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AN OVERVIEW OF MAGNETIC FIELD EXPOSURE ON GERMINATION BEHAVIOR OF SEEDS UNDER SALINE STRESS

AMEETA SHARMA*[1] AND SHEFALI SHEKHAWAT [2]

[1, 2] Department of Biotechnology, The IIS University, Jaipur-302020, Rajasthan, India.

ABSTRACT

Scarcity of good quality water for irrigation as well as presence of average quality of water for use in agriculture has given rise to need for eco-friendly and safe approaches to promote plant growth and productivity. One of the most promising approaches, for future that may improve crop productivity and assures crop quality seems the use of static electromagnetic fields. In the present scenario as compared to the conventional chemical processes, magnetic field is considered as one of the simple and economic methods for enhancing and stimulation of seed germination process. The seed germination improvement have been accomplished by diverse pre-sowing seed treatments which includes a range of physical factors such as laser treatment, magnetic field and electric field application and microwave radiation. Magnetic field treatment results in accelerated growth of roots of plant as well as more proteins biosynthesis. Current research studies establish that magnetic field exposure improves seed germination parameter in various plants. Magnetic field influences germination of seeds at molecular, morphological and physiological parameters in a positive and promising way. It also helps in overcoming different types of stress especially saline. The referenced research studies provide a clear-cut explanation of the mechanism of magnetic field effect on plant seeds.

KEYWORDS: *Magnetic Field, Germination, Saline Stress, Plant Seeds*

AMEETA SHARMA *

Department of Biotechnology, The IIS University, Jaipur-302020, Rajasthan, India.

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INTRODUCTION

Plants are the primitive living organisms, evolved during the early formation of earth and these form a key component which makes the life possible on earth. There are wide ranges of stress both biotic and abiotic which affect the quality and quantity of agricultural crops generated or produced. Amongst the wide range of abiotic stresses, salt stress is one of the major environmental stress which effect the plants and also highly reduces the growth and development of salt sensitive plants.[1] As shown by FAO [2] data 20% of irrigated land and 2.1% of dry land agriculture are salt affected. The problem becomes much more adverse due to poor soil and water management in irrigated areas.

MAGNETIC FIELD EFFECT vs. SALT STRESS

For a developing country like India, the day by day increase in population leads to problem for supplying an adequate amount of good and healthy food to the increasing population. Various types of research studies have been done with an aim to increase the quality and quantity of the crops, but one of them which has significantly used as a 'Brahmastra' is the use of magnetic field. The progress and status of research on the effect of Magnetic Field on plant life have been reviewed in the past years. [10 – 18] A magnetic field is the magnetic effect of electric currents and magnetic materials. It is denoted by symbol B and measured in tesla. It influences all living organisms present on earth.[19] The intensity of geomagnetic field is known as geotaxis or electrotropism. [20] It is about 50 micro Tesla. Near the equator it is recorded as 35 micro Tesla whereas as we move towards the poles it becomes 70 micro Tesla in which the plant and seedling generally grows.

EFFECT OF SALT STRESS ON PLANTS AT MOLECULAR LEVEL

Salt stress leads to oxidative stress which than afterward, leads to the formation of reactive oxygen species (ROS).[3] The ROS are produced during the oxidation reactions, leading to a significant damage to cell structures. However, the ROS is produced during the normal cellular metabolism in the plant cells but as their concentration increases under the abiotic stress such as saline, then after it is widely known as oxidative stress. [4] The antioxidants are found to have a significant role in reducing the damage caused by ROS.[5] It largely affects the carbohydrates, proteins and nucleic acids present in cells and often cause peroxidation of membrane lipids. For their protection from this oxidative damage, seed has developed various enzymatic and non enzymatic defense mechanisms. [6, 7] As we come to the molecular level, just like any other charged molecules DNA also have negative charge and increase the potential of magnetic field impact. The magnetic field activates the protein synthesis for the further development of root system. [8, 9] But one should keep in mind the theoretical aspect of DNA which prolongs the free radical ion lifetime. It does by inducing the singlet - triplet transition of the unpaired electrons which in turn leads to oxidative stress. The oxidative stress than becomes the major factor that enhances mutation and then finally increase the biological stress.

EFFECT OF MAGNETIC FIELD ON PHYSIOLOGICAL ASPECTS

Magnetic field is thought to increase or fasten the time for seed germination. [21] Researches proved that when the aquatic plants (*Valisneria and Chera)* were placed in magnetic field the movement of cytoplasm was decreased to minimum. When the lines of magnetic field become perpendicular to the direction of movement and when the line are parallel, in both conditions, it does not have the same affect.[22] Later on, with further study it was proved that in a parallel magnetic field with strength of 0.7 T the movement of cytoplasm decreases by 15-30 %, whereas with decreased magnetic field of same strength the density of cytoplasm movement is increased by a large amount.[23] Then after a long duration a theory has been given in 1970 according to which when wheat kernels were subjected to the magnetic field of strength (0.18 T) it has shown lower respiration coefficient than control seeds.[24] The difference is 20% after a time lag of 20 hours and it gets smaller with further increase in time. After a year, later in 1971 it was published that the seeds of barley were germinated earlier by a time lag of 8-12 hours as compared to control. On further continuing the experiment it was examined that on applying a magnetic field of 0.15 T at temperature 23 degree Celsius (300 K) and conducting the experiment for 120 hours.[25] It is also known that amylo-lytic activity is shown by germinating seeds due to pretreatment with magnetic field before soaking them for germination. It was shown that with changing magnetic field, the gene expression, protein biosynthesis, enzyme activity, cell reproduction and other activities of cellular metabolism increases in the plant that are fully exposed as compared to the control. Thus plants are shown to alleviate the inhibitory effect of heat shock when they are exposed to pulsed magnetic field preceding the heat treatment.[26, 27, 28]

EFFECT OF MAGNETIC FIELD ON MORPHOLOGICAL ASPECTS

As per the experiments conducted earlier, the magnetic field other than having effects on physiological factors also has marked effects on the morphological factors. Plants grown under the influence of magnetic field have shown deeper roots as well as more vigorous growth as compared to control one without any influence. It is also known that magnetic field has marked influence on the initial growth stages of the plant. [29] When the seeds are pretreated under the magnetic field of lower strengths it is shown to improve the growth and yield of plants like in maize, [30] rice, [31] mungbean [32] and sunflower. [33] Other than improving the growth and yield of plants the magnetic field also reduces the harmful and toxic effects of pathogenic microbes and cadmium salt stress.[34, 35]

ADVANTAGES OF MAGNETIC FIELD

The use of magnetic field to overcome the effect of salt stress has become popular as it is cost effective and safe method to increase plant growth and productivity without involving huge expenditure. Salt stress mainly influences stomatal opening and closure, which in turn

than influences the CO_2 uptake in the leaves and then reduces photosynthetic activity. The photosynthetic activity therefore in presence of magnetic field has been shown to increase. The plant metabolic activities can be said as energy exchange independent. The nature and degree of these interactions varies according to the magnetic field source, their exposure duration, filed intensities and plant species under study. [36, 37, 38] The percentage of mitotic abnormalities may also increase in certain cases after giving all the exposure treatments which in turn ultimately leads to change in protein biosynthesis. For this cause, for many years there have been research studies to perk up seed germination and to protract the seeds for sowing. Earlier many studies have been done which focuses on the germination response of different plant varieties under various types influences for example germination response of cowpea varieties to metal stress of Zinc and its relationship with the germination.[39] Effect of magnetic field on germination parameters of seed can be one of the important factors which enhances seed germination, hence studies related to it can be highly beneficial.

FUTURE PROSPECTS

As seen till date, the increasing world population marks a alarming need to create various new crop cultivators. Among the environmental unfavorable conditions salinity is most widespread in the world. Crop production and growth severely decreases under salt stress however some crop cultivators show significant tolerance against the negative impacts of salinity. Among the salt stress responses of crops, magnetic field response play pivotal role in their ability to withstand it and have become the main center of notice. Magnetic field is known to have potential to increase crop production per unit area of land without having any damaging effect towards any environmental components. Other than overcoming the problem for growing the crop plants in saline conditions, magnetic field can also be used for growing the ornamental and medicinal plants at any sort of environment. In the future, a number of variables may be studied in greater depth to further clarify the effects of a magnetic field on plant tissues. To date there is still no definitive explanation of how a magnetic field alters plant growth. Besides, for magnetic field seed treatment to be used as viable technique for improving seed germination by plant propagators, cost competent magnetic field-generating equipments are needed. Additional research using a range of magnetic flux densities may be also is useful. Thus one can conclude that magnetic field can be of utmost importance in relation to overcoming stress in plants.

CONCLUSION

Increasing world population and depleted water resources result in increased food demand and crop production all over the world. Water scarcity is increasingly accepted as a major limitation for increased agricultural production and food security. The magnetic field treatment for seeds used in cultivation becomes an important candidate in list of environmentally friendly methods. Magnetized seeds are somehow protected from damaging effects of NaCl. It can be thus said that magnetized seeds usually have improved germination and early seedling growth under high salt concentration and it is harmless and eco-friendly technology. Results obtained from various studies showed the promising effects of magnetic field on molecular, physiologic factors, and morphological parameters of seeds. The enhancing impact of magnetic field on the germination may be due to the better radicle and plumule growth. Thus, it's a safe and recommended method to improve overall plant growth under salinity conditions.

CONFLICT OF INTEREST

Conflict of interest declared none.

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