The Effects of Magnetic Fields on Plants Growth: A Comprehensive Review

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***Abstract*— Climate change is a key global concern particularly in the field of agriculture. Farmers around the world mainly in developing countries are faced with the critical problem due to reduction of potential crop yields and a decrease in water availability for irrigation and increasing food demands to cover the population needs. As a result, water shortage and poor yield are being increasingly accepted as major limitations. Researchers have documented that magnetic treatment can conserve both the quantity and quality of water and crop yield. This paper presents an extensive survey of studies on the effects of the fields on plants over the past 20 years. Many aspects of plants growth, seed germination, yield, quality and water as affected by magnetic fields (MF) are investigated. The inconsistency and contradictory outcomes from the studies appear to indicate that the effects of MF on plants may be dependent on species and/or MF characteristics such as intensity and exposure time.**

***Index Terms*—Magnetic field, plants growth, plants yield, review**

I. Introduction

Magnetic fields are everywhere. The earth itself has its own magnetic field called the geomagnetic field (GMF). The strength of geomagnetic field (GMF) on the Venus surface and in the vicinity of the sun was investigated and estimated by physicists and other scientists around the world. According to literature retrieved, the strength of geomagnetic field does not exceed 0.1nT in the vicinity of the sun- 0.21 nT, and on the Venus surface-3nT [1]. However, there are other several natural fields that exist in and about the earth and are grouped into what can be called the overall geophysical field [2]. These fields are: gravitational field, electric field, radioactive field seismic field, geothermal field, geochemical field, magnetic field and it is believed that a variation in one or more of this field have some visible effect on organisms and it is conceivable that plants like other organism sense different wavelengths of the light, respond to gravity, react to touch and electrical signaling and might react according to one or more of these changing force fields [3].

Subsequently, a man has created other sources of electromagnetic fields in his environment which differ in their frequency and intensity for the stimulation and development of plants [4]. According to [5] EMF can be viewed as the combination of an electric field and a magnetic field. Electric field is produced by stationary charges, and the magnetic field by moving charges (current) which can be macroscopic currents in wires or microscopic current associated with electrons in atomic object [1 and 6]. However, magnetic field can pass through most material while electric fields are easily shields or weakened by the conducting objects such as trees and buildings. Moreover, the magnitude of both types of fields decreases with distance from their source. Furthermore, magnetic field decreases in intensity more rapidly than does the electric field.

Since this creation, the stimulation of plants with magnetic field as a way to increase the quantity and quality of seed germination, seedling development and yields of different species, such as field, fodder and industrial crops, herbs and medicinal plants, different vegetables and fruits, grasses, ornamentals and model crops together with their physiological and biochemical influences and possible physiological mechanisms, has caught the interest of many scientists in the entire world [7]-[9].

Nevertheless, some authors argue about this inclusion, they believe that the study of magnetic fields on organisms is not biologically active nor science based but rather pseudoscience [10]. Nonetheless, there have been breakthrough discoveries in the past 20 years, mainly related to enzyme activity, germination and water uptake in seeds [1 and 11]. However, there is no a complete conclusion on how this fields achieve such a change on the plants but a number of theories had been proposed to explain this action. Magnetic treatment are assumed to enhance plant vigour by influencing the biochemical process that involve free radicals and by stimulating the activity of proteins and enzymes [12]. In the same manner, [13]-[16] associated the mechanism of magnetic

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field with the activation of phyto-hormone such as gibberellic acid-equivalents, indole-3-acetic acid and trans zeatin as well as activation of the bio-enzyme systems which [6] Stated that, magnetic field alters the the membrane structure of the plant cells so that the plants absorbs more water and nutrients. In addition, the vast majority of biological substances are proteins that contain metal ions, such as hemoglobin, cytochrome or ferritin, which can be paramagnetic [17], [18].

Due to all that have been mentioned above, the key purpose of this survey is to compare results obtained after the plants were exposure to different intensities of Magnetic Fields (MF), electromagnetic fields (EMF), Electric Fields (EF) and magnetized water on the germination, growth and development of different plants. And finally, these studies provide a basis for collaboration among researchers and farmers. Research works are reviewed and summarized in Table 1, which provides the source authors, a summary of the research focus, electromagnetic field technology covered and comment on This section of paper is divided into different category of magnetic field intensity and time exposure applied on plant system namely on;

- Pre-treatment of seedling
- Seed germination
- Plant growth and development

TABLE I: REVIEW OF MAGNETIC FIELD INTENSITY APPLIED ON PRE-TREATMNET OF SEEDLING

Authors	Method	Focus of the Review	Comments on key results
Azita, S., and Ahmad, M. [19]	Pre-treatment of seedling	The study focused on a seeds of Lentil (*Lens culinaris L.*,) which contains significantly Fe^{2+} as a ferromagnetic element) which were magnetically pretreated by different magnetic field intensities from 0.06 to 0.36 tesla (T) using Zeeman system for different periods of time 5, 10 and 20 minutes. Under natural light cycle 14-h light/10-h darkness and 25±3°C daily and night temperature	Magnetic treatment improves first stages of growth in higher plants and increases stress enzyme like APX in seedling which grown from pretreated seeds.
Sunita, K., Lokesh, B.K.N., and Guruprasad [20].	Pre-treatment of seedling	Evaluation of magnetopriming on germination and early growth characteristics of seeds under saline conditions exposed to static magnetic field of 200mT for 1hour	The adverse effect of salinity on germination and seedling vigour can be alleviated by magnetoprimig with SMF of 200mT for 1 h and it can also be used to increase water uptake and higher activity of hydrolytic enzymes (α amylase and protease)
Nilimesh, M., Sudipta, C., Debashis, C., Anjali, A., Pramila, A., and Shantha, N [21].	Pre-treatment of seedling	Looking at the possible involvement of magnetic field (MF) pretreatment in physiological factors of Phaseolus vulgaris in three different treatments; (T1) control, (T2) magnetic field with B=1.8 mT for 30 min per day in 10 days, (T3) magnetic field with B=1.8 mT for 60 min per day in 10 days	Using a magnetic time exposure for 30-60min led to a higher generation of Reactive Oxygen Specie and garden to decrease the biosynthesis of chlorophyll, carotenoid, phenolic and flavonoid compounds.
Bilalis, D.J., Katsenios, N., Efthimiadou, A., and Karkanis, A. [22]	Pre-treatment of seedling	Treatment of corn seeds with pulsed EMFs for 0, 15, 30 and 45min.	Using pre magnetic treatment has been found to perform the best results with economic impact on producer's income in a context of a modern, organic, and sustainable agriculture
Abou El-Yazied, A., El-Gizawy, A.M., Khalf, S.M., El-Satar, A., and. Shalaby O.A. [23]	Pre-treatment of seedling	The work aimed to determine the effects of magnetic bio-stimulation on tomato plants Lycopersicon esculentum (Mill) cv. under NPK fertilizer levels.	Treated tomato seeds (cultivar Castle Rock) with magnetic field by 100 gauss for 15 minutes with magnetically treated irrigated water improved vegetative growth, increased total phosphorus content of tomato leaves and total yield while reduced pH value in soil extraction.

Claudia, H.A., Arturo D.P., Aquiles, C.C., Alfredo, C.O., Rumen, I., Jose, L.B., and Justo, P.V.M.[24]	Pre-treatment of seedling	In this study alternating magnetic field treatments at low frequency (60 Hz) with combinations of three magnetic flux densities (20, 60 and 100 mT) and three exposure times (7.5, 15 and 30 minutes) were used as pre-sowing seed treatments in three maize (Zea mays L.)	The results show that electromagnetic field treatment provide a simple and ecologically well compatible method to improve seed vigour in maize but is necessary to find the optimal irradiation parameters to induce a positive bio stimulation in the maize seeds which also depends on the seed genotype.

TABLE II: REVIEW OF MAGNETIC FIELD APPLIED ON GERMINATION

Authors	Method	Focus of the Review	Comments on key results
Oleg A.K., and Karl H.H. [25]	Seed germination	Studying the Physical characteristics (density p and magnetic susceptibility x) of amyloplasts and ratio of the velocities of individual amyloplasts in the presence and absence of a high gradient magnetic field (HGMF).	Using uniform magnetic fields causes neither curvature nor changes in growth rate and emerging root and shoot of germinating plants adjust to the gravity vector by changing the rate of elongation of the top and bottom of the root or shoot.
Rashmi, S., Sunita, T., Pandey, Omvati, V., Neha, J., Sriastava, R.C. [26]	Seed germination	The study focused on the physical energy through static magnetic fields of 100 to 250 milli Tesla intensity with the intervals of 50 milli Tesla for 1-4 hour, and to metaphysical energy through BK Rajyog meditation (BKRYM, a positive thought energy based meditation) with an interval of 1 hour.	Exposure of seeds to physical energy treatments through static magnetic field of strength below 250 mT for one hour and metaphysical energy treatment through BK RYM, (a positive thought energy based treatments) for two and four hours could be a suitable, cheap and easy seed invigoration method for improving germination and seedling vigour indices of poor quality seed. Seed enhancing energy treatments not only increase the growth and vigor parameters of seedlings but also play a significant role in enhancing biochemical properties of seeds
Ma, E. R., Aquiles, C.C., and Claudia, H. A. [27]	Seed germination	This study provides insight into a new way of improving maize productivity under rainy season conditions under variable magnetic field of 560 mT for 30 min prior to sowing	By treating seed with magnetic fields, it is possible to improve short cycle varieties, adapted to rainy season zones.
Hasenstein, K.H., John, S., Scherp, P., Povinelli, D., and Mopper, S. [28]	Seed germination	The examination of corn, wheat and potato starch grains suspension movement with video microscopy under parabolic flights of 20–25s of weightlessness	The advantage of using Magnetic gradient is that it can move diamagnetic compounds under weightless or microgravity conditions and serve as directional stimulus during seed germination in low-gravity environment
Fariba, R. V., Ahmad, M., Taher, N., and Sedighe, A. [29]	Seed germination	The study examined the effect of electromagnetic fields on seed germination and seedling growth of Satureja bachtiarica, seeds were soaked in water for 5 hours and placed on the screen, between the two parallel coils electromagnetic generating device and were under electromagnetic irradiation with one mT intensity with connection to the electricity for two hours	Germination speed showed a significant increase in the treated samples whereas morphological comparison of the treated and control samples showed a significant decrease in the mean shoot length, leaf area, fresh and dry weight
Rostami, Z.E., Majd, A., and Arbabian, S. [30]	Seed germination	Seed of *(Urtica Dioica L*) were put under electromagnetic field by 0.8 and 1.6mT for duration of 5, 10, 20 minutes.	The interaction of magnetic field and exposure time indicates that certain combination of magnetic field and duration, such as 0.8 mT for 20 min is highly effective in enhancing germination

Lucietta, B., Graza, T., Fabio, Fregola and Michela , Z. [31]	Seed germination	This study concerns the effects of a weak static magnetic field (MF) at 10 μT oriented downward, combined with a 16-Hz sinusoidal MF (10 μT), on in vitro pollen germination of kiwifruit (*Actinidia deliciosa*).	Using ELF-MF treatment might partially remove the inhibitory effect caused by the lack of Ca^{2+} in the culture medium, inducing a release of internal Ca^{2+} stored in the secretory vesicles of pollen plasma membrane. Although preliminary, findings seem to indicate the in vitro pollen performance as adequate to study the effects of ELF-MFs on living matter
Sara, F., Ahmad, M., Sedigheh, A., Davoud, D., and Mehrdad, H.[32]	Seed germination	Investigated the effects of electromagnetic field strengths (1 and 2mT) on seeds germination, seedlings ontogeny, and protein content and catalase activity in Valerian seeds (*Valeriana officinalis L.*).	Electromagnetic fields probably degenerate proteins in the early stages of seedlings ontogeny and the treated valerian seedlings can increase catalase activity by decreasing free radicals against electromagnetic fields tension.
Aksyonov, S.I., Grunina, T. Yu., and Goryache, S. N. [33]	Germination	The study focused On the Mechanisms of Stimulation and Inhibition of Wheat Seed Germination by Low-Frequency Magnetic Field	Stimulation of wheat seed germination by brief exposure in a 50-Hz electromagnetic field (EMF) is shown to depend on the extent of membrane stretching upon seed swelling in sucrose solutions.

TABLE III: REVIEW OF ELCTRO MAGNETIC FIELD APPLIED ON PLANT GROWTH AND DEVELOPMENT

Authors	Method	Focus of the Review	Comments on key results
Hozayn, M., Abd, E.M.S.A., Abd, E.A.A., Abdelraouf, R.E., and Ebtihal, M. A. E. [34]	Plant growth and development	Looking on a way of producing more food from less water and optimization unit area for improvement of water productivity and yield crop using magnetic water technology.	Treatment of magnetic water could be used to improve quantity and quality traits of faba bean and water productivity under sandy soil conditions.
Omid, S. [35]	Plant growth and development	Evaluation of the effects of irrigation with magnetized water on some agronomic and physiological traits.	Using structured irrigation system (magnetized irrigation) has shown a remarkable increase in the yield, yield components, chlorophyll content, net photosynthetic rate, WUE, RWC, HI, plant height and biomass production. Nevertheless, magnetized water can be considered as one of the most valuable, safe, practical and economical technologies that can help in improving yield, WUE and thus saving water resources.
Magdalena, M.,Krzysztof, K., Stanisław, P., Mariusz, G. [36]	Plant growth and development	Focused on the stationary magnetic field (130 mT) on the mitotic activity and selected biochemical parameters of lupin (*Lupinus angustifolius L.*).	The data presented on this paper concludes that 130-mT MFS enhances the growth and development of aboveground parts, which is manifested by an increase in the length and weight of the shoots and an increase in the photosynthetic pigment content. Nevertheless, the study concluded that, MFS is beneficial for the improvement of growth and productivity of economically important.
Małgorzata, R. [37]	Plant growth and development	Looking at seed improvement of three varieties of sugar beet growth using low frequent magnetic field acting independently and in combination with other method of seed improvement.	Low frequent magnetic field, used independently or in combination with other methods of post- harvest influenced the chlorophyll content. However, the best results were obtained using

			the magnetic field together with conditioning. Magnetic field treatment also had a positive influence on content of nitrogen in plants through the better uptake of nitrogen from the soil.
Hsin, H.H., and Show-Ran, W. [38]	Plant growth and development	Looking at the biological effects of both a 60Hz sinusoidal MF and a 60Hz pulsed MF on the early growth of plants.	Sinusoidal and pulsed MFs affect the plant growth in different ways (with respect to different kinds of plant). However, the 60Hz sinusoidal has an apparent enhancing effect on growth but with the occurrence of some morbid state phenomena. Nevertheless, the pulsed MF harms plant growth rather than enhancing growth as the sinusoidal MF does.
Yu. I.,Novitskiia, G. V., Novitskayaa, D. R., Molokanova, Y. A., Serdyukova, and Yusupovab, I. U. [39]	Plant growth and development	Looking at the influence of weak horizontal permanent magnetic field (PMF) produced by Helmholtz coils of 400 A/m strength under controlled conditions of illumination and temperature in phytothrone.	Using a weak horizontal PMF of a strength of 400 A/m had a positive influence on head stone due to a significant reduction of the polar and neutral lipids and the content of glycolipids decreased among PL, in particular, of MGDG, which are structural components of the reaction center of photosystem. Hence, the content of PG, PC, PE, and PI decreased among phospholipids.
Shahin M. M., Mashhour A. M. A., and bd-Elhady, E. S. E. A. [40]	Plant growth and development	Aim of the study was to evaluate the effect of different magnetic field strengths (0.0, 20.0, 40.0 and 60.0 m T), at different time intervals ranging from 0 to 300 minutes on some properties of irrigation water the pH, electric-conductivity (EC), and total dissolved salts (TDS).	The magnetic treatment of irrigation water had a positive effect on growth parameters, yield, increasing germination, absorption of the nutrients (N, P, K, Fe, Mn, Zn, and Cu) and decreasing ion toxicity.
Kordyum, E.L., Bogatina, N.I., Kalinina, Y.M., and Sheykina, N.V. [41]	Plant growth and development	Evaluating the structure and functional organization of cap statocytes under combined MF at the resonance frequency of Ca^{2+} ions inside a μ-metal shield and the altered gravitropic reaction of cress (*Lepidium sativum*).	The experimented conditions were observed to change normally positively gravitropic cress root to exhibit negative gravitropism
Mihaela, D.R., Dorina, C., and Carmen, A (42]	Plant growth and development	The study presented in this paper was focused on the biochemical changes induced by extremely low frequency magnetic field in maize plants during their early ontogenetic stages (first 12 days of growth). Under five different magnetic doses 1 – 2 – 4 – 8 – 10 mT) at 50 Hz frequency	Electromagnetic energy could trigger complex synergetic cellular mechanisms that can lead to the growth disturbing
Mohammadjavad, S., Hassan, F., Gholamreza, M., and Aliasghar, B. [43]	Plant growth and development	The study focused on two irrigation treatments (control and water stress) and six methods of fertilizer treatment (control, NPK-F, using magnetic band-M, using silver nano particles- N, M+N and M+N+50% F) on performance of ajowan.	Magnetic field exposure, probably by encourage nutrient uptake efficiency could be applied to reduce fertilizer requirement. On the other hand the cultivation of plants under low MF could be an alternative way of WUE improving.
Massimo E.M. [44]	Plant growth and development	This review describes the effects of altering Magnetic field (MF) conditions on plants by considering plant responses to M Values either lower or higher than	Understanding Geomagnetic field effects on life will provide the fundamental background necessary to under- stand

		those of the GMF. The possible role of GMF on plant evolution and the nature of the magneto receptor were also discussed	evolution of life forms in our planet and will help us to develop scientific recommendations for design of life- support systems and their biotic components for future space exploration.
Khonsari, A., Gorji, K., Alirezaei, M and Akbar, A. [45]	Plant growth and development	The aim of this study was to examine the different level of intensities from weak MF (20, 40, 60, 80 gauss) on percentage of seed germination and seedling growth of (*Myrtus communis L.*)	The exposure of Myrtus communis L. seeds to weak MFs (20, 40, 60 and 80 gauss) reduces germination of seeds, and exposure of 60 gauss for 10 consecutive days, showed a significant reduction in seed germination.
Elfadil, A. G., and R. A. Abdallah [46]	Plant growth and development	This study was conducted to determine the impact of sun light, UV and magnetized water on Dura Sorghum sp. variety plants the Sudanese main stable food	The effect of magnetized water on the plant indicated that magnetized water has a positive effect on Dura plant growth and development
Jaime A. T.S., and Judit, D.[47]	Plant growth and development	This review focuses on the use of MW in a bid to alter plant growth and development	The application of MW might be a very practical way to improve the quantitative and qualitative attributes of agronomic and horticultural production under greenhouse or field conditions.
Andrei, P.C., Jonas, B., and Gabriel, B.[48]	Plant growth and development	The purpose of this study was to observe the effects of Electromagnetic Fields on the growth and photosynthesis of the Lima bean plant (Phaseolus lunatus).	No significant difference was observed between the plants grown under magnetic field and the free ones but the seeds under electric field didn't grow up at all.
Leo C. R., and Marites, M.R. [49]	Plant growth and development	The study aimed to determine the effect of electro-magnetic field on the growth characteristics of Okra, Tomato and Eggplants and set to establish baseline data for farmers on the possible utilization of Electro-Magnetic Field (EMF)	The study proved that Okra, Tomato and Eggplant plants when exposed to EMF are less susceptible to insects and pests. Thus, occurrence of pest and insects lessen in plants that are exposed to EMF.
Musa, T., Cabir, T., Peyami,B and Mehmet, E.E. [50]	Plant growth growth and development	Looking at the effects of a continuous static magnetic field (SMF) on growth and concentration of phytohormones and chlorophylls in maize and sunflower plants SMF in two directions; parallel to gravity force (field-down) and anti-parallel (field-up)	The negative effect of static magnetic field in both directions was seen on dry weight of maize plants, whereas a prominent increase in roots of sunflowers was detected. However, the field-up direction caused a significant increase in IAA and t-Z contents.
Ahamed, M.E.M., Elzaawely, A.A., and Bayoumi, Y.A [51]	Plant growth and development	A study was carried out to understand the effect of magnetic field on the seed germination, growth, yield and fruit quality of sweet pepper (*Capsicum annuum*)	Magnetic field is an effective method for the pre sowing treatment of the seeds that enhance their germination and increases yield capacity and fruit quality

The tables above has presented an overview of various magnetic field intensity that has been used for plant growth and development, pre-treatment of seedling and to speedup germination stage, it further elaborate on the focus of the review and comments on key results.

After analysing this table, it can be concluded that magnetic field device is a remarkable alternative tool for improving productivity in crops, with negligible deleterious effects. The inconsistency and contradictory outcomes from the studies appear to indicate that the effects of magnetic fields on plants may be species-specific and/or is dependent on the characteristics of field exposure such as intensity and duration periods.

III. Discussion of Publication

After surveying various methods used to improve the quantitative and qualitative attributes of agronomic and botanical production in greenhouse or field conditions, it is recorded that the biological effects of MF or EMF treatments depends on the strength and exposure period of plant. The interaction of magnetic field and exposure time indicated that certain combination of magnetic field

and duration are highly effective in enhancing growth characteristics.

- The application of pre-treatment of seedling have shown promising potentials in different areas particularly in agriculture. Pre-treatment of seedling with magnetic field is gaining more application with significant advantages such as improvements of Magnetic treatment improves first stages of growth in higher plants and increases stress enzyme like APX in seedling which grown from pre-treated seeds [19]. The results show that electromagnetic FIELD TREATMENT PROVIDES A SIMPLE AND ECOLOGICALLy well compatible method to improve seed vigour in maize but is necessary to find the optimal irradiation parameters to induce a positive bio stimulation in the maize seeds which also depends on the seed genotype [24]. Nevertheless, the adverse effect of salinity on germination and seedling vigour can also be alleviated by magnetoprimig with SMF of 200mT for 1 h and it can also be used to increase water uptake and higher activity of hydrolytic enzymes (α amylase and protease) [20]. In addition, using pre magnetic treatment has been found to perform the best results with economic impact on producer's income in a context of a modern, organic, and sustainable agriculture [22].
- The advantage of using Magnetic gradient is that it can move diamagnetic compounds under weightless or microgravity conditions and serve as directional stimulus during seed germination in low-gravity environment [28]. The application of magnetic field on germination is a suitable, cheap and easy seed invigoration method for improving germination and seedling vigour indices of poor quality seed [26]. Seed enhancing energy treatments not only increase the growth and vigour parameters of seedlings but also play a significant role in enhancing biochemical properties of seeds [26], [30]. Treated seed revealed the stimulatory influence of on the plants in their early ontogenetic stages: significant enhancement of the fresh tissue mass, assimilatory pigments level as well the chlorophyll ratio, average nucleic acids level, increase of the average plants length (exception: the dry substance mass accumulation) [25], [26]. The variable magnetic field flux is a very significant factor in influencing the germination process. However, it must be remembered, that this influence is varied and depends on the magnetic field flux and the plant type.

The applications of Magnetic Water Treatment (MWT) device on the biological system of plant have shown promising potentials in different areas particularly in agriculture. Magnetized technology is gaining more application with significant advantages such as improvements of irrigation water quality and quantity, crop yields and quality, soil improvement and water saving [35]. Understanding MWT effects on life will provide the fundamental background necessary to understand evolution of life forms in our planet and will help us to develop scientific recommendations for design of life- support systems and their biotic components for future space exploration [44]. Sinusoidal and pulsed MFs affect the plant growth in different ways (with respect to different kinds of plant). However, the 60Hz sinusoidal has an apparent enhancing effect on growth but with the occurrence of some morbid state phenomena [38]. Nevertheless, the pulsed MF harms plant growth rather than enhancing growth as the sinusoidal MF does. Nonetheless, using structured irrigation system (magnetized irrigation) has shown a remarkable increase in the yield, yield components, chlorophyll content, net photosynthetic rate, WUE, RWC, HI, plant height and biomass production [35]. Magnetized water can be considered as one of the most valuable, safe, practical and economical technologies that can help in improving yield, WUE and thus saving water resources. MWT improves overall crop conditions indirectly and directly by adjusting water or soil features [50].

IV. Recommendations and Conclusion

The review paper gives an overview of different magnetic field intensity and time exposure applied in the field of agriculture and engineer. By using proper combination of magnetic field intensity and time exposure is a fundamental key to consider in other to enhance the crop productivity and development.

The exposure of plants to magnetic field is one of the potential, safe and affordable physical application for enhancing the crop productivity and to improve the quantitative and qualitative attributes of agronomic and botanical production in greenhouse or field conditions. This technology does not emit wastes of any kind, does not generate harmful radiation and neither does require power, so it is environmentally, economically friendly, sustainable and attribute highly desirable in modern agriculture. This has a potential to increase crop production and water productivity per unit area of land without having any damaging effect towards any environmental component. However, there is still a need of further research, since the variety of magnetic devices tested makes it difficult to apply under field condition to enhance post germination, plant development and crop stand. However, the inconsistency and contradictory outcomes from the studies appear to indicate that the effects of magnetic fields on plants may be species-specific and/or is dependent on the characteristics of field exposure such as intensity and duration. A review of work done in electro /magnetic field for improving physiological activity of plants in recent years indicates a promising potential of such research characteristics in the future.

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