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Influence of corona discharge field on seed viability and dynamics of germination

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A b s t r a c t. Literature sources state that an electromagnetic field causes physiological-biochemical changes in seeds. Water assimilation becomes faster, breathing of a germinating seed intensifies and its viability improves. Having reviewed the data about using electromagnetic fields in stimulating seed viability by different authors, it becomes obvious that research of seed germination dynamics is scarce. In addition, viability of ill- condition seeds is rarely indicated. The research reported herein was performed with carrot, radish, beet, beetroot and barley seeds, using corona discharge electric field of continuous current. During the research it was established that the germination density function of the seeds affected by corona discharge field is described by lognormal distribution and that of the non-affected seeds – by normal distribution. This fact shows that the seeds affected by corona discharge field germinate faster than those non-affected, and their germination dynamics is greater. Due to the influence of the stimulating field, carrot seed viability increased by 24%, that of radish and beetroot – by 12%, beet seeds – 7%, and barley seeds – 9%. Viability increase was also substantial.

K e y w o r d s: corona discharge field, seeds, viability, germination dynamics

INTRODUCTION

It has been observed that electromagnetic (electric and magnetic) fields cause physiological-biochemical changes in seeds. Water assimilation becomes faster, breathing and photosynthesis of germinating seeds intensifies, and all this results in improved viability of a viable seed (Putincev *et al*., 1997). Industrial, high and superhigh frequency electromagnetic, alternating or continuous current corona discharge and electrostatic fields, as well as magnetic fields of different intensity are used for the treatment.

It has been established that while treating carrot, beetroot, turnip, dill and radish seeds with superhigh frequency (2.4 GHz) equipment, low viability 15-30% seed does not react to the field impact but viability of conditioned seed increases by 7-14% (Borodin, 1997). It has been established as well that treating onion seed with electromagnetic field of the same frequency improved field viability by 6-8% and the shoots appeared 3-4 days earlier (Jurtajev, 1997). The research on high frequency electromagnetic impact on vegetable seeds done at Moscow SAU showed that their viability increased by 14-18% (Borodin and Scerbakov, 1998). The treatment of cereal, vegetable and flower seeds with 50 Hz frequency electromagnetic fields resulted in increase of growing vigour and viability by up to 30% (Guteckii, 1999).

Many researchers studied the stimulation of seeds by using corona discharge electric field (Baneviciene and Pozeliene, 1995; Palov, 2003; Borodin and Scerbakov, 1998). Some of them suggested treatment with corona discharge field only (Baneviciene and Pozeliene, 1995; Palov, 2003; Borodin, 1997; Borodin and Scerbakov, 1998), and noted an increase of viability within the range of 7-19%. Others suggested treatment with corona discharge field together with soaking and further watering of plants with magnetization water (Szendro and Kaltay, 1995).

In addition to corona discharge, an electrostatic field was also used to stimulate seeds (Gan-Mor, 2003; Ksenz and Kaciesvili, 2000; Yadov, 2000; Smigel and Nijazov, 1998). Such a field increased seed germination energy by 5-20% (Ksenz and Kaciesvili, 2000), and the related gain in yield was 20-25% (Gan-Mor, 2003).

It is known that using magnetic fields activates enzyme complexes in the seed, which ensures faster growing of the germ, increases germination energy, and speeds up rooting (Carbonell *et al*., 2000; Davies, 1996; Pietruszewski, 1996). The mentioned authors indicate that field viability increases

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by 8% after magnetic treatment. One of those authors (Davies, 1996) states that impulse magnetic field activates intercellular seed structures which are bound in between magnetically. Treatment of seeds with low temperature plasma and magnetic field (Ircha *et al*., 1996) allows increasing germinating energy and viability by 6-10%.

At the Stavropol State Academy of Agriculture the influence of unipolar corona discharge field, and of continuous and alternating magnetic fields and infrared rays on seed metabolism and plant development was studied (Bobrysev *et al*., 2000). The mentioned author states that such treatment of preplant, viable but ill-conditioned viability seeds allows achieving standard indicators. The authors attribute such a phenomenon to seeds obtaining additional energy from the acceleration of biological processes (Bobrysev *et al*., 2000).

Notwithstanding different literature sources analysing the influence of electromagnetic fields on stimulation of seed viability, we have not found data about germination dynamics of stimulated seeds. The influence of corona discharge field strength and seeds moisture on barley seeds germination is described in the paper (Lynikiene and Pozeliene, 2003).

The research objective is the establishment of the influence of corona discharge field impact on seed germination dynamics and stimulation effect on viability.

MATERIALS AND METHODS

In the research of the influence of corona discharge field on seed germination dynamics, ill-conditional viability seeds of carrot, radish, beetroot, beet and barley were chosen. The viability was expressed as a percentage quantity of normally sprouting seeds in the seed sample under analysis. The viability was determined by sprouting seeds under the best standard conditions. The seeds were treated with corona discharge field at the Energetics Department of the Institute of Agricultural Engineering, Lithuanian Agricultural University. The strength of corona discharge field for carrot (*Daucus carota*) and radish (*Raphanus sativus*) seeds was E=2 10^5 V m^{-1} and that for beetroot, beet (*Beta vulgaris L.)* and barley (*Hordeum sativus L.*) seeds – E=3 10^5 V m^{-1}. The duration of seed treatment in the field was the same for all seed types: t =2 s. Control viability of carrot seeds was 33%, beetroot – 43%, barley – 65%, radish – 70% and beet – 67%. The moisture content of seed was standard: radish – 9%, carrot – 11%, beet and beetroot – 14%, barley – 15%. The parameters of corona discharge field for seeds of different plants were selected according to the data of previous research analysis which were presented in articles (Pozeliene and Lynikiene, 1998; Pozeliene, 2000). The seeds treated with corona discharge field were seeded 10 days after the action. The seeds were germinated on moist filtration paper in Petri dishes put into a TPS-2 thermostat at 20°C temperature. Each variant was germinated in 4 repetitions at 100 seeds. The number of germinated seeds in all the variants was calculated every day. Student's criterion was used to evaluate mean viability values of control seeds and of those treated with the field, and Pearson's criterion was applied for evaluation of experimental data regarding lognormal and normal distributions.

RESULTS AND DISCUSSION

The germination dynamics of carrot, radish, beetroot, beet and barley seeds are shown in Figs 1-5.

During the analysis of the results obtained it was observed that the germination density function of untreated (control) seeds was described by using normal distribution (Kruopis, 1993):

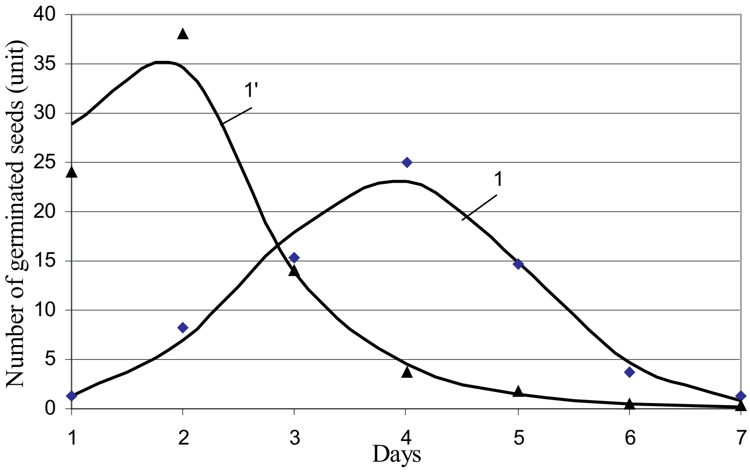

Fig. 1. Germination dynamics of radish seeds: 1 – radish seeds (control); 1' – radish seeds (treated).

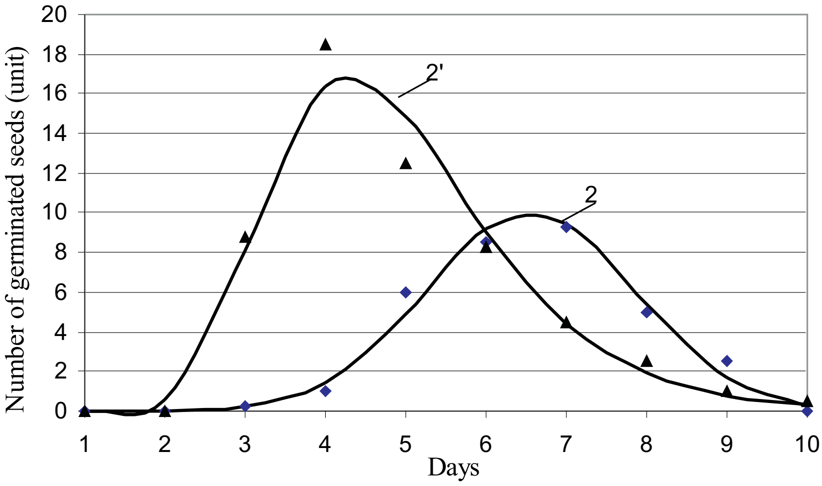

Fig. 2. Germination dynamics of carrot seeds: 2 – carrot seeds (control); 2‘ – carrot seeds (treated).

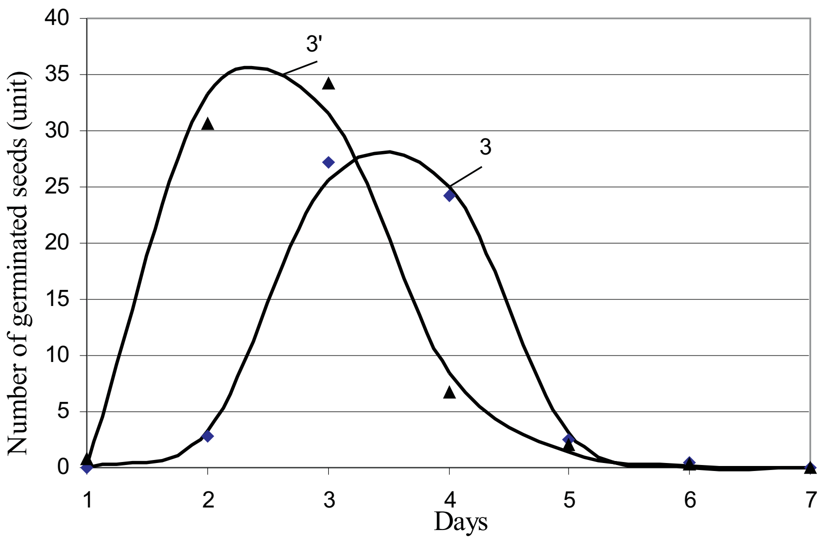

Fig. 3. Germination dynamics of beet seeds: 3 – beet seeds (control); 3‘ – beet seeds (treated).

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right), \quad (1)$$

where: *f(x)* – density function, *x* – days, unit; μ – mean, $\mu = \sum_{i=1}^{n} n_i x_i \,/\, \sum_{i=1}^{n} n_i$; n_i – number of germinated seed per day, unit; *n* – number of days; σ – standard deviation.

Lognormal distribution was used for describing seeds treated with corona discharge field (Kruopis, 1993):

$$f(x) = \frac{1}{x\sigma\sqrt{2\pi}} \exp\left(-\frac{(\ln x-\mu)^2}{2\sigma^2}\right), \quad (2)$$

where: μ – mean of *ln(x)*, $\mu = \sum_{i=1}^{n} n_i \ln(x_i) \,/\, \sum_{i=1}^{n} n_i$; σ – standard deviation of *ln*(*x*).

Numerical values of Eqs (1) and (2) are given in Table 1. Lognormal distribution, which is typical for germination density of seeds treated with corona discharge field, proves the proposition that the seeds treated in such a field germinate several days earlier. While analysing standard deviations of germination density functions of control seeds and the seeds treated with corona discharge field (Table 1), we can see that germination of the treated seeds is much more compatible. Standard deviation σ (germination diffusion) of field treated seeds is 2-3 times lesser than that of the control ones.

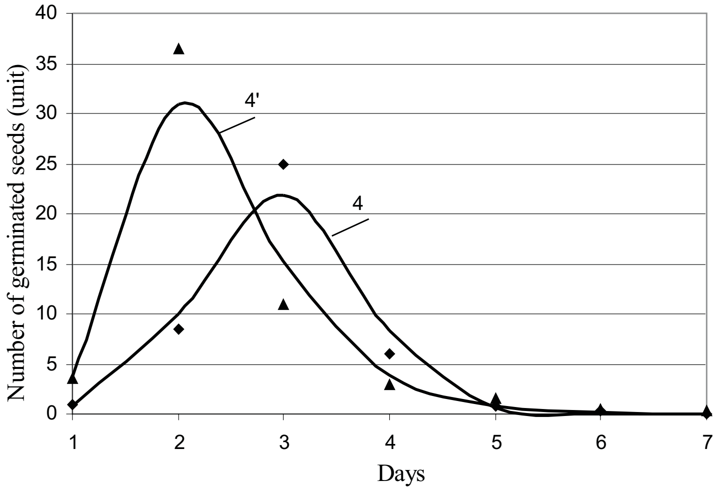

Fig. 4. Germination dynamics of beetroot seeds: 4 – beetroot seeds (control); 4‘ – beetroot seeds (treated).

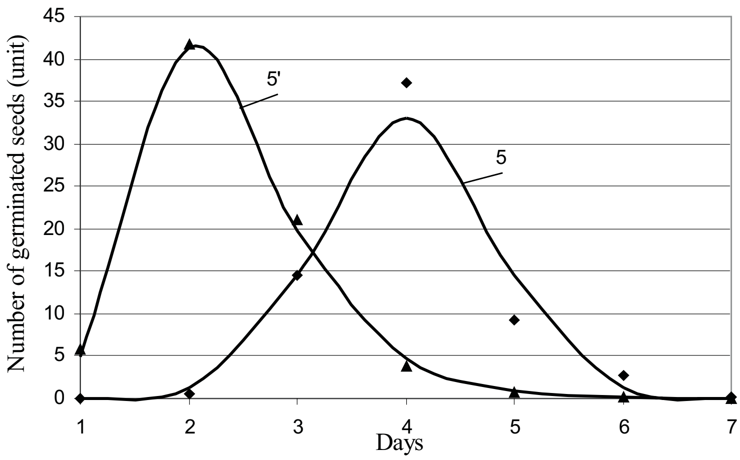

Fig. 5. Germination dynamics of barley seeds: 5 – barley seeds (control); 5‘ – barley seeds (treated).

T a b l e 1. Parameters of normal and lognormal distributions

Seeds	Variants	μ	σ	χ^2	Distribution
Carrot	Control	6.55	1.29	1.19	Normal
	Electric field	1.55	0.29	1.75	Lognormal
		At f=9 and p=0.05: $\chi^2_{0.95}$=16.9			
Radish	Control	3.80	1.15	4.14	Normal
	Electric field	0.59	0.39	10.91	Lognormal
Beet	Control	3.49	0.69	4.49	Normal
	Electric field	0.96	0.28	1.79	Lognormal
Beetroot	Control	2.95	0.76	11.22	Normal
	Electric field	0.81	0.34	5.07	Lognormal
Barley	Control	4.00	0.78	7.54	Normal
	Electric field	0.80	0.33	0.58	Lognormal
		At f=6 and p=0.05: $\chi^2_{0.95}$=12.6			

Note: f - number of respective degrees of freedom; p – probability level; χ^2 – Pearson's criterion.

Table 2. Evaluation of results of corona discharge field impact on seed viability

Seeds	Variants	$\bar{x}$	s	$t_{calc.}$	$t_{(0.95;6)}$	Notes
Carrot	Control	70.0	2.16		2.45	
	Electric field	82.2	2.99	6.6		substantial
Radish	Control	32.5	3.0		2.45	
	Electric field	56.5	5.57	7.6		substantial
Beet	Control	67.3	6.81		2.45	
	Electric field	74.5	7.19	3.5		substantial
Beetroot	Control	43.3	3.3		2.45	
	Electric field	55.5	2.08	6.3		substantial
Barley	Control	64.5	4.55		2.45	
	Electric field	73.5	3.46	3.2		substantial

Note: $\bar{x}$ - arithmetic mean of viability; s - estimated standard deviation; $t_{calc.}$, $t_{(0.95;6)}$ – calculated Student's criterion and Student's criterion value form the table.

The results obtained show that the seeds treated with corona discharge field not only germinate faster and in a more compatible manner, but their viability is also better than that of control seeds. Viability of seeds treated with corona discharge field is higher than that of control seeds as follows: carrot – by 24%, radish and beetroot – 12%, beet – 7% and barley – 9%. In judging about the substantial or incidental increase in viability of the treated seeds Student's criterion was used. The evaluation of influence of corona discharge field on seed viability is given in Table 2.

Statistical processing of the data shows that the increase in viability of the seeds treated with corona discharge field is substantial in comparison with the control.

CONCLUSIONS

1. Corona discharge field has positive influence on germination dynamics of low viability seeds. It speeds up seed germination by 2-3 days and increases germination compatibility.
2. Density function of the seeds treated with corona discharge field is described by lognormal distribution and that of untreated seeds – by normal distribution.
3. Viability of the seeds treated with corona discharge field exceeds viability of control seeds as follows: carrot seeds – by 24%, radish and beetroot – 12%, barley – 9% and beet – 7%. The increase in viability is substantial.

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