EFFECT OF SOIL TEMPERATURE AND MOISTURE OVER GERMINATION OF SEED COVERED BY ORGANIC POLYMER

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Abstract: Organic polymers used for seed coating have been reviewed aiming to protect the seeds placed into the soil under unfavorable for them conditions. Organic materials could be important hydrophobic agent in both high moisture and low temperature which could protect seeds from early germination. At the same time polymer film couldn’t be a obstacle for seed germination in favorable environment. Study of the polymers is important issue for the agricultural science and practice. In present work effect of soil temperature and moisture over germination of seed covered by organic polymer have been studied. It has been found that seeds coated with thin layer of organic polymer stead in dormancy under 8 ^{0}C independently of soil moisture. The polymer doesn’t effect on seeds germination ability as well.

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

1. Introduction

Sowing of corn seeds is usually done in the spring months in the presence of a changing climate and often unfavorable conditions. Optimal weather condition which are suitable for preserving the viability of seeds at the same time (temperatures over 8° C and soil moisture of 13-16%) are available for too short periods of time. Sowing seeds at high temperature and higher soil moisture and then rapidly declining could lead to seeds frosting due to premature germination.

To initiate the germ growth process, the seeds must be hydrated. They are located in the soil and therefore the degree of hydration will depend on the water soil potential. Hydration works because of the difference in water content in seed and soil. [10]

Each crop has different requirements about soil moisture, for example, this value for corn is 30%, wheat 40% and soybean 50%. The amount of water the plant receives is very small, but it is enough to initiate the process [4}.

The temperature is an another important factor for seed germination, biochemical reactions course and germ cells growth. Optimal temperature for corn seeds germination is 15-30^{o}C. Low temperature delay germ growth also it could be deadly for germ If the temperature is too low for long period of time [5].

A method of corn seed germination delay has been study in present work. It’s been necessary for reliable seeds germination in appropriate weather and soil conditions i.e. germ grow could be possible only when temperature is optimal for long period of time and have a minimum risk for germ frosting.

This effect can be achieved by additional protection of organic polymer seeds to which the following requirements have to be faced [11] such as: water-soluble; biodegradable; to allow good aeration and hydration of the seed; cheap and affordable for farmers; to cover easy and complete seed surface; non toxic.

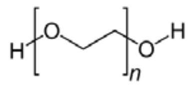
The plant cell has a natural cellulose exoskeleton, therefore modified cellulose polymers could be potential seeds coating agent, e.g. Methylcellulose, ethylcellulose ect [7].

Chitin is another natural biopolymer that could be used as seed coat. It covers insect cells and have cell protection function similar to cellulose at plant cells [6].

Some synthetic polymers are possible options for seed coating: polietielnglikoli, polyvinyl alcohol, polyacrylamide, etc. They have different properties and rate of water solubility. That could affect of their seed coverage ability [8].

2. Preconditions and means for resolving the problem

In this study has been used polyethylene glycol (PEG) as a coating agent with the general chemical formula:



Precisely PEG has been chosen because it meets most of the requirements: comparatively inexpensive, biodegradable and non-toxic, water-soluble and easy to apply to seeds [8,9].

Similar to all water-soluble polymers, PEG has a hydrophobic "tail" represent by a long polymer chain of ethylene glycols and a hydrophilic "head" which is a polar hydroxyl group at both ends of the polymer chain. A schematic structure is shown in Figure 1

When polar molecule of water reach polymer coated seed surface, a swelling process is observed. As a result, would be slowed down the process of transfer of water molecules onto the seed. Increasing the temperature accelerates the process of water diffusion through the polymer sheath.

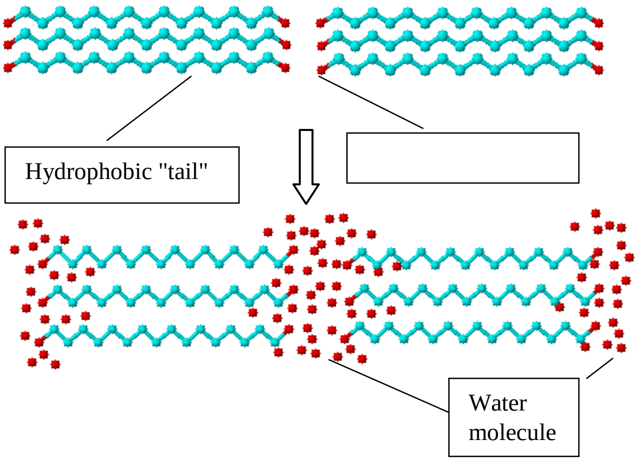


Fig.1 PEG molecule chemical structure and mechanism of water molecule diffusion through the polymer chains

For the purposes of the experiment, aqueous solutions of high molecular weight polyethylene glycol with a concentration of 0.1 and 0.05% were used. Some of the physicochemical properties are presented in Table 1.

Table 1 Physicochemical properties of PEG

Properties	Units	0,1% PEG	0,05% PEG
Viscosity (Brookfield)	cP	80	50
pH		9	9
Density	g/cm^3	1.003	1.002

Test seeds were placed in the beaker and pour the previously prepared PEG aqueous solution. The seeds were mechanically stirred for 5 minutes, then the solution was decanted and the seeds were placed in petri dishes on a filter paper for drying. The drying process is continued for 24 hours under intensive ventilation under laboratory conditions.

In accordance with the tasks set, an active experiment is being conducted. By its nature, it is a multifactorial regression analysis performed in laboratory conditions.

For conducting the regression experiment, control factors include: soil temperature x_1, absolute soil moisture x_2 and polymer concentration x_3. It is known that the nature of appearances occurring during seed germination has many and difficult to determine factors, but the three chosen are important for solving the task. Accepted levels of controllable factors are consistent with the recommended values given to them in the literature [1].

The task in conducting these tests is to check the possibility of controlling the germination process of maize seeds. In this sense optimization parameter is germination of the seeds defined in % – Y.

The cybernetic approach is used in the study. This approach allows you to study and manage an object just by its reactions Y_j, $j = 1,2,..p$, due to the external influences exerted on it, called factors - manageable ($x_1, x_2,...x_m$) and unmanageable If the controllable factors are quantifiable (measurable) general appearance of the relationship between the parameter Y_j the manageable factors are represented by the so-called "Response function" [2]:

$$, \quad E\left[Y_j / x_1,...,x_m\right] = \varphi(x_1, x_2,...x_m) \qquad (1)$$

where $E\left[Y_j / x_1, x_2,...x_m\right]$ is the conditional average of the parameter Y_j.

The type of function $\varphi(x_1, x_2,...x_m)$ depends on the nature of the parameter change Y_j in the selected area of change of factors $x_1, x_2,...x_m$ and is called the equation of regression. In conducting multifactor experiments that have the character of optimization tasks to obtain the type of equation (1), a second-order polynomial model is used which has the following factor:

$$, \quad \tilde{y} = \sum_{i=0}^{m} \beta_i x_i + \sum_{i,k=1}^{m} \beta_{ik} x_i x_k + \sum_{i=1}^{m} \beta_{ii} x_i^2 \qquad (2)$$

where $\beta_0, \beta_1,....\beta_m$ are the parameters of the model.

It should be borne in mind that the polynomial model simply approximates the function with some accuracy $\varphi(x_1, x_2,...x_m)$ in a small area of variability of the manageable factors. Therefore, one of the main tasks of each experimental study is the search for some approximation of the response function based on the received experimental data. In order for this approximation to be good, the experiments must be carried out on a special scheme - a plan of the experiment.

Very good properties are plans type B_m. In order to simplify the recording of the experiment conditions and to facilitate the processing of the experimental data, the coded factor values are used in planning the experiment in the plans. If the factor x_j, j = 1, 2, ..., m ranges at three levels - lower, middle and upper, the coded values of these levels will be -1, 0 and +1, respectively.

To find a polynomial of the type (2) relating to the series of experiments, a second-order plan Ha_3 (Hartley plan) [2] is used, which is written in Table 2. The use of compositional plans in the study allows to evaluate the individual and mixed influence of the individual manageable factors as well as to look for a possible optimum of the observed parameter.

The processing of all the results of the experiments carried out, as well as the determination of the necessary numerical characteristics of the studied parameters, was carried out with the help of the specialized software product "Statistics" 10.

Essential for the reliability of the resulting test results is the exclusion of non-established modes. In specific experiments, such a mode is the process of adapting the soil in the sample boxes to a certain level of the controllable factors x_1 and x_2. The duration of the individual experiments of the multifactor experiment at predefined levels of controllable factors is 4 days. Within this range, seed germination is reported at 12 hours. Each sample contains 50 pcs. Seeds of hybrid maize P9911.

All samples are placed in a special thermal insulated chamber (fig. 2), which provides the desired levels of temperature (0÷40^{o}C ±0.1^{o}C), relative air humidity (0÷100%) and level of lighting (0÷2300 lm) for a chosen period. Their control and management is achieved through an electronic control system. The operator can define levels of controlled factors and activate regime heating/cooling, damping pump and lighting system through the touch display of the chamber (fig. 3). During the experiments, humidity and temperature of the air in the chamber and soil in the samples are monitored using a set of sensors.

Fig. 2. Thermal insulated chamber

The average and upper levels of the factor x_2 correspond to 50% of the field capacity (FC) and of the FC for the type of soil in the vessels. According to its mechanical composition the type of soil used is leached black earth [3].

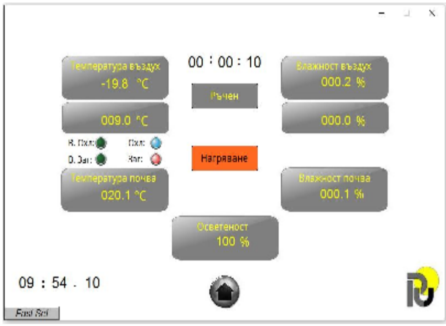


Fig. 3. Operator’s interface for programming

The electronic control system of the chamber is in automatic regime during all experiments. This way the programmed by operator levels of air temperature and humidity and hourly level of lighting are guaranteed.

The results for the Y parameter at the respective factor levels and the output matrix of the experiment are shown in Table 2. The graphical these results are represented by the surface of the response and the lines of the same level shown in Fig.4

Table 2. Factor levels, experiment matrix, and plan Ha3 research results

Levels	**Factors**		
	Temperature of the soil $x_1 - {}^0C$	**Absolute soil moisture x_2 -%**	**Polymer concentration x_3- %**
Low (-1)	**8**	**0**	**0**
Middle (0)	**11**	**18**	**<0,1**
High (+1)	**14**	**37**	**0,1**

Experiment matrix and results

№	x_0	x_1	x_2	x_3	x_1x_2	x_1x_3	x_2x_3	x_1^2	x_2^2	x_3^2	Parameter Y, %
1	1	+1	+1	+1	1	1	1	1	1	1	98
2	1	-1	+1	+1	-1	-1	1	1	1	1	0
3	1	+1	-1	+1	-1	1	-1	1	1	1	0
4	1	-1	-1	+1	1	-1	-1	1	1	1	0
5	1	+1	+1	-1	1	-1	-1	1	1	1	100
6	1	-1	+1	-1	-1	1	-1	1	1	1	0
7	1	+1	-1	-1	-1	-1	1	1	1	1	0
8	1	-1	-1	-1	1	1	1	1	1	1	0
9	1	+1	0	0	0	0	0	1	0	0	99
10	1	-1	0	0	0	0	0	1	0	0	0
11	1	0	+1	0	0	0	0	0	1	0	98
12	1	0	-1	0	0	0	0	0	1	0	0
13	1	0	0	+1	0	0	0	0	0	1	100
14	1	0	0	-1	0	0	0	0	0	1	100
15	1	0	0	0	0	0	0	0	0	0	98

3. Results and discussion

According to experimental data from Table 3 it was found that the average seed germination was 99%, which is close to 97% germination of the seeds from the control according to standard methodology. The germination rate of the seeds from the samples and the control corresponds to the germination indicated by the producer - over 96%.

The results of the Multi-factor regression analysis carried out with the “Statiska 10” multi-factor regression analysis are shown in Table 3. It shows that the germination factors are important for the factors x_1 and x_2. They

Affect both their linear parts and their mixed interaction with their quadratic part. This is confirmed by the obtained p-value, which for these two factors and their parts is less (the red lines) of the significance level $\alpha = 0,05$. As unimportant, the analysis indicates the factor x_3, in which, in all its parts, the probability p is greater than α. Consequently, the presence or absence of seed coating does not affect their germination. In this sense, the polymer used at different concentrations does not adversely affect the genetic potential of the seeds.

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Table 3. Results of multifactorial regression analysis performed with "Statistica-10"

	Regression Summary for Dependent Variable: Y (Spreadsheet1) R= ,97215595 R?= ,94508719 Adjusted R?= ,84624414 F(9,5)=9,5615 p<,01145 Std.Error of estimate: 20,048					
N=15	b*	Std.Err. of b*	b	Std.Err. of b	t(5)	p-value
Intercept			90,0889	10,77548	8,36055	0,000401
x_1	0,490950	0,104798	29,7000	6,33973	4,68474	0,005411
x_2	0,489297	0,104798	29,6000	6,33973	4,66897	0,005488
x_3	-0,003306	0,104798	-0,2000	6,33973	-0,03155	0,976054
x_1x_2	0,365933	0,104798	24,7500	7,08804	3,49180	0,017437
x_1x_3	-0,003696	0,104798	-0,2500	7,08804	-0,03527	0,973229
x_2x_3	-0,003696	0,104798	-0,2500	7,08804	-0,03527	0,973229
x_1^2	-0,368496	0,119317	-38,6111	12,50212	-3,08836	0,027210
x_2^2	-0,373268	0,119317	-39,1111	12,50212	-3,12836	0,026006
x_3^2	0,113465	0,119317	11,8889	12,50212	0,95095	0,385299

With the results obtained from the program, the following adequate regression model for the parameter Y is obtained:

$$Y = 90{,}09 + 29{,}7.x_1 + 29{,}6.x_2 + 24{,}75.x_1.x_2 - 38{,}61.x_1^2 - 39{,}11.x_2^2 \quad (3)$$

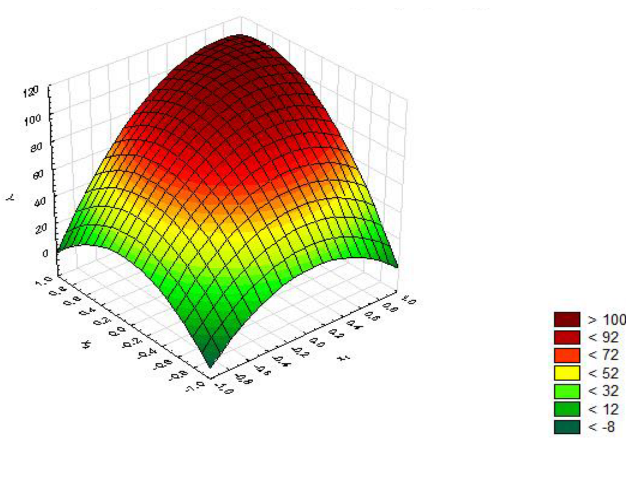
The adequacy of the model is proved by the calculated probability p that satisfies the condition:

$$p \; < \alpha \quad (4)$$

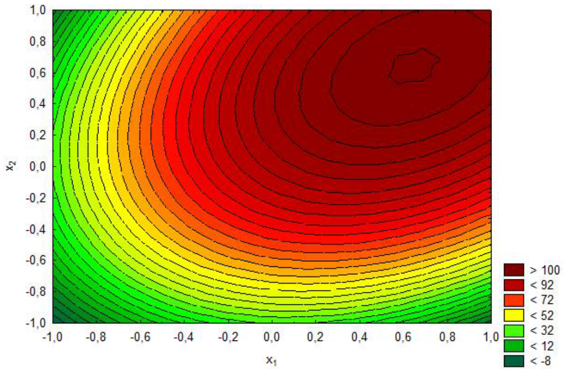
or

$$p_2 = 0.011 < \alpha = 0.05 \quad (5)$$

The analysis of equations (3) shows that the influence of soil temperature (x_1) and soil moisture (x_2) is equivalent to Y. This is confirmed by the values for the coefficient of determination (R^2) For the model after the sequential exclusion of these factors from the expression (3). In both cases, it has a value of 0.46. In its fullest form, an expression (3) shows that 95% (R^2 = 0.945) of the change of Y is due to the control factors x_1 and x_2, and is described with the represented second-degree model.



a)



б)

Fig.4. Graphic presentation of experiment results: a) - the surface of the response; b) - lines of the same level

Referring to Fig. 4 (a) and (b) graphs show that the regression equation for the Y parameter takes high enough for the practice values at factor levels: $x_1 > 0$ и $x_2 > 0$.

4. *Conclusion*

According to obtained experiment results could be made following conclusions

1. PEG as seed coat have no negative influence over seed germination, and couldn't be a limitation factor on seed growth
2. All PEG-coated seeds do not germinate at temperatures below 8 ° C, regardless of the soil moisture, which allows the seeds to remain at dormancy until monthly temperatures become stabile above this temperature, and hence to reduce the chance of frost.
3. Detailed studies are needed to establish the exact PEG coated seed germination temperature.

5. Literature

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