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POSSIBILITY OF USING BIOLOGICAL AND PHYSICAL METHODS AS AN ALTERNATIVE TO CHEMICAL SEED TREATMENT

MOGUĆNOST KORIŠĆENJA BILOŠKIH I FIZIČKIH METODA KAO ALTERNATIVA HEMIJSKOM TRETMANU SEMENA

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ABSTRACT

An essential prerequisite for high yield is a healthy plant, which will be developed from a healthy seed. Seed quality is affected by many biotic and abiotic factors that decrease yield and its quality, and can be life-threatening to humans and animals if consumed. One of the most efficient and economical methods of achieving and maintaining good health condition of seeds is chemical treatment. Using active ingredients with systemic mode of action, plants will be protected during the most critical period of their development, germination and sprouting. Since pesticides cannot be applied in organic farming, new solutions had to be found for this increasing market. New methods, like high temperatures, low energy electrons, UV and gamma rays, magnetic energy, cold plasma, microorganisms etc. have been tested. Hot humid air and low energy electrons are already being used commercially, with the effects that are equal to chemical treatment. The tests conducted with microorganisms for seed disinfection showed that this method still cannot match the chemical seed treatment. Nevertheless, it has the potential that should be further tested. Perhaps the solution is a combination of biological and physical methods.

Key words: *seed treatment, low energy electrons, biological control, organic production.*

REZIME

Osnovni preduslov za visoke prinose je zdrava biljka, koja će se razviti iz zdravog semena. Na kvalitet semena utiču brojni faktori biotičke i abiotičke prirode, koji smanjuju visinu prinosa i njegov kvalitet, a mogu ugroziti zdravlje i život čoveka i životinja, ukoliko konzumiraju takvo seme. Jedan od najefikasnijih i ekonomski najprihvatljvijih načina postizanja i očuvanja dobrog zdravstvenog stanja semena je hemijski tretman. Koristeći aktivne materije sa sistemičnim dejstvom, zaštitićemo biljku tokom najkritičnijeg perioda njenog razvoja, tokom klijanja i nicanja. Tretman semena predstavlja odličnu alternativu primeni zemljišnih pesticida i folijarnoj primeni tokom vegetacije, jer se na ovaj način unosi znatno manje aktivne materije u prirodnu sredinu, i smanjuje opasnost od slučajne intoksikacije čoveka i životinja.

Kako primena pesticida nije dozvoljena u organskoj proizvodnji, poslednjih godina se radi na pronalaženju novih rešenja koja bi zadovoljila zahteve ovog rastućeg tržišta. Metoda termodezinfekcije je već zaživela u komercijalnoj primeni, a podrazumeva korišćenje toplog, vlažnog vazduha, koji destruktivno deluje na ćelije patogena, bez štetnog efekta na seme. Prednosti ove metode su širok spektar dejstva i efekat na patogene organizme koji je jednak hemijskom tretmanu. Zadovoljavajuće rezultate pokazao je i tretman elektronima niske energije. Niska energija ograničava prodiranje elektrona na debljinu semenjače, pa nema opasnosti po klicu. Pored fungicidnog, metoda pokazuje i dobro insekticidno dejstvo na jaja, larve, lutke i imaga skladišnih štetočina. Obe metode su pogodne kako za organsku, tako i za konvencionalnu poljoprivrednu proizvodnju.

Ispitivanja vršena sa mikroorganizmima pokazala su da ova metoda po rezultatima još uvek značajno zaostaje za hemijskim i fizičkim tretmanom semena. Bez obzira na dosadašnje rezultate ispitivanja u prirodnim i laboratorijskim uslovima, svakako da ima potencijal koji bi tretbalo ispitati i iskoristiti. Možda bi, u budućnosti, rešenje trebalo tražiti u kombinaciji biološkog i fizičkog metoda tretmana semena.

Ključne reči*: tretman semena, elektroni niske energije, biološka kontrola, organska proizvodnja.*

INTRODUCTION

People have appreciated the importance of healthy seed since the day they started to farm land. Some of the first data about seed treatment are associated with the ancient Romans and Egyptians, who used onion sap for seed treatment. Some modern methods are based on experience gathered in the past, for instance hot humid air seed treatment is based on hot water treatment. The first evidence of using hot water dates from 1765. Immersing seed into water at the temperature of 45ºC for two hours eliminated some species of fungi from the seed surface (*STEC, 1999*). Modern tendencies in seed treatment are focused on creating new active ingredients that provide control of a wide range of diseases and pests, have systemic action and are highly effective in small dosages.

Increasing demands for organic food and environment preservation induced the development of new methods based on ecological principles, for achieving and maintaining seed health. Some of these methods include using high temperatures, low energy electrons and natural enemies of diseases and pests.

MATERIAL

Chemical seed treatment

Chemical seed treatment is one of the most efficient and economical methods of crop protection. When the treated seed is sown, a protective zone is being formed in the ground, leaving the seed free of pests and diseases. If the active ingredient has systemic action, some of it will be absorbed by the roots, and transported to the epigeous part of the plant, providing protection from the above ground pests and diseases. One or more active ingredients can be applied to the seed surface, mixed together, or in layers (*Đilvesi et al., 2008*). Applying pesticides to the seed also has less damaging effects to the organisms that are not targeted, and the occurrence of drift is minimal. Seed treatment

provides good health condition of seeds during storage, sowing, germination and sprouting, but cannot improve low germination due to mechanical and other damages, or poor storage conditions. One of the key factors for high quality treatment is applying an adequate polymer. Polymers provide better adherence of the active ingredient to the seed, better seed flow, minimal release of pesticide dust during application and later, manipulation of the treated seed. In the Institute of Field and Vegetable Crops imported pesticide carriers have been used since the beginning of 1990s. The experiments with domestic carriers started in 1992 and since the season 1993/94 they have been in regular use in seed treatment (*Đilvesi et al., 2009*).

Seed purity also significantly affects treatment quality. Organic and inorganic impurities absorb the active ingredient, which leads to improperly protected seeds on one hand, and high amount of pesticide dust on the other, representing danger to people, animals and environment. Seed treatment quality is being measured by Heubach test, an officially acknowledged method in Austria, Switzerland and Slovenia. The test is based on the assumption that all of the released dust is active matter. The maximum allowed amount of dust ranges from 2 to 4 mg per 100 kg of seed. To prevent accidental consumption of the treated seeds, legislature in many countries instructs that the treated seed has to be coloured. The colour also has a significant role in appearance of the seed, and can be used to emphasize certain characteristics of the seed, for instance resistance to herbicides. The colours can also be used for simple and quick determination of the seed by adding invisible markers that emit fluorescent light of certain wavelength when exposed to ultra violet light.

Hot humid air seed treatment

The method is based on the assumption that pathogens have lower tolerance to high temperatures than seeds. It represents a combination of treatments with hot water and dry hot air, eliminating detrimental effects such as soaking and drying of the seed, or excess drying due to dry hot air.

Feasibility of hot humid air use for seed disinfection has been tested since 1999 with the financial support of European Union. Tests were conducted in a modern laboratory with precisely defined conditions and computer control. The first process line for thermal seed treatment was built in Sweden in 2005. It started working in spring 2006, with the capacity of over 200 tons of wheat per day (*Thermoseed)*.

The limit value of air temperature for seed treatment is defined as the highest temperature that a seed can be exposed to for certain duration of time and air humidity, without significant detrimental effects on germination, or delay of germination (*Forsberg, 2004*). The limit value of air temperature depends on plant species, as well as a seed lot, as a result of different weather conditions that crops have been exposed to, and consequently different chemical compound and water content. It is determined by prior testing of samples for each lot. Samples are exposed to air current of different temperatures, in the range that is expected to be optimum. Germination of the treated seed and control is determined afterwards. Relative humidity of air should be above 90%. In this case moisture content on the seed surface rises during the treatment, inducing higher susceptibility of pathogens towards high temperatures. The treatment should be stopped before the negative effect of temperature is expressed on the seed embryo (*Forsberg, 2004*).

Successful application of this method depends on following:

– Moisture content – seed with smaller moisture content can tolerate higher temperatures, while at the same time pathogens become more susceptible due to excess moisture added by the air current with high relative humidity.

– Treatment duration – adequate treatment duration provides the maximal effect on pathogens, without detrimental effects to the seed.

– Seed maturity – a mature seed has lower tolerance for high temperatures.

– Location of the pathogen – if the infection of the seed is internal, possibility of eliminating it is smaller.

– Temperature range that enables efficient elimination of pathogen with preserved quality of the seed.

– Shell thickness – seed with thicker shell can endure higher temperatures (*Forsberg, 2004*).

– Advantages of the method are multiple:

– Results show that by the effect on pathogens this method can match chemical treatment.

– Products can be exported to foreign markets without registration.

– It can be used in production of organic food.

– No introduction of pesticides into the environment.

– Affects a wide range of diseases.

– No toxic materials that represent danger to operators.

– If the treated seed is not used for sowing, it can be used as food without risk.

– Pathogens do not develop resistance.

The method has some drawbacks; namely, it has low effect on internal infections of the seed, and no ability to prevent infections through infected soil, water and by airborne pathogens.

Low energy electrons seed treatment

The method has been developed in Germany, and shows satisfying results in experiments carried out in several countries. It is based on the destructive action of low energy electrons (below 300 keV) to pathogen cells, without detrimental effect to the seed itself. Penetration depth of electron beam depends on power of electric field in which the electrons are being accelerated and cannot exceed depth of seed tegument (0.025-0.5 mm). Otherwise, it would lead to damage of the seed and mutations, and therefore lower germination (*Eschrig et al. 2007*).

Tests carried out in Romania, showed that the seed treated with electrons gave an increase of yield of 11% compared to control (*Zago and Rela, 2007*).

This method can also be used for elimination of eggs, larvae, pupae and adults of some insect species in stored grains. The number of developed adults of species that feed inside the seed was below 10% compared to control, and for the species that are fed externally, not one adult was developed from the treated seed (*Imamura et al, 2004*).

This method also shows good results in delaying potato tubers from sprouting. Electrons with energy between 250 and 350 kV can significantly delay sprouting, even after 4 months at 20 ºC (*Todoriki and Hayashi, 2000*).

This method has the same advantages and disadvantages as hot humid air treatment.

Biological seed treatment

Biological seed treatment implies the use of microorganisms (MO) and products of plant metabolism in order to protect seeds and seedlings. Most of the registered preparations are based on bacteria and fungi. When the treated seed is planted, between MO on the seed surface and those in the soil, one of the following relationships will be established: parasitism, competition, antagonism or antibiosis (*STEC, 2000*). Due to the specific mode

of action, the majority of preparations are effective on one pathogen.

Treating seed with adequate MO can significantly increase the number of healthy plants that develop from infected and treated seeds. However, results show significant variations in repetitions of the same treatment, which means that the level of protection varies *(Tinivella et al., 2009)*. It often happens that, although a preparation has good efficacy in laboratory conditions, this is not the case when tested in the field. It is probably due to low quality application of MO to the seed surface, competition with the MO in the soil or unfavorable climatic and soil conditions (*Jensen et al., 2000)*.

Protection of some vegetables, like carrots and peas, is especially hard, and there is still no adequate solution, as far as biological seed treatment for seed transmitted diseases is concerned (*Tinivella et al., 2009, Koch et al., 2010*). The combination of physical (hot humid air) and biological methods shows better results. In this case, the regime of the physical method can be downsized, decreasing detrimental effects to the seed (*Koch et al., 2010*).

Slower development of this technology is the result of many problems regarding formulation of preparations, shelf life of preparation and treated seed, lack of knowledge concerning relationships that are established between MO of the soil and on the seed surface, etc. In some countries there is no law that regulates this area, so that biological preparations cannot be registered, nor can the treated seed be introduced into the market.

DISCUSSION

The chemical seed treatment is the most widely accepted method of seed protection. It provides protection against a wide range of diseases and pests during storage, planting, germinating and sprouting. Using chemically treated seeds, a lower amount of pesticides is introduced into the soil, and the number of treatments during the season is decreased.

The effects of the hot humid air seed treatment and low energy electrons can match the chemical seed treatment. Since these methods do not have a long lasting effect, the treated seed should be planted in the areas where there is no danger for the seed to be infected, since planting healthy seed in infected soil makes no sense. These methods should be applied in the areas with lower pressure of diseases and in organic farming. Going by the regulations of the European Union, the seeds used for organic production also have to be produced according to the principles of organic farming.

The effectiveness of the biological method is limited, since it shows good results in laboratory, which are inconsistent in the field. It is due to a large amount of factors that affect the efficacy of microorganisms. The solution should be looked up in the combination of physical and biological methods, thus widening the range of affected pathogens, and lengthening the period of time during which the seed is protected.

CONCLUSION

General demand of pesticide free food stresses the need of biological and physical seed treatment methods. Some of them, hot humid air and low energy electrons for instance, have shown excellent results in seed disinfection, and are commercially applied. It is expected that further research will lead to a wider range of reliable, non-pesticide methods that contribute to the environment conservation.

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