Magnetic Field and Agriculture Sustainability

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Received 22 September, 2022; Revised 3 October, 2022; Accepted 3 October, 2022
Available online 3 October, 2022 at www.atlas-journal.org, doi: 10.22545/2021/00206

Short Letter

Agriculture's sustainability depends on the need to use practices and technologies that are environmentally friendly and have no bad impact on the environment, are cost-effective and easily accessible to farmers, resulting in overall food productivity enhancement. Additionally, the positive outcomes of sustainable agriculture can be carbon balance, pesticide control and food productivity. However, the main challenge is to develop policies for agriculture production sustainability in both developed and developing countries [1, 2]. During the past half-century, the use of pesticides, agricultural machinery, irrigation water and fertilizers helped increase agricultural productivity, but assuming that these relationships will remain linear in the future would be overly optimistic. Novel advanced techniques are required that integrate ecological and biological procedures to enhance food production and reduce the use of non-renewable resources, which are harmful to the environment and the health of individuals [1, 2]. The earth's magnetic field (MF) is one of the inevitable environmental factors affecting plant growth and yield. Because the MF technique is environmentally friendly, produces no waste, requires no power supply, and does not emit harmful radiation, it can be used for agricultural sustainability. It has two types; both weak and strong MF play a particular role in the growth and development of plants [3]. According to a study, confined variations have been found in the direction and strength of MF. Meanwhile, MF of the earth existed from the start of plant life and plays a key role in water accessibility, temperature, light and gravity, and it is also a significant part of plant evolution. During plant evolution, all other factors constantly varied except gravity. MF contributes to selection pressure and abiotic stress, ultimately leading to specie formation and diversification [4]. Magnetic susceptibility refers to the presence of various concentrations and types of oxy-hydroxide and iron oxide. MF also affects the hydrophobic and hydrophilic properties of water concerning minerals absorption, electrical conductivity, soaking time and several other properties [5].

Furthermore, plant stimulation with MF can be affected by physiological and biochemical mechanisms. MF can be used for the removal of undesirable ferrous metals from bulk and grain, for the cleaning of harmful metal debris and also used for disease prevention [6]. Another study stated that MF could enhance plant productivity by altering its physiological processes like water relations, uptake of nutrients, photosynthesis, respiration and biochemical aspects comprising genes of secondary metabolites, proteins, enzymes, antioxidants and reactive oxygen species (ROS) [3].

The technology of magnetic treatment is increasing day by day in the field of agriculture (Figure 1). However, most agricultural studies do not focus on soil magnetism, which is one of the significant factors having a substantial role in agriculture development. Soil magnetic susceptibility can be used for various applications like agronomy, archeology, pollution and climatic conditions. Soil magnetism can be affected by several factors like topography, vegetation, microbial activity, bacterial inoculation, temperature, gelation, soil drainage and climate [5].

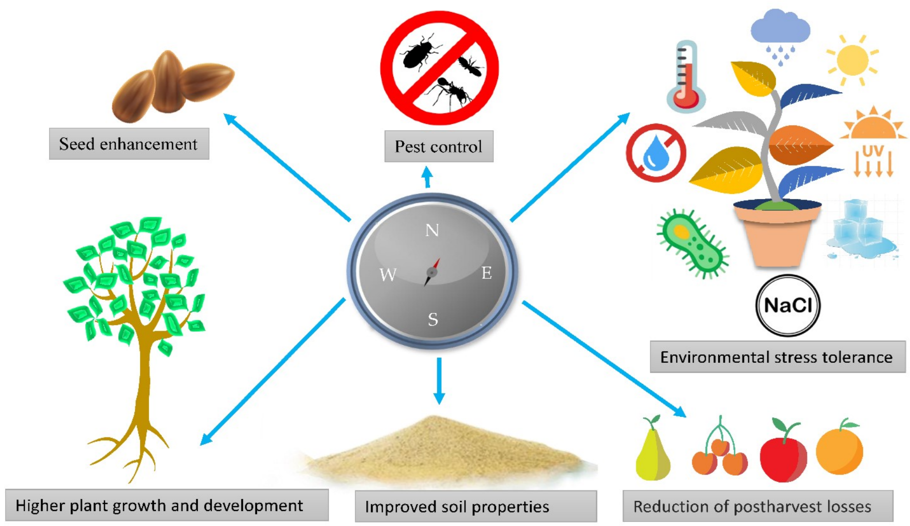

Figure 1: *Effect of magnetic field on sustainable agricultural production.*

During magnetic treatment, seeds are exposed to varying periods of magnetism. Magnetic treatment stimulated seeds better than untreated cultivars. The treatment of magnetic pre-sowing resulted in an enhanced percentage of seed germination. Further, seeds treated with magnetic treatment improved the length of root and shoot, vigor index and especially seed germination [7]. In another study, the effect of MF on the germination percentage was exposed for corn seeds, and the results suggested that MF treatment enhanced seed germination percentage and vigor [8]. Seeds exposed to MF result in accelerated metabolism, which leads to enhanced germination percentage [9]. Another study also reported the increased germination rate, germination rate index and vigor in radish seeds treated with MF [10].

Tomatoes irrigated with agricultural drainage water result in reduced quality and yield, which can be mitigated with the help of MF treatment. MF improves the quality, growth and yield of plants, thus ensuring food safety [11]. So, MF is an old technology that is known for its role in plant growth and development as well as for agricultural sustainability to meet future food demands, so it should be given the main focus of future research.

The application of altering and static MF helps to control the postharvest losses by affecting sprouting and shrinkage characteristics in potatoes. The potatoes subjected to both alternating current (AC) and direct current (DC) MF showed significantly lower weight reduction. The results suggested that potatoes exposed to DC MF resulted in fewer sprouts per tuber [12].

Plants being static, are continuously exposed to altered environmental conditions. MF helps to alleviate the adverse effects of abiotic stress conditions via decreasing oxidative stress and increasing antioxidant machinery. MF exposure was also found to overcome the stunted growth of plants under high temperature and light stress [9]. Magneto-priming can be carried out with the help of MF, which acts as an un-intrusive and physical stimulant for stress tolerance and improves the seed vigor of the major field crops [13]. Salinity is a major threat to agriculture sustainability [14]. It is increasing day by day and needs to be controlled. Electromagnetic energy can be used to alter the saline behavior of water in *Vigna radiata*. MF in soil as well as in normal and salt-treated water was detected to promote growth by improving nutrients and water absorption [15].

Seed pretreatment with MF aids in the control of natural pest infestations such as *Bemisia tabaci, Phenacoccus solenopsis, Thrips tabaci* and *T. urticae.* Plants treated with MF displayed a positively enhanced defense mechanism in soybean crop with a decline in pests, specifically *T. urticae.* Pests displayed a negative correlation with MF exposed seeds along with irrigation rate. Seeds respond to MF exposure time by altering the oil content, ash, chlorophyll, protein and carbohydrates as a 3rd degree polynomial model [16]. Furthermore, a study stated that MF treatment could reduce the disease index by modifying calcium signaling and pathways of polyamines and proline [9].

A study by Vashisth and Joshi [17] reported the MF treatment in maize. Maize seeds were exposed to various static MF levels, such as from a minimum of 50 to a maximum of 250 for the duration of 4 h. Among these levels and time periods, 200 mT for about 1 h was found to be the best as it resulted in greater values of chlorophyll content, dry weight of root and shoot, leaf number, shoot length, leaf area index (LAI) and improved root system. Similarly, another study regarding MF seed treatment was conducted on soybean. MF treatment of 150 and 200 mT for 1 h was found to be most effective as it enhances seed parameters such as vigor, seedling length, germination rate and water uptake. Plants treated with MF were found to have greater fluorescence at JIP by polyphasic Chl a fluorescence (OJIP). The map of total soluble proteins showed increased intensities of bands corresponding smaller and larger RUBISCO subunits [18]. Further, another study regarding the application of 200 mT SMF treatment for 1 h indicated that it significantly increased various parameters such as the ratio of ASA/DHA, nitrogenase activity, photosynthesis, leaf area and leaf weight; however, it caused significant reductions in antioxidant enzymes, ASA and hydrogen peroxide which helps to increase plant yield and biomass accumulation [19]. Moreover, MF has also been documented to reduce soil reduction via the magnetization of potable water. The results indicated that MF significantly increased Ca and 5% of Mg concentration in the soil, which suggested that MF could help reduce the degree of soil dispersion [20]. Furthermore, MF increased soil moisture as soil treated with magnetized irrigation water consists of greater soil moisture [21].

Authors' Contribution: The contribution of this paper is similar for all authors.

Funding: This research received no external funding.

Conflicts of Interest: The authors declares no conflict of interest.

References

[1] Pretty, J., (2008). Agricultural sustainability: concepts, principles and evidence. *Philosophical Transactions of the Royal Society B: Biological Sciences,* 363(1491), 447-465.

[2] Farooq, M.S., M. Uzaiir, A. Raza, M. Habib, Y. Xu, M. Yousuf, S.H. Yang, and M. Ramzan Khan, (2022). Uncovering the Research Gaps to Alleviate the Negative Impacts of Climate Change on Food Security: A Review. *Frontiers in Plant Science,* 13, 927535.

[3] Hafeez, M.B., N. Zahra, N. Ahmad, Z. Shi, A. Raza, X. Wang, and J. Li, (2022). Growth, physiological, biochemical and molecular changes in plants by magnetic field: A review. Plant Biology.

[4] Girija, T., K. Nandini, and M. Parvathi (2021).*Plant Growth Responses for Smart Agriculture: Prospects and Applications.* CRC Press.

[5] Talat Rashad, R., (2022). Soil Magnetism and Magnetically Treated Water and Possible Role for Sustainable Agriculture: A review. Egyptian Journal of Soil Science, 62(1), 73-83.

[6] Sleptsov, I., M. Shashurin, and A. Zhuravskaya, (2019). Short-Term Impact of a Permanent Magnetic Field on the Physiological, Morphological, and Biochemical Characteristics of Amaranthus retroflexus, Agastache rugosa, and Thlaspi arvense Seedlings.*Russian Journal of Plant Physiology,* 66(1), 95-101.

[7] El-Mugrbi, W., J. Bashasha, and S. Mohammeda, (2022). Protective Role of Magnetic Treatments for Seeds and Sea Water on Germination of Triticum Aestivum L.(Wheat). *AlQalam Journal of Medical and Applied Sciences,* 89-97.

[8] Bilalis, D.J., N. Katsenios, A. Efthimiadou, and A. Karkanis, (2012). Pulsed electromagnetic field: an organic compatible method to promote plant growth and yield in two corn types. *Electromagnetic biology and medicine,* 31(4), 333-343.

[9] Radhakrishnan, R., (2019). Magnetic field regulates plant functions, growth and enhances tolerance against environmental stresses. *Physiology and Molecular Biology of Plants,* 25(5), 1107-1119.

[10] Konefał-Janocha M., A. Banaś-Zabczyk, M. Bester, D. Bocak, S. Budzik, S. Górny, S. Larsen, K. Majchrowski, and M. Cholewa, (2018). The effect of stationary and variable electromagnetic fields on the germination and early growth of radish (Raphanus sativus). *Polish Journal of Environmental Studies,* 28(2), 709-715.

[11] El-Zawily, A.E.-S., M. Meleha, M. El-Sawy, E.-H. El-Attar, Y. Bayoumi, and T. Alshaal, (2019). Application of magnetic field improves growth, yield and fruit quality of tomato irrigated alternatively by fresh and agricultural drainage water. *Ecotoxicology and environmental safety,* 181, 248-254.

[12] Irungu, F.G., F.G. Ndiritu, C.M. Mutungi, S.G. Mathenge, and S.M. Mahungu, (2022). Static and varied magnetic fields effects on shrinkage and sprouting characteristics of stored potatoes. *Cogent Food & Agriculture,* 8(1), 2079207.

[13] Panda, D. and S. Mondal, (2020). Seed enhancement for sustainable agriculture: an overview of recent trends. *Plant Arch,* 20(1), 2320-2332.

[14] Raza, A., J. Tabassum, A.Z. Fakhar, R. Sharif, H. Chen, C. Zhang, L. Ju, V. Fotopoulos, K.H. Siddique, R.K. Singh, W. Zhuang, and R.K. Varshney, (2022). Smart reprograming of plants against salinity stress using modern biotechnological tools. Critical Reviews in Biotechnology, 1-28.

[15] Kaur, H. and G. Singh, (2022). *Studies on Potential of Magnetic Field Applications for Sustainable Agriculture. in Journal of Physics: Conference Series.* IOP Publishing.

[16] Alakhdar, H.H., M.M. Abou-Setta, Z.E. Ghareeb, and K.A. Shaban, (2022). Enhancing soybean defense mechanism against certain piercing-sucking pests and its growth parameters under water deficit stress by exposing seeds to three magnetic field exposure durations. *International Journal of Entomology Research,* 7(2), 583-590.

[17] Vashisth, A. and D.K. Joshi, (2017). Growth characteristics of maize seeds exposed to magnetic field. *Bioelectromagnetics,* 38(2), 151-157.

[18] Shine, M., K. Guruprasad, and A. Anand, (2011). Enhancement of germination, growth, and photosynthesis in soybean by pre-treatment of seeds with magnetic field. *Bioelectromagnetics,* 32(6), 474-484.

[19] Kataria, S., L. Baghel, M. Jain, and K. Guruprasad, (2019). Magnetopriming regulates antioxidant defense system in soybean against salt stress. *Biocatalysis and Agricultural Biotechnology,* 18, 101090.

[20] Ashrafi, S., M. Behzad, A. Naseri, and M.H. GHAFARIAN, (2012). The study of improvement of dispersive soil using Magnetic field.

[21] Surendran, U., O. Sandeep, and E. Joseph, (2016). The impacts of magnetic treatment of irrigation water on plant, water and soil characteristics. Agricultural water management, 178, 21-29

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