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ELECTRIC FIELDS FROM HIGH-VOLTAGE POWERLINES AFFECT SOIL *Penicillium sp.* ACTIVITY IN AGRO-ECOSYSTEMS

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Abstract

Amid increasing concerns over the food chain and ecological agriculture, raises the question whether the intense extra low frequency (ELF) electric (EF) and magnetic fields (MF) emanating from high voltage power-lines might be affecting microorganisms in the environment in topsoils below them. Their habitat in topsoils affords an easy route into the food chain, since arable lands and pasturelands are highly integrated agro-ecosystems.

Since so far there had not been found a single organism or its part that would not be susceptible to EM fields, the aim of this investigation was to find if a soil microorganism Penicillium sp) could be affected by such fields and to what extent. Culture of that fungus derived from the same site's topsoil was exposed to 400, 275 and 132 kV powerlines, being placed under their midspans. Our results suggest possible impact of examined fields on certain elements of soil physiology.

Key words*: agro-ecosystems, Penicillium sp., soil microorganisms, electro-magnetic fields, high voltage powerlines*

Introduction

Presence of microorganisms in soil measures by up to ten million cells per gram of soil, bacteria and fungi making the greatest portion. Soil microorganisms are essential for the maintenance of soil physiology, since they are involved in vast majority of chemical transformations in soil. Microbial activities in the cycles of nutrients required for plant

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growth are responsible for soil fertility. They transform organic matter that enters the soil (dead plant and animal cells and excretory products) into minerals, making it available to primary producers. In symbiosis with certain mycorrhizal fungi, leguminous plants roots can acquire the capability of fixing nitrogen. Some other soil microorganisms can increase the amount of nutrients present in the soil. Microorganisms that improve the soil fertility and contribute to plant growth are called biofertilizers and are used as microbial inoculants in agriculture. Phytostimulators are microorganisms that produce vitamins and plant hormones and can both improve plant health and contribute to higher yield.

During the last fifty years, for the first time during their existence and evolution, microorganisms have been continually exposed to electromagnetic fields emanating from various sources, including high voltage powerlines (Galonja *et al.,* 1999) that directly spread over pasturelands and arable lands. Based on vital role of microorganisms in soil physiology and the fact that electromagnetic fields are used to stimulate seed germination, the concern about possible adverse effects of electromagnetic fields on soil microorganisms emerges. Some high and low frequency electromagnetic fields are known for their capability of causing significant changes in microorganisms (Reese *et al*., 1998; Cellini *et al*., 2008; Ratushnyak *et al*., 2008), acting as stress factors.

Materials and methods

For the experimental exposure of microbial cultures, three sites were selected under the midspans of 132, 275 and 400 kV powerlines that crossed similarly characterized topsoil. A common soil fungus (*Penicillium sp.*) derived from the site's topsoil was cultured in Agar for fungi (Merck, Leicester, UK), taking care about avoiding all unnecessary exposure to electromagnetic fields emerging from the laboratory apparatuses. To achieve that, an air jacketed incubator was used (Stuart Scinetific Incubator SI 60, Stuart Scinetific Ltd., England) instead of usual water jacketed incubator, which generates high internal electromagentic fields.

Penicillium acted as a representative eukaryotic microorganism that is a regular inhabitant of agricultural soil rich in organic matter. Its importance in soil is based on their capability of solubilizing various mineral matter, such as rock phosphates (Asea *et al*., 1998), making them available for plants.

Fungi were placed on agar in sealed test tubes with stoppers enveloped in aluminium foil to allow the exposure to the electric field. The control samples were prepared the same way. Two samples from the same batch of each organism type were left under the powerlines and a third was placed some 70 metres distant. Cultures were left in place for 5 and 10 days. Fungal morphology was examined microscopically. Control samples were kept under the same temperature conditions as the exposed samples, out of reach of electro-magnetic fields, shielded in mu-metal containers.

Electric and magnetic fields were monitored by EMF metar (Delta-T Devices, Cambridge, England), constructed in accordance with IEEE (Institute of Electrical and Electronic Engineering) i IEC (International Electrotechnical Committee) standards.

It consists of 20 cm orthogonal magnetic field probe, one bipolar vertical electric filed probe as well as humidity, temperature and light conditions probes. Readings were collected by Delta-T Devices dataloger. Characteristics of electric and magnetic fields the samples were exposed to were as shown in next table.

Table 1: Some characteristics of the fields samples were exposed to

power line	400 kV		275 kV		132 kV	
location	beneath	distant	beneath	distant	beneath	distant
EP (V/m)	160-370	3	50-80	2	2	1
MP (μT)	1	0,08	0,7	0,08	0,04	0,03

Electric field strength (EF) in case of 400 kV power line extremely varied during the day, so it is shown as the interval of variation. The parameters for other two transmission lines varied within 10 percent and are shown as average values of the readings.

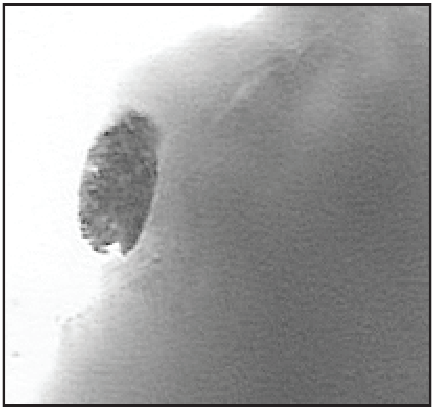
Results

By visual macroscopical examination of fungal samples, presence of yellowish-orange exudate on the surface of fungal colonies was revealed. The amount of exudate seemed to bee in linear correlation with field strengths applied. The exudate was clearly present in the samples kept under the 400 kV and 275 kV transmission lines while slightly present in the samples kept under the 132 kV lines. In the control samples kept in mu-metal container for EMF protection, in the laboratory and under the same temperature conditions as those in the field, no orange exudate was found. For visual examination, numbers from 0 to 3 were used to describe levels of exudate present. Zero refers to absence of exudate, 1 to slight presence, 2 to moderate presence and 3 to strong presence of exudate (Table 2).

Table 2: Presence of exudate on the surface of fungal colonies, exposed to electric fields from respective powerlines for 5 and 10 days

Initial state	0		
Powerline (pl)	**Placement (powerline)**	**5 day exp.**	**10 day exp.**
400 kV	Under midspan	3	3
	70 m distant	2	0
275 kV	Under midspan	3	3
	70 m distant	0	1
132 kV	Under midspan	2	1
	70 m distant	1	0
Control sample (laboratory)		0	0

Microscopic analyses confirmed that exudate presented fruiting bodies (kleistoteciae), responsible for sexual reproduction in fungi (Picture 1). It is worth noting that fungi often convert to sexual reproduction as a response to various stress factors, such as temperature changes or lack of food.



Picture 1 – Open kleistotecia in fungal sample kept for 10 days under 400 kV power line

Conclusions

The results obtained indicate that some soil microorganisms are susceptible to environmental electromagnetic fields. High voltage power lines acted as a source of stress factors, resulting in switching to stress-response behaviour (sexual reproduction). It is notable that most fields applied induced faster proliferation (Galonja Coghill *et al*., 2008).

Thoroughly studied and precisely aimed, alternating electric and magnetic fields could enable improving of microbiological component of soil.

Knowing that soil shelters lots of potentially harmful microorganisms as well, an investigation into electromagnetic patterns regarding various microorganisms is needed.

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