SEED PROTECTION DURING EARLY SOWING

Assist. Prof. Vasil Kopchev[1], PhD, Assoc. Prof. Georgi Mitev[1], DSc, Kr. Bratoev, Ph D[1]
[1]University of Ruse "Angel Kanchev", Bulgaria

vkopchev@uni-ruse.bg; gmitev@uni-ruse.bg; kbratoev@uni-ruse.bg;

Abstract: Present study aims to investigate the effectiveness of using water-soluble polymers as a protective coating and rate of influence of additional seed coat on the germination and emergence of seeds. There have been conducted series of experiments using aqueous solutions of high molecular weight polyethylene glycol at a concentration of 0.1 and 0, 05% for the preparation of polymeric coatings of varying thickness. The research have been performed in laboratory and field conditions. There have been reported values for air and soil temperature, soil humidity and precipitation during the investigation period as major factors affecting seed germination.

Key words: Seed coating, organic polymer, germination rate, soil temperature effect, soil moisture effect

1. Introduction

Sowing of corn seeds is done during the spring months when the weather conditions are changing and often unfavourable. The period when there are optimal meteorological conditions, which are also appropriate for preserving the vitality of seeds, i.e. temperatures over 8^{0}C and humidity of 13-16%, is too short. When sowing is done at temperatures lower than 8 ^{o}C and high humidity, there is a risk of sowing failure.

To initiate the process of germination, the seeds need to be hydrated. They are located in the soil, so the degree of hydration will depend on the soil water potential. In real conditions, hydration is caused by the difference between water content in the seed and in the soil. [7].

For each crop there is a certain critical humidity of the soil. For corn this value is 30%, for wheat 40%, and for soybeans - 50%. The amount of water received by the plant is rather small, but it is enough to initiate the process [1].

Temperature is equally important for seed germination and the course of bio-chemical processes in germ cell development. The optimal temperature is between 15-30^{0}C. It can be a factor for plant death as well because with long periods of low temperatures the germ could freeze and die [2].

Germination processes can be delayed for a certain period after sowing until weather conditions become normal in late spring and germination can be stable. In other words, the process of germination can be possible only after temperatures remain high for a long period and the chance of germ freezing becomes minimal.

This effect can be achieved through additional seed protection by an organic polymer. Applied as a thin layer on the seed surface, the polymer provides additional seed protection and possibility to delay germination until certain parameters of the environment become available. Besides, additional biological protection substances, as well as seed germ nutrients have been added.

Requirements for protective coatings

Protective coatings for such activities have to meet a number of requirements like: [8]:

- *Water solubility* – this is a necessary condition for providing free access to water, needed for the bio-chemical processes in the course of germination. For this purpose, a certain hydrophobicity of the coatings at low temperatures is required so that germination can be delayed until normal environmental parameters have been reached;
- *biodegradability* – the coating used does not cause soil contamination and does not reduce soil fertility;
- *good seed aeration and hydration* – to provide free access to oxygen, which is a necessary condition to ensure the process of breathing and the normal bio-chemical processes in the course of germ development;
- *cost-effective and affordable* – the low price allows for economic efficiency and justifies the additional treatment of seeds with protective coatings;
- *easy application* – an important condition for efficient application of the polymer

coating, the thickness and quality of the coating;

- *to be non-toxic* – does not contaminate the environment, the soil and does not endanger the health of those who work with it.

2. Preconditions and means for resolving the problem

Types of polymers used for seed coatings

The plant cell possesses a natural exoskeleton, based on cellulose. That is why, one of the potential organic polymers could be cellulose derivative [4]. Example: methylcellulose, ethylcellulose, etc. Those polymers have mesh structure of cellulose fibres and like the cellulose of the plant cell wall, fig. 1, they provide access to water and oxygen and are biodegradable. They are water-soluble and could be applied on the seed surface.

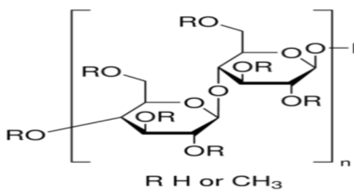
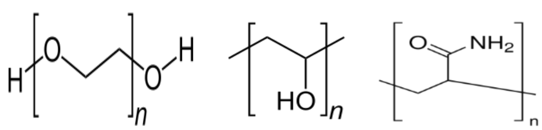


Fig. 1 Structural formula of methylcellulose

Generally, cellulose is non-toxic. Example: methylcellulose is used as a stabiliser, which preserves the viscosity and consistency of the nutrients.

Versions of some artificial polymers are possible: polyethylene glycols, polyvinyl alcohol, polyacrylamide [5].



А) Б) В)

Fig.2 Artificial water-soluble polymers: A) polyethylene glycol; B) polyvinyl alcohol; C) polyacrylamide

Polyethylene glycol is a water-soluble polymer of the ethylene glycol (fig.2a). It is used in food industry and pharmaceuticals for improving the solubility of some substances as a suspending agent, carrier and humidifier. It is not so easily dissolved in water and initially it swells. In general, it meets most of the requirements: it is relatively inexpensive, biodegradable and non-toxic, water-soluble and easy to apply on seeds [5,6].

Polyvinyl alcohol – water-soluble polymer of the vinyl alcohol (fig.2b). In pharmaceuticals it is used as a thickener and adhesive material, and in food industry – as emulsifier. Concerning its use as protective seed coating, its properties are similar to those of polyethylene glycol.

Polyacrylamides – water-soluble polymers based on acrylamide (fig. 2b). It is used for purification of drinking water, as a coagulate and flocculant, due to its tendency to form a gel. It is non-toxic and biodegradable like the above-mentioned polymers [3].

Principle of action of seed protection coatings

What all polymers reviewed have in common is that they possess hydrophobic “tail”, which is a long polymer chain of monomers and hydrophilic “head”, which is a polar group at both ends of the polymer chain. The schematic structure is shown on fig. 3. On contact with the polar molecule of water, a process of swelling is observed, which slows the transfer of water molecules to the seed coating. Increasing the temperature accelerates the process of water diffusion through the polymer coating.

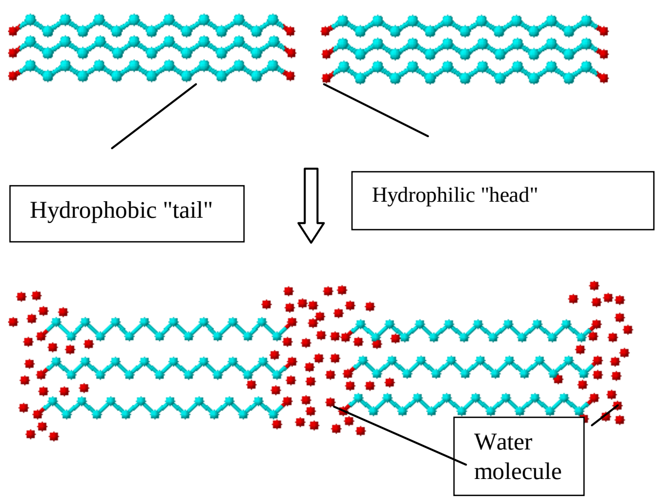


Fig.3. Molecule structure of water-soluble polymers and mechanism of water molecule diffusion through them

Spreading the polymer coating over the seeds

For this purpose different apparatuses and techniques are used, which guarantee the different thickness of seed coatings. The main processes are wetting with polymer solution, followed by drying. Usually the two processes run parallel to each other in drum draining apparatuses. A diagram of this type of apparatus is shown on fig.4

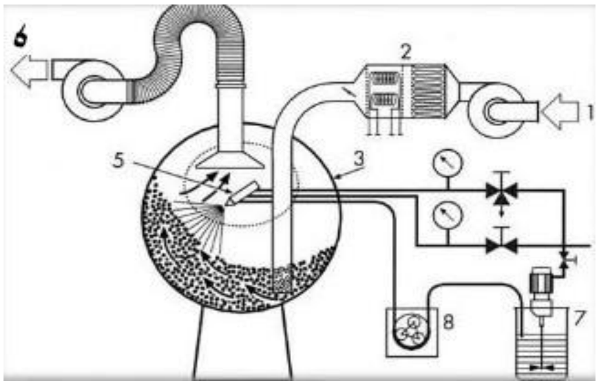


Fig. 4 Apparatus for seed coating

The principle of action is as follows: The seeds are placed in the drum (3). Through the air duct (1) air is fed after initially being heated by the heater (2) into the drum with the seeds. From the tank (7), equipped with a mechanical stirrer, a solution of the polymer used for seed coating is fed. Through the pump (8), the solution is pressurized разтворът се подава под налягане към to the nozzles for fine spraying (5) and is sprayed into the drum. Under the effect of the hot air, the polymer solvent, which is most often water, evaporates and is taken out through the air duct (6).
The quality of the coating produced through this method depends on the following factors:

- composition, concentration and viscosity of the polymer solution used;
- mode of even spraying of the solution through the nozzles;
- optimal drum rotation speed;
- optimal temperature and quantity of the air fed.

As a result of the polymer coating applied, seeds that are resistant to unfavourable sowing conditions are obtained, which is achieved through a certain delay of germination until favourable soil and climatic conditions have been reached.

Since the polymer coating provides a "protective capsule" for the seed, different substances are often added to it, which aid the development of the germ additionally. These are artificial bacterial fertilizers, completing the mineral soil content; pesticides and bactericides, which contribute to reducing the harmful effect of rival plants and pathogenic bacteria.

The choice of polymer coating composition is determined to a great extent by the type of seeds, the composition of soils and the expected climatic conditions, with one of the main factors being the economic efficiency.

3. *Results and discussion*

Empirical research

For determining the efficiency of using water-soluble polymers as protective coatings and the extent to which they influence plant germination and sprouting, a series of experiments have been conducted, using water solutions of polyethylene glycol of high molecular weight with concentration 0,1 and 0,05% to obtain polymer coatings with different thickness.

The experiments conducted in laboratory and field conditions have the nature of multifactorial regression analysis. Air temperature in the period 14.12.2017 to 08.03.2018 changed from -8 oC to 14 ^{o}C.

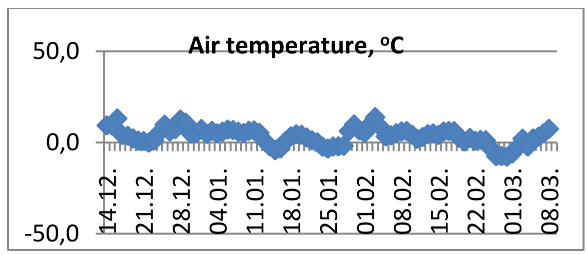


Fig.5. Change of air temperature in the surroundings of Ruse in the period 14.12.2017 – 08.03.2018

Generally, this period is not suitable for sowing of any spring crop, but it is appropriate for studying the polymer properties, in terms of duration of the period for seed protection. The soil temperature in such relatively warm winter is under the critical 8^{o}C, when the seeds get activated and germinate, fig.6.

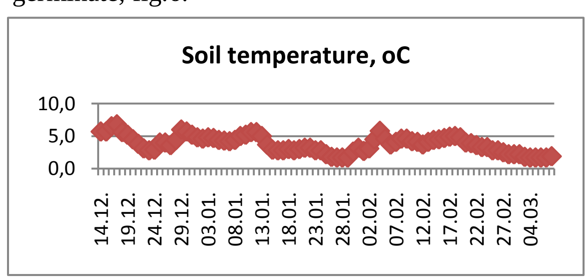


Fig. 6. Change of soil temperature in the period under study

The third factor, soil humidity, is appropriate for such research because it exceeds the normal values of 14-16%, required for seed germination and there will be no situation when the seeds will experience water stress, fig. 7.

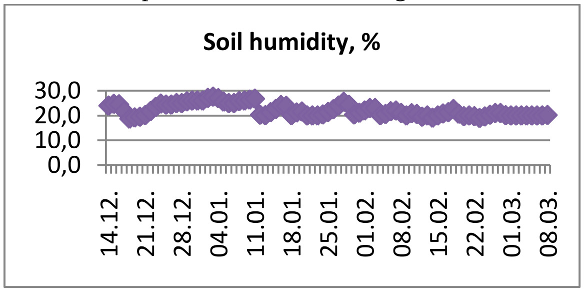


Fig. 7. Soil humidity during the period under study

Even in winter precipitation is irregular and the sum total is below the normal one, which is required for storing water at 0,80 m, fig. 8.

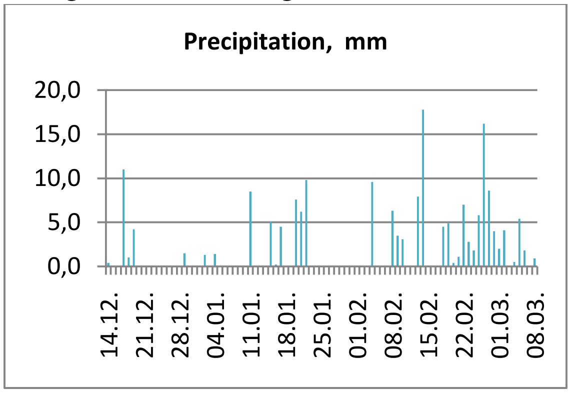


Fig. 8. Precipitation during the period under study

For conducting the regression analysis, the following controllable factors have been included: soil temperature x_1, absolute soil humidity x_2 and polymer concentration x_3. It is known that a multitude of factors, hard to define, have an impact on the nature of phenomena in the process of seed germination, but the three selected ones are crucial for the solution of the assignment set.

The aim of the experiments conducted is to check the possibility of controlling the germination process of corn seeds. In this sense, the seed germination, determined in % - Y, is the parameter of optimisation.

From the test results it was determined that the average seed germination is 99%, which is close to 97% germination of the control seeds, based on standard methodology. The seed germination from the samples and the control group correspond to the germination value of the farmer – over 96%.

Fig. 9. State of protected seeds 20 days after sowing, in laboratory conditions

Fig.10. State of protected seeds 20 days after sowing, in field conditions

Fig.11. Chamber with controllable parameters of heat, light and humidity of soil and air

4. Conclusion

The following conclusions were drawn from the experiment:

1. Polyethylene glycol does not reduce the possibilities for seed germination and is not a limiting factor in the germ development.
2. Seeds covered by polyethylene glycol do not sprout at temperatures under 8^{o}C in either of the solution concentrations, irrespective of the soil humidity. This allows the seeds to remain at rest until stabilization of average monthly temperatures above 8^{o}C, thus reducing the chances for freezing.
3. Additional research is needed to establish the exact temperature at which the seeds coated by polyethylene glycol germinate.

It is important to note that fresh solutions of polyethylene glycol were used for the experiment and the seeds stayed at different temperatures within a week.

The subsequent experiments under the same scheme with a polymer, which has stayed for two months at direct sunlight and temperatures of 30-35^{o}C, led to lack of germination and aborting of the seed germs, most probably due to suffocation because of a change of the polymer's molecular mass, and/or other changes in the polyethylene glycol.

When the stay was longer than a month, in conditions of high humidity, even at low temperatures there was germination and freezing of seeds, which also poses a number of questions, concerning the exploitation of the polymer coating used.

The questions to be resolved are the following:

1. What is the optimal concentration of the polymer, which can be used without injuring the germ while at the same time delaying its development in unfavourable conditions? The optimal thickness of the coating should be determined as well.
2. How long and under what conditions can the polymer be stored without changing its properties?
3. How long and under what humidity does the polymer delay seed germination? The answer to this question can help to determine the optimal period for preparation of seeds and sowing.
4. How long can the seeds treated by the polymer be stored before sowing and under what conditions (temperature, humidity, light, etc.)?
5. How does soil microflora affect the polymer coating?

5. Literature

1. Benech-Arnold RL, Sanchez RA, eds., Handbook of seed physiology: applications to agriculture, New York, NY, USA: Food Product Press and the Haworth Reference Press, ISBN 1-56022-928-4
2. Cutforth H. W., Shaykewich C. F. and Cho C. M. Effect of soil water and temperature on corn (Zea mays L.) root growth during emergence, Can. J. Soil. Sci. 66, 51-58, (1986)
3. Dizaj K.A., Seed coating of safflower (Carthamus tinctorius L.) in order to delay germination, African Journal of Plant Science Vol. 4 (7), pp. 267-269, July 2010
4. Kumar at al., Development of polymeric seed coats for seed quality enhancement of soybean (Glycine max), Indian Journal ofAgricultura1 Sciences 77 (11): 738-43, November 2007
5. Sadeghi at al., Effect of seed osmopriming on Seed germination behavior and vigor of soybean (Glycine max L.), ARPN Journal of Agricultural and Biological Science, Vol. 6, no. 1, January 2011 ISSN 1990-6145
6. Schmolka, I.R. (1988). Seed protective coating. U.S. Patent No. 4735015
7. Shaban M. Effect of water and temperature on seed germination and emergence as a seed hydrothermal time model, Int J Adv Biol Biom Res. 2013; 1(12):1686-1691.
8. Zeng D. F. et al., Preparation and mechanism analyses of a new corn seed coating agent, Agricultural Sciences 2 (2011) 457-464