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Research Article

The Comparative Study On The Effect of Electric And Magnetic Fields On Seed Germination: A Review

Devendra Singh[1], Ankur Kumar[1*], Ṛajeev Saxena[2], Prakhar Singh[3]

ABSTRACT

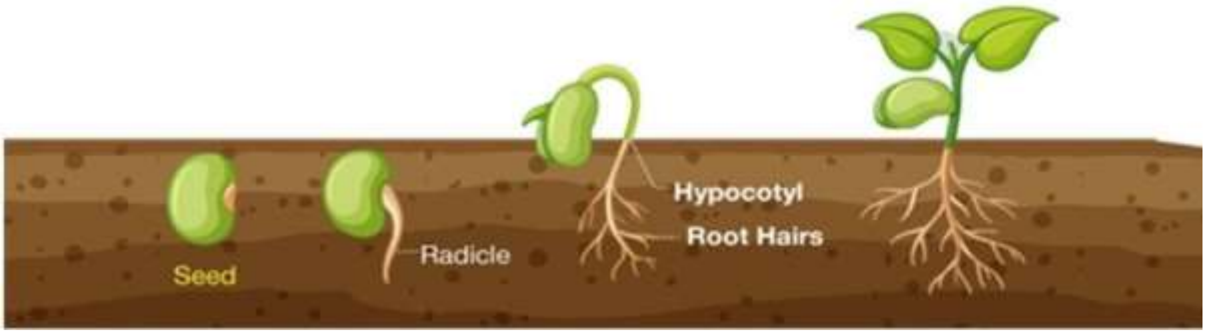
The purpose of this study is to observe the rate of seed germination under the influence of electric and magnetic field of various strengths theoretically. Here the germination rates of seeds treated with electric field and non- treated are comparatively studied. It is also seen that electric field affects the movement of ions, electrons and other charged species and causes changes in cell division and growth of the plant. It is concluded that the seeds stimulated by magnetic field germinate earlier than the seeds stimulated by electric field. In this way, it is concluded that overall growth factor is found more significant in magnetically treated seeds than electrically treated seeds. An attempt to compare effects of electric and magnetic fields on the germination of seeds has been made in the study. Future aspects of these kinds of studies has been discussed in details.

Key Words: Bio-Chemical Parameters; Electric Field strength; Emergence Ratio; Magnetic field strength; Mitotic Activity; Germination Percentage; Germination Rate; Physiological Parameters; Root; Speed of germination; Shoot; Vigour Index.

I.INTRODUCTION

Seed germination is the keen process by which different species of grow from a single seed and convert into a plant. This process affects both crop-yield and its quality. A common example of seed germination is the sprouting of a seedling from a seed of an angiosperm. The complete process of seed germination is carried out in the following steps:

[1] Gurukula Kangri Vishwavidyalaya, Haridwar, India-249404
[2]Uttarakhand Science Education and Research centre, Dehradun, India-248001
[*Corresponding author – physicsankur@gmail.com]



During the beginning stage of germination, the seeds take up water rapidly and this results in swelling and softening of the seed coat at an optimum temperature. This stage is called as Imbibition. It starts the growth process by activation of enzymes of the plant. The seed activates its internal physiology and initiates to respire and produce proteins and metabolizes the stored food. This is a lag phase of seed germination. By rupturing of the seed coat, radicle emerges to form a primary root. The seed initiates absorbing underground water. After the emerging of the radicle and the plumule, shoot initiates growing upwards. In the final stage of seed germination, the cell of the seeds becomes metabolically active, elongates and divides to give rise to the seedling. Some of the factors are more essential for germination like water- It is extremely necessary for the germination of seeds. Some seeds are extremely dry and need to take a considerable amount of water, relative to the dry weight of the seed. Water plays an important role in seed germination. It helps by providing necessary hydration for the vital activities of protoplasm, provides dissolved oxygen for the growing embryo, softens the seed coats and increases the seed permeability. It also helps in the rupturing of seed and also converts the insoluble food into soluble form for its translocation to the embryo-oxygen. It is an important and essential source of energy required for seed growth. It is required by the germinating seed for metabolism and used as a part of aerobic respiration until it manages to grow green leaves of its own. Oxygen can be found in the pores of soil particles, but if the seed is buried too deep it will be deprived of this oxygen and temperature around 25-30°C is required for the germination of a seed. Quite obviously different seeds require different optimum temperatures. There are some seeds which require special requirements either lower or higher temperature between 5 to 40°C, light or darkness. It can act as an environmental trigger. Many seeds do not germinate until sunlight falls on them. The seeds undergo rapid expansion and growth of the embryo and subsequently rupturing the covering layers and emergence of the radicle. This radicle emergence is considered the completion of germination. All the plants on the Earth exist in electric and magnetic fields because the Earth has its magnetic field and there is also an electric field between clouds and the Earth. extensive studies have been conducted upon effects of electric fields on living organisms. Almost all human life is affected by electric and magnetic fields. Electrical functioning takes place in all the living cells for survive and their tissues also reveal electrical properties. Wheaton et al. (1971) did an experimental study on the influence of electric field on seed germination and they found that electric field does not affect significantly the germination rate of air-dry soybeans and soaked corn. More study is required to evaluate this possibility because this study gave the negative results.

Male (1992) reported the transport and uptake of calcium ions induced by a magnetic field. Moon and Chung (2000) found in their study that germination of tomato seed enhances by the magnetic field of ranging from 0.3 to 100mT. Moreover, it's also seen that extremely low frequency magnetic field causes a significant enhancement of germination (Takimoto et al.,2001). Furthermore, the seed treated with field gives a big enhance in seed germination relatively untreated seed (non-magnetised). Zamiran et al. (2013) did their experimental study on the effect of electromagnetic field on Zinnia (Zinnia elegans) seeds. They used four magnetic strengths of 15, 100, 400 and 800 μT to magnetise the seeds in four durations of 30, 60, 120 and 240 min. It has been observed that magnetic field significantly affects the root length, shoot length, fresh and dry root weight, fresh and dry shoot weight, seedling length and weight, germination percentage, speed of germination, vigor index I and II. Moreover, it is confirmed that magnetic field significantly affects soil emergence factors of root length, shoot length, dry root weight, dry shoot weight, seedling length, emergence percentage and emergence speed at 0.05 level of probability. The best magnetic field strength for seed germination and seed emergence is 400 μT. The durations of 240 and 30 min gave fine results over all magnetic fields in seed germination and emergence, respectively.

In addition to present study, Rostami Zadeh et al. (2014) found in their experimental study that seeds treated with electromagnetic field of intensities 0.8mT for 5 minutes and 1.6mT for 10 minutes in dry seeds and also for 5 minutes in wet seeds give the fastest germination among treated seeds and also gives the better growth of the plants. Moreover, Yao and Shen (2015) found in their experimental study that Pinus tied seeds treated with magnetic field get the enhanced speed of germination (SG) and germination percentage significantly in comparison to untreated seeds while the seeds treated with a static magnetic field of intensity 150 mT for 24 h and 48 h decelerates the germination speed and germination percentage. Furthermore, in an experimental study, magnetic field accelerates the germination parameters (germination percentage, emergence index, mean germination time and vigor index I and II). The growth parameters (root length, root & shoot dry & fresh weights and leaf area also increased significantly by the magnetic field stimulation). In general, 25 mT for the durations 30 and 45 min, 50 mT for 30 and 45 min and 75 mT for 15 and 30 min treatment gave the better performance. This experimental study confirmed that pre-sowing magnetised seeds get the more enhanced germination and seedling growth than the non-magnetised seeds (Iqbal et al.,2016). Nevertheless, the low-frequency magnetic field exposure makes a physiological and biochemical changes. Moreover, under such exposure, plants get a change in biometric parameters, mitotic activity, assimilation pigment content (Mroczek-Zdyrska et al., 2016).

In addition to this, it is also seen that the pre-sowing magnetic field stimulation gives the better rectification in the germination of potato tubers, vegetative growth, potato yield and and its other components in comparison to untreated true potato seeds (El-Gizawy et al., 2016). Furthermore, Srikanth et al. (2018) did an experimental study in which seeds were treated with the magnetic field strengths of 250 Gauss, 500 Gauss, 750 Gauss, and 1000 Gauss for 30 minutes. Out of these magnetic field strengths 1000 Gauss gives the most effective performance. Moreover, it is also confirmed that high magnetic field enhances the germination capacity as well as seedling growth and vigour of seeds. Magnetic field exposure enhances the germination rate of a seed faster than electric field exposure. In a recent experimental study, it is seen that the coffee seeds treated with magnetic field strengths of 10 mT & 28 mT improve the permeability of the cellular membranes and advance the activation of the antioxidant system in the first six days of germination. Therefore, seed germination becomes accelerated (Braga Junior et al., 2020). However, it is seen that the seed treated with electric field gives a significant enhance in seed germination compared with the untreated seed (non-electrified). The strength of the electric field has the greatest effect on the seed germination of the first fraction, while seed moisture has the greatest impact on the seed germination of the second fraction (Lynikiene and Pozeliene,2003). Furthermore, energy content conveyed to seed depends on the strength of the electrical field and seed electrical properties (Lynikiene and Pozeliene,2003). Nevertheless, positive growth takes place in the plants due to the pulsed electric field stimulation (Eing et al., 2009).

It should be noted that Asavasanti et al. (2010) did an experimental study and they found that there are significant influences of critical electric field strength on onion tissues. It is also seen that the effects of different voltages of electrical current has a significant effect on germination of seeds of various Pistacia vera varieties Ak et al. (2011). The germination of seeds of various Pistacia vera varieties enhances first and then it recedes with enhancing the electrical voltage Ak et al. (2011). It has also been observed that exposure of germinating barley to pulsed electrtic field affects radicle emergence without significantly affecting the seed's gross metabolic activity (Dymek et al., 2012). Moreover, in an experimental study, Rezaei-Zarchi et al.(2012) found that electric field affects the movement of ions, electrons and other charged species and causes changes in cell division and growth of the plant. In addition to this, there is also a possibility that an appropriate magnitude of electric field strength can positively affect the cellular metabolism. It is also seen a positive effect of 3V electric field strength in the alfalfas plant growth and germination while the administration of 7 V electric field could effectively enhance the overall germination process in this plant.

In addition to this, Piras et al. (2013) found the negative results in their experimental study that negative electrostatic field has no effect in improving the germination percentage of pine seeds. In one more experimental study, it is observed that the action of a high-intensity AC electric field may be an effective tool for enhancement of germination. Furthermore, the modification in germination and subsequent seed vigour are statistically significant when electrically treated samples (seeds) are compared with untreated samples. The application of 20 kV cm^{-1}, voltage gradient for 20 second duration is the most convenient for the best germination (Patwardhan & Gandhare,2013). It is also seen in an experimental study that high voltage electric field makes a change in the cell membrane barrier height. Thus, an effect on the permeability of cell membrane takes place (Shi et al., 2014).

Moreover, electric field stimulates germination of bitter gourd seeds positively at lower levels and has a decelerating effect on germination at higher levels (Mahajan & Pandey, 2015). The behaviour of a magnetic field on seed germination is altogether different from that of an electric field, showing a continuous positive stimulation at all applied values (Mahajan & Pandey,2015). It is also seen that the influence of static electric field on wet mungbean seeds depends on field strength and exposing time. Furthermore, the exposure of 2.5 hours with a static electric field of intensity 2.4 kV/m on wet mungbean seeds affects the growth in vegetative phase that's why these treated seeds have heavier fresh weight and longer length of roots, stems, and leaves in comparison to non-treated (Khotimah et al., 2016). Moreover, in another experimental study, it is observed that there is no significant difference between the treated and non-treated sunflower seed germination (Seyyed et al., 2017).

In addition to this, it is also found in one more experimental study that electrically treated seeds have a delay in water absorption relatively untreated seeds. Furthermore, it causes an increase in mean germination time and transition time (Nisar et al.,2018).

Moreover, the findings of an experimental study confirms that magnetic field enhances the germination rate more faster than the electric field (Srikanth et al.,2018).

It is also observed in further experimental study that the rate of seed germination is improved by the electric field. Moreover, cellular metabolism can also be positively increased by using the appropriate electric field strengths (Afrasiyab et al.,2020).

II. LITERATURE REVIEW

By knowing the values of germinated seeds and the total number of seeds sown in the pots, the percentage of germination can be computed by the equation (1):

$$Percentage\ of\ germination\ = \frac{\text{The}\ number\ of\ germinated\ seeds}{The\ total\ number\ of\ seeds\ sown} \times 100$$

(Rezaei-Zarchi et al.,2012)

(1)

The coefficient of germination rate can be computed by the equation (2).

$$\text{The coefficient of germination rate} = \frac{\mathrm{G}_1 + G_2 + \mathrm{G}_3 + \cdots + G_n}{1\mathrm{XG}_1 + 2XG_2 + 3X\mathrm{G}_3 + \cdots + nXG_n} \times 100$$

(Rezaei-Zarchi et al.,2012)

(2)

Where

G_1-G_n = The number of germinated seeds from the 1st day to n[th] day

By knowing the values of average seedling's length, Seed vigor index can be evaluated by the equation (3)

$$\text{Seed Vigor Index} = \frac{\textbf{The average length of seedlings x Germination}}{\textbf{100}}$$

(Rezaei-Zarchi et al., 2012)

(3)

In order to achieve the desirable moisture, the seed can be artificially wetted. The essential amount of water Q is evaluated by the equation (4)

$$Q = \frac{\mathrm{m}(W_{2-}W_1)}{100 - W_1}$$

(Stefa Lynikiene & Ausra Pozeliene,2003)

(4)

Where,

m = Weight of seed (kg)

W_1 & W_2 = Required initial seed moisture %

The amount of energy (λ, J/m^3) propagated to seed is expressed by the following expression

$$\lambda = E^2\ A^2(½\epsilon\epsilon_0 + \gamma t),$$

(Stefa Lynikiene & Ausra Pozeliene,2003)

(5)

Where

$$A = \frac{1}{1 + \Phi\{\frac{\gamma}{(k\rho)-1}\}},$$

(Stefa Lynikiene & Ausra Pozeliene,2003)

(6)

E – Strength of electric field (V/m)

ϵ_0 - Dielectric permittivity of seed

ϵ_0– Electric constant permittivity, εo =8.85X10^{-12} (F/m)

γ - Relative volumetric seed conductance (Ω^{-1} m^{-1})

t – Exposure time (seconds)

Φ - Depolarisation coefficient

k – Mobility of ions (m^2 V^{-1}s^{-1})

ρ - Volumetric density of ion charge, (C/m^3)

The percentage of growth rate can be evaluated by the equation (7)

$$Percentage\ of\ growth\ rate = \frac{\text{Plant height at maturity}}{Number\ of\ days\ taken} \times 100$$

(Iqbal et al., 2016)

(7)

Emergence rate index (ERI) can be evaluated by the following equation:

$$ERI(\%) = \Sigma\{\frac{X_1+X_2+X_3+\cdots+X_n}{N(n_P)}\}$$

(Iqbal et al., 2016)

(7)

Where

X1, X2, …Xn = The number of seedling emerged on 1st, 2nd,… nth day after sowing

N =The days taken for germination

n_{p} = Presenting germinated seed

Mean germination time (MGT) can be evaluated by using the eq. (9), where

n = The number of seeds germinated on day D,

D = The number of days counted from the beginning of germination

and

Σn = The final germinated seed

$$MGT = \frac{\Sigma D_n}{\Sigma n}$$

(Iqbal et al., 2016) **(9)**

Table 1: Comparative study of seed germination under the influence of electric & Magnetic fields

Reference	**Country's Name**	**Region selected for the study**	**Temperature**	**Seed's name used in study**	**Scientific name of seed**	**Seeds Purchased from**	**Methodology used to generate the electric field/ Magnetic field**	**Factors studied**	**Drawbacks**
1.Rezaei-Zarchi et al.(2012)	Iran	Marvast region of Yazd	17^0C(Annual average temperature)	Native Iranian alfalfa seed	Medicagosativa from Fabaceae (Leguminosae) family		To generate the electric field Trans model Haoxin(TXN-1502D) used	Fresh weight of the plant(g), Stem length(cm), Root length(cm), germination percentage, Germination rate(day) , Seed vigour(cm),	No fruit study

								Coefficient of germination rate(day), dry weight of the plant(g)	
2. Stefa Lynikiene & Ausra Pozeliene(2003)	Lithuania	Raudondvaris, Kaunor		Barley	Hordeum Vulgare		Conveyor type corona discharge field electric separator		
3. Asavasanti et al. (2010)	America	Davis	25^0C	Onion	Allium Cepa		Function generator, Oscilloscope, PEF generator, HV power supply, LCR meter, Arbor press, electrodes and sample holder	Onion tissues	
4.Shi et al. (2014)	China	Changchun		Barley	Hordeum Vulgare	Barley seed (Liao Ning 5) is bought from Jilin province Runhe seed industry co., LTD.	Bur high pressure electrostatic field device	The number of seed germination , germination potential, germination index, vigor index of seed	
5. Dymek et al.			20^0C	Barley	Hordeum Vulgare	Malting barley seeds	Electric pulses delivered	Radicle Emergence	

(2012)						(Hordeum vulgare cv. Prestige, 6.5 g/100 g humidity) were provided by the Swedish University of Agricultural Sciences (SLU), Alnarp, Sweden	using a CEPT pulse generator, A digital oscilloscope connected to the system to monitor the delivery of the pulse to the sample		
6. Nisar et al. (2018)	India			Chickpea seed	Cicer Arietinum	Pusa - 362, a variety of desi Chickpea is used.	Electric field is generated with a power supply and the test cell which is basically a capacitor	Root length, Shoot length, Coefficient of water uptake, Rate of water uptake	No heating effect and no fruit study
7. Piras et al. (2013)	Italy	Cagliari	25^0C	Pine	Pinus		Circuit used to generate the negative electrostatic field	Germination, Root length, Vigor index, Seedling growth	No fruit study
8. Srikanth et al. (2018)	India	Allahabad(Now Priyagraj)		Chilli seed	Capsicum Frutescens		Electric field generator fabricated by using NaCl as electrolyte with Cu &	Germination percentage, Speed of germination, Seedling length, Dry weight, seed vigor,	No fruit study, no flowering and no heating effect study

							Zn respectively as positive and negative electrodes. A battery of 24V DC as a power source for electrolytic treatment	Electrical conductivity, Root length and shoot length	
9. Wheaton et al. (1971)	Iowa			Corn & Soybeans	Zea mays & Glycine max	Pioneer 3306 seed corn and Hawkeye soybeans were	Static electric field of frequency 60Hz	Percentage of seed germination, Rate of seed germination	Electric field does not impart significant effect on the germination of these seeds
10.Afrasiyab et al. (2020)	Pakistan	College N0.1 Abbottabad		Chickpea seed	Cicer Arietinum		The electric made through the soil stainless copper electrodes placed one of the each end of the seedbed (pot)	Plant's height (%), Root length (%), Number of leaves (%), Number of leaves (%), Number of flowers (%) & dry weight	No fruit study
11. Khotimah et al. (2016)	Indonesia			Mungbean seeds	Vigna Radiata		Dc power supply to generate the static electric field	Germination percentage, Percentage of seeds which have not germinated,	No fruit study

								weight, length of roots, stems and leaves	
12. Eing et al. (2009			24^0C	Arabidopsis Thaliana	Arabidopsis Thaliana	rabidopsis seeds (ecotype Columbia-0	Set up for the production of Pulsed electric field	Leaf Area, Plant growth, Seedlings	Positive growth stimulation due to PEF treatment
13. Ak et al. (2011) Proc.				Pistachio seed	Pistachio Vera	Pistachio seeds of Pistacia vera varieties of Siirt and Uzun were used	Corona electric shocking device	Seedling height, Stem Diameter	No fruit and flower study took place . Lower dosages of electric current has Stimulative effect
14. Patwardhan & Gandhare (2013)	India	Amravati		Tomato	Solanum Lycopersicum		A fully adjustable AC high voltage supply used to generate electric field	Seedling, Root length, shoot length, fresh weight, Dry Weight, enzyme activity, Seed vigor1 and seed vigor2	No fruit study
15. Seyyed et al. (2017)	Iran			Sunflower	Helianthus		Roll type corona discharge separator		No effect on the germination found
16. Mahajan & Pandey(2015)	India	Patiala	24^0C-27^0C	Bittergourd	Momordica Charantia		Dc supply for the generation of electric field.	Germination rate	The electric field stimulates

							Electric field generator with two circular aluminum electrodes of 8cm diameter.		germination of bittergourd seeds positively at lower level and has a retarding effect on the germination at higher level.
17. Asavasanti et al. (2010)				Onion	Allium Cepa		Functional generator, oscilloscope, PEF generator, LCR meter, HV power supply	Ion leakage determination, Alliinase Activity, Texture measurement	No fruit study
18. Zamiran et al.(2013)	Iran	Jiroft		Zinnia seed	Zinnia sp.	Pakan Seed Company (Pakan & Co.)	To generate the magnetic field two magnetic spool coils, two aluminum sliding cores and a power supply were used.	Root length, shoot length, fresh and dry root weight, fresh and dry shoot weight, seedling length and weight, germination percentage, speed of germination, vigor index I and II. root weight, dry shoot weight,	No fruit study No mechanism of magnetic field on seed Germination

								seedling length, emergence percentage and emergence speed at 0.05 level of probability.	
19. Iqbal et al. (2016)	Pakistan	Faisalabad	20^0C	bitter gourd	Momordica Charantia	Ayyub Agriculture Research Institute, Faisalabad, Pakistan	Electromagnet used to generate the required magnetic field	Growth rate, Germination Percentage, Emergence root index(ERI), Mean Germination Time(MGT), Vigour Index I & II, Leaf Area, Root Lentgth, Shoot Length, Root fresh weight, Shoot fresh weight, Root dry weight and shoot dry weight	No Mechanism of effect of magnetic field on seed germination
20. Mahajan & Pandey(2015)	India	Patiala	24–27°C	Bittergourd	Momordica Charantia	The bitter gourd variety SEJAL of M. charantia obtained from Tropica Seeds (P) Ltd	Electromagnet of the magnetic field generator. Flat faced pole pieces with a diameter of 7.5 cm in cylindrical	Growth Percentage, Germination rate	No Fruit study No mechanism of magnetic field on seed Germination

						Bangalore	shape. The gap between the magnetic poles varied from 5 to 10 cm. A digital Gauss meter was used to check the field strength between the pole pieces.		
21. Srikanth et al. (2018)	India	Allahabad(Now Priyagraj)		Chilli seed	Capsicum Frutescens	Seeds of chilli(capsicum annum L.) G-4 variety of healthy and uniform size were selected and used to study the effects of magnetic field	To treat the seeds electromagnetic field generator "OMEGA EMU-10" with variable horizontal magnetic strength with a gap of 5cm between pole pieces was fabricated. Magnetic field flows through the cylinders when we input the power	Germination Percentage, Speed of germination, Seedling length, Dry weight, Seed vigour and Electrical Conductivity, The number of seed germination, germination potential, germination index, vigor index of seed	No Fruit Study No mechanism of magnetic field on seed Germination

							supply. A digital gauss meter OMEGA DGM-20 (230V AC ±10% at 50HZ) was used to monitor the field strength produced in the pole gap of magnetic field generator.		
22. Braga Júnior et al. (2020)	Brasil		30^0C	Coffea Seed	Coffea arabica	Coffea arabica L., cultivar Catuaí Vermelho 144, from the 2017 harvest, sieve 19.	Permanent magnets(circularly shaped) used to treat the seeds magnetically	Germination Speed Index(GSI), Emergence Speed Index(ESI), Enzyme Analysis	No Fruit Study No mechanism of magnetic field on seed Germination
23. Yao and Shen (2015)	China	Nanjing	25 ± 2°C	loblolly pine	Pinus taeda	China National Tree Seed Corporation	Square magnets with magnetic induction value B = 150 mT were used to generate the required magnetic field. The dimensions of square	Root length, growth of hypocotyl, Cell division, Cell lengthening, Germination Speed, Mean Germination Time	No heating effect No fruit study No mechanism of magnetic field on seed Germination

							magnets were 50 mm length, 50 mm width, and 5 mm high. The magnetic field induction was measured by a HT20/HT 20A digital Gauss meter (Shanghai Huntoon Magnetic Technolog y Co., Ltd., China)		
24. Rostami Zadeh et al. (2014)	Iran	Tehra n	(24±0. 5) ^{0}C	Also known as Commo n Nettle	Urtica Dioica L	Seed and plant improve ment agricult ure instate Isfahan, Iran	The magnetic field was generated by means of a pair of Helmholtz coils system that creates a uniform magnetic field into a relatively large space volume allowing the Each Helmholtz	Percentage of seed germination , speed of seed germination , Water Absorption, Ions Absorption, Root length, Shoot length and leaves	No fruit study No mechani sm of magnetic field on seed Germina tion

							coil from exposure device has a diameter by 260mm and 1000number of turns.		
25. Takimoto et al.(2001)	Poland		37^0C	Arabidopsis Thaliana	The Thale Cress, Mouse-ear cress or Arabidopsis is a small flowering plant native to Eurasia and Africa			Germination percentage, Rate of germination, lengths of mitotic phases	No fruit study No mechanism of magnetic field on seed Germination
26. Mroczek-Zdyrska et al. (2016)	Poland	Lublin	$(20\pm2)^0C$	Lupin	Lupinus			Mitotic activity, Physiological Parameters, Bio-chemical Parameters, Average length of roots and shoots, Fresh weight of roots and shoots, Specific Activity of enzyme	1. There is no significant effect of magnetic field on the fresh weight of root and shoot. 2. There is no significant effect of magnetic field on root weight ratio (RWR)

									and shoot weight ratio (SWR) 3. There is no fruit study. 4. Ther is no mechanism of magnetic field on seed Germination
27. El-Gizawy et al. (2016)	Egypt	Ain Shams University		True Potato Seeds	Solanum tuberosum		By using a magnet type N100 (Oxford Company, England) device for the pre-sowing seed treatment by magnetic field equipped with an electromagnet with continuous adjustment of magnetic induction. For the measurement of the magnetic field	Plant length (cm), Number of leaves per plant, Number of potato tubers per plant, Fresh weight of potato tubers per plant (g), Diameter of potato tubers (cm), Nitrate content of potato tubers, Potassium content of potato tubers (ppm) and Phosphorus content of potato	No fruit study and no mechanism of magnetic field stimulation

							strength a tesla meter, (Misr Fatramo Comp. Egypt) was used.	tubers (ppm)	

III CONCLUSION

On the basis of overall theoretically comparative study, it is concluded that the seeds stimulated by the magnetic field germinate earlier than the seeds stimulated by electric field. Moreover, electric field affects the movement of ions, electrons and other charged species and causes changes in cell division and growth of the plant while magnetic field affects the factors like root length, shoot length, weight, enzyme activity, seed vigor I&II, seedling height, stem diameter, germination percentage, percentage of seeds which have not germinated, weight, plant's height percentage, root length percentage, number of leaves percentage, number of flowers percentage, coefficient of water uptake and rate of water uptake. In this way, it is concluded that overall growth is found more significant in magnetically treated seeds than electrically treated seeds. Although, most of studies have demonstrated the significant growth in the seed with positive feedback, yet none of the studies introduce any possibility of genetic mutation of plants and their products. After overall study, it is concluded that magnetic field is more effective in seed germination than the electric field. Although very few studies gave the negative results but most of the studies gave the positive results. No study has observed the effect of these fields on the fruit (is it adverse or significant?) If it is found significant then it could be utilized to enhance the farming production. Moreover, no study has been explored so far the mechanism of the influence of the electric and magnetic fields on the seed germination.

IV RECOMMENDATION

The tabularized comparison concludes that mostly work has been carried out that effect of electric and magnetic fields on the morphological factors like Root length, shoot length, weight, enzyme activity, Seed vigor I&II, seedling height, stem diameter, Germination percentage, Percentage of seeds which have not germinated, weight, Plant's height (%), Root length (%), Number of leaves (%), Number of flowers (%), Coefficient of water uptake and Rate of water uptake**.** No study has observed the effect of these fields on the fruit (is it adverse or positive?). In most of experimental studies, heating effect is discarded. Moreover, no study has also been explored so far the mechanism of the influence of the electric and magnetic fields on the seed germination. Therefore, work can also be carried out on these factors in future. If the effect of both of the fields on the fruit is found to be significant then it could be utilized to enhance the farming production.

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