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Effect of magnetic field on the shoot length of *Triticum aestivum*

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Abstract

The present study provides an observation and documentation on the effect of static magnetic field on the growth of *Triticum aestivum.* The seeds are allowed to germinate and the seedlings are grown in an environment of the controlled static magnetic field while other physical factors such as temperature, light exposure, soil pH, etc. are held constant. Also, a comparison of influence on the average height between both the poles of the magnet is estimated and north pole oriented magnet is found to imply a significant difference. Finally some of the potential applications of the study in non-invasive protein silencing, GMO production, Vertical farming and Terraforming are briefly discussed.

Keywords: *Plant growth, Magnetic field, Triticum aestivum, Non-invasive protein silencing*

1. Introduction

There have been several reports on the effects of magnetic fields of plant growth, and it seems clear that magnetic forces do have some influence on plants (Namba *et al*., 1995).

Krylov and Tarakonova (1960) were among the first to report on Magnetic field effects on plants. They proposed an auxin-like effect of the magnetic field on germinating seeds, by calling this effect magnetotropism. Effect of magnetic field on the growth of plants now can be explained by these three main proposed theories:

- The subtle change in soil temperature caused by electro-magnetic fields which accelerate plant metabolism (Kirkham and Hartmann, 1982).
- The attraction of iron particles and starch grains by magnets; stimulating plant growth (Nagaraja, 2002, NASA).
- The excitement of Calcium ions (Ca2+) by magnetic fields which are essential to many areas of plant growth and development (Casper, 2007).

Numerous literature described the effect of magnetic field intensities on *Triticum aestivum* (seed and seedlings). When they are exposed to 4 or 7 mT magnetic field intensity, the promotion of germination has

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been observed (Cakmak *et al.*, 2010). In 30 mT, amyloplast displacement is encountered (Hasenstein *et al.*, 2013) and increased catalase but reduced peroxidase activity also has been documented (Payez *et al.*, 2013).

Considering the possible application of the magnetic field influence in agricultural practices, we investigated the static magnetic influence on the early stages of the development upon the of *Triticum aestivum*.

2. Materials

A staple and model crop species - *Triticum aestivum* (Wheatgrass) was selected for the experimental study. Selection of species for this experiment was governed by the following factors:

1. It is a model crop. Hence, its whole genome sequence is available for further genetic analysis.
2. It reproduces asexually and it is genetically identical. So if during the study any change occurs, it is more likely to be a result of the independent variable which is being tested.
3. It is a worldwide available crop and it grows rapidly, hence allowing multiple trials of experiments to be conducted in a shorter time frame.
4. Wheatgrass grows straight up as single glass blade and interfering structures like leaves are absent which allows accurate height measurement.
5. It is easily available and a major source of food worldwide, hence improvement in its production without the cost of chemical fertilizers will cause a huge impact on commercial food market as well as on global food crisis.

Neodymium magnets ($Ne_2Fe_{14}B$) of grade N52 with magnetic strength approximately 200 mT were used for this experiment. The magnetic field was calculated by azimuthal symmetry (Camacho *et al.*, 2013) and a standalone device with linear Hall-effect sensor integrated with Arduino UNO is used to measure the magnetic field strengths (Sharma, 2020), which was finalized at 205.3 mT. Whereas the Earth's field at ground level is around 0.5-1 Gauss (0.00005-0.0001 Tesla) (Odenwald, 2006).

Poles of the magnet were identified by using a regular compass. Also reconfirmed by matching it with the poles of a known magnet. Styrofoam cups were used as pots and soil of pH 6.8 was used to grow *Triticum aestivum.*

Shape: Discs / Cylinders

Diameter: 12 mm

Radius: 6 mm

Height: 2 mm

Field Strength: 205.3 mT

Figure 1: Neodymium magnet used in the experiment

3. Methodology

Three pots were placed in controlled temperature, humidity, light exposure with seeds of *Triticum aestivum*, which were already overnight soaked in water for 12 h.

After overnight soaking, seeds are randomly distributed for samples and control. The seeds are then planted into the pot in appropriate orientation.

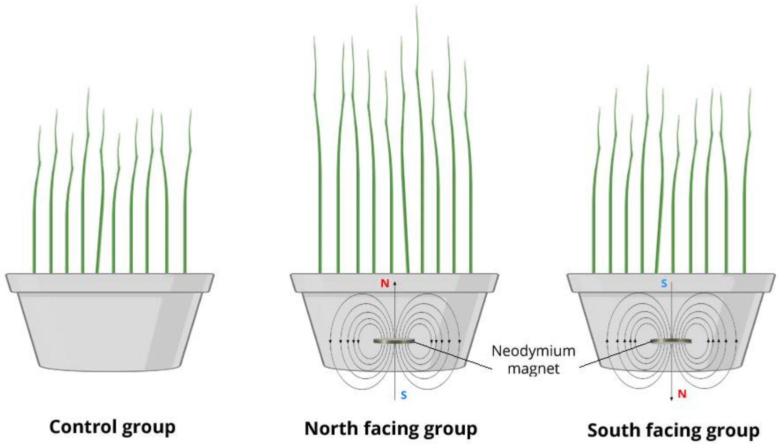

Figure 2: Experimental setup

Then, the seeds are allowed to germinate in 3 settings – 1 in the influence of north pole facing magnet, 1 in the influence of south pole facing magnet and 1 was kept as control which was allowed to grow without any influence of external magnetic field (only Earth's magnetic field).

Total of 45 samples was used in the complete study for the duration of 15 days. Five samples for each – Control, south pole facing and north pole facing were observed and shoot length data was collected.

4. Results

The experiment was conducted on 15 samples for a period of five days in each trial. Total three trials were conducted and data set of 15 days for 45 samples, out of which total 15 samples were controls, 15 samples were placed in south pole facing magnet and 15 samples were placed in north pole facing magnet. The total average height of each trial is calculated total average height in all three trial for each pool of sample is given in Table 1.

Table 1: Control and magnetic fields average heights in all three trials

Type of Magnetic Field	Average Heights (cm) Trial 1 | Trial 2 | Trial 3	Total Average Height (cm)
Control	5.274, 5.22, 5.164	5.219
North Field	7.62, 7.668, 7.744	7.677
South Field	6.972, 6.972, 6.984	6.976

All the height averages from all three trials have been calculated. The average height of all the controls is 5.219 cm. The total average height for samples placed in north field is 7.677 cm and for the south field is 6.976 cm.

Table 2: Control average height and total average magnetic fields height

Type of Magnetic Field	Average Heights (cm)	Total Average Height (cm)
Control	5.219	5.219
(North + South) Field	7.677 + 6.976	7.326

Sum of the average height of both north and south fields is 7.326 cm. Difference between total controls average height and sum of total average heights in both the field orientations comes out to be 2.107 cm.

5. Conclusion

In this present experimental result, an average height difference of 2.107 cm between the control average height and total magnetic fields average height has been calculated from the recorded data sets. The present results suggest that magnetic field implies a positive effect on *Triticum aestivum*'s average height. Moreover, when the plant was placed with a south pole facing magnet, the average height difference with control was 1.757 cm whereas, when it was placed with a north pole facing magnet, the average height difference with control was 2.458 cm. So even the magnetic orientation itself implies an effect of around 0.701 cm on average height of the plant. Hence, the north pole oriented magnet implies a significant change in the average height of the plant.

Future applications

Magnetic field intervention clearly affects the *Triticum aestivum* in a positive way. Although the magnetic field used for the experiment was ~200 mT and there is a lot of magnetic field strengths and their different permutations which should be tested. There is a lot of scope for further research in this direction well which may find its application in following fields:

Vertical farming parameter

Vertical farming is the new concept of agriculture in controlled environment. Currently, luminous intensity and temporal exposure, temperature, plant nutrient supply, etc. are considered at a vertical farm. But we propose that magnetic field should also be used as one of tshe controlling parameter. Optimum magnetic field strengths for different plants along with other parameters may produce economically beneficial results.

Non-invasive protein silencing and GMO production

Gene profiling of sample and control can explain the magnetic influence at the genetic, plant hormonal and protein production level. Such knowledge would be helpful to design GMO with appropriate changes and to increase food quality. Also, changes in protein activity levels by the influence of certain magnetic flux may enable us to use magnetic field as a non-invasive protein silencing tool. So the new-age GMO will not be produced by genetic or invasive changes but by the up and down regulation of genes/proteins by certain magnetic field strengths.

Terraforming

Terraform is the hypothetical process of modifying the atmosphere of any exoplanet/satellite so that the planetary environment becomes habitable by homo sapiens. Astrobiologist from prominent space organizations and some private companies are very interested in expedition of Mars, Moon, Titan, etc. in the search of next human habitat. Terraforming is the only process by which such hostile environment can be turned into a habitable place. As every planet have different local magnetic field, it will be very helpful if we know how plants will respond to different magnetic strengths along with different parameters. Researchers may develop magnetic field resistant crops which may be grown on exoplanets and execute the process of terraforming.

Conflicts of interest

The authors declare no conflict of interest, financial or otherwise.

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