THE EFFECT OF LOW INDUCTIVITY STATIC MAGNETIC FIELD ON SOME PLANT PATHOGEN FUNGI

NAGY Pál

Department of Agricultural Mechanisation, University of Veszprém, Georgikon Faculty of Agriculture, H-8360 Keszthely, Deák F. u.16. Hungary,
Tel. 36/83/311 290, Fax. 36/83/311 233, e-mail: nagyp@georgikon.hu

Manuscript received: October 12, 2004; Reviewed: April 14, 2005; Accepted for publication: April 27, 2005

ABSTRACT

Growth and sporulation of phytopathogen microscopic fungi were studied under a static magnetic field. The applied flux densities were 0,1, 0,5 and 1 mT. As a result of our experiments, the magnetic field decreased the growth of colonies by 10 % using this flux density region. At the same time, the number of the developed conidia of Alternaria alternata and Curvularia inaequalis increased by 68-133 percent, but the number of Fusarium oxysporum conidia decreased by 79-83 percent.

KEY WORDS: phytopathogenic fungi, sporulation, static magnetic field

ÖSSZEFOGLALÁS

Vizsgálataink célja néhány növénypatogén mikroszkópikus gomba növekedésének és sporulációjának tanulmányozása mágneses tér hatására. Az alkalmazott térerősségek 0,1, 0,5 és 1 mT voltak. Kísérleteink eredményeképpen megállapítottuk, hogy ebben a térerősség tartományban a mágneses tér átlagosan mintegy 10%-al csökkentette a tenyészetek növekedését. Ugyanakkor az Alternaria alternata és a Curvularia inaequalis fajok esetében 68-133 %-kal növekedett, Fusarium oxysporum esetében pedig 79-83 %-kal csökkent a képződött konídiumok száma.

KULCSSZAVAK: növénypatogén gombák, sporuláció, statikus mágneses tér

INTRODUCTION

Numerous earlier experiments proved that the static or extremely low frequency magnetic fields with small flux density had an effect on various living organisms. A considerable part of the investigations dealt with the effect of electromagnetic fields on macromolecules or cells. The effect of electromagnetic fields on whole living organisms was also very frequently examined, however, mainly in the following three areas.

(i) The microwave region of 300 MHz-300 GHz. The possible effect of producing cancer on human organisms was studied in this exposure range (Stagg et al. 2001; Zook et al. 2001).

(ii) The region of magnetic field generated alternating currents of 50/60 Hz. The subject of investigations was also the cancer producing and/or other effects of the scattered electromagnetic fields of power line and electric engine on human and animal organisms (Korpinen and Partanen 1996; Harris et al. 1998; Owen 1998), as well as the effect of scattered electromagnetic fields on the germination and growth of plants (Ruzic et al. 1998a, b).

(iii) The region of static or pulsating extremely low frequency magnetic fields. The orientation of birds and insects by the geomagnetic field was also studied. The effect of a magnetic field on the growth and the germination of plants (Smith and Mays 1984; Ruzic et al. 1993) and rare on fungi (Sadauskas et al. 1987; Broers et al. 1992; Ruzic et al. 1997) were studied.

Broers et al. (1992) investigated the germination of Mycotypha africana exposed to 150 MHz frequency magnetic field modulated at frequencies ranging 0,8-50 Hz, with flux densities ranging between 0-1,2 nT. According to their experience a magnetic field of 1,2 nT flux density modulated 10 Hz was the most effective. They observed a 20 % increase in germination ratio following a 4 hour exposure to 1,2 nT magnetic field, modulated at 10 Hz. The germination ratio remained constant after increasing the exposure time to 24 hours. Experiments were carried out in cavity resonator, so the effect of electric field on germination could be examined. According to their analysis, the electric field had no observable stimulating effect.

Ruzic et al. (1997) studied the effect of 50 Hz frequency magnetic field of 0,025 and 0,1 mT magnetic flux density on mycelial growth and ergosterol content of mycorrhizal fungi. The cultures were grown in a magnetic field for 28 days and the dry and wet weight as well as the ergosterol content of cultures was measured on the 7th day. The stimulation effect of magnetic field of 0,1 mT flux density could be seen more quickly, between the 7th and 14th day of treatment, than the effect of magnetic field of 0,025 mT flux density. The ergosterol content slightly increased in the first week of treatment.

Sadauskas et al. (1987) examined the effect of 200 mT flux density static and 29 mT flux density pulsating magnetic field on the different species of fungi. According to their examination, morphological changes were observable on the conidia of Aspergillus puniceus and Alternaria alternata. The pigmentation of the colony of Aspergillus niger changed, the cultures remained white.

The aim of the present work was examine the effect of static magnetic fields with flux densities which are not much greater than the flux density of the average geomagnetic field on the mycelial growth and the formation of conidia of plant pathogen fungi.

MATERIAL AND METHOD

Examinations were made on the fungi Alternaria alternata, Curvularia inaequalis and Fusarium oxysporum species, all belonging to the Deuteromycota. Alternaria alternata, and Curvularia inaequalis were isolated from pepper and Fusarium oxysporum from maize. The cultures were grown on Czapek agar. The inoculum for our experiments were taken from the growing zone of basic cultures. The cultures were incubated for 48-72 hours after the inoculation at 22-24 °C, in darkness. After the incubation the cultures, uniform from the point of view of growing and morphology, were placed into the magnetic field. The experiments were made in four replications.

For the investigations of the effect of a magnetic fields on the mycelial growth and conidium formation a solenoid was made with 0,5 m length and 10 cm diameter for the present experiment, in which 16 Petri dishes of 6 cm diameter could be placed. The coil was made from enamelled copper wire of 1,6 mm diameter with 1800 number of turns. The copper wire of 2 mm^2 cross section could be loaded by the current of 4 A, which means a magnetic flux density of 18 mT. The coil must be cooled above 5 mT. A ventilator could be used for this purpose. The magnetic flux density has been changed by a change of loading current according to the equation $B = \mu_0 \cdot n \cdot I / l$, where B was the magnetic flux density, μ_0 was the vacuum permeabilty, n the number of turn, I the current and l the length of coil. The values of the flux densities of the applied magnetic fields were chosen on the basis of our earlier unpublished experiences.

In the course of experiments, the ambient temperature and relative humidity were the same for the control and the treated cultures (t=22-23 °C h_r=45-50 %). The cultures were grown in darkness. The diameters of the growing cultures were measured every 24 hours in two directions, perpendicular each other. The average of this two diameters was used as the diameter of the culture. It can be ascertained from our earlier results (Nagy and Fischl 2002) that the growth of fungi followed the well known logistic function (Wilson and Bosset 1981). The middle part of this function can be fitted by a straight line. A straight line was fitted for the average diameters with the help of Excel computer program, and the growth speed in mm/h was calculated as a slope of straight line. The confidence intervals of 95 % level were also determined from the slope and the errors of estimation. The significance level of the growth speed were determined by the Student t-test with the help of Excel.

The developed conidia of Alternaria alternata, Curvularia inaequalis and Fusarium oxysporum were counted with the help of Buerker cell under the light microscope. According to this purpose five ml tap water was poured on the Petri dishes and the conidia were counted from this conidium suspension in the 10 sub cells of 0,004 mm^3 of the Buerker cell. The average number of conidia found in one ml of suspension can be also calculated, multiplying the average number of conidia in one sub cell by 250000.

RESULTS AND CONCLUSIONS

1. The effect of static magnetic field on the growth of mycelia

The growth speed of Alternaria alternata, Curvularia inaequalis and Fusarium oxysporum colonies was studied in the static magnetic fields of 0,1, 0,5 and 1mT magnetic flux densities can be seen in Table 1, in the percent of the control. The confidence intervals of 95 % in the percent of control as well as the result of t-test can be also seen here.

On the basis of the data of Table 1, the growth speed of the all examined phytopathogen fungi cultures were decreased in the linear growing region due to the static magnetic field of 0,1-1 mT flux density region. This relative decrease was in average 10 %, although in some cases a larger decrease could be observed. This result is in contradiction to the results of the literature. For example, according to the result of Ruzic et al. (1997), the dry and wet mass of micorrhizal fungi were stimulated by 50 Hz frequency magnetic field of 0,1 mT magnetic flux density. The discrepancy can be interpreted, as our investigations were carried out in static magnetic field. Furthermore the smallest magnetic flux density was equal to the largest one applied by Ruzic et al. (1997). Further disagreement could be arisen from those fact, that the dry and wet mass of a culture doesn't correlate with its diameter and the reaction of micorrhizal fungi could differ from the reaction of plant pathogen fungi.

2. The effect of the static magnetic field on the formation of conidia

The effect of static magnetic field of 0,5 and 1 mT magnetic flux densities were determined on the formation of conidia of Alternaria alternata, Curvularia inaequalis and Fusarium oxysporum cultures. The average number of conidia in one sub cell of Buerker cell and in one ml of conidia suspension, as well the result of Wilcoxon rank sum test can be seen in Table 2. The sporulation of Alternaria alternata and Curvularia inaequalis cultures 120 hours after inoculation can well be seen in the Fig. 1.

On the basis of Table 2 it can be ascertained that the number of conidia of Alternaria alternata and Curvularia inaequalis increased significantly and the number of conidia of Fusarium oxysporum decreased significantly. The extent of increase at Alternaria alternata and Curvularia inaequalis is 68-133 %, while the extent of decrease at Fusarium oxysporum is 79-83 %. The Wilcoxon Rank Sum Test applied for the control and treated group resulted significant deviation at 95 % level, except one case. This results indicated that the magnetic fields with small magnetic flux density (2-20 times larger than the geomagnetic flux density) effectively influenced the formation of conidia of examined plant pathogen fungi. In consequence of these the geomagnetic activity

Table 1. The growth speed of the fungi cultures, in static magnetic fields, as compared to the untreated control

	Relative growth speed in percent of the control		
Fungi Species	0,1 mT	0,5 mT	1 mT
Alternaria alternata	90,2±6,1 (***)	96,4±12,2 (NS)	84,9±32,0 (*)
Curvularia inaequalis	88,5±6,8 (***)	79,8±16,4 (**)	96,3±44,3 (NS)
Fusarium oxysporum	91,7±8,3 (***)	92,0±27,2 (NS)	93,9±31,7 (NS)

Abbrevations: NS: Not Significant, *: Significant at 95 % level, **: Significant at 99 % level, ***: Significant at 99,9 % level

Table 2. The number of conidia due to static magnetic field

	Alternaria alternata		Curvularia inaequalis		Fusarium oxysporum	
Number of conidia at 0,5 mT flux density						
	Control	Treated	Control	Treated	Control	Treated
Average	0	0,3	0,6	1,4	10.9	2,3
SD	-	0,67	0,69	0,69	2,13	1,16
Wilcoxon test		-		*		*
Conidia/ml conidia suspension	0	75000	150000	350000	2725000	575000
Number of conidia at 1 mT flux density						
Average	1,5	3,0	1,3	2,2	5.5	0,9
SD	0,57	1,05	0,82	1,23	5,12	1,1
Wilcoxon test		*		NS		*
Conidia/ml conidia suspension	375000	750000	325000	550000	1380200	208300

Abbrevations: NS: Not Significant; *: Significant at 95 % level

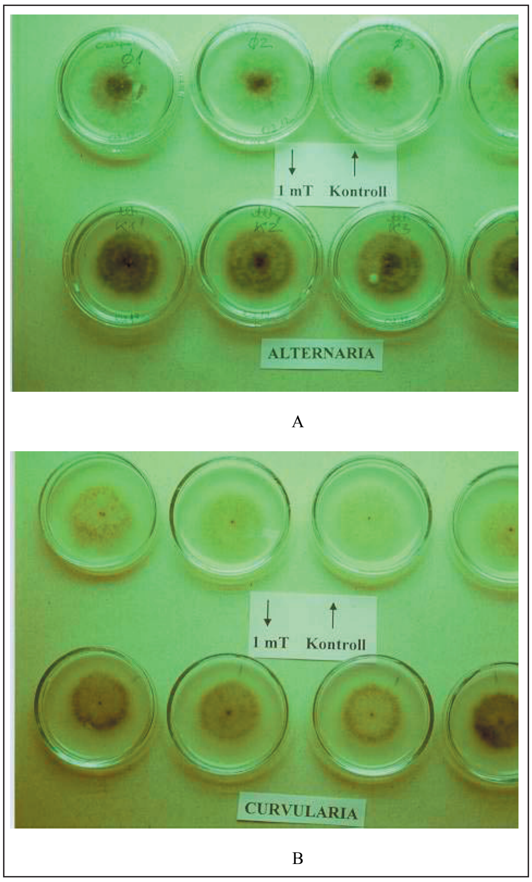

Fig 1.: The sporulation of treated and control Alternaria alternata (A) and Curvularia inaequalis (B) cultures 120 hours after inoculation (up: control, down: in static magnetic field at 1 mT magnetic flux density).

may influence the formation of conidia of plant pathogen fungi.

REFERENCES

[1] Broers D., Kraeplin G., Lamprecht I., Schultz O. 1992. Mycotypha africana in low-level athermic ELF magnetic fields. Bioelectrochemistry and Bioenergetics 16: 281-291.

[2] Harris A. W., Basten A., Gebski V., Noonan D., Finnie J., Bath M. L., Bangay M. J., Repacholi M.H. 1998. A test of lymphoma induction by long-term exposure of Eμ-Pim1 transgenic mice to 50 Hz magnetic fields. Radiation Research 149: 300-307.

[3] Korpinen L., Partanen J. 1996. Influence of 50 Hz magnetic fields on human blood pressure. Radiation and Environmental Biophysics 35: 199-204.

[4] Nagy P., Fischl G. 2002. Effect of UV and visible light irradiation on mycelial growth and sclerotium formation of Sclerotinia sclerotiorum. Acta Phytopathologica et Entomologica Hungarica 37: 83-89.

[5] Owen R. D. 1998. MYC mRNA abundance is unchanged in subcultures of HL60 cells exsposed to power-line frequency magnetic fields. Radiation Research 150: 23-30.

[6] Ruzic R., Jerman I., Jeglic A., Fefer D. 1993. Various effects of pulsed and static magnetic fields on the development of Castanea sativa mill. in tissue culture. Electro- and Magnetobiology 12: 165-177.

[7] Ruzic R., Gogala N., Jerman I. 1997. Sinusoidal magnetic fields: Effects on growth and ergosterol content

in mycorrhizal fungi. Electro- and Magnetobiology 16: 129-142.

[8] Ruzic R., Jerman I., Gogala N. 1998a. Water stress reveals effects of ELF magnetic fields on the growth of seedlings. Electro- and Magnetobiology 17: 17-30.

[9] Ruzic R., Jerman I., Gogala N. 1998b. Effects of weak low-frequency magnetic fields on spruce seed germination under acid conditions. Can. J. For. Res. 28: 609-616.

[10] Sadauskas K. K., Lugauskas A. Y., Mikulskene A. I. 1987. Vlijánie postojannogo impulsnogo nizkochastotnogo magnitnogo polja na mikroskopicheskie gribi (Effects of constant and pulsating low-frequency magnetic field on microscopic fungi). Mikologija i Fitopatologija 21: 160-163.

[11] Smith R. D., Mays R. 1984. Effect of pulsed magnetic fields on root development in plant cuttings. Bioelectrochemistry and Bioenergetics 12: 567-573.

[12] Stagg R. B., Hawel L. H., Pastorian K., Cain C., Adey W. R., Buys C. V. 2001. Effect of immobilization and concurrent exposure to a pulse-modulated microwave field on core body temperature, Plasma ACTH and corticosteroid, and brain ornithine decarboxylase, Fos and Jun mRNA. Radiation Research 155: 584-592.

[13] Wilson E. O., Bosset W. H. 1981. Bevezetés a populációbiológiába (A Primer of Population Biology). Budapest: Gondolat, pp. 130-133

[14] Zook B. C., Simmens S. J. 2001. The effects of 860 MHz radiofrequency radiation on the induction or promotion of brain tumors and other neoplasms in rats. Radiation Research 155: 572-583.