PARIPEX - INDIAN JOURNAL OF RESEARCH | Volume - 14 | Issue - 04 | April - 2025 | PRINT ISSN No. 2250 - 1991 | DOI : 10.36106/paripex

ORIGINAL RESEARCH PAPER

Botany

EFFECT OF ELECTROMAGNETIC FIELD ON *IN VITRO* POLLEN GERMINATION OF PLANT SPECIES FROM VARIOUS ECOLOGICAL HABITATS

KEY WORDS: Electromagnetic field, Pollen, Hall effect experiment, *in vitro* germination

N. C. Vora M.N.College, Visnagar.

ABSTRACT

All electrical equipment including solar panel emit electromagnetic radiation. In the present study, effect of Electromagnetic field (EMF) was observed during *in vitro* pollen germination of *Catharantus roseus, Bombax siba, Ipomea aquatica* and *azolla pinnata* collected from arid, terrestrial, marshy and aquatic habitat, respectively. To generate EMF, Hall experiment instrument was used with DC at 1, 2, 3, 4 and 5 Amp/min. Compared to control, rate of *in vitro* pollen germination was found to be higher with EMF treatments when observed after 2-4 hrs. The response of these treatments was higher in aquatic plant sp. compared to terrestrial plant. The arid plant species was found to get least affected by the EMF treatments. Moreover, for the treatments above 3 Amp/min., generating 338 Guass and above of EMF, the cytoplasmic content of some of the pollen was lost and degradation of cell membrane and distortion of pollen tube was observed, showing a risk of EMF for pollen viability.

INTRODUCTION

The movement of electric charge from electrical equipment causes electric and magnetic fields produced in the space surrounding the charge. The voltage gets increased with increased use of electricity infrastructure as well as the development of renewable energy utilizing increased lines, underground cables and solar panels developed across the world. The strength and extent of these fields is directly proportionate to the power outputs and the level of shielding around the equipment (Anonymous, 2025). However, the magnitude of Earth's magnetic field at its surface ranges from 0.25 to 0.65 Gauss, which varies in different geographical regions (Anonymous, 2015).

Earlier, researchers have investigated the effect of EMF on plant production and plant physiology including on seed germination, plant water cycle, photosynthesis, plant mineral nutrition, oxidative stress and pest prevention (Sadaf *et al*, 2023). Moreover, impact of EMF on the quality of onion seeds was investigated and speed of germination was found to be ambiguous (Górski *et al,* 2019).

Study on pollen germination exposed to EMF was earlier reported by Ahmad *et al* (2013) at 2-10 mT for 10 to 20 min, where pollen germination of *Archillea wilhelmsii* was found to get decreased significantly. However, pollen tube growth of *Camellia* sp. when exposed to EMF showed higher growth under DC compared to AC fields of the same strength (Carlos, 2016). Moreover, germination of *Zea mays* L. seeds was enhanced with pre-treatment of EMF (Muhammad *et al,* 2024). Effect of EMF on plant growth of various plant sp. was reviewed earlier by Maffei (2014). Lipid synthesis was found to get increased by 2.5 times when exposed to EMF at 50 Hz-500 μT for radish seedlings (Novitskaya, 2010). Increased pollen germination was reported in *Carica papaya* (Alexander and Ganeshan, 1990). Enzymatic activities have been shown to increase for many plant species (Alain *et al*, 2016).

However, EMF significantly increased DNA damage in rats at 10 μT for 24-48 hrs and shown to have carcinogenic risks in human (Górski *et al*, 2019). Nowadays, the level of electric fields and radiations in everyday situations are higher than many decades due to electrical applications and advancement in the technology. The present investigation was carried out to understand its impact at cellular level and to find susceptibly of plants from various ecological habitats for the same.

MATERIALS AND METHODS

The device emitting EMF from 1 Amp to 5 Amp of DC was utilized, which is generally used to study Hall effect experiment at Physics Laboratory, M.N. College, Visnagar. The distance between two polls was kept at 2.072 cm. (Fig. 1)

To study the effect of EMF on *in vitro* pollen germination, four plant species from various ecological habitat were selected, viz. *Catharanthus roseus* growing in an arid condition,

Bombax ceiba as a terrestrial plant species, *Ipomea aquatica* from marshy soil growing near lake and *Azolla pinnata,* a free-floating pteridophyte from a fresh water lake. The flowers were collected in the month of March from Ahmedabad and Gandhinagar Districts during early morning hours and used freshly for the experiment. For germination of pollen, a modified Brewbaker and Kwack (1963) solution was used. Pollen germination *in vitro* was carried out in a solution containing 15 % of Sucrose with 50 mg of Boric acid for all the plant species. The concentration was standardized earlier for *Catharanthus* pollen germination *in vitro* to obtain germination within 2-4 hrs, for which data is not shown here.

Fig 1. Hall experiment instrument set up used for the study of effect of EMF on *in vitro* pollen germination

Treatments of EMF was provided through DC of 1, 2, 3, 4 and 5 Amp for 1 Minute creating 115, 233, 338, 428 and 502 Guass frequency, respectively. EMF was provided using the test tubes (Borosil, 12.5 cm X 1.5 cm) containing anthers immersed in a sucrose and boric acid solution, each with 5 anthers in 1 ml of solution. For *Azolla*, however, 1 gm of sporophytic plant body was used in test tube with 1 ml of solution. The cavity slides were used for germination after the treatments during which anthers were crushed and squeezed to remove pollen grains. The observation was made after 2-4 hrs of the treatment using a stereomicroscope (LabRon Research Microscope, LI-604). No EMF was provided for control of each species, but incubated for the same period of time at room temperature (28-30°C). The Mean value was calculated from minimum ten observations of germinated pollen *in vitro*.

RESULTS AND DISCUSSION

Higher rate of *in vitro* pollen germination was found after treatment with EMF for a min. in all the plants compared to control (Fig. 2). Free-floating hydrophytic fern *Azolla* was affected at much faster rate than the plants from other ecological habitat. Where the maximum rate of *in vitro* pollen germination was achieved by EMF generated through 1 Amp/ min. of DC, which was higher than control by 196 %. Similarly, *Ipomea aquatica* from the marshy soil showed maximum rate of *in vitro* pollen germination at 5 Amp/ min treatment, which was higher than control by 14.3 %.

Terrestrial plant species *Bombax ceiba* showed the highest rate of pollen germination under 3 Amp/ min treatment, which was higher than control by 39 % (Fig. 3). However, *Catharanthus roseus*, growing under arid condition was least affected by the application of EMF for 1 min at various Amp of DC. The maximum rate of *in vitro* pollen germination was found in control for *Catharanthus*, followed by 2 Amp/ min and 5 Amp/ min treatments, which was lower than control by 20.24 % and 21.62 %, subsequently (Fig. 2).

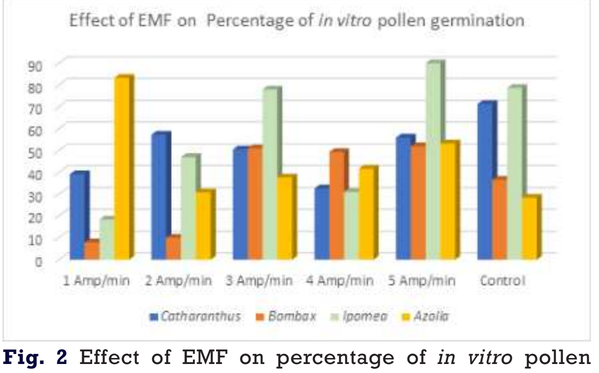

Fig. 2 Effect of EMF on percentage of *in vitro* pollen germination on various plant species

However, for the treatments above 4 Amp/min, the cytoplasmic content of pollen grains was found to be lost in some, showing risk of pollen viability (Fig. 4 B, C & D). Similar observations were made by Ahmad *et al* (2013) in *Achillea Wilhelmsii* in which the treatment of pollens under electromagnetic fields of 4mT for 20 min showed abnormal, shrunk, destroyed, defective and fragile pollen. The microscopic observations revealed that if radiation is increased in the environment after a certain limit due to increased consumption of electronic instruments, membrane disruption may occur at cellular level. After the EMF treatments, pollengrains showed linear arrangement in *Catharanthus* at 2 Amp/min (Fig. 4A).

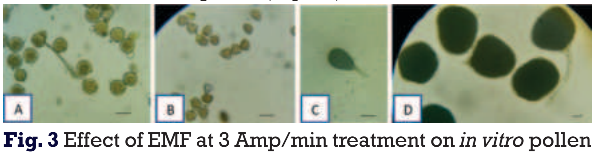

Fig. 3 Effect of EMF at 3 Amp/min treatment on *in vitro* pollen germination A. *Catharanthus*, B. *Bombax*, C. *Ipomea*, D. *Azolla* (Scale = 0.4 μm)

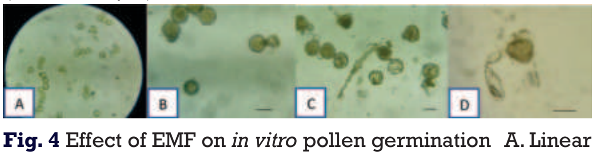

Fig. 4 Effect of EMF on *in vitro* pollen germination A. Linear arrangement of pollen after 2 Amp/min treatment for *Catharanthus*; B. Pollen content being lost after treatment at 5 Amp/ min in *Catharanthus*; C. Distorted pollen tube in *Catharanthus*; D. Bulging of pollentube after 4 Amp/ min treatment in *Bombax* (Scale = 0.4 μm)

It has been proposed that due to high solar radiation, altered EMF induce dipole transition, including Ca^{2+} regulation and ATP synthesis. Moreover, such treatments of radiations have been shown to improve resistance to environmental stress (Alain *et al*, 2016).

CONCLUSION

Present study suggests that hydrophytes are more sensitive towards radiations followed by marshy, terrestrial and arid plants. Furthermore, if radiation exceeds after a certain limit or for a longer period of time, viability is sacrificed due to disruption of content and breakdown of cell membrane. But, the low radiation for limited period of time can provide increased rate of success showing its application for *in vitro* fertilization and germination after further investigation and standardization of the dosage.

ACKNOWLEDGEMENT

The author would like to thank Dr. R. D. Modh (Principal), Prof. D. D. Bihola (Head, Biology Department) and Dr. Y. J. Thakar (Head, Physics Department) for their support for utilizing lab facilities and Dr. K. B. Zankat and Dr. Mayur M. Patel for their help during the study with Hall experiment instrument at Physics Laboratory, M.N. College, Visnagar.

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