Original Article

Electromagnetic transference of molecular information in garden cress germination

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ABSTRACT

We followed the hypothesis that biologically relevant information from various substances can be non-chemically transferred to organisms through the combination of a high voltage electric field that can stably imprint information into water or a water solution. A special device was constructed and a thoroughly tested biological sensor system (cress seedlings exposed to heat stress) was used. Results showed biological effects of electrically imprinted information of biologically active substances into water solutions, however not necessarily with an obvious connection to the effects of the original (donor) substance. The growth reaction of cress seedlings was either stimulatory or inhibitory depending on the time of application.

Keywords: molecular information, electromagnetic transfer, heat stress, herbicide, cytokine, cress, germination

1. Introduction

There is no doubt about the direct, albeit sometimes variable, effects of the alternation of electromagnetic or magnetic fields (EMFs) on plant growth and germination, where the ability to germinate, as well as the growth of roots, are influenced by using different EMF intensities and frequencies [1,2]. For instance, very weak electric fields promote the root growth of garden cress [3,4], whereas a high electric field of more than 12 kV with an exposure time of more than 1 minute yields an inhibitory effect on the germination of tomatoes [5].

There are many published experiments indicating that the effects of EMFs can also be attributed to changes in the properties of water. This is important because water is one of the main environmental factors in the germinating process. Namely, lettuce exposed to a static magnetic field (MF) absorbs more water [6,7], while our own experiments demonstrated significant biological effects of alternating (AC) EMFs on water [8]. Many authors claim that water exposed to AC EMFs has a biological effect similar to the direct exposure of organisms to applied fields [9,10,11]. Fesenko even suggests that mediation via water can represent the bulk of mechanisms for the non-thermal biological effects of EMFs on organisms [10].

Experiments using weak EMF emission on organisms indicate that exposure acts as a sort of a mild stress. Hardly detectable biological effects become observable when EMF exposure is combined with an additional environmental stress agent [12-18]. For instance, Ruzic et al. [19] found that exposure to an EMF applied before heat stress, prepares the germinating seeds to stress and thus reveals biological effects of weak EMFs. Without heat stress, the effects of EMFs would be insignificant. Findings of this sort of reaction to EMFs were also confirmed in experiments with human cells [20] and are also known from plant physiology studies with multiple environmental stress factors. In the latter it was shown that exposure of tissue to moderate stress also induces resistance to other stresses [21].

Many other well-performed experiments reported in high-rated peer-reviewed journals point out to unusual properties of water under certain treatments. In one such case, thermodynamic methods were used. Using a standard calorimetric method at 25°C, Elia and Nicolli showed that mixing 0.01 mol/kg of NaOH with ultra high diluted salts (or inversely, by mixing an acid with ultra high diluted salts) produces a significant excess of heat [22]. Rey, on the other hand, demonstrated that ultra high diluted aqueous solutions of LiCl or NaCl emit light in wavelengths totally agreeing with the

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wavelengths of light emitted by the control solutions of LiCl or NaCl [23]. The authors maintain that the cause of the observed results cannot be attributed to donor ions, but to some physical structure or the information imprint of the donor ion.

Besides physical experiments, biological effects of ultra high diluted solutions have also been discovered [24-28]. A thorough statistical analysis of a series of experiments using a simple biological model (wheat germination *in vitro*), where a large number of seeds was treated with homeopathic preparations of arsenic trioxide, demonstrated that some dilutions repeatedly produced stimulatory effects, while others, e.g. 1. 10^{-45} dilution, produced an inhibitory effect. High dilutions prepared without the shaking process showed no significant effects [29].

In addition, there are some well performed experiments showing that *molecule information* of any chosen chemical substance or an ion can be transferred to water also via electric or EM fields, eliciting biological effects. Thomas et al. [30] suggest that phorbol myristate acetate molecules emit signals that can be electronically transferred to neutrophils, which then begin to produce the superoxide. This effect was found to be highly specific. Next, electronically transferred thyroxin information influences the metamorphosis of *Rana temporaria* [31]. After an initial acceleration period, the development from 2- to 4-legged tadpoles as well as to the juvenile frogs slows down. Also, by using bacteria *Escherichia coli,* Jerman et al. [32] demonstrated that the electrical water imprint of $MgSO_4$ and $MgSO_4$ on molecular form induced the same statistically significant decrease in the number of adaptive mutants relative to the control environment.

In spite of so many well-performed experiments, published in various peer-reviewed journals, the existence of so-called “water memory" is still a subject of intensive scientific debate, mainly because there is still no generally accepted theory to explain in a satisfactory manner how biologically effective information can be imprinted and stored in water or a water solution. One of the most prevalent hypotheses predicts changes in water microstructures by forming more or less permanent clusters [33,34]. Some physicists suggest that molecule information might be stored in water through the collective motion of water dipoles, which have a great ability to be electrically polarized. External sources, with low-frequency polarization field (e.g., other molecules), can be imprinted into water by modulating its fundamental frequency [35]. When the imprinting of radio-frequency EM radiation on water is in question, a gas/liquid interface was proposed as the field receptor. Different amplitudes of such radiation perturb interface water and consequently affect the behavior of colloids and ions present in water. The perturbed gas/liquid interface modifies the hydrogen bonding networks in water, hydration shells of ions, and interfaces between them. In certain experiments it was demonstrated that outgassing of water resulted in the absence of most of EMFs effects, including magnetic memory [36].

According to our proposal, the phenomenon of water memory consists of three distinct stages: **transfer stage** (transfer of molecule information from the donor substance into water or a water solution), **storage stage** (storage of molecule information in the same medium for a longer period) and **effective stage** (observable biological, chemical or physical effects). The transfer stage could be implemented via strong excitations of phonons. The details of this model, its terminology and experiments are comprehensively described in Jerman et al [32].

Our previous experiments with *Amanita muscaria* dust molecule information transfer to water yielded highly significant results [32]. This research was performed on cress seedlings subjected to mild heat stress and produced an inhibitory effect in the growth of seedlings as compared to controls by 15%. Transfer of information was implemented by a high voltage electric field together with a magnetic one. Encouraged by these results, we made the following three hypotheses: a) molecule information can be transferred to water by means of a high voltage electric field, b) stored information will evoke biological responses similar to the original substance’s and c) the medium of storage of molecular information is not important in eliciting biological effects.

To test these hypotheses we chose two chemicals with strong and specific physiological effects on plants: a herbicide and a cytokinin – a plant growth regulator. With herbicide molecular information we expected an inhibition of growth, whereas with cytokinin molecular information we expected its stimulation. To test the receiver solutions we used pure bi-distilled water and 60 % ethanol.

2. Materials and methods

2.1. Protocol for measuring biological effects of water imprints

To test the hypothesis that the molecular information of a chosen chemical substance can be transmitted and stored in water by a high voltage electric field, we watered cress seeds with water or a water solution previously exposed to the aforementioned field. The latter was assumed to enable the transfer of the chosen molecular information into water. Chemical substances serving as donors of molecular information were herbicide glyphosate and a plant growth regulator (cytokinin) BAP. When diffused through the plant, glyphosate (in molecular form) works as a systemic

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herbicide that inhibits the production of some aromatic amino-acids essential for plant growth [37]. On the other hand, cytokinin BAP is a plant growth regulator with dual action, i.e. in low concentrations it stimulates growth in length and inhibits it in high ones [38].

Each experimental group of seeds consisted of 4 glass Petri dishes (9 cm diameter) lined with filter paper. Each one contained 50 cress seeds (*Lepidium sativum* L.) washed with 3 ml of bi-distilled water. We wrapped up 2 Petri dishes together with one layer of aluminum foil (thickness 11 μm). The latter was used to protect Petri dishes from the incubator's electric field and from illumination during the experiment. Cress seeds were used due to their uniformity, a high ability to germinate and fast growth. Prior to the experiment, seeds were stored dry at 5°C. Just before the onset of the experiment these dry seeds were warmed at room temperature for 10 minutes. Then, properly prepared water was poured into the Petri dishes. During the preparation of the experiment, the seeds were exposed to artificial as well as to natural light. Natural illumination was present only during the preparation of the experiment, for about one hour.

2.2. Heat Stress

An exact timetable of the procedure is thoroughly described in Ruzic and Jerman [19]. In short, stress exposure was always performed 24 hours (± 0.5 hour) after the onset of the experiment. Petri dishes with the cress seedlings were heated to 42 ± 0.5°C in an incubator for 40 minutes. The Petri dishes were incubated in positions where the measured magnetic field, produced by the electricity required for heating (50 Hz), was homogeneous and at the lowest level (around 2 μT). Because of the aluminum foil, temperature inside Petri dishes increased slowly; during the heating process we performed exact temperature measurements with a digital thermometer (thermocouple) every 5 minutes. Outside the incubator, the Petri dishes cooled down to room temperature after 2 and a half hours. After that, the Petri dishes were placed inside a thermally isolated growth box with no electrical supply. Average temperature inside the growth box was (23.1 ± 0.8) °C.

2.3. The imprinting procedure

To perform the imprinting of the field of a chosen molecule into water or a water solution efficiently, a special device was constructed. The system consisted of a high voltage electric field source (26 kV, 1.7 Hz) and a gold-plated wire installed in a quartz test tube with a donor compound. The quartz test tube (40x12 mm) was placed in an ordinary glass test tube (17x30 mm) filled with 15 ml bidistilled water or 60% ethanol (the receivers of molecular information). The magnets produced a static magnetic field of 400 mT on their upper and lower surfaces. The south poles were turned up. The dimensions of the magnets (toroidal form) were: width 80 mm, inner hollow aperture 40 mm, and thickness 11 mm. Two magnets were used to attain better homogeneity of the applied magnetic field. After 15 minutes, the high voltage source was turned off; thereupon, ethanol solutions with a supposed molecular information imprint were further diluted as described below (see Types of experiments).

All solutions containing molecular information were handled properly. Cotton or rubber gloves and protective masks were always used, iron equipment was completely avoided, only wood, and Styrofoam or plastic was used.

2.4. Donors of molecular information

Information donor was always a (nearly-)saturated aqueous solution of the chosen compound. The following chemical substances were tested: herbicide glyphosate (N-phosphonomethyl glycin; Pinus Race, Slovenia) and plant growth regulator cytokinin BAP (6-benzylaminopurine - research grade; Serva chemicals). Chemical analysis of bidistilled water (used as receiver) was also performed at Actlabs Group of Companies (Canada) which proved that under our experimental conditions absolute chemical isolation between donor and receiver was assured.

2.5. Types of experiments

Every single experiment belonged to one of the following 4 groups depending on the treatment of the receiver:

- **Control group A** was subjected to 10,000 times diluted 60 % ethanol with no molecular information. The dilution process involved 2 successive dilutions 1:100 with intermediate rigorous shakings (succussions) (i.e. dynamized 60% ethanol solution in water without information). The reason for dilution, developed and used in ordinary homeopathic experiments and treatments, is that 60% ethanol as receiver cannot be used for watering plants directly because it is highly poisonous.
- **Control group B** was subjected to pure untreated bidistilled water (i.e. water without succussion and no information - water at rest).
- **Control group C** was watered by 10,000 times diluted 60% ethanol imprinted with bidistilled water imprint - the donor of molecular information was pure untreated bidistilled water (i.e. water information dynamized in water via ethanol solution as information receiver).

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- **Tested group** was subjected to 10,000 times diluted 60% ethanol imprinted with herbicide or cytokinin BAP information imprint (information donor was a nearly-saturated aqueous solution of the herbicide or cytokinin BAP, respectively) (i.e. drug information dynamized in water via ethanol solution as an information receiver).

In some experiments, instead of 60% ethanol, bidistilled water was used as receiver of information. In this case, the dilution process was not performed (i.e. informed water was used directly - without succussion - for watering the seeds).

2.6. Measurement and statistics

The seeds started to germinate after 16 hours and on average their ability to germinate amounted to about 97%. After 48 hours the length of seedlings (stem length from the upper limit of the radicle to cotyledons) was measured. To make measurements easier and more accurate, the seedlings were first frozen for at least 1 hour and then thawed [19].

In the present research, seeds were considered germinated and were included in measurements when radicles were longer than 5 mm. Each type of experiment (same watering solution and physiological conditions) was repeated 3 or 4 times. Since statistical distribution of the radicles length was normal, we calculated the arithmetic mean, the standard deviation and the confidence interval. Statistical significance of the difference among groups (p) was calculated either by Student's t-test (two-tailed) or one-way ANOVA test. Significance was determined by Tamhane's T2 or LSD tests, according to the significant inequality or equality of variances, respectively. Significance in figures is marked as follows: *: $p<0.05$, **: $p<0.01$ and ***: $p<0.001$.

3. Results

Preliminary tests were performed to observe the effects of herbicide and cytokinin BAP as normal chemical compounds. These tests showed that above 2% concentration, the herbicide inhibited the germination and early growth of garden cress. Our tests with BAP showed that at concentrations around 0.1 mg/l it produced stimulatory effects on cress growth, but above that level inhibitory effects appeared (both tests were performed under heat stress procedure).

3.1. Bidistilled water as receiver

Bidistilled water – without dilution and sucussion - was used as receiver of molecule information and to water the seeds. Results showed that when the seeds were exposed to optimal germinating conditions **without** application of **heat stress** and were watered with bidistilled water (receiver) supplemented with herbicide or BAP information imprint, no statistically significant biological effects occurred. (Table 1) The experiments were performed in the morning. The only statistically insignificant difference (3%) was found between the following two groups: herbicide information imprint and bidistilled water imprint. According to these results and to some previous experiments with magnetic fields [19], we decided to introduce heat stress in the following tests.

Table 1: Growth effects of cress seedlings exposed to *bidistilled water* as receiver of molecular information– without heat stress.

					95% CI for Mean	
	N	Mean	SD	SE	Lower Bound	Upper Bound
control group A	191	29,5	6,8	0,5	28,5	30,4
information imprint of water	191	29,2	8,7	0,6	28,0	30,5
information imprint of herbicide	193	30,0	9,1	0,7	28,7	31,3
information imprint of BAP	195	29,7	7,5	0,5	28,6	30,8

	ANOVA	Sig.
Between Groups		0,861

Control group A: dynamized ethanol in water without information; Information imprint of water: bidistilled water as information receiver without succussion, water as source of information; Iinformation imprint of herbicide: herbicide as a source of information; bidistilled water as information receiver without succussion; Information imprint of cytokinin BAP: BAP as source of information; bidistilled water as information receiver without succussion, N: number of measured seedlings; Mean: average length (mm); SD: standard deviation; SE: standard error; CI: confidence interval, Sig.: statistical significance between groups).

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When **heat stress** was used and bidistilled water was the receiver of information, BAP information imprint produced a statistically significant difference relative to control groups, i.e. "control group A" or "information imprint of water" (Table 2). The length was reduced by 8% in both cases ($p<0,001$, Table 2a). The herbicide information imprint showed no significant difference when compared to other groups. The experiments were performed in the morning.

Table 2: Growth effects of cress seedlings exposed to *bidistilled water* as receiver of molecular information – with heat stress.

	N	Mean	SD	SE	95% CI for Mean Lower Bo	Upper Bound
control group A	190	20,9	4,7	0,3	20,3	21,6
information imprint of water	193	21,0	4,7	0,3	20,3	21,7
information imprint of herbicide	197	20,8	4,0	0,3	20,2	21,3
information imprint of BAP	191	22,6	4,3	0,3	22,0	23,2

Table 2a: Statistical significance of the results.

ANOVA - LSD test		
Control group	Compared group	Sig.
control group A	information imprint of water	0,9257
	information imprint of herbicide	0,6882
	information imprint of BAP	0,0002
information imprint of water	control group A	0,9257
	information imprint of herbicide	0,6192
	information imprint of BAP	0,0003

Control group A: dynamized ethanol in water without information; Information imprint of water: bidistilled water as information receiver without succussion, water as source of information; Information imprint of herbicide: herbicide as source of information; bidistilled water as information receiver without succussion; Information imprint of cytokinin BAP: BAP as source of information; bidistilled water as information receiver without succussion; N: number of measured seedlings; Mean: average length (mm); SD: standard deviation; SE: standard error; CI: confidence interval, Sig.: statistical significance between main and the other groups.

3.2. 60 % ethanol as receiver

60% ethanol solution was used as receiver of molecule information and then diluted and succussed with bi-distilled water before watering the seeds. Results of tests performed in the morning (Fig. 1) showed that herbicide information imprint and BAP information imprint produced a statistically significant reduction in the growth of seedlings when compared to the main control with no molecular information imprint, by 19 % and by 8 %, respectively ($p<0.0001$). The inhibitory effect means that the stress reaction to heat was enhanced by the imprinted information. However, in these experiments even bidistilled water information imprint (control group C) produced statistically significant effects (by 8-9 %; $p<0.0001$), but they were less inhibitory and distinctive from the results with the herbicide information imprint. The results obtained with BAP information imprint did not distinguish themselves from the effects of bidistilled water information imprint.

Results of tests performed in the afternoon showed statistically significant effects for the herbicide information imprint (Fig. 2). The difference against the control was 4% ($p=0.02$). However, the molecular information of the herbicide had reversed polarity and smaller magnitude than the imprints from the "morning" experiments. Thus, the growth effects were stimulatory. In this case, the water imprint (the control group C) did not produce any changes in the length of the seedlings.

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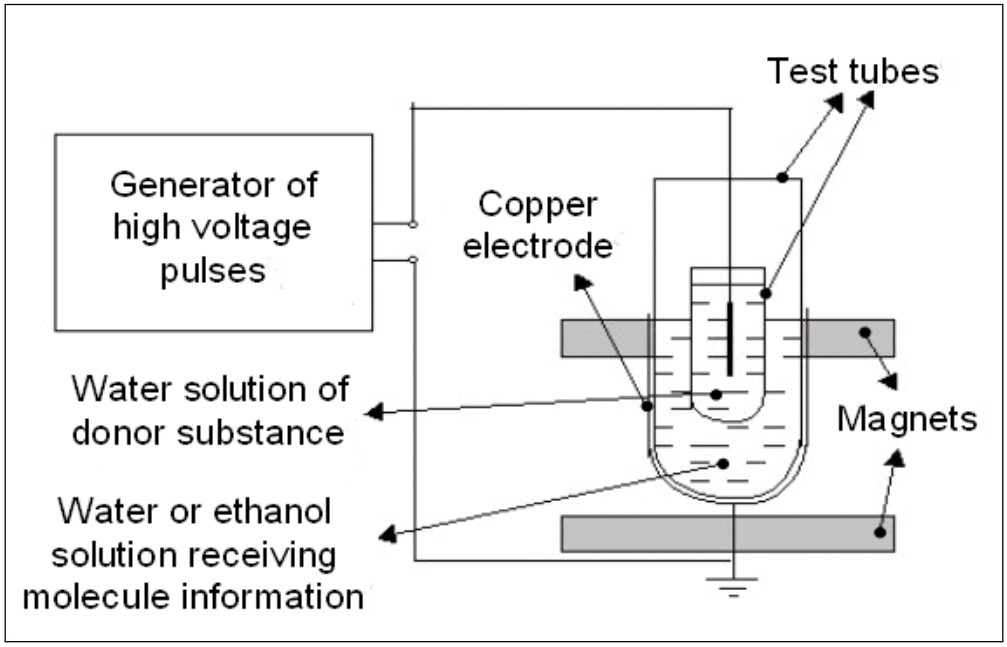

Figure 1: Scheme of the electronic imprinting of a chosen compound into water or ethanol solution.

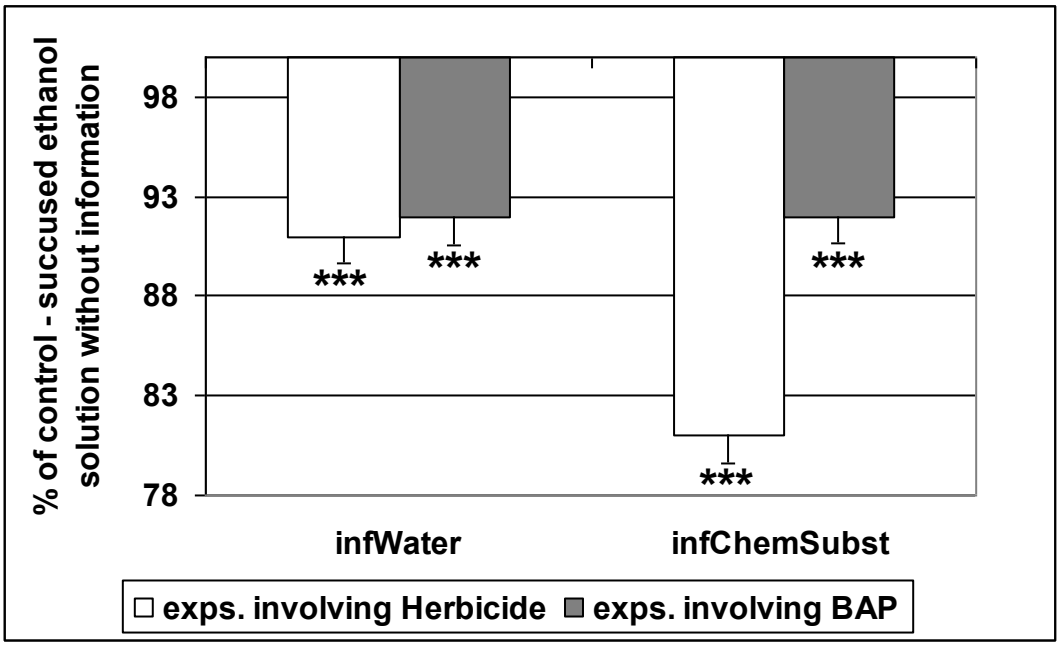

Figure 2: Comparison of the effect (in % regarding the control) of either herbicide or BAP informed solution (groups infChemSubst) and information imprint of water (group infWater) on the growth reaction of cress germinating seeds – immediately after informing (5 experiments involving 3271 seedlings). Receiver of information was 60%ethanol diluted and succussed with bidistilled water before watering the seeds. All experiments were prepared in the morning between 8 and 9 a.m. Statistical significance of the difference among groups is marked as follows: *** $p<0.001$.

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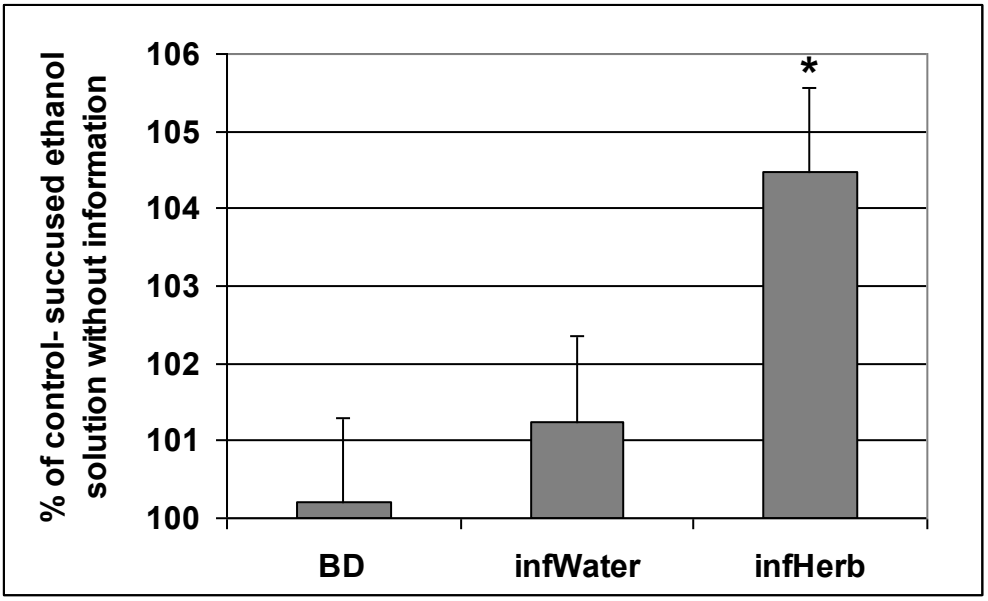

Figure 3: Comparison of the effect (in % regarding the control) of herbicide informed solution (group infHerb), information imprint of water (group infWater) and water with no information and without succussion (BD) on the growth reaction of the plant sensor system – immediately after informing (4 experiments involving 2189 seedlings). Receiver of information was 60% ethanol diluted and succussed with bidistilled water before watering the seeds. All the experiments were prepared in the afternoon between 3 and 4 p.m. Statistical significance of the difference among groups is marked as follows: * $p<0.05$.

Table 3: Growth effects of cress seedlings exposed to *ethanol solution* as receiver of molecule information and 14 days after imprinting procedure – with heat stress (information receiver was 60% ethanol solution, stored for 14 days and succussed with distilled water before watering the seeds).

					95% CI for Mean	
	N	Mean	SD	SE	Lower Bound	Upper Bound
control group A	196	22,4	5,6	0,4	21,6	23,2
information imprint of water	187	21,7	5,6	0,4	20,9	22,6
information imprint of herbicide	196	22,8	5,4	0,4	22,1	23,6
information imprint of BAP	187	22,0	5,9	0,4	21,1	22,8

Control group A: dynamized ethanol in water without information; Information imprint of water: bidistilled water as information receiver without succussion, water as source of information; Information imprint of herbicide: herbicide as source of information; bidistilled water as information receiver without succussion; Information imprint of cytokinin BAP: BAP as source of information; bidistilled water as information receiver without succession N: number of measured seedlings; Mean: average length (mm); SD: standard deviation; SE: standard error; CI: confidence interval, Sig.: statistical significance between main and the other groups).

Table 3a: Statistical significance of the results.

ANOVA - LSD test		
Control group	Compared group	Sig.
control group A	information imprint of water	0,2707
	information imprint of herbicide	0,4404
	information imprint of BAP	0,5001
information imprint of water	control group A	0,2707
	information imprint of herbicide	0,0625
	information imprint of BAP	0,6726

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3.3. Effects of informed 60% ethanol stored at room temperature for 14 days

The information receiver was 60% ethanol solution stored for 14 days at room temperature, diluted and succussed with bidistilled water before watering the seeds. In contrast to the experiments performed immediately after the imprinting procedure, 14- day informed 60 % ethanol did not yield significant effects, either when herbicide or BAP water imprint were used (Table 3 and 3a). The experiments were performed in the morning.

4. Discussion

There are many theories seeking to explain the controversial hypothesis that water is able to "store" information, either of an electric and magnetic field or of a chemical substance [10,33,35,36]. While this question remains for biophysicists or quantum physicists finally to settle, the results of our and many other biological experiments showed that molecular information can be transmitted via a special electromagnetic process to water, stored there and later (though not much later, see also Table 3) elicit biological effects [30-32].

Regarding our hypotheses, the experiments confirmed the first, namely that a high electric and magnetic field can transfer molecular information to water. The answer to the second hypothesis, however, was not so clear. The inhibitory effect of the herbicide was demonstrated only in the morning experiments (and with 60 % ethanol solution as receiver; Fig. 2), while in the afternoon the effect was even slightly stimulatory (Fig. 3). The results with the herbicide information imprint were also consistent with our previous results concerning Amanita dust information imprint [32], namely in polarity as well as in the magnitude of the effect.

Obviously, molecular information does not evoke straightforward effects, which largely depend on the physiological conditions of the plants. While the inhibitory effect observed in the morning was much stronger than the stimulatory one in the afternoon, we may say that there is some correlation, although not very reliable, between the biological effects of the herbicide water imprint and the effect of the herbicide as substance. Such similarity of effect was confirmed also in other experiments with neutrophils [30] or bacteria and Mg^{2+} ions [32].

However, no known study of this kind took into account a possible strong influence of the moment of the day when the experiment was performed. From many studies it is known that biological effects vary according to the season of the year. For example, a weak magnetic field may produce different outcomes in different times of the year [39, 40]. It is similar with some physiologically effective chemicals, like the effects of plant hormones, that vary in relation to the season of application (spring or autumn) [41]. So far, these physiological endogenous phenomena are still poorly understood. To our best knowledge there is no study that found a correlation between plants' responsiveness to environmental factors and the various stages of their diurnal rhythm.

With information-source cytokinin BAP and ethanol solution as information receiver, there was no difference from the effects of water as source of information (Fig. 2). The effects of BAP information came to the fore with water as information receiver, when they proved to be stimulatory (Table 2). Namely, BAP as a chemical substance, in small concentrations stimulates the growth of plants and the same effect was observed when its information was applied, but not under all conditions. It is difficult to explain why this effect was obtained only when water was the information receiver. Maybe relatively pure water is – at least in some cases – more open as receiver for some chemical substances than ethanol solutions. More extensive research should be performed in this direction.

As it has been already been observed, our third hypothesis, i.e. the medium for storage of molecular information is not important in eliciting biological effects, was not confirmed. The experiments in both cases (herbicide, cytokinin) demonstrated that the biological effects strongly depended on the storage medium; and even not in the same way for specific molecular information. While with cytokinin effects appeared only with bidistilled water, the herbicide yielded no effects in this case. With 60% ethanol the situation was reversed.

Moreover, it is clear that the physiological state of the organism is as important as the experimental procedure including a properly designed device. The chosen organism (in our case, germinating plants) has to be exposed to a stress condition. If we compare the results in Table 1 to other results, seedlings not exposed to heat stress did not vary in length. This means that an organism reacts to weak environmental information only when it is thrown out of its physiological equilibrium. This phenomenon can be observed in many studies concerning the biological effects of weak magnetic fields [13,15,16,18].

An additional interesting phenomenon, stemming from our experiments, concerns the results obtained when we monitored the biological effects of the bidistilled water information imprint (group C, Fig. 2 and 3: column "infWater"). This may be due to the important role of water during germination; the other possibility is that the electric field alters the properties of water in a way leading to an inhibitory physiological effect on the seeds. This is possible if we take into account the current knowledge concerning water or water solutions exposed to various electromagnetic fields or microwave

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irradiation, that reliably produce distinct biological effects [10,11,35].

Therefore, from our present research new questions and hypotheses arise that demand new experiments. There is strong indication that there is a highly non-linear connection between the biological effects of molecular information on the one hand, and the medium of information storage and physiological state of the tested plant on the other. These relations should be put to further rigorous and systematic tests.

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