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Assembly of the Complex Iron-Sulfur: Plants' Potential Participants in Magnetic Induction

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INTRODUCTION

Iron-sulfur (Fe-S) clusters are a highly regulated process that are involved in fundamental biological reactions and a complex sequence of protein-protein interactions that are catalyzed by nuclear, mitochondrial, and cytosolic reactions. Iron-Sulfur Complex Assembly (ISCA) scaffold proteins play a role in the biosynthesis of the Fe-S cluster as well as the metabolism of nitrogen and sulfur. ISCA proteins are involved in abiotic stress responses, and they form a Magnetosensor (MagS) complex with Cryptochrome (Cry) to function as a magnetic sensor in the pigeon. MagR quality exists in the genomes of people, plants, and microorganisms and the cooperation among Cry and MagR is profoundly preserved. We believe that plants may have a magnetoperception mechanism similar to that of pigeons because of the abundance of ISCA proteins and the homology between animal and human MagR with at least four ISCAs from Arabidopsis and several ISCAs from various plant species. We propose that ISCA proteins, which are similar to MagR in animals, are potential candidates that could aid in our comprehension of plant magnetic induction. As a result, we urge additional research in this area to fully comprehend the plant molecular mechanisms of MagR/Cry-mediated magnetic induction and the possibility of a coupling between magnetic induction and light.

Reactive Oxygen Species

The geomagnetic field, also called the Earth's magnetic field, is where plants developed. Plants perceive changes in MF intensity and inclination as an abiotic stress condition with genomic and metabolic responses that alter growth and development processes. The requirement of the GMF for Lima bean photosynthesis and Reactive Oxygen Species (ROS) production was evaluated by reducing the GMF to Near Null Magnetic Field (NNMF) values with a triaxial Helmholtz coils system. The NNMF conditions had an impact on the levels of chlorophyll and carotenoid as well as the leaf area, stomatal density, chloroplast ultrastructure, and a few biochemical parameters like the amount of protein in the leaf, total carbon, carbohydrate, and 13C. In addition, RubisCO activity and content decreased in NNMF. The GMF was expected for the response community's productivity and for the decrease of quinones. The expression of the MagR homologs PlIScA2 and PlcpIScA was reduced under NNMF conditions, indicating a link between photosynthetic efficiency and magnetoreception. Finally, we demonstrated that the GMF increased the levels of H2O2 and other peroxides as well as increased the expression of genes involved in ROS production. According to our findings, photosynthesis in Lima beans requires the GMF, and PlIScA2 and PlcpIScA may modulate MF-dependent responses to photosynthesis and oxidative stress in plants. Earth's environment includes the Geomagnetic Field (GMF), which, along with gravity, light, temperature, and the availability of water, has always existed since plant evolution. The GMF shields Earth's life from cosmic radiation and solar wind, which would otherwise deplete the planet's atmosphere, including the ozone layer, which shields the planet from harmful ultraviolet light. In addition, it is possible that the GMF had an impact on life's creation and development. Although there are significant regional variations in the Earth's magnetic field's strength and direction, the average GMF amplitude is about 40 T. The vertical component has a maximum value of approximately 67 T at the magnetic pole and a zero value at the magnetic equator at the Earth's surface. The horizontal component is zero at the magnetic poles and reaches its maximum at the magnetic equator, which is approximately 33 T. Interestingly, with most other ecological elements, and like gravity, the GMF is available both around evening time and during the day, is generally unaffected by climate and seasons, and exists for all intents and purposes wherever on The planet. As a result, it may not come as a surprise that a wide variety of organisms, including vertebrate animals and bacteria, have developed methods for utilizing the GMF to direct their movements.

Cryptochromes

Many biological processes are influenced by the GMF, which acts on living things. Reversible light-dependent chemical reactions are the foundation of the magnetic compass sense, according to the leading hypothesis about a Magnetic Field (MF) receptor center on the Radical Pairs (RP) model. It has been demonstrated that cryptochromes are involved in MF responses and undergo a light-dependent electron transfer reaction in plants. It has been demonstrated that cryptochromes and MF response are linked. Charge separation results in the formation of the primary RP in Photosystem II (PSII) following the excitation of the reaction Center Chlorophyll (Chl) P680. Abiotic stress responses involve iron-sulfur (Fe-S) Complex Assembly (IScA) scaffold proteins, which are crucial to the operation of photosystems. By forming a Magnetoreceptor (MagR) complex with Cryptochrome (Cry), they function as magnetic sensors in animals. Different organisms have demonstrated the expression of the MagR and Cry genes, and the model plant Arabidopsis thaliana was used to test this. Under conditions of iron deprivation, the GMF alters both the availability of Fe-S and the expression of iron-uptake genes in this plant. Additionally, homeostasis and Fe content are affected by changes in GMF intensity. The Fe-S cluster is able to catalyze redox reactions and transfer electrons in electron transfer chains (such as those used in photosynthesis). In the Electron Transport (ET) chain, plastids are essential to photosynthesis because they are a major subcellular sink for iron and Fe-S clusters. 2Fe-2S-containing chloroplast ferredoxin, 3Fe-4S-containing ferredoxin-glutamine oxoglutarate aminotransferase, and 4Fe-4S-containing Photosystem I core proteins PsaA, PsaB, and PsaC are examples of chloroplastic Fe-S proteins. A hypothesis of RP recombination in reaction centers provided an explanation for the MF-stimulating effects that have been described regarding the evolution of a RP that appears in both photosystems I and II (PSI, PSII). As a result, changes in the MF may alter the primary RP's recombination to generate the triplet state of the primary donor (3P680). This triplet state can react with oxygen to produce reactive singlet oxygen, which can harm PSII by preventing the repair of photoinhibited PSII. Therefore, one of the effects of plant responses to GMF is the production of Reactive Oxygen Species (ROS).