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IMPACT OF MAGNETIZED WATER ON GERMINATION ENERGY OF SEEDS AND WEIGHT OF GARDEN SAVORY *(SATUREJA HORTENSIS L.)*, BUCKWHEAT (*FAGOPYRUM ESCULENTUM* L.), YELLOW LUPINE (*LUPINUS LUTEUS L.*) AND WINTER RAPE (*BRASSICA NAPUS L.*) SEEDLINGS

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Abstract

The laboratory experiment was carried out in 2008-2009. It consisted of several series of measurements, which were designed to evaluate the effect of magnetized water on seeding value and growth of seedlings and the weight of selected plant species. The results confirmed a diverse reaction of assessed species seeds towards the type of water used. Magnetized water stimulated the seed germination of garden savory and rape, while had no effect on the seeds of yellow lupine. In case of the seeds of buckwheat, this parameter decreased under the influence of magnetized water in the first six days of the experiment. A beneficial effect of bio-stimulation with magnetized water on the rate of growth of the aboveground parts of seedlings was recorded. The positive effect related to all species. The greatest stimulation was observed in buckwheat and garden savory. The use of magnetized water reduced the growth rate of roots at garden savory and buckwheat, while it increased the growth of winter rape roots. It had no effect in yellow lupine. The type of water exerted a significant influence on the fresh weight and roots of seedlings. Regardless of the assessed species, the use of magnetized water resulted in a significant

increase in fresh weight and roots by 6% and 9%. No significant influence of the water type on dry matter of seedlings of analysed plant was assessed.

Key words: Magnetized water, seed germination, fresh and dry weight of seedlings

INTRODUCTION

A clear increase in the interests in applying direct and alternating magnetic fields to pre-sowing seed treatment and to stimulate the growth and development of different plant species, has been observed among scientists since early 80s. In addition, magnetic-treated water is applied to irrigate plants, especially in Mediterranean as well as Middle East and Far East countries. Spectrum of studies indicate the positive effect of this type of water on plants growth and development, and in consequence, the high crop yields (Baskin and Rokhinson 1996, Pang and Deng 2008, Maheshwari and Grewal 2009, El-Yazied *et al.* 2012, Deshpande 2014, El Sayed and El Sayed 2014, Shahin *et al.* 2016).

Remarkable deficiency in rainfall, occurrence of high air temperatures and excessive salinity of land, where irrigation has to be applied, are very unfavorable factors in arid zone countries. It has been demonstrated that applying the direct and alternating electromagnetic fields, besides positive impact on germination and initial growth of a variety of plant species, can also diminish unfavorable salinity effects (Hachicha *et al.* 2016, Mahmood and Usman 2014, Teixeira da Silva and Dobranszki 2014).

The influence of an external direct magnetic field can affect the transfer rate and direction of polarized particles of a substance, which in consequence, may determine the rate and direction of many processes occurring within plants (Kordas 2000, Pietruszewski 1999). Beneficial properties of magnetized water widely reported by Pang and Dang (2008) as well as Teixeira da Silva and Dobranszki (2014), can be also used during providing plants with nutrients through a fertigation treatment. However, this type of magnetized water application is not fully understood yet.

Despite of the fact that there are plenty of experiments upon the influence of magnetized water on seed germination and initial growth of plants, achieved results are often difficult to compare because of different conditions applied.

Nevertheless, all researchers conclude that the final effects of magnetized water depend on the degree and intensity of magnetic induction, flowing water exposure time, a number of water stream passes through magnetic field, as well as water flow rate, and obviously plant genotype.

Therefore, there are results confirming a stimulating influence of magnetized water on seed germination and plant growth. There are also results that

do not confirm this impact or indicate their negligible effect. In general, there are no research results pointing out to strictly negative influence of magnetic-treated water on seeding value and plant vegetation (Pietruszewski 1999, Podsiadło and Leśniak 2009, Pietruszewski *et al.* 2013, Teixeira da Silva and Dobranszki 2014).

The aim of the study was to determine the impact of water treated with direct magnetic field on seeding value and weight of above ground parts and roots of buckwheat, yellow lupine, winter rapeseed, and garden savory seedlings.

MATERIAL AND METHODS

In 2008-2009, the laboratory experiment was conducted, and consisted of a series of tests aiming at determining the effects of magnetized water on germination and initial growth of buckwheat, yellow lupine, garden savory, and winter rape seeds.

The tests were carried out in germination chambers of 12cm × 22cm dimensions and on Petri dishes. The substrate contained two layers of filter paper free of harmful chemicals, characterized by neutral pH, and high water capacity. The air temperature in the experimental room was maintained at 20-22°C for the whole period of research. Individual plants were tested according to the following pattern: four replicates of 100 seeds each, for the control as well as for the objects treated with magnetized water. The neodymium direct magnetic field magnets were used for magnetic treatments. In order to get a prolonged "water magnetization" effect, the magnetizer was composed of several sections. Each section was built of the same elements. A particular section consisted of axis-magnetized ring-shaped magnet made of barium ferrite and ring-shaped steel pole. The magnetic fluxes generated by magnets, after penetrating the pole, changed their direction from axial to radial.

The magnetizer used in the experiments had no rim, while was characterized by induction of 0.30 T. The effect of water magnetic treatment was realized by a single pass of medium through the magnetizer. Water flow rate was 0.8 $m^3 \cdot h^{-1}$.

The aime of the experiment was determining the influence of water treatment process on germination dynamics of seeding material, growth of fresh weight and dry matter of above ground parts and roots of buckwheat, yellow lupine, winter rape and garden savory.

Germinated seeding material was counted for 12 days. In order to emphasize differences in germination and seedling growth dynamics, data to analyses were collected on 2, 4, 6, 8, and 10 day. The germination energy was evaluated on 4 day, while germination ability on 10 day of experiment.

Study results, as mean values of every replicate, were statistically processed applying analysis of variance and Tukey test at the significance level of $\alpha = 0.05$.

RESULTS AND DISCUSION

Results of studies upon dynamics of seed germination of tested plant species varied, which also was reflected in other authors' reports (Pietruszewski 1999, Podsiadło and Leśniak 2009, Shahin *et al.* 2016). There was a decrease in the buckwheat seed germination rate, especially during the first 6 days of experiment in objects treated by magnetized water. In subsequent days, the germination dynamics was similar for both water variants.

Other impact of magnetized water on seed germination was observed for yellow lupine, at which magnetic treatment of water only slightly improved germination rate. Meanwhile, a clear stimulation of seed germination dynamics was found for two remaining plant species: garden savory and winter rapeseed.

Among tested plant species, the lowest germination dynamics values were shown by seeding material of winter rape and garden savory (Figure 1).

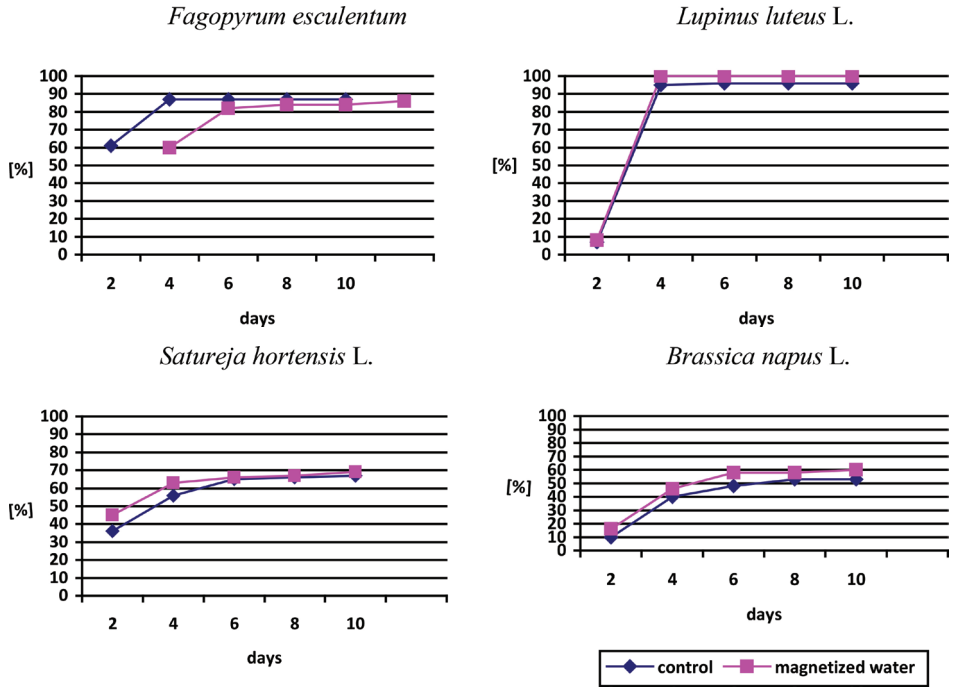

Figure 1. Dynamics of seed germination (%)

Seeding material of tested plant species revealed different germination energy and ability. The highest levels of both indicators were found for yellow lupine – 98% and 98% as well as for buckwheat – 85 and 87%,, respectively,

whereas the lowest germination energy and ability was shown by seeding material of winter rape (43% and 56%) and garden savory (60% and 68%) . There was no significant influence of magnetized water on assessed seeding values indicators for tested plant species (Table 1).

Table 1. Influence of the water type on germination energy and plant species (%)

Species	Type of water	Germination energy	Germination ability
Fagopyrum esculentum	C*	87	87
	M	82	86
Mean		85	87
Lupinus luteus	C	95	96
	M	100	100
Mean		98	98
Satureja hortensis L.	C	56	67
	M	63	69
Mean		60	68
Brassica napus L.	C	40	53
	M	46	58
Mean		43	56
Mean	C	70	76
	M	73	79
$LSD_{0.05}$ for species		10	9
$LSD_{0.05}$ for type of water		n.s.**	n.s.
$LSD_{0.05}$ for interaction		12	13

*C – control, M – magnetized water
** – not significant difference

Moreover, the research results demonstrated a positive effect of water magnetic bio-stimulation on a dynamics of above ground parts of seedling growth (Figure 2).

This positive influence referred to all species, namely up to the 6 day of magnetized water application. To the greatest extent, the stimulating effects were observed for buckwheat and garden savory, while in the case of winter rape seedlings, the impact was the weakest.

Dynamics of root growth at tested seedlings species was different. This differentiation was the most evident during the first four days of experiment. Applying the magnetized water decreased the root growth rate of buckwheat and garden savory, while increased the rate of winter rape roots. It had no impact in

the case of yellow lupine (Figure 3). The longest roots were recorded on the last day of experiment in all species treated with magnetized water.

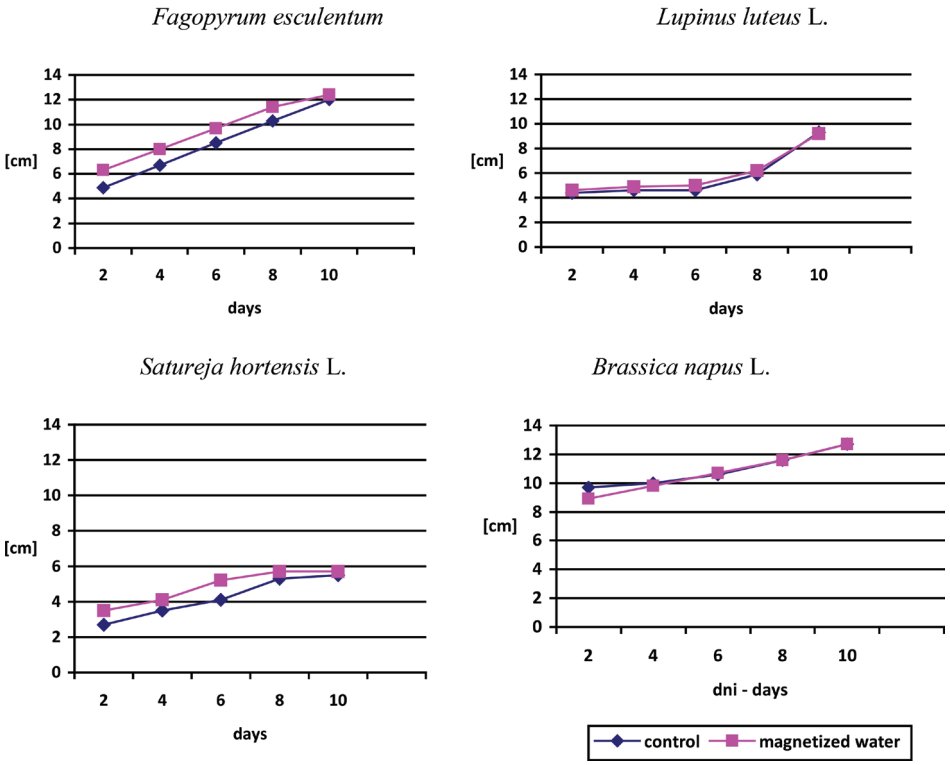

Figure 2. The growth dynamics of above ground parts of seedlings (cm)

Another parameter that was evaluated during the experiment was dry and fresh weight of seedlings (Table 2). Type of applied water exerted considerable effect on the fresh weight of the above ground parts and roots of seedlings. Regardless of the species, the use of magnetized water caused significant increase in the fresh weight of above ground parts and roots by 6% and 9%, respectively. No significant effect of the water type on dry matter of tested seedlings species was observed.

Of tested plants, the highest weight, both of above ground parts and roots, was produced by yellow lupine and buckwheat, while the lowest by garden savory seedlings. The largest increase in the fresh weight and dry mater due to the magnetic treatment was recorded for winter rape (by 62% and 100%, respectively) as well as buckwheat (by 6% and 13%, respectively). In the case of two

remaining plant species, no significant influence of applied magnetized water was observed.

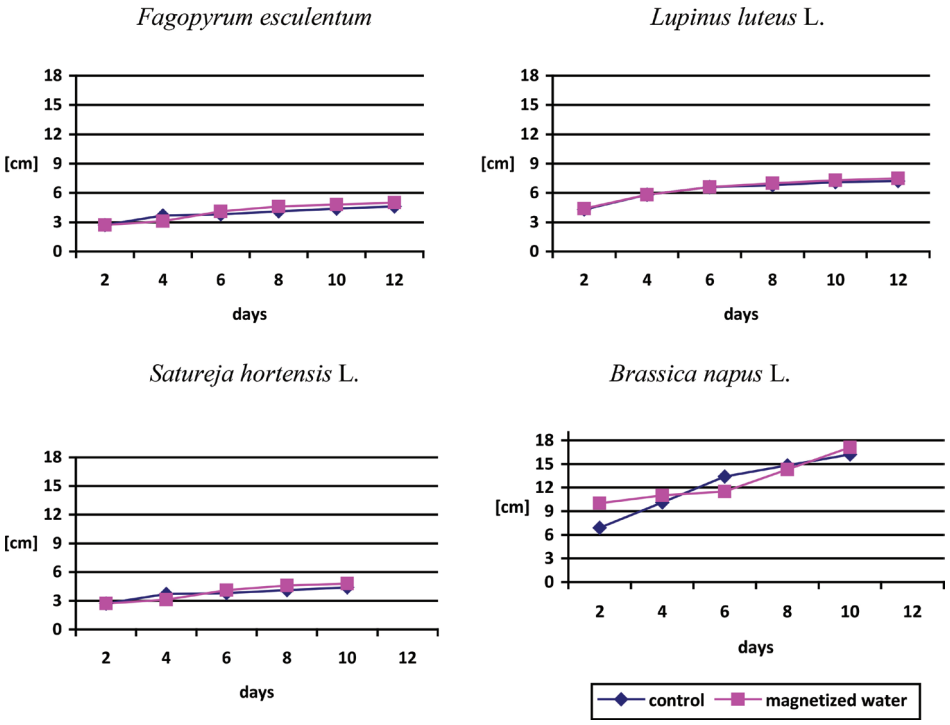

Figure 3. Seedling root growth dynamics (cm)

The study results achieved from the experiments indicate that plant's reaction towards magnetized water treatment varied. In most cases, the water type exerted positive effects as evidenced by increased germination energy and ability as well as growth of the above ground parts of tested species seedlings, however, some of them revealed insignificant or negligible reactions.

The obtained results proved the opinions of numerous authors that the impact of magnetic treatment on seeding value and seeds initial growth is diverse. This is mainly affected by the type and dose of applied magnetic fields, exposure time, water flow rate through magnetizer, and plant genotype (Pietruszewski 1999, Podleśny and Gendarz 2008, Maheshwari and Grewal 2009, Podsiadło and Leśniak 2009, El-Yazied *et al.* 2012 Shahin *et al.* 2016).

Table 2. Influence of the water type on fresh weight and dry matter of seedlings (g)

Species	Type of water	Fresh weight		Dry matter	
		Above ground parts	Roots	Above ground parts	Roots
Fagopyrum esculentum	C*	1.64	0.87	0.22	0.06
	M	1.74	0.99	0.22	0.06
Mean		1,62	0.93	0.22	0.06
Lupinus luteus L.	C	4.33	1.37	0.53	0.11
	M	4.23	1.30	0.52	0.10
Mean		4.28	1.33	0.52	0.10
Satureja hortensis L.	C	0.28	0.09	0.05	0.01
	M	0.29	0.10	0.05	0.01
Mean		0.28	0.09	0.05	0.01
Brassica napus L.	C	0.71	0.18	0.12	0.03
	M	1.15	0.36	0.14	0.04
Mean		0.93	0.27	0.13	0.03
Mean	C	1.74	0.63	0.23	0.05
	M	1.85	0.69	0.23	0.05
$LSD_{0.05}$ for species		0.71	0.23	0.10	0.05
$LSD_{0.05}$ for water		0.07	0.04	n.s.**	n.s.
$LSD_{0.05}$ for interaction		0.89	0.45	0.15	0.05

*C – control, M – magnetized water
** – not significant difference

CONCLUSIONS

1. The type of applied water differentiated the seeding value of tested plant species. Magnetized water stimulated germination of garden savory and winter rapeseed, while had no influence on seeds of yellow lupine. This parameter decreased in buckwheat seeds in the first 6 days of experiment.
2. A positive influence of water magnetic bio-stimulation on a growth dynamics of the above ground parts of seedlings was recorded. The positive effect referred to all tested species. The largest stimulation was observed in case of buckwheat and garden savory.
3. The use of magnetized water lowered the root growth rate of buckwheat and garden savory, but increased it in case of winter rape. The applied factor had no influence on yellow lupine

4. The type of applied water exerted significant impact on fresh weight of the above ground parts and roots of seedlings. Regardless of the species, the use of magnetized water caused significant increase in the fresh weight of above ground parts and roots by 6% and 9%, respectively. No significant influence of the water type on dry matter of tested seedlings was recorded.

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