

This article is a 'work in progress' incorporating new information whenever time permits.

## Fungi, plants, trees, seeds and EMFs

1. Fungi
2. Plants
3. Seeds
4. Trees
5. Water
6. References – 34 references

## Fungi, plants, trees, seeds and EMFs

Roux ([2008](#)) found that 900 MHz RF radiation below thermal levels affected plants. When exposed, the plants initiated “self-repair” processes very similar to those expected when the plant perceives itself to be injured. Roux concluded *“Taken as a whole, the data provide new evidence supporting the hypothesis that plants perceive and respond to microwave irradiation as though it was an injurious treatment.”*

Tkalec ([2009](#)) found cellular effects in germinating onions when they were exposed to 400 and 900 MHz electric fields of 41 and 120 V/m. Whilst the upper value is above ICNIRP the lower value is not, and a quite feasible field level to be received by the head when talking on a mobile phone.

Sharma ([2009](#)) concluded that mobile phone radiation inhibited root growth of mung beans by inducing ROS-generated oxidative stress despite increased activities of antioxidant enzymes. Another study by Singh ([2012](#)) confirmed that mobile phone radiation affected biochemical processes manifesting as oxidative stress which impaired root growth in mung beans.

### Fungi

Electromagnetic fields were found to promote hyphal growth in *Tuber borchii* (Potenza [2012](#)).

### Plants

Gagliano ([2012](#)) found that seeds and seedlings of the chili plant, *Capsicum annuum*, are able to sense neighbours and identify relatives using alternative mechanisms beyond previously studied channels of plant communication. The authors offer a hypothetical mechanistic explanation as to how plants may do this by quantum-assisted magnetic and/or acoustic sensing and signaling.

Pulsed electromagnetic fields as a presowing treatment was found to enhance plant growth in tomato plants. Yield per plant was higher in magnetic field treatments (Efthimiadou 2014).

Pulsed electric field processing could be a suitable process to stimulate production of broccoli with high health-promoting glucosinolate content (Aguiló-Aguayo 2014).

Isaac Alemán (2014) suggested that the application of 60 Hz magnetic field to in vitro coffee plants may improve the seedlings quality by modifying some photosynthetic physiological and molecular processes, increasing their vigour, and ensuring better plant development in later stages.

Exposure to sustained low intensity microwaves can constitute a stress for the *Ocimum basilicum* (basil) plants, reducing the emissions of volatile organic compounds. Microwave irradiation reduces those qualities of oils that make this plant a very sought-after flavour, including as pesto, in kitchens (Lung 2016).

Wheat grain yields were 7% higher (average of 5 years) in the plots with the lowest field exposure than in the plots nearer to a high voltage transmission line (Soja 2003).

Halgamuge (2015) found that observed effects on the growth of soybean seedlings were significantly dependent on field strength as well as amplitude modulation of the applied field.

## Seeds

Pretreatment of PMF plays important roles in improvement of crop productivity of soybean through the enhancement of protein, mineral accumulation and enzyme activities which lead to increases in growth and yield (Radhakrishnan & Ranjitha Kumari 2012, Asghar 2016, Asghar 2017). A further study by the same team found that 10 Hz PMF treatment enhanced the germination and seedling growth of soybeans (Radhakrishnan & B Kumari 2013).

Results indicate that static magnetic field application enhanced maize seed performance in terms of percentage germination, speed of germination, seedling length, and seedling dry weight significantly compared to unexposed control. Plants raised from seeds exposed to 200 mT for 1 h had higher values of leaf area index, shoot length, number of leaves, chlorophyll content, shoot/root dry weight, and root characteristics as compared to corresponding values in untreated control (Vashisth 2017).

Microwave pretreatment for 5 or 10 seconds conferred tolerance to cadmium stress in wheat seedlings (Qiu 2011). The results also showed that the microwave radiation had a positive physiological effect on the growth and development of cadmium stressed seedlings. Pre-seed electromagnetic treatment has been used to minimise drought-induced adverse effects on maize (Javed 2011).

Pulsed electromagnetic fields have been found to promote germination and improve early growth characteristics of cotton seedlings. Such priming techniques are especially valuable in organic cultivation, where chemical compounds are prohibited. Magnetic field treatment of 15 minutes was found to stimulate germination percentage and to promote seeds, resulting in 85% higher values than control seeds under real field conditions. Seeds that were treated with a magnetic field performed better in terms of early-stage measurements and root characteristics (Bilalis 2012).

In soil, seeds exposed to static magnetic fields produced significantly increased seedling dry weights, dramatic increase in root length, root surface area and root volume. The improved

functional root parameters suggest that magnetically treated chickpea seeds may perform better under rainfed (un-irrigated) conditions where there is a restrictive soil moisture regime (Vashisth & Nagarajan [2008](#), Mridha [2016](#)).

Seeds pre-primed for 6 minutes on and off pulsed magnetic fields showed significant improvement in germination (7.6%) and vigor (84.8%) over unexposed aged seeds (Bhardwaj [2016](#)).

Germination enhancement was optimum for the mung beans exposed to 100 mW for 1 hour power-duration level, while for water convolvuluses the optimum germination power-duration level was 1 mW for 2 hours. When both seed types were exposed at the early sprouting phase with their respective optimum power-duration levels for optimum seed growth, water convolvuluses showed growth enhancement while mung bean sprouts showed no effects (Jinapang [2010](#)). Perhaps discrepancies may be explained by the results of one experiment where the growth in mung beans exposed to low frequency EMF was inhibited at low field intensity, but was enhanced at a higher intensity (Costanzo [2011](#)). There may be other considerations with respect to differential research findings. The results of a study by Huang & Wang ([2008](#)) indicate that the magnetic field induced by a 20 or 60 Hz SPWM voltage (sinusoidal pulsed width modulation) has an enhancing effect on the early growth of mung beans, but the magnetic fields induced by SPWM voltages of other frequencies (30, 40, and 50 Hz) have an inhibitory effect, especially at 50 Hz.

Fermentations of the yeast *S cerevisiae* with magnetic treatment reached their final stage in less time, i.e., approximately 2 hours earlier than controls (Perez [2007](#)).

Treatment of sunflower seeds in magnetic fields increased the speed of germination, seedling length and seedling dry weight under laboratory germination tests (Vashisth & Nagarajan [2010](#)). Exposure of seeds to magnetic fields improved seed coat membrane integrity and reduced the cellular leakage and electrical conductivity. Treated seeds planted in soil resulted in statistically higher seedling dry weight, root length, root surface area and root volume in 1-month-old seedlings. Higher enzyme activity in magnetic-field-treated sunflower seeds could be triggering the fast germination and early vigour of seedlings.

Poinapen ([2013](#)) found higher germination (~11.0%) was observed in magnetically-exposed seeds than in non-exposed ones, although seedlings emerging from static magnetic field treatments did not show a consistent increase in biomass accumulation.

Results from a study by Aydin ([2016](#)) suggested that low intensity static magnetic field may trigger genomic instability and DNA methylation in wheat.

## Trees

Fresh and dry weight of leaves, content of MDA, proline, and protein increased in both healthy and infected plants under electromagnetic fields, compared with those of the control plants. EMFs decreased hydrogen peroxide and carbohydrates content in both healthy and infected 2-year old Lime trees compared to those of the controls (Abdollahi [2012](#)).

In a study by Waldmann-Selsam ([2016](#)) that looked at trees near mobile phone base stations, the measurements of all trees revealed significant differences between the damaged side facing a phone mast and the opposite side, as well as differences between the exposed side of damaged trees and all other groups of trees in both sides. The damage inflicted on trees by mobile phone towers usually start on one side, extending to the whole tree over time.

## Water

Electromagnetic-treated water was found to have diverse biological effects on both animal and plant cells (Yamabhai [2014](#)).

Amyan & Ayrapetyan ([2004](#)) suggested that EMF-treated water has a different biological effect on the process of barley seed hydration, solubility and water binding in seed and germination. Frequency "windows" for the effect of EMF were discovered, which could explain variability in studies.

## References

**Abdollahi F** et al 2012 - *Biological Effects of Weak Electromagnetic Field on Healthy and Infected Lime (Citrus aurantifolia) Trees with Phytoplasma* ScientificWorldJournal 2012:716929 PMID: 22649313

**Aguiló-Aguayo I** et al 2014 - *Optimization of pulsed electric field pre-treatments to enhance health-promoting glucosinolates in broccoli flowers and stalk* J Sci Food Agric 95(9):1868-75 PMID: 25171771

**Amyan A & S Ayrapetyan** 2004 - *The biological effect of extremely low frequency electromagnetic fields and vibrations on barley seed hydration and germination* ScientificWorldJournal 4 Suppl 2:55-69 PMID: 15517103

**Asghar T** et al 2017 - *Comparison of HeNe laser and sinusoidal non-uniform magnetic field seed pre-sowing treatment effect on Glycine max (Var 90-1) germination, growth and yield* J Photochem Photobiol B 166:212-219 PMID: 27984750

**Asghar T** et al 2016 - *Laser light and magnetic field stimulation effect on biochemical, enzymes activities and chlorophyll contents in soybean seeds and seedlings during early growth stages* J Photochem Photobiol B 165:283-290 PMID: 27835746

**Aydin M** et al 2016 - *Static magnetic field induced epigenetic changes in wheat callus* Bioelectromagnetics 37(7):504-11 PMID: 27513309

**Bhardwaj J** et al 2016 - *Pulsed magnetic field improves seed quality of aged green pea seeds by homeostasis of free radical content* J Food Sci Technol 53(11):3969-3977 PMID: 28035152

**Bilalis DJ** et al 2012 - *Investigation of pulsed electromagnetic field as a novel organic pre-sowing method on germination and initial growth stages of cotton* Electromagn Biol Med 31(2):143-50 PMID: 22268861

**Costanzo E** 2011 - *Influence of extremely low-frequency electric fields on the growth of Vigna radiata seedlings* Bioelectromagnetics 32(7):589-92 PMID: 21416477

**Efthimiadou A** et al 2014 - *Effects of presowing pulsed electromagnetic treatment of tomato seed on growth, yield, and lycopene content* ScientificWorldJournal 2014:369745 PMID:25097875

**Gagliano M** et al 2012 - *Acoustic and magnetic communication in plants: Is it possible?* Plant Signal Behav 7(10):1346-8 PMID: 22902698

**Halgamuge MN** et al 2015 - *reduced growth of soybean seedlings after exposure to weak microwave radiation from GSM 900 mobile phone and base station* Bioelectromagnetics 36(2):87-95 PMID: 25644316

**Huang HH & SR Wang** 2008 - *The effects of inverter magnetic fields on early seed germination of mung beans* Bioelectromagnetics 29(8):649-57 PMID: 18521844

**Isaac Alemán E** et al 2014 - *Effects of 60 Hz sinusoidal magnetic field on in vitro establishment, multiplication, and acclimatization phases of Coffea Arabica seedlings* Bioelectromagnetics 35(6):414-25 PMID: 25043829

**Javed N** et al 2011 - *Alleviation of adverse effects of drought stress on growth and some potential physiological attributes in maize (Zea mays L.) by seed electromagnetic treatment* Photochem Photobiol 87(6):1354-62 PMID: 21883242

**Jinapang P** et al 2010 - *Growth characteristics of mung beans and water convolvuluses exposed to 425-MHz electromagnetic fields* Bioelectromagnetics 31(7):519-27 PMID: 20564175

**Lung I** et al 2016 - *Induction of stress volatiles and changes in essential oil content and composition upon microwave exposure in the aromatic plant Ocimum basilicum* Sci Total Environ 569-570:489-95 PMID: 27362630

- Mridha N** et al 2016 – *Pre-sowing static magnetic field treatment for improving water and radiation use efficiency in chickpea (Cicer arietinum L.) under soil moisture stress* Bioelectromagnetics 37(6):400-8 PMID: 27442612
- Perez V H** et al 2007 - *Bioreactor coupled with electromagnetic field generator: effects of extremely low frequency electromagnetic fields on ethanol production by Saccharomyces cerevisiae* Biotechnol Prog 23(5):1091-4 PMID: 17663568
- Poinapen D** et al 2013 - *Seed orientation and magnetic field strength have more influence on tomato seed performance than relative humidity and duration of exposure to non-uniform static magnetic fields* J Plant Physiol 170(14):1251-8 PMID: 23759543
- Potenza L** et al 2012 - *Effect of 300 mT static and 50 Hz 0.1 mT extremely low frequency magnetic fields on magnetic Tuber borchii mycelium* Can J Microbiol 58(10):1174-82 PMID: 23061534
- Qiu Z** et al 2011 - *Microwave pretreatment can enhance tolerance of wheat seedlings to CdCl<sub>2</sub> stress* Ecotoxicol Environ Saf 74(4):820-5 PMID: 21145593
- Radhakrishnan & B D Kumari** 2013 – *Influence of pulsed magnetic field on soybean (Glycine max L.) seed germination, seedling growth and soil microbial population* Indian J Biochem Biophys 50(4):312-7 PMID: 24772951
- Radhakrishnan R & B D Ranjitha Kumari** 2012 - *Pulsed magnetic field: a contemporary approach offers to enhance plant growth and yield of soybean* Plant Physiol Biochem 51:139-44 PMID: 22153250
- Roux D** et al 2008 – *High frequency (900 MHz) low amplitude (5 V m<sup>-1</sup>) electromagnetic field: a genuine environmental stimulus that affects transcription, translation, calcium and energy charge in tomato* Planta 227(4):883-91 PMID: 18026987
- Sharma VP** et al 2009 – *Mobile phone radiation inhibits Vigna radiata (mung bean) root growth by inducing oxidative stress* Sci Total Environ 407(21):5543-7 PMID: 19682728
- Singh HP** et al 2011 – *Cell phone electromagnetic field radiations affect rhizogenesis through impairment of biochemical processes* Environ Monit Assess 184(4):1813-21 PMID: 21562792
- Soja G** et al 2003 – *Growth and yield of winter wheat (Triticum aestivum L.) and corn (Zea mays L.) near a high voltage transmission line* Bioelectromagnetics 24(2):91-102 PMID: 12524675
- Tkalec M** et al – 2009, *Effects of radiofrequency electromagnetic fields on seed germination and root meristematic cells of Allium cepa L.* Mutat Res 672(2):76-81 PMID: 19028599
- Vashisth A & DK Joshi** 2017 – *Growth characteristics of maize seeds exposed to magnetic field* Bioelectromagnetics 38(2):151-157 PMID: 27859499
- Vashisth A & S Nagarajan** 2010 - *Effect on germination and early growth characteristics in sunflower (Helianthus annuus) seeds exposed to static magnetic field* J Plant Physiol 167(2):149-56 PMID: 19783321
- Vashisth A & S Nagarajan** 2008 – *Exposure of seeds to static magnetic field enhances germination and early growth characteristics in chickpea (Cicer arietinum L.)* Bioelectromagnetics 29(7):571-8 PMID: 18512697
- Waldmann-Selsam C** et al 2016 – *Radiofrequency radiation injures trees around mobile phone base stations* Sci Total Environ 572:554-569 PMID: 27552133
- Yamabhai M** et al 2014 – *Diverse Biological effects of electromagnetic-treated water* Homeopathy 103(3):186-92 PMID: 24931750