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Effect of magnetic and electric field seed treatment on the seedling attributes of brinjal (*Solanum melongena*) seeds

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Abstract
The present experiment was conducted in Laboratory at Department of Genetics and Plant Breeding, Naini Agriculture Institute, SHUATS and Laboratory of Physics, Shepherd Institute of Engineering and Technology, SHUATS, Allahabad, UP. To study the effect of presowing seed treatment with magnetic field, electric field and combination of both fields on brinjal seeds (traditional variety Deshvali paccha vanga) were studied. Seeds were subjected to different intensities of magnetic field (200G, 400G, 600G, and 800G for 30 minutes), elctric field intensity (100mA, 200mA, 300mA, 400mA for 1 minute) and combined treatments of both magnetic and electric field ranged from (200G+100mA, 400G+100mA, 600G+100mA, 800G+100mA for 30 minutes (MF) and 1 minute (EF)). The seeds treated with magnetic field (800 G for 30 minutes) showed significant increase in germination percentage, shoot length, root length, seedling length, fresh weight, dry weight, speed of germination followed by combined seed treatment with 800G+100mA for 30 minutes (MF) and 1 minute (EF) and electric field seed treatment with (200mA for 1 minutes). Among all the treatments, 800G for 30 minutes exposure of magnetic field seed treatment has given best results. So seed treatment of brinjal seeds with magnetic field is best compared to electric field and combined field seed treatment.

Keywords: Brinjal seeds, Magnetic field, Electric field and seedling parameters

1. Introduction
To maintain vigour and viability of seeds there were many chemical treatments which are time taking and environmentally ineffective. Seed treatment with chemicals or organics is a time consuming procedure which involves solution preparation, seed treatment, drying of seeds for storage and packing etc. In doing all these procedures cost of seed processing and storage is increased. It leads to increase in price of seeds. The new technological concepts like physical methods are time and environmental effective, initial cost may be high for adoption of physical methods but same equipment can be used for several years. Nowadays, electric and magnetic fields are used as a non-chemical method in agriculture (Das and Bhattacharya, 2006) [8]. Use of physical methods for plant growth stimulations is getting more general due to the less damaging effects on the environment (Aladjaadjiyan, 2010).

In present situation farmer finds seeds with germinative limited power, this initiated a large interest for searching new tools and technology, that has emerged in order to stimulate the response of post-germination of the plants, is exactly the magnetic treatment of seeds (Pietruszewski, 2014) [17]. Every farmer expects to get highly vigourous seeds at low cost. So by adopting physical method of seed treatment can reduce the processing cost to some extent, by this method cost of seed production can be decreased. Excluding the environmental and time saving factors the concept of electric and magnetic field seed treatment improves germination percentage, speed of germination, vigour, viability, root and shoot length. Physical methods also decrease ageing of seeds as we can store the seeds for longer time.

Studies should be undergone regarding development of proper machinery which can be adoptable at industrial level both in electric and magnetic field seed treatment.

2. Materials and methods
Brinjal Seeds (Farmers variety Deshvali paccha vanga) were taken from the village named Virava, East Godavari District, Andhra Pradesh, India. In South India, brinjal can be grown

round the year, the main sowing being done during July to August. In hilly regions, the seeds are sown in March to April and seedlings are transplanted in May. Seed material is of one year old.

2.1 Method of magnetic field
To treat the seeds, electromagnetic field generator ''OMEGA EMU-10'' has been used, having two cylinders with space in between them to place the material to be treated. Space between the cylinders of magnetic field generator can be adjusted from 5 to 10cm with wheels provided on the top of the cylinders. Magnetic field flows through the cylinders when we on the input power supply. Constant current power supply unit of 230AC (0-4 Amp) (±10% AC 50 HZ) has been used to pass the current into the electromagnetic field generator. A digital Gauss meter type OMEGA DGM-020(230V AC ±10% at 50HZ) was used to monitor the field Strength produced between the cylinders of magnetic field generator. A probe made of indium arsenate crystal and encapsulated to a nonmagnetic sheet is used. This could measure in steps of the magnetic field.

2.2 Method of electric field
To expose the seeds to electric field, an electric field generator was fabricated by using sodium chloride as electrolyte with copper (+) and zinc (-) electrodes. A battery of 24V DC was used as the power source for the electrolysis treatment of brinjal seeds. The two electrodes were placed vertically inside the plastic tray parallel to each other. In the plastic tray seed material were placed in already prepared electrolyte solution (Nacl) in such a way that upper level of electrolyte solution lies below the level of electric cord connecting point. Electric power cords were connected with power supply unit in respective places. An electric current of DC 24 V was passed at required intensities for different duration as per the treatment requirement through the seeds to serve electrotherapy treatment.
Germination percentage was determined by using Top of the paper method by placing 25 seeds above germination paper in each Petri dish. Seeds were germinated on top of the paper method with four replications of 25 seeds each. The number of seeds germinated was recorded on daily basis up to the day of final count. The speed of germination was calculated by using the formula.

$$\text{Speed of germination} = \frac{G_1}{D_1} + \frac{G_2}{D_2} + \ldots\ldots\ldots + \frac{G_n}{D_n}$$

Where, G_1, G_2, --- Gn are the number of seeds germinated on D_1, D_2, --- Dn day, five best seedlings were taken from each replication to measure fresh weight, root length, shoot length and they cut free from their cotyledons and placed in envelopes and dried in an oven at 80±1 ^{0}C for 24 hours. Vigour index-I is calculated by the formula Seedling Vigour Index I = Germination percentage x Total seedling length in (cm). Seed vigour index-II = Germination (%) x Mean seedling dry weight (gm). Electrical conductivity of seed leachate is measured after soaking the seeds in 25 ml distilled water for 5 hours. The electrical conductivity of seed leachate is measured in digital conductivity bridge (Elico) with a cell constant 1.0 and the mean value were expressed in deci simons per meter (dsm^{-1}).

3. Results and discussion
Seeds subjected to magnetic, electric and combination field seed treatment improved all seedling characteristics and reduction in ageing was found. Improvement in seedling characteristics such as germination percentage, speed of germination, shoot and root length, vigour index-I and vigour index-II was shown and decrease in leachate content of seeds was observed when measured with electrical conductivity meter(dsm^{-1}).
A range of 87 to 98 percent was observed in germination percentage. Maximum germination percentage (98%) was recorded with T_4-800G for 30 minutes followed by (97%) with T_{12}-800G magnetic field for 30minutes +100mA electric field for 1 minute and (97%) T_3-600G for 30 minutes given best results. An optimal external electromagnetic field can influence the rate and percentage of germination. When seeds come into contact with the water dipoles, an interaction between the seed dipoles and water dipoles occurs. This interaction affects the water uptake by the seed, which further affects the germination time and germination rate. Molecular mobility of cytoplasmic bulk water and hydration water of macromolecules were higher as indicated their respective relaxation times this may be responsible for early germination over control. (Mahajan *et al.* 2014) [13].
A range of 5.83 to 9.35 was observed in speed of germination. Maximum speed of germination was recorded (9.35) in T_4 with application of 800G of magnetic field, followed by T_{12} (9.09) with application of 800G+100mA and (8.85) with T_6-200mA electric field. There may be a resonance-like phenomenon which increase the internal energy of the seeds, and that occurs when there is appropriate combination of magnetic field and exposure time. (Vasisth *et al.* 2017) [26].
A range of 3.14 to 4.07 was observed in shoot length. And maximum shoot length was observed in T_4-800G (4.07cm) followed by T_3-600 Gauss for 30 minutes (4.01cm) and T_2-400 Gauss for 30 minutes (3.91cm). This static field positively influenced plant growth by increasing the shoot length and root length. Application of magnetic field of extremely low frequencies positively effects seed germination, shoot development, plant length, and fresh weight. Martinez *et al.*, 2000, 2002 [14, 15] and Racuciu, 2006 [18], cakmak *et al.*, 2010 [6], Vasisth *et al.*, 2017 [26].
The mean performance of seedling root length ranged from 3.26 cm to 5.20 cm. Maximum root length (5.20cm) was recorded in T_4-800G in magnetic field followed by (4.82cm) T_{11}-600G+100mA and (4.76cm) T_6-200mA of electric field. Better root growth and development in young seedling affected by magnetic field might leads to better root system through the enhancement in leaf area and leaf dry weight and increased photosynthetic rates due to the greater interception of light and greater amount of assimilates available for vegetative growth. Increased in field intensity increases root length to an extent and decrease gradually. Increasing the exposing time causedthe length of root to be decreased. (Sedigi *et al.*, 2013, Rathod *et al*., 2016, Kataria *et al.*, 2017) [19, 12].
The mean performance of seedling length ranged from 6.73 cm to 9.17 cm. Maximum seedling length (9.17cm) was recorded in T_4 with 800G of magnetic field followed by (8.76cm) T_{12}- 800G of magnetic field +100mA electric field combination treatment and (8.64cm) T_6-200mA electric field. Found that low magnetic field could elongate the seedling because magnetic field nanoparticles in a molecular process are an endogenous source of magnetic exposure to living

tissues and cells. Increased physiological activity due to greater absorption of moisture by treated seeds may be responsible for increase in seedling length. (Joshi *et al.,* 2017) [26].

The mean performance of seedling fresh weight ranged from 0.09 gm to 0.16 gm. Maximum seedling fresh weight (0.16 gm per 5 seedling) was recorded in T_{1}-200G of magnetic field followed by (0.15gm per 5 seedlings) T_{2}- 400G, T_{3}- 600G of magnetic field and T_{11}-
600G+100mA electric field while treatments T_2, T_3, T_{11} given the same fresh weight. Application of magnetic fields of extremely low and high frequencies has also given positive results regarding fresh weight. (Cakmak *et al.* 2010) [6].

The mean performance of seedling dry weight ranged from 0.02 gm to 0.08 gm was recorded. Maximum seedling dry weight (0.08 gm per 5 seedling) was recorded in T_{4} -800G of magnetic field was followed by T_{12} (0.07gm per 5 seedlings) of 800G+100mA. Increased physiological activity due to greater absorption of moisture by treated seeds may be responsible for increase in dry weight effects of electromagnetic field with low frequency on oak tree reported the increase in the height of main stem, dry weight, and germination rate. (De Souza *et al.,* 2006) [9].

The mean performance of vigour index-I ranged from 588.12 to 898.66.Maximum vigour index-I (898.12) was recorded in T_4 with application of 800 Gauss of magnetic field followed by T_{12} (859.72) with application of 800G+100mA and (820.80) in T_6- 200mA electric field**.** Increased physiological activity due to greater absorption of moisture by treated seeds may be responsible for increase in vigour index and the vigour index increased with increase in electric field (Vasisth *et al*., 2013, Dew Biswas *et al.* 2016) [10].

The mean performance of seedling vigour index-II ranged from 1.95 to 7.90. Maximum seedling vigour index-II (7.90) was recorded in T_4 with application of 800G of magnetic field followed by T_{12} (6.79) with application of 800G+100mA and (3.84) with T_6- 200mA electric field. Molecular mobility of cytoplasmic bulk water and hydration water of macro molecules were higher as this indicated their respective relaxation times which may be responsible for higher vigour over control. Increased physiological activity due to greater absorption of moisture by treated seeds may be responsible for increase in vigour index. Vigour index increased with increase in electric field. (Biswas *et al.*, 2016) [10].

Minimum electrical conductivity reading was observed in T_4 (0.201) with the application of 800G magnetic field to seeds and maximum was recorded in T_6 (0.426) with application of 200mA electric field. It has to be noted that electric conductivity is measured in vice versa i.e. lower reading is the positive and the higher is the negative. So it is noted that T_4 (0.201) with 800G magnetic field application is best because lower reading of electric field indicate good membrane integrity in seed. Higher the membrane integrity higher the viability of seed.

It is founded that magnetically treated seeds have a less rate of leachate, due to higher integrity of cellular membrane, and have a higher mitotic index and higher incorporation of H-thymidine into the molecule of DNA and the related resonance disrupts the sequestration of Ca^{2+} ion and increases the concentration of free Ca^{2+} resulting in an early mitotic cycle.

Electromagnetic field modify the rate of ion transport across the plasma membrane or otherwise affect the structure of cell membrane lipid protein dynamics, this may cause the alternation in the permeability of the plasma membrane of plant root. Electrostatic fields with certain intensity could increase the content of free radicals in seeds. (Florez *et al*., 2007, Vashisth & Nagarajan, 2008) [11, 24].

Table 1: Mean performance of the brinjal seedlings during the experimentation

Treatments		Germination (%)	Speed of Germination	Shoot Length (cm)	Root Length (cm)	Seedling Length (cm)	Fresh weight (gm)	Dry weight (gm)	Vigour Index-I	Vigour Index-II
Control		94	5.83	3.35	3.41	6.73	0.10	0.03	632.62	2.82
T_1		94	5.91	3.69	4.43	8.17	0.16	0.03	767.98	2.82
T_2		93	5.97	3.91	3.83	7.83	0.15	0.04	728.19	3.74
T_3		97	6.02	4.01	3.67	7.71	0.15	0.02	746.90	1.95
T_4		98	9.35	4.07	5.20	9.17	0.14	0.08	898.66	7.90
T_5		94	8.71	3.87	4.73	8.6	0.11	0.03	808.20	2.87
T_6		95	8.85	3.89	4.76	8.64	0.12	0.04	820.8	3.84
T_7		87	7.43	3.14	3.26	6.76	0.14	0.03	588.12	2.54
T_8		94	8.67	3.17	4.46	7.43	0.09	0.03	698.42	2.82
T_9		94	8.39	3.57	4.53	8.05	0.14	0.04	756.07	3.76
T_{10}		92	7.51	3.55	4.19	8.26	0.13	0.04	759.92	3.62
T_{11}		93	6.05	3.15	4.82	7.95	0.15	0.04	739.35	3.71
T_{12}		97	9.09	3.75	4.47	8.76	0.10	0.07	859.72	6.79
Range	MIN	87	5.83	3.14	3.26	3.26	0.09	0.02	588.12	1.95
	MAX	98	9.35	4.07	5.20	5.20	0.16	0.08	898.66	7.90
S.Em		1.544	0.179	0.054	0.084	0.180	0.005	0.001	1.464	0.052
CV		3.281	4.766	2.962	3.914	4.495	7.027	6.359	0.388	2.758
CD (at5% significance)		4.416	0.513	0.155	0.240	0.514	0.013	0.004	4.187	0.149

Table 2: Indicating Electrical Conductivity of Seeds

Treatments	Intensity	Duration	Electrical conductivity
T_0	Control	-	0.328
T_1	200Gauss	30 minutes	0.287
T_2	400Gauss	30 minutes	0.204
T_3	600Gauss	30 minutes	0.202
T_4	800Gauss	30 minutes	0.201
T_5	100mA	1 minute	0.421
T_6	200mA	1 minute	0.426
T_7	300mA	1 minute	0.421
T_8	400mA	1 minute	0.399
T_9	200Gauss+100mA	30 minutes+1minute	0.408
T_{10}	400Gauss+100mA	30 minutes+1minute	0.411
T_{11}	600Gauss+100mA	30 minutes+1minute	0.419
T_{12}	800Gauss+100mA	30 minutes+1minute	0.398

4. Conclusion
The present study concluded that the seed treatment with magnetic field to brinjal seeds showed best results as compared to electric and combination treatments. Among all seed treatments T_4-800 Gauss for 30minutes exposure of brinjal seed to magnetic field given best results followed by combined seed treatment T_{12} (800Gauss for 30 minutes+100mA) and electric field for 1 minute, and T_6-200 mA for 1minute exposure given best results. Hence seed treatment of brinjal seeds with magnetic field is recommended for the improvement of seedling characters.

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