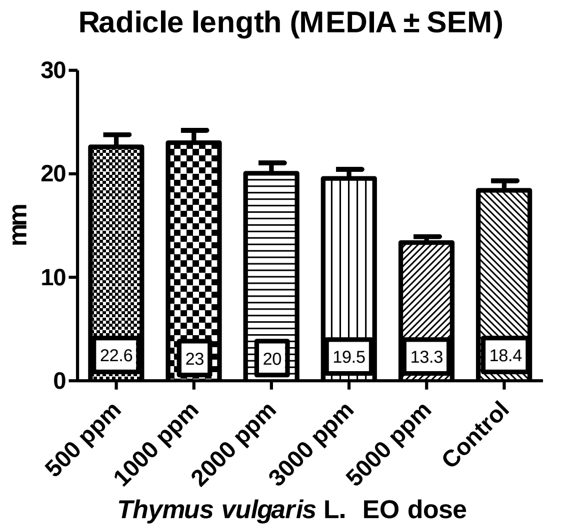


Figure 7. Radicle length at 3 days - *Thymus vulgaris* L. EO treatment

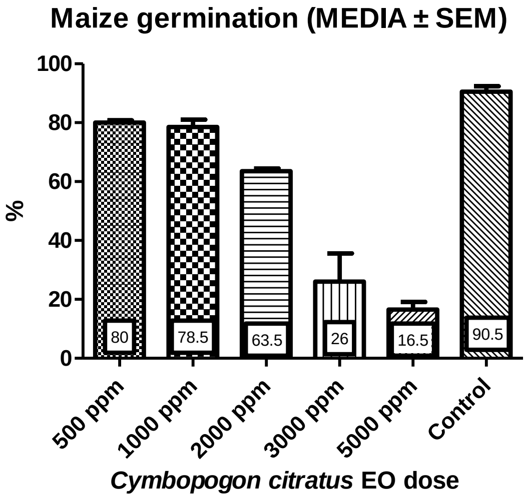


Figure 8. Maize germination at 4 days - *Cymbopogon citratus* EO treatment

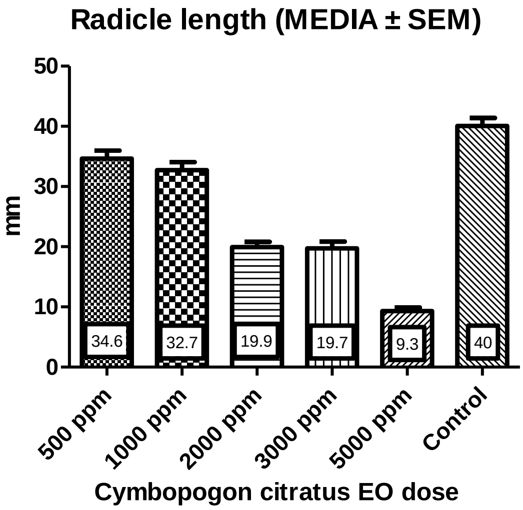
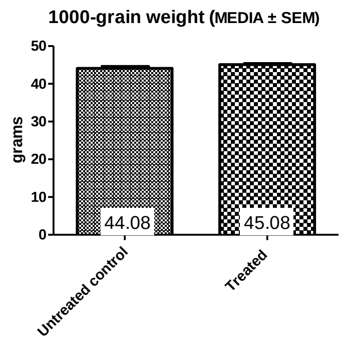
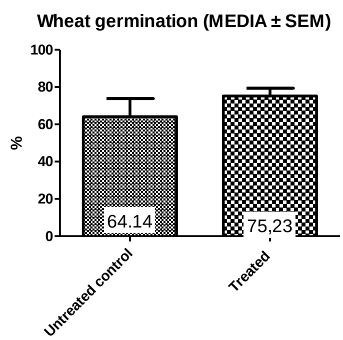
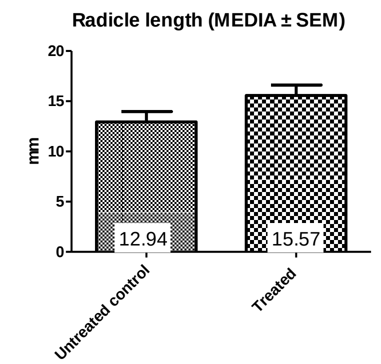


Figure 9. Radicle length at 4 days - *Cymbopogon citratus* EO treatment

In the second stage of the experiment, as a result of the storage of wheat seeds in the presence of lavender vegetal debris, essential oil of lemongrass, essential oil of thyme and diatomaceous earth dust, it was found that the weight of 1000 grains for the treated samples was greater with one gram (44.09 ± 1.015-control, 45.09 ± 0.5289 treated) versus control. Positive results were recorded for germination, where the treated seeds germinated about 11% more than untreated (64.15 ± 19.37 - control, 75.24 ± 8.234 - treated). The process of conserving the germination capacity of the treated wheat seed at the entry into storage was found in the case of root growth, when the radicles generated from the treated seeds exceeded the control with a significant mean value of 2.6 mm (Figure 10).

Table 1. 1000-grain weight, germination, radicle length

	Mann Whitney test P value Exact or approximate P value? P value summary Are medians signif. different? (P < 0.05) One- or two-tailed P value? Sum of ranks in column A,B Mann-Whitney U	 0.1143 Exact ns No Two-tailed 12 , 24 2.000
	Mann Whitney test P value Exact or approximate P value? P value summary Are medians signif. different? (P < 0.05) One- or two-tailed P value? Sum of ranks in column A,B Mann-Whitney U	 0.3429 Exact ns No Two-tailed 14 , 22 4.000



Mann Whitney test	
P value	0.0191
	Gaussian
Exact or approximate P value?	Approximation
P value summary	*
Are medians signif. different? (P < 0.05)	Yes
One- or two-tailed P value?	Two-tailed
Sum of ranks in column A,B	15626 , 14755
Mann-Whitney U	6173

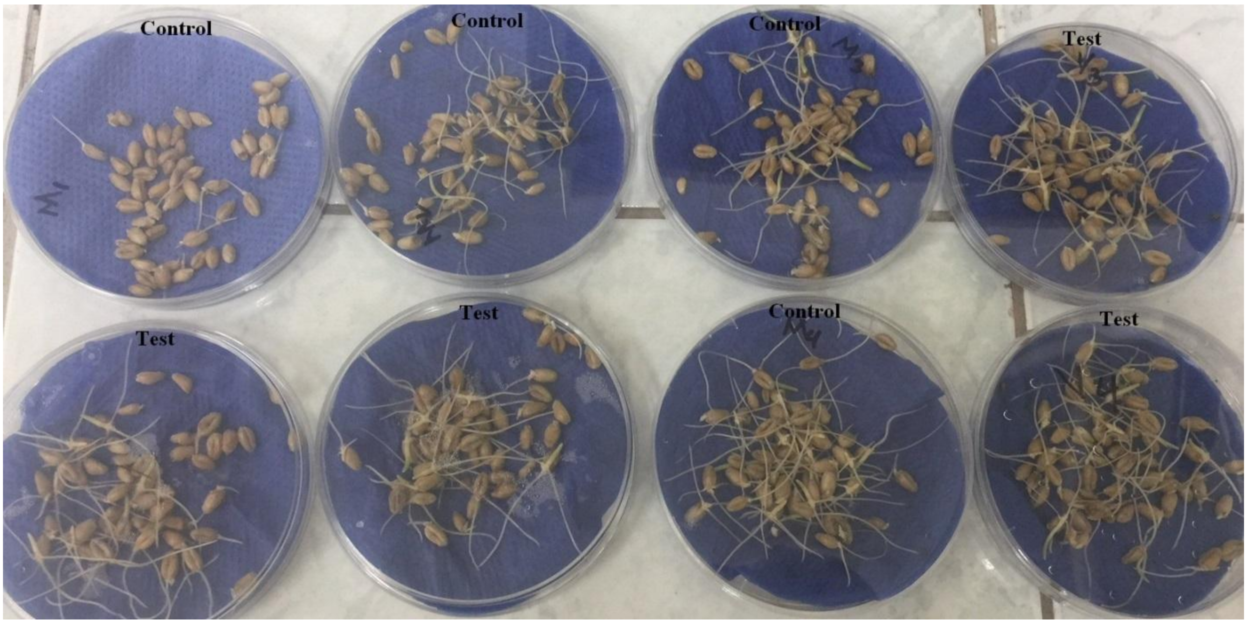


Figure 10. Wheat germination and radicle growth at 3 days

CONCLUSIONS

This experiment has highlighted that the use of products which have the ability to slow down the cellular respiration and implicitly to reduce the starch consumption during storage is an important research topic in the agricultural field. The essential oil of *Cymbopogon citratus* is the only component of the product that could cause irreversible changes in seed during storage (permanent loss of germination capacity). However, the composition of the product based on 10-fold low concentrations of essential oils and on their combined action did not allow negative changes in germinative capacity. Analyzing the slightly lower level of standard error of mean for the measurements made on the test samples, it can be concluded that the treatment with this natural product gives a higher homogeneity to the seeds. This homogeneity may be due to the inhibition of harmful microorganisms present on the surface or within the seeds.

ACKNOWLEDGEMENTS

The research was funded by the Ministry of Research and Innovation the project ’Produse ecologice pe baza de diatomită şi uleiuri esenţiale pentru diminuarea reziduurilor şi contaminanţilor din lantul alimentar' and by MADR the Contract no. 414 entitled 'Tehnologii integrate de prevenire şi combatere a organismelor dăunătoare la plantele agricole şi horticole cu consum minim de resurse'.

REFERENCES

AKHTER M., NAWAB B., JAMIL K., ABBAS T. and PERVEEN S. (2011), Role of natural product waste on viability and yield parameters of wheat (*Triticum aestivum*), Pakistan Journal of Biochemistry and Molecular Biology, 44(4), 125-128.

ANDERSON J. D. (1970), Metabolic changes in partially dormant wheat seeds during storage, Plant Physiology (1970) 46, 605-608.

ANGELINI L.G., CARPANESE G., CIONI P. L., MORELLI I., MACCHIA M., FLAMINI G. (2003). Essential Oils from mediterranean lamiaceae as weed germination inhibitors, Journal of agricultural and food chemistry, 51, 6158-6164.

CHIRILOAIE A., ATHANASSIOU C., VASSILAKOS T., FĂTU V., DROSU S., CIOBANU M. (2014), Influence of grain type on the efficacy of some formulations of diatomaceous earth against the rice weevil (*Sitophilus oryzae* L.), Scientific Papers. Series A. Agronomy, Vol. LVII, 140-145.

FRIESEN O.H., HUMINICKI D.N. (1986). Grain aeration and unheated air drying, Agdex 732 - 1, Manitoba Agriculture, Winnipeg, Canada.

GERMINARA G. S., STEFANO M. G., ACUTIS L., PATI S., DELFINE S., CRISTOFARO A., ROTUNDO G., (2017), Bioactivities of *Lavandula angustifolia* essential oil against the stored grain pest Sitophilus granaries, Bulletin of Insectology 70 (1), 129-138.

HAMMER K.A., CARSON C.F., RILEY T.V. (1999). Antimicrobial activity of essential oils and other plant extracts, Journal of Applied Microbiology, 86, 985-990.

JIANFANG C., RONGYIN M., LINGZHI L., YIYING D. (1998). Optimum moisture contents of seeds stored at ambient temperatures, bioversityinternational.org.

KOHIYAMA C. Y., RIBEIRO M. M. Y., MOSSINI S. A. G., BANDO E., BOMFIM N. S., NERILO S. B., ROCHA G. H. O., GRESPAN R., MIKCHA J. M. G., MACHINSKI M. Jr. (2015). Antifungal properties and inhibitory effects upon aflatoxin production of Thymus vulgaris L. by Aspergillus flavus, Food Chemistry, 173, 1006-1010.

DUDAI N., POLJAKOFF-MAYBER A., MAYER A.M., PUTIEVSKY E., LERNER H. R. (1999). Essential oils as allelochemicals and their potential use as bioherbicides. Journal of Chemical Ecology, 25 (5), 1079-1089.

ROBERTS E.H. (1972). Storage Environment and the Control of Viability. In: Viability of Seeds, Roberts, E.H. (Ed.). Chapman and Hall, Landon, 14-58.

ROJHT H., HORVAT A., ATHANASSIOU C. G., VAYIAS B. J., TOMANOVIC Z., TRDAN S. (2010). Impact of geochemical composition of diatomaceous earth on its insecticidal activity against adults of *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae). Journal of Pest Science, 83 (4), 429–436.

TEACĂ C.A., BODÎRLĂU R., OPREA A., TĂNASE C., COLCERU S. (2008). Influence of plant extracts on germination and postgermination development of different species, Cellulose Chemistry and Technology, 42 (1-3), 47-53.