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Original Article

Response to a Low Magnetic Field during the Growth of Sprout Length of Gram Seeds

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Abstract: *In open-air settings, low magnetic fields of 0.0mT, 0.0215mT, 0.0373mT, and 0.646mT are applied throughout the sprout length growth phase following germination and post-germination of gram seeds (Cicer arietinum). When magnetic fields increase, the sprout length reduces and non-linear changes are seen in the graphs. As a result, the sprout length elongation of seeds is negatively impacted by these magnetic fields. Less diffusion through the cell wall or a slower rate of cell division caused by the other cell components' waning activity could be the cause of the sprout length drop. This could affect the method used to preserve seeds.*

Keywords: *Bar Magnet, Magnetic Field, Seed, Germination, Sprout.*

I. INTRODUCTION

Earth's magnetic field called geomagnetic field is always an inescapable environmental factor for both biotic and abiotic components. Its effect on materials is the subject of physical science while it steadily acts on living systems. The strength and direction of the geomagnetic field vary with values of the horizontal and vertical components (B_H, B_V) of it are (0,0.033mT) and (0.067mT, 0) respectively at the magnetic poles and the equator [1]. In the literature, there are lots of contradictory theoretical predictions about the biological action of geomagnetic fields so it is interesting to study the response of plants exposed to either weak or strong magnetic fields other than geomagnetic fields.

The exposure of low electric field on the growth of sprout length of seeds has been tested earlier [2-5]. The earliest reference on this topic was given by Sidaway [6]. Here the effect of the low magnetic field at the time of growth of the sprout length of one leguninosae family member (subfamily: Papilionaceae) gram seed (*Cicer arietinum*) has been discussed. In the next section germination of seed after which there will be a plant growth section, theory, experimental, results, and discussion sections will appear.

II. GERMINATION OF SEEDS AND PLANT GROWTH

A seed is a little plant that is still in the embryonic stage, usually with some stored food reserves. It has one development point that forms the stem and the other the root, and it is covered with a layer known as the seed coat [7-8]. The three main components of a typical seed are an embryo, a seed coat (also known as the testa), and a supply of nutrition for the embryo that will develop into a seedling inside the seed. Its germination is the process by which a seed embryo turns into a seedling or by which a plant, fungus, or both emerges from a seed or spore and starts to grow. Under favorable conditions, it entails the reactivation of the metabolic pathways that result in development and the radical or seed root and plumule or shoot emerging. There are three different stages of seed germination: the lag phase, the radical emerging phase, and water imbibitions (soak up water).

Throughout its existence, the plant grows without limits. Because meristems are present in specific places throughout its body, it can grow. The growth rate (a) is the increased growth rate per unit of time, and it has three phases. The lag phase is the term for the early, slow growth rate. After that, it quickly expands and is referred to as the exponential growth phase. Here, both of the child cells that result from mitotic cell division are still capable of dividing. However, the growth slows down and enters a stationary phase as a result of the restricted nutrition supply. A sigmoid or S curve will be obtained; if y is the time and yo and y are the final and starting sizes, respectively, then y = yoeat}- (1). Water, oxygen, and nutrients are necessary for growth. Furthermore, the ideal temperature range is most conducive to its growth.

III. THEORY

It is well known that the axial magnetic field of a bar magnet is equivalent to the same magnetic field created by the current-carrying solenoid. Also, the magnetic moment of a bar magnet is equal to the product of the total number of turns, cross-sectional area and current flowing through an equivalent solenoid. If M is the magnetic moment of a bar magnet of length d and x is the distance of an axial point then the magnetic field will be $B = \frac{\mu_0 M x}{2(x^2 - \frac{d^2}{4})^2}$. Here μ_0 is the permeability of free space. For $x \gg d$ it will be $B = \frac{\mu_0}{2\pi x^3}$. A pair of almost identical bar magnets with their opposite poles facing each other produces a low magnetic field which is $2B = \frac{\mu_0 M}{\pi x^3}$. The problem of measuring magnetic moment M and thereby magnetic field $2B$ in

Between two bar magnets can be solved by noting the horizontal component of the geomagnetic field $B_H = 0.0373 mT$ (milli Tesla). For this reason, the wooden frame of the deflection magnetometer is adjusted along B_H, and pair of almost identical bar magnets with their opposite N and S poles facing each other is drawn along the scale of the wooden frame from opposite sides and at equal distances from the magnetic needle. The angle of deflection of the magnetic needle corresponding to different positions of the bar magnets on both sides is noted. Ifthe angle of deflection of the magnetic needle is θ then

$$2B = B_H \tan\theta = 0.0373 \tan\theta\, mT \qquad - (2)$$

IV. EXPERIMENTAL

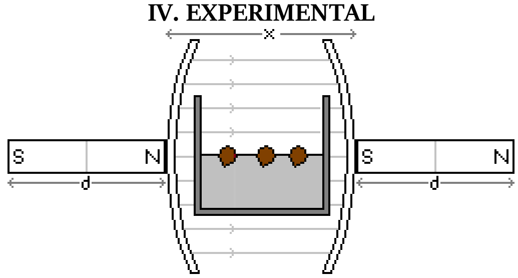

Figure 1: Schematic Diagram of the Experimental Setup

In the experimental setup, the deflection magnetometer is adjusted along the horizontal component of the geomagnetic field B_H. The angle of deflection θ of the magnetic needle corresponding to different positions of a pair of almost identical bar magnets with their opposite N and S poles facing each other on both sides of the magnetic needle is determined. Using the standard value of $B_H = 0.0373 mT$ the magnetic fields for different distances and angles (x, θ) are calculated which are (0.076m, 60°), (0.1m, 45°), and (0.18m, 30°).

Four plastic teapots readily available in the market are taken and ten-gram seeds are placed in each teapot over wet sand and soil mixture as shown in Figure 1. Out of four such prepared teapots, one is kept at normal conditions. Three other teapots are placed within a pair ofslightly concave inward iron circular parallel plates (about 0.1$meter$ diameter, x = 0.06$meter$). A pair of almost identical bar magnets with their opposite N and S poles facing each other is attached to the convex sides of iron circular parallel plate pairs on both sides to produce a uniform low magnetic field. Three different distances are chosen for which magnetic fields are 0.0mT, 0.0215mT, 0.0373mT, and 0.646mT with different distances of separation.

Using a sensitive thermometer, the experiment's maximum and lowest room temperatures were observed daily; the average was found to be 32 and 21.

In this constant low magnetic field treatment germination will start in due course of time and sprout will grow. After one day of exposure the seeds are taken away from pots one by one every day from constant low magnetic field condition for a short while for the measurement of sprout length accurately with the help of a sharp divider and scale and average is computed. Then they are kept inside the pot as it was before. The process is repeated for three to four more days till the budding of green leaves and the mean sprout length for each case is taken.

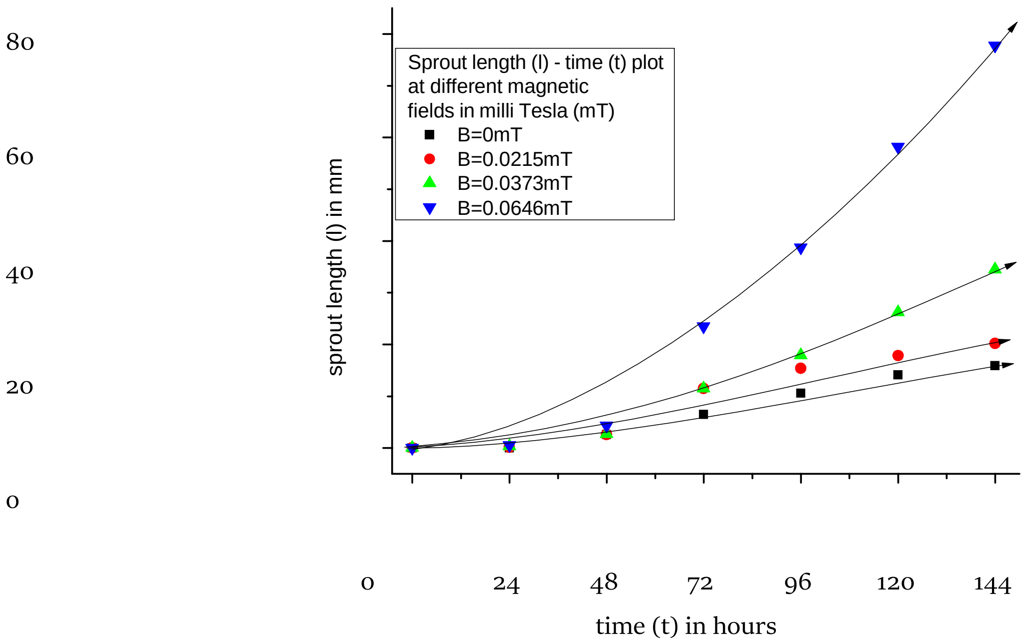

Figure 2: Variation of Sprout Length (l) with time (t) for Different Magnetic Fields ($2B$) of Gramseeds

V. EXPERIMENTAL RESULTS

The variables are as follows: (i) magnetic fields $2B$; (ii) distance between parallel plates x; (iii) deflection θ; (iv) sprout length l; and (v) sprout length t growing time. Typically, for different applied low magnetic fields $2B$, the mean or average of ten sprout lengths at a specific time of sprout length growth for gram seeds (l) is plotted along the vertical axis and the time duration of growth of sprout length (t) along the horizontal axis with values $0.0mT$, $0.0215mT$, $0.0373mT$, and $0.646mT$ corresponding to three different distance of separation of plates. Figure 2 depicts the nature of the $l - t$ graph for various $2B$. The graphs become more curved toward the vertical axis as $2B$ increases.

VI. DISCUSSIONS AND CONCLUSION

These non-linear plots make it evident that the amount of applied low magnetic fields $2B$ determines how much a seed would grow. It is currently uncertain what the precise nature of the growth of the sprout length l and the mathematical dependency of low magnetic fields $2B$ are. Because of this, it is challenging to suggest a fitting equation for these non-linear graphs. Furthermore, there are numerous fitting options. In any event, the increased rate of cell division for decreasing low magnetic fields $2B$ may be the physical explanation for it. This could be biologically explained by stronger activity of the other components of the cell or increased diffusion through the cell wall. While scatter plots will display discontinuity, the suggested lines in the figures demonstrate continuity in the germination and post-germination processes. This explains why lines connecting scatter points should be drawn.

Although a low magnetic field $2B$ is taken still it is comparable to the horizontal component of the geomagnetic field $B_H = 0.0373mT$. Care is taken to nullify B_H by keeping $2B$ of bar magnets normal to B_H.

VII. ACKNOWLEDGEMENT

The author designed the whole experimental setup and measurements of different sprout lengths, highest and lowest temperatures, and measurement of different magnetic fields (B) usingdeflection and vibration magnetometer were performed by three second-year undergraduate students of session 2013-16 (Ardhendu Pal, Sourav Basak and Sayandeep Chatterjee) of Department of Physics, Maulana Azad College, 8, Rafi Ahmed Kidwai Road, Kolkata-700013, West Bengal, India.

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