Int. Agrophysics, 2008, 22, 255-259

INTERNATIONAL
Agrophysics
www.international-agrophysics.org

Influence of alternating magnetic field on respiration of sugar beet seeds

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Received February 21, 2008; accepted March 27, 2008

A b s t r a c t. The effect of 5 different methods of sugar beet seed treatment on seed vigour was examined. The methods were: rubbing, conditioning, alternating magnetic field treatment, rubbing in combination with alternating magnetic field treatment, conditioning in combination with alternating magnetic field treatment. Some treatments influencing the true sugar beet seed inside the pericarp (conditioning, conditioning with 16 Hz treatment) caused an increase of seed respiration on the 1st day of germination. The average respiration increased during the 3 days of the experiment. Only two seed treatments – conditioned and conditioned together with magnetic field treatment – reached their maximum respiration on the 2nd day after the beginning of germination.

K e y w o r d s: sugar beet, seed treatment, seed respiration, seed vigour

INTRODUCTION

Modern agriculture needs sowing material of best quality. That means high seed vigour. The highest vigour seeds germinate in almost 100% and germinate quickly giving normal seedlings. Also the field emergence is high and uniform, even under non-optimal environmental conditions (temperature, soil moisture).

It is not so easy to obtain high quality seed. Vigour of seed depends not only on genotype and conditions of maternal plant growth, but also on time and method of harvest and post-harvest seed treatment.

Traditional methods of post-harvest seed preparation, like drying, cleaning or seed dressing, have been used by seed companies for a long time (Durrant and Mash, 1990). The seed industry is still developing new methods to improve seed quality and field emergence. Seed pelleting is now common in vegetables and sugar beet. Also seed conditioning becomes more popular. In 2003, 30% of sugar beet seeds sown in Great Britain were conditioned. Other methods, like fluid drill, growth regulator treatment, stimulation with laser or magnetic and electric field treatment are being developed (Tonkin, 1979; Phirke *et al*., 1996; Samuilov *et al*., 2004; Wilczek *et al*., 2005).

Different methods of improvement are used for different seed types. Sugar beet seeds are in fact monogerm fruits and have very thick pericarp, rich in germination inhibitors. To improve the quality of sugar beet seeds, methods like rubbing are also needed.

Treatments improving sugar beet seed quality can be divided into two groups. The first group of methods (for example rubbing) consists in changing the structure of pericarp. The second group of methods includes conditioning and magnetic field treatment which influence directly the true seed inside the pericarp. There are also methods combining elements from both groups, like rubbing or conditioning combined with magnetic field treatment.

Respiration process is responsible for releasing energy which is stored in ATP. Embryos that have a better supply of organic compounds and more energy develop faster and better. So the respiration of seeds at the beginning of germination may be a good indicator of seed vigour.

The objective of this work was to measure the influence of alternating magnetic field on sugar beet seeds respiration.

MATERIAL AND METHODS

Sugar beet seeds of 3 varieties: Jastra, Jamira and PNMono 1, were obtained from the Sugar Beet Breeding Station in Kutno (Poland). Jastra and PN Mono 1 were diploid, Jamira was triploid. In this experiment the most numerous seed fraction (3.5-4 mm of seed diameter) was used. Seed samples were prepared in the following ways:

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– rubbing by hand with emery paper. The treatment removes the external layer of pericarp and enables water to get to the true seed inside of pericarp;
– conditioning during 24 h under optimal water and temperature conditions (65% of full water capacity of blotting paper, 20°C). The seeds stayed in germination boxes on moist blotting paper for one day and after that they were taken out and air-dried at room temperature;
– treatment with 16 Hz alternating magnetic field (described below);
– rubbing in combination with 16 Hz alternating magnetic field treatment;
– conditioning in combination with 16 Hz alternating magnetic field treatment.

In last two combinations the seeds were rubbed or conditioned before the magnetic treatment.

Air-dried seeds were treated with an alternating magnetic field of low frequency (16 Hz) for 2 h. Magnetic flux density was 5 mT. The magnetic field generator was constructed by the Electronic Department of the University of Technology in Wrocław (Poland). The generator produced a homogenous magnetic field of frequency 16 Hz and strictly determined magnetic flux density. The design of the generator eliminated the electric component of the field and enabled treatment of seeds with only alternating magnetic field. To avoid overheating, the seeds inside the equipment were cooled by an air stream at room temperature.

Samples consisted of 100 seeds in three replications. The control group consisted of seeds of the same varieties but not treated at all.

Seed respiration was measured with LICOR–6200 produced by LICOR Company, Nebraska, USA. Respiration was measured during three consecutive days during the beginning of seed germination. Seeds were germinated at optimum water content in germination medium (65% of full water capacity of blotting paper), temperature of 20°C, in darkness.

Pieper's coefficient is the mean time of germination of a single seed and it was calculated according to the formula:

$$W = \Sigma(d\ Pd)/k\ ,$$

where: W – Pieper's coefficient, d – day of seed germination, Pd – number of seeds germinated on a given day, k – number of all germinated seeds.

All the results were analysed in 2 factor variance analysis (ANOVA program, Student test) (Mądry, 1998).

RESULTS

Tables 1 and 2 show the results of the germination tests. Magnetic field treatment (single or in combination with other methods) increased germination percentage (Table 1). In the case of speed germination (Pieper's coefficient) (Table 2) magnetic field is favourable for diploid varieties (Jastra and PN Mono 1). Rubbing increased seed germination only in combination magnetic field treatments (Table 1). The most effective method of seed vigour improvement was conditioning in combination with alternating magnetic field treatment. Seed conditioning has been known for a long time as a very effective method of seed quality improvement measured by germination ability and field emergence (Podlaski *et al*., 2003). Germination percentage (Table 1) and germination speed (Table 2) of the two diploid varieties (Jastra and PN Mono 1) did not differ significantly. Seeds of the triploid variety Jamira had a lower germination percentage and germinated more slowly. The additional chromosome set in Jamira genome could influence the ability to germinate and germination speed. However, the seeds of all examined sugar beet varieties reacted in the same way. The effect of magnetic treatment was more visible in diploid than in triploid varieties. The highest germination percentages were obtained for conditioned and magnetic field treated seeds.

Tables 3 and 4 the present changes in respiration of sugar beet seeds during the first 3 days of germination. The respiration of sugar beet seeds changed with time after the beginning of germination. The lowest values of respiration for all the seed treatments were observed on the 1st day after the beginning of germination. The average respiration increased during the 3 days of the experiment. Treatment with magnetic field did not influence the seeds respiration. But in combination with rubbing and especially conditioning it caused a significant increase in it. However, two seed treatments: conditioning and conditioning together with magnetic field treatment reached their maximum respiration on the 2nd day after the beginning of germination.

The treatments strongly influenced seed respiration. During the first 3 days of germination the highest respiration was reached by conditioned seeds and seeds conditioned in combination with magnetic field treatment. The other treatments also increased the respiration but the increase

T a b l e 1. Germination percentage of seeds of 3 sugar beet varieties after 4 days of germination

Seed treatment	Germination (%)			
	Jamira	Jastra	PN Mono1	Average
Control	55.3	65.3	65.0	61.8
Rubbed	73.3*	67.0	61.7*	67.3
Conditioned	84.0*	81.1*	83.3*	82.8*
16Hz	71.0*	71.0*	74.0*	72.0*
Rubbed + 16 Hz	81.0*	84.7*	80.7*	82.1*
Conditioned + 16 Hz	90.3*	91.0*	92.3*	91.2*
LSD P<0.05	6.26	3.80	2.87	10.31

*Results significantly differ from control.

T a b l e 2. Germination speed (Pieper's coefficient) of seeds of 3 sugar beet varieties after 4 days of germination

Seed treatment	Pieper's coefficient (days)			
	Jamira	Jastra	PN Mono1	Average
Control	3.77	3.69	3.64	3.70
Rubbed	3.45	3.34*	3.50*	3.37*
Conditioned	3.07*	3.11*	2.84*	3.01*
16Hz	3.63	3.61*	3.45*	3.56
Rubbed + 16 Hz	3.26	3.20*	3.12*	3.19*
Conditioned + 16 Hz	3.03*	2.93*	2.65*	2.87*
LSD P<0.05	0.59	0.06	0.06	0.25

*Explanations as in Table 1.

T a b l e 3. Respiration of sugar beet seeds per gram of fresh weight during first 3 days of germination

Seed treatment	Respiration (mg CO_2 h^{-1} g of fresh weight)		
	1st day	2nd day	3rd day
Control	0.10	0.15	0.21
Rubbed	0.10	0.19*	0.25*
Conditioned	0.13*	0.33*	0.24*
16Hz	0.08	0.17	0.23
Rubbed + 16 Hz	0.12*	0.22*	0.25*
Conditioned + 16 Hz	0.14*	0.34*	0.29*
LSD P<0.05	0.02	0.03	0.03

*Explanations as in Table 1.

was smaller. Conditioned seeds and seeds conditioned in combination with magnetic treatment reached maximum respiration on the 2nd day of germination, followed by a rapid decreased. Seeds treated with other combinations of treatments showed a rapid increase of respiration during the 1st and the 2nd day of germination. During the 2nd and the 3rd day the respiration still increased strongly, except for rubbed and conditioned seeds for which there was less increase (Table 4).

The three sugar beet varieties differed in respiration (Table 5). The differences were not significant at the begining of experiment but they increased every day and were significantly different after 2 days. Differences, however, were visible only when the respiration was expressed as mg CO_2 h^{-1} g of fresh weight (Table 5). The differences in seed respiration between the varieties were the smallest for

T a b l e 4. Respiration of sugar beet seeds per 100 seeds during first 3 days of germination

Seed treatment	Respiration (mg CO_2 h^{-1} g of fresh weight)		
	1st day	2nd day	3rd day
Control	0.18	0.27	0.39
Rubbed	0.16	0.28	0.39
Conditioned	0.23*	0.58*	0.45*
16Hz	0.15	0.31*	0.45*
Rubbed + 16 Hz	0.18	0.33*	0.39
Conditioned + 16 Hz	0.25*	0.63*	0.48*
LSD P<0.05	0.03	0.03	0.03

*Explanations as in Table 1.

untreated (control) seeds and the largest for conditioned seeds and conditioned + 16 Hz seeds (Table 5). The highest average respiration was found for seeds of PN Mono 1 variety. But on the 3rd day of the experiment both diploid sugar beet varieties (Jastra and PN Mono 1) reached the same average respiration. The mean respiration of triploid variety (Jamira) seeds was lower (Table 5). The varieties differed also in reaction to seed treatment. Triploid variety (Jamira) reacted differently to the treatments than the diploid varieties (Table 5).

DISCUSSION

Vigour of seeds of sugar beet can be increased by two groups of methods. The first group consists of changes in pericarp structure (rubbing). The second group acts directly on the true seeds inside the pericarp (conditioning and magnetic field treatment). These methods can be used separately or in combination. It was interesting to compare the influence of alternating magnetic field with other post-harvest methods of improvement of sugar beet seeds (Tenforde, 1991).

The highest respiration was found for seeds that were conditioned and conditioned + magnetic field treated. These also had the highest germination percentage and shorter mean time of germination (Table 1) of single seed (Pieper's coefficient) (Table 2) compared to the other treatments. Magnetic field had a favourable influence on the true sugar beet seeds. Treatments that influenced the true seeds inside of pericarp (like conditioning, conditioning + 16 Hz, rubbing + conditioning and conditioning + 16 Hz) significantly increased the seed vigour measured as respiration. The most effective seed treatment was the combination of conditioning and treatment with magnetic field.

T a b l e 5. Respiration of sugar beet seeds (mg CO_2 h^{-1} g of fresh weight) during first 3 days of germination with relation to variety and method of seeds treatment

Day	Variety	Control	Method of seeds treatment					$LSD_{P<0.05}$
			Rubbed	Conditioned	16 Hz	Rubbed +16 Hz	Conditioned +16 Hz	
1	Jastra	0.08	0.10	0.13	0.07	0.11	0.12	0.02
	Jamira	0.11	0.11	0.12	0.09	0.11	0.13	
	PN Mono1	0.12	0.10	0.14	0.08	0.12	0.17	
	Mean	0.10	0.10	0.13	0.08	0.12	0.14	
2	Jastra	0.13	0.20	0.28	0.20	0.17	0.33	0.03
	Jamira	0.16	0.19	0.29	0.18	0.26	0.34	
	PN Mono1	0.15	0.22	0.40	0.15	0.24	0.41	
	Mean	0.15	0.19	0.33	0.17	0.22	0.35	
3	Jastra	0.18	0.19	0.23	0.21	0.22	0.25	0.04
	Jamira	0.19	0.25	0.22	0.24	0.23	0.32	
	PN Mono1	0.25	0.28	0.26	0.22	0.29	0.3	
	Mean	0.21	0.25	0.24	0.23	0.25	0.29	

Respiration is an important indicator of seed dormancy breaking and subsequent seed germination (Bogatek and Rychter, 1984). Rapid rise in respiration in our experiments was correlated with higher germination percentages and quicker germination. For agronomic practice it is obvious that faster development of seedlings leads to higher yield.

Magnetic field stimulates seed respiration and energetic metabolism, helps to reach normal respiration intensity and normal energetic metabolism, accelerates germination and plant growth, especially under stress conditions – for example at low temperature (Rochalska, 1997).

The effect of conditioning and conditioning in combination with magnetic field treatment was also noted by Halpis-Ingham and Sudstrom (1992). The phenomenon was connected to higher metabolic activity in the early stages of germination and accelerated development of seedlings (Bhupendra-Singh and Ganwar, 2005).

The results presented in this paper confirmed the thesis that magnetic field, whether separately or in combination with other treatments, especially acting directly on the true seeds, is an efficient way of pre-sowing seed quality improvement for several species (Rochalska and Orzeszko-Rywka, 2005).

CONCLUSIONS

1. For sugar beet seeds the measurement of seed respiration is a suitable method of assessment of the effects of magnetic field stimulation.

2. It describes the status of the true seed inside of pericarp and reflects its future germination course and seedling emergence.

3. The seed respiration in the early stages of germination confirmed the favourable influence of magnetic field on sugar beet seed quality and metabolism.

REFERENCES

Bhupendra-Singh R. and Ganwar C.B.S., 2005. Seeds vigour evaluation in mungbean. Farm Sci. J., 14, 82-84.

Bogatek R. and Rychter A., 1984. Respiration activity of apple seeds during dormancy removal and germination. Physiol. Veg., 22, 181-191.

Durrant M.J. and Mash S.J., 1990. Sugar-beet seed treatments and early sowing. Seed Sci. Technol., 18, 839-850.

Halpis-Ingham B. and Sudstrom F.J., 1992. Pepper seed water content, germination response and respiration following priming treatments. Seed Sci. Technol., 20, 589-596.

Mądry W., 1998. Experimentation (in Polish). SGGW Development Fundation Press, Warsaw, Poland.

Phirke P.S., Patil M.N., Umbarkar S.P., and Dudhe Y.H., 1996. The application of magnetic treatment to seed: method and responses. Seed Sci. Technol., 24, 365-373.

Podlaski S., Chrobak Z., and Wyszkowska Z., 2003. The effect of parsley seed hydratation treatment and pelleting as seeds vigour. Plant Soil Environ., 49, 114-118.

Rochalska M., 1997. Influence of alternating magnetic field on germination of maize seeds at low temperature. Roczn. Nauk Roln., A, 112, 91-99.

Rochalska M. and Orzeszko-Rywka A., 2005. Magnetic field treatment improves seed performance. Seed Sci. Technol., 33, 669-674.

Samuilov F.D., Ionenko I.F., Pakhomov D.V., and Matveeva N.M., 2004. Changes in energy metabolism and water state in germinating seeds under influence of presowing hardening and treatment with synthetic cytokinins analogues. Russia Agric. Sci., 4, 8-12.

Tenforde T.S., 1991. Biological interactio of extremely-low-frequency electric and magnetic field. Bioelectrochemistry and Bioenergetics, 25, 1-17.

Tonkin J.H.B., 1979. Pelleting and other pre-sowing treatments. Advances Res. Technol. Seeds, 4, 84-105.

Wilczek M., Koper R., Ćwintal M., and Korniłłowicz-Kowalska T., 2005. Germination capacity and health status hybrid alfalfa seeds after laser treatment. Int. Agrophysics, 19, 257-261.