Annals of Warsaw University of Life Sciences – SGGW
Agriculture No 57 (Agricultural and Forest Engineering) 2011: 65–69
(Ann. Warsaw Univ. Life Sci. – SGGW, Agricult. 57, 2011)

Ecological treatment of grain in electric fields of high voltage

O.N. BEREKA, L.S. CHERVINSKIY
National University of Life and Environmental Sciences of Ukraine
Ukraine

Abstract: *Ecological treatment of grain in electric fields of high tension.* A method and system for pre-disinfecting and processing of grain in electric fields of high voltage are presented.

Key words: electric field of high voltage, partial discharges, ozone, grain weight, plant.

INTRODUCTION

Crop production is one of the most important branches of agriculture. Increasing production and improving the quality of crop is possible by reducing post harvest losses of phytopathogenic microflora and maximizing the potential of biological features of seed.

The microflora of grain mass consists almost entirely of anaerobic microorganisms. Anaerobic organisms are represented in it with yeast, some types of Mucorales fungi and bacteria. In circumstances where it is possible to develop micro-organisms, as in the recently assembled and long stored grain and seeds of all crops, as a rule, the fungi are primarily developed; there are about 220 species of them in the grain mass. They are able to form about 100 mycotoxins, which cause various diseases in farm animals and humans. Some mycotoxins are teratogenic, mutagenic and carcinogenic.

In order to prevent the development of the grain microflora there exist the chemical, biological and physical methods. Currently, treatment of grain is carried out mainly by chemical means. But along with the achievement of positive results, the use of chemicals has several negative consequences, including environmental contamination by pesticides and their accumulation in soil and in crop production, that bring about a threat to human and animal health, and the complexity of the performance of work [1].

Under these circumstances, the advanced countries of the world approved the state program of creation of organic farming to reduce the pesticide use and to develop the alternative methods for processing plants. First of all, attention is paid to electro-physical methods that involve the processing of seeds by electromagnetic, ionizing, light, ultraviolet, laser, and other methods. But these methods have not acquired the industrial use, because of the insufficiently precise reproducibility of results and low efficiency in the fight against pathogens of seeds; besides, some of them are very energy-consuming.

In recent years, there are developed the seed treatment methods with the help of the microwave field. But the

main drawback of microwave treatment is energy equipment for the generation of these fields, the low efficiency and significant weight and size, because it is difficult to make mobile installation.

To get effective results the electrophysical seed treatment should be based on two groups of factors: first – the impact on the physical processes directly in the grain, which leads to a biological stimulation of the second – the effect on the microorganisms that are on the grain surface, to neutralize their destructive activities.

High voltage electric fields are one of the most promising means of influence on grain crops. One of the directions in the electric fields of high voltage is pre-sowing grain handling, storage and processing [2, 3].

MATERIAL AND METHODS

At the department of electric and electro National University of Life and Environmental Sciences of Ukraine an attempt was undertaken to solve the scientific problems: development of scientific and technical prerequisites for the use of an electric field of high voltage to electrical seed treatments, that are based on the patterns of factors' influence of the electric field on the grain mass because of its physical characteristics that enhances crop yields and efficiency of storage of the grain material.

The establishment of effective technological modes of influence on the grain material calls for a clear understanding of the ways and mechanisms of action of the treatment method. It is essential to perform a complex theoretical and experimental studies of the electrical processes that occur in an individual grain and the grain weight of an electric field high voltage.

To study the mechanism of stimulation of biological processes there was considered a single grain in the electric field of high voltage direct current. We have proposed and theoretically justified hypothesis about the concentration of ions in the interstitial fluid and, accordingly, the trans-membrane potential of cells as a result of the passage of the conduction current under the electric field of high voltage. As a result the grain yield increases from the equilibrium state provided by seeding due to much more active process of germination and the subsequent growth.

To move to a new stable state, the grain must undergo biochemical changes, i.e. it must undergo a period of stabilization. Period of stabilization depends on the changes in the concentration of substances in interstitial fluid and the type of crop. This period can last from several days to several tens of days.

RESULTS

Figure 1 (a) shows the state after treatment: for example in sodium ions (black dots) lot outside a little, but even there, and there charges of sodium ions compensated by negative charges of the anions. On (b) there is shown the final state of dynamic equilibrium, where part of the sodium ions penetrates through the semipermeable membrane, outward positive ions become more chim negative inside the contrary. Anions of sodium ions pulled back, resulting in flow of sodium ions across the membrane to the side and on the second side become smooth.

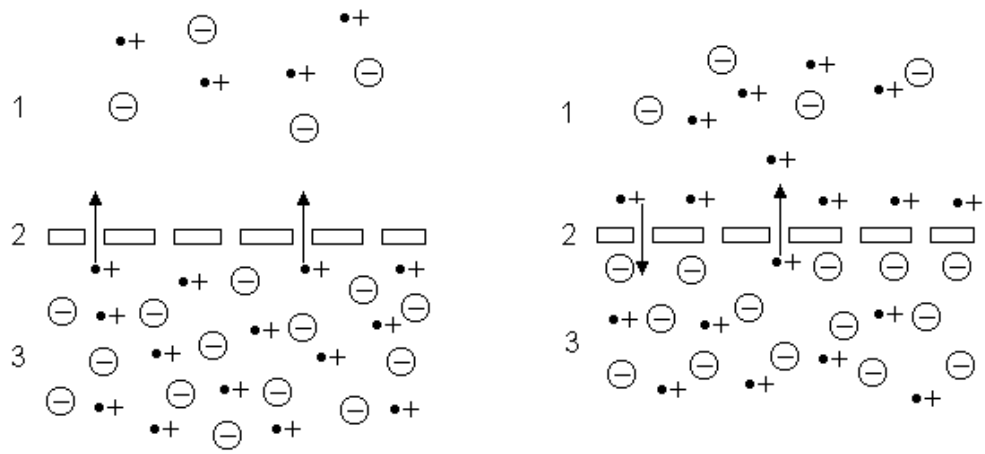

FIGURE 1. The process of resuming a steady state between cell and extra-cellular fluid: 1 – solution of interstitial fluid with a low concentration of ions, 2 – semi-permeable membrane, 3 – solution with a high concentration of ions inside the cell

When the flow of ions out in mid-equal, there is established a dynamic equilibrium, and the membrane potential difference is maintained constant. Its value is described by Nernst [4]:

$$E = \frac{RT}{F} \ln \frac{K_{p1}}{K_{p2}} \qquad (1)$$

where:
E – the potential difference on the cell membrane;
R – universal gas constant,
T – temperature,
K_{P1}, K_{P2} – the concentration of substances from outside and in the middle of the cell, respectively;
F – Faraday constant.

Thus, the cells will tend to level the change in concentration of ions by changing the intensity of metabolic processes. Experimental studies on the resistivity of flour from treated seeds and seed quality confirmed the correct hypothesis.

For the process conditions there should be considered a significant number of grains in one volume, so important to study physical processes in the grain mass.

To investigate the seed mass under the action of the high voltage electric field there were installed and grounded the previously unknown electrical processes, of scientific and practical value in the electro-technological seed treatment. This is the case of partial discharges, which are accompanied by ionization processes, and electro-synthesis of ozone in the air gaps of the grain mass.

Grain weight is a heterogeneous system (grain – air). When placing it between the flat parallel electrodes, which are connected to high voltage, for the values of the electric field of the initial flat Epoch (the electric field at which the partial discharge occurs), or large throughout the volume of grain mass in the air inclusion, partial discharges. The discharge current is determined by the

presence of free charges in the air gap and on the grain surface. Therefore, the total current in the grain mass can be represented as the sum of the conduction current and discharge current:

$$I_{зм} = I_n + I_p \quad (2)$$

where:
$I_{зм}$ – the total current in the grain mass;
I_n – current conduction;
I_p – discharge current.

Establishing the process of ozone formation in the whole volume of grain mass opens up new technological possibilities for disinfecting seed treatment. There is no need for a separate ozone generator, as an alternative to chemical drugs.

Modern ozonizer, in which ozone is produced with the help of electrical discharge in the air, including in itself, except for ozone generators, involves the auxiliary equipment: a system of cleaning and drying the air cooling system, compressor, air line system, measuring device. When applied, the ozone from generator to the processing chamber is partially decomposed, leading to significant losses. In addition, such treatments do not provide uniform contact with the production of ozone, which reduces the effectiveness of treatment.

The way proposed by the department of electric and electro National University of Life and Environmental Sciences of Ukraine is much more efficient in terms of uniformity of treatment and cost-effective, because ozone is formed directly in the seed mass, which in this case plays the role of the electrode system and is part of electrical industry.

Grain weight is located between the electrodes under an electric field. With an appropriate electric field in the volume of production, partial discharges in air inclusions, where the uniformity of distribution of electrostatic field will be the greatest. With increasing applied voltage, ionization occurs in an increasing number of air inclusions, and the magnitude of partial discharge pulses in the following aircraft is longer than in the previous ones. In addition there will be increased the intensity of ionization in the inclusions, where it started earlier. At the appropriate level of field strength over the entire volume of products, the ozone-air ion mixture is produced, the concentration of which is regulated by the electric field of high voltage.

There was found that the intensity of ionization processes in the air inclusions and grain mass, respectively, the ozone concentration depended on the magnitude of input voltage to the electrodes, between which the grain mass is placed, the specific conductivity of grain weight and shape of grains.

Research-based pilot plant was developed. Exterior view of the apparatus for processing corn into high-voltage electric field is shown in Figure 2.

The proposed electrical complex electrodes with a high potential with respect to the grounded casing inside the chamber treatment eliminates contact with them during processing. This makes the production plant safe for staff.

CONCLUSIONS

1. Professional studies proved that treatment of grain in high-voltage electric field can increase the yield of grain crops by 35%.

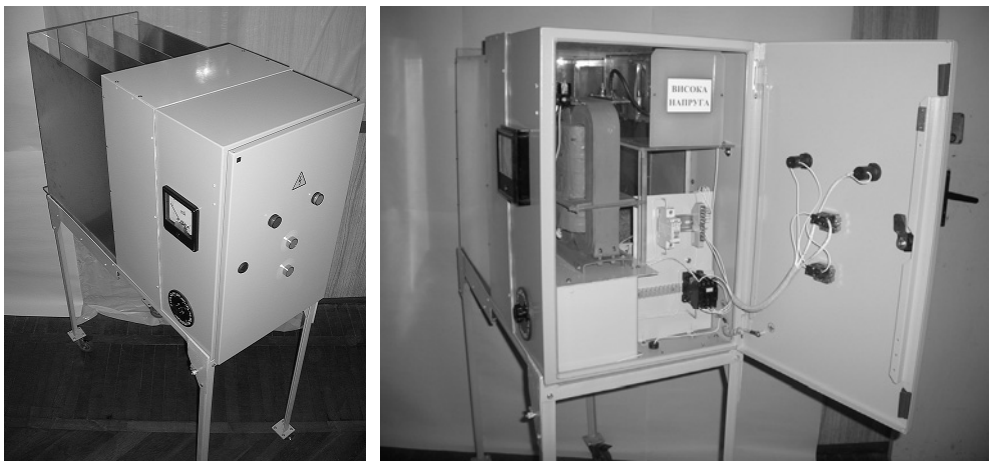

FIGURE 2. View of equipment for the processing of grain crops in the electric field of high voltage

2. Laboratory investigations proved that the proposed method enables to neutralize about 90% of spores solid sazhki. It should be noted that the studies were conducted on wheat with an artificial background. The concentration of spores sazhki was about 500 units per sample of grain. In the natural background this figure is considerably smaller (about 10).

REFERENCES

1. Кобець М.І. Органічне землеробство в контексті сталого розвитку / М.І. Кобець // Актуальні питання аграрної політики: Зб. робіт 2003–2004 рр. – К., 2004. – С. 108–131.
2. Бадретдинов Б. Ф. Электротехнология и урожайность сельскохозяйственных культур / Бадретдинов Б. Ф., Тюр А. А., Каюмов Я. М. – Уфа: БГАУ, 2000. – С. 90 – 92. – (Электрификация сельского хозяйства. Вып. 2).
3. Берека О.М. Пророщування пивоварного ячменю в електростатичному полі високої напруги / Берека О.М., Червінський Л.С., Салата М.П. – К.: НАУ, 2003. – С. 9 – 12. – (Електрифікація та автоматизація сільського господарства. Науково – виробничий журнал. № 2).
4. Беркинблит М. Б., Глаголева Е. Г. Электричество в живых организмах. – М.: Наука, 1988. – 288 с.

Streszczenie: *Ekologiczna obróbka ziarna w polu elektrycznym o wysokim napięciu*. Przedstawiono opracowaną metodę oraz wyniki badań laboratoryjnych dotyczących wpływu pola elektrycznego o wysokim napięciu na proces dezynfekcji i obróbki ziarna pszenicy. Stwierdzono wzrost plonów ziarna o 35% oraz zmniejszenie ilości zarodników grzybowych na powierzchni ziarna o 90%.

MS. received February 2011

Authors' address:
Bereka O.N., Chervinskiy L.S.
Education and Research Institute of Energetic and Automation National University of Live and Environmental Sciences of Ukraine
Heroyiv Oborony str. 15
03041 Kiev
Ukraine