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Role of Neurotransmitters in Plant Growth and Environmental Stress Response

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ABSTRACT

The term neurotransmitter denotes chemicals which help in the neurotransmission process in an organism's body. These NTs can be found in both plants and animals. This particular research report aimed to examine the role of neurotransmitters on plant growth and environmental stress response. The findings of this research have shown that a wide variety of NTs such as acetylcholine, glutamate, and serotonin increases the growth of root, seeds and stem by using chemical channels. On the other hand, chemical channels such as Ca2+ also regulated by the presence of NTs of plants.

Keywords- Neurotransmitter, Environmental stress, Acetylcholine, Glutamate, Serotonin.

I. INTRODUCTION

The term neurotransmitter denotes the endogenous chemicals which help in the neurotransmission process in an organism's body. These neurotransmitters are also described as the chemical messenger of the body because they help to carry nerve impulse throughout the body. It was identified that plants are the natural source of neurotransmitters. Not only in mammals, neurotransmitters such as Melatonin, γ-aminobutyric acid (GABA), serotonin, and glutamate can be easily found in plants also. In addition, most common neurotransmitters of a human being such as acetylcholine, indoleamines, biogenic amines (dopamine, noradrenaline, adrenaline, histamine) are present in different plant species. Findings from previously completed research papers have shown that these chemical compounds hold the ability to maintain the environmental stress response in a plant. In this particular research report, the role of neurotransmitters in plant growth and environmental stress response maintenance are investigated.

II. LITERATURE REVIEW

2.1 Neurotransmitters and its application

According to Kandimalla, R. and Reddy, 2017, neurotransmitter are chemical compounds which maintains the neuron network within the human being. In a human being, these NTs play one of the most vital roles in brain functioning. Since their discovery in 1921, more than 200 neurotransmitters' presence have been identified in a wide variety of organisms. The increase in the finding of NT is ascribed to biomolecules with neuroactive characteristics. This particular scientific work has shown how the molecular makeup of neurotransmitters is used to categorize them.

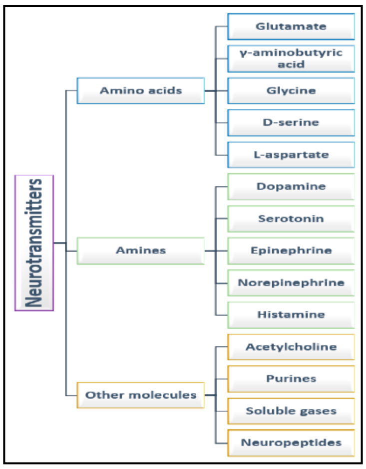

Figure 1: Classification of Neurotransmitters
(Source: https://www.mdpi.com/1422-0067/23/11/5954)

Figure 1 shows the classification of discovered NTs based on amino acid, amines and other molecule based composition. Among the most commonly used neurotransmitters are glutamate, glycine, dopamine, serotonin, and acetylcholine.

The research paper of Akula and Mukherjee, 2020, discussed new discoveries regarding the activities of neurotransmitters in plants. Over the past few years, common neurotransmitters have been discovered in different types of plant species. These NTs include acetylcholine, histamine, catecholamines, and SER etc. It was identified that the activities of these signaling compounds have a significant impact on the plant's cellular communication. According to the authors, plants also produce and transmit different types of cellular signals. The electrical impulses produced by plants helps in the formation of physiological functions in plants. The structures of the plant based neurotransmitters are almost alike with the structure of the animal NTs. Regarding this, the researchers have used the method of a complete literature review in order to understand the factors regarding the neurotransmitters and their activities in plants. It has been found that this study's results show that the role of NTs in plants is related to the development, adoption of stress, interaction with other living organisms as well as in the enrichment process of foods.

2.2 Action of neurotransmitters on plant growth

Abbasi *et al.,* 2020 assumed that the serotonin (5-hydroxytryptamine; 5-HT) is one of the most vital and essential neurotransmitter because it has been detected everywhere in earth, even in plants. It was then discovered that this particular chemical's working function is related with a broad spectrum of physiological activity during the development of a plant. Furthermore, this chemical is thought to be one of the critical elements involved in the plant cell signaling process. Molecules of 5-HT from the serotonin molecule have the capability of dictating plant growth through a number of mechanisms of reactions. The impact of this particular molecule on the plant cell signaling process increases the development of root architecture, flowering and reproduction, shoot organogenesis etc. It was identified that the calcium signaling and auxin phytohormones interaction process become the reason for this plant growth.

It was identified from the research paper of Roshchina *et al*. 2016, that neurotransmitter can be found in plants which includes glutamate, serotonin etc. These plant GLRs denote the extracellular amino acid sensors of a plant. They play a very significant role in the psychological process of regulation of plants. However, there is an obvious link between Ca2+ signaling and this particular signaling pathway. An enormous variety of outcomes, such as the growth of stems, the formation of roots, and the germination of seeds.

It was identified that GLRs have the ability to increase the control of endogenous and environmental signals which helps in maintenance of factors such as water, temperature, and light.

2.3 Role of neurotransmitters for environmental stress response in plants

According to Gołembiowska *et al*. 2016, growth of plant have significantly affected by environmental factors. These issues contain abiotic stresses which cause negative outcomes such as plant growth, productivity, and the nutritional quality of plants. It was found that a stressful environment can cause high levels of cellular disruption. However, to tackle these environmental stresses, plants created different cellular strategies. These reaction mechanisms also include the use of neurotransmitters also. The findings of this study have shown that certain neurotransmitters that are produced from plants, such as dopamine, melatonin, serotonin, γ-aminobutyric acid, and acetylcholine, might trigger a defense mechanism in reaction to the emergence of an environmental stress response.

III. METHODS

The methods of this particular research report are discussed in this particular part of the report. This description contains the description of the data collection and analysis process used to complete this research.

3.1 Research Method

In this research, the use of mono method was selected as the most appropriate research method. It was identified that this particular type of method denotes the process of one type of data collection (Bala, 2020). It should be either primary or secondary research information. Only one type of data which is the secondary information linked to plant neurotransmitters and their impact on plant growth and environmental stress response are used.

3.2 Research Approach

The selection and use of deductive research approach was used in this study. It was found that deductive approach of research demonstrates the process of reviewing pre-existing information. In this study, the literature review was completed using this approach.

3.3 Data Collection Method

The data for this research work has been collected through secondary sources of information. A wide variety of data in the form of articles, journals, online websites related to this area of research have been gathered. These sources of data include online authentic databases of literature.

3.4 Data Analysis Method

The collected secondary information undergoes analysis for deriving several conclusions. A comprehensive review approach has been used for its analysis. Important findings out of this secondary data are obtained after critical analysis to find out the role of neurotransmitters in plant growth and environmental stress response.

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IV. RESULT

4.1 Role of plant neurotransmitter and their growth

The examples of these neurotransmitters are identified as melatonin, γ-aminobutyric acid (GABA), acetylcholine, serotonin, and glutamate etc. Among these NTs the plant based glutamate (GLRRs) molecules become most vital for plant growth.

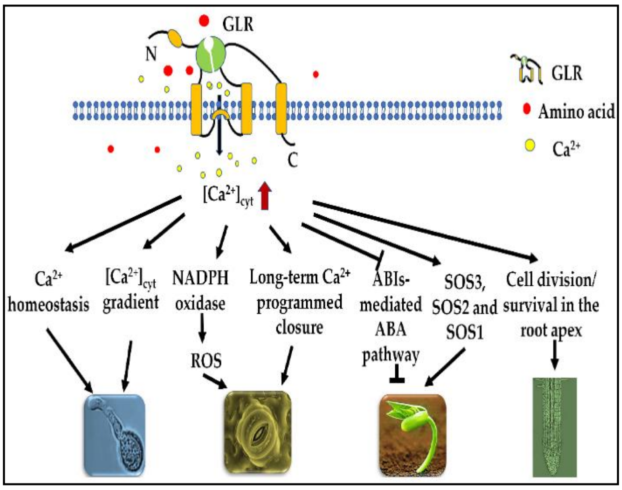

Figure 2: Main roles played by neurotransmitter in growth of plants
(Source: https://www.mdpi.com/2223-7747/11/24/3450)

This above-mentioned framework shows the impact of GLR on the growth and maturation of plants.

Germination of seed

It was identified that the germination process of seeds is very significant and the primary stage of plant growth. The control process of seed germination is associated with the development of endogenous and environmental signals. Neurotransmitters such as GLR controls the process of plant germination by inducing the level of ABA and ethylene. For the formation of this particular procedure, this neurotransmitter uses the Ca2+ signaling channel.

Root development

The development of plant roots holds the needs of a proper environment. Also, it is very important for a plant because of nutrient uptake, drought resilience, and crop yield. It was identified that during the process of root development, cell division and individual cell survival control is required (Tanveer and Shabala, 2020). The proper expressions of AtGLR3.6 have the capability to properly maintain the process of primary and lateral root development.

Other development

Other growth elements of a plant include the maturation of Pollen tubes, tip growth etc. The findings of previously completed research papers have shown that neurotransmitters can also regulate the growth of pollen tubes with the help of Ca2+ influx.

4.2 Role of neurotransmitters to plant environmental stress response

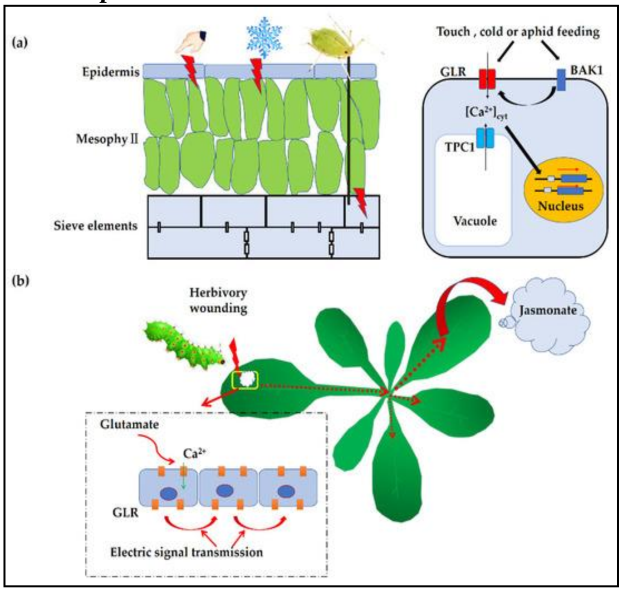

Figure 3: Role of neurotransmitter in Plant Response to Environmental Stress
(Source: https://www.mdpi.com/2223-7747/11/24/3450)

The role of neurotransmitters in the environmental stress response of different types of plants can be understood from this above image (figure 3). It was found that a NT can generate a response very rapidly to any external wound of a plant. On the other hand, their impact can be also found in the formation of defense mechanisms against the herbivory attacks.

V. DISCUSSION

In the particular part of this report, all the secondary findings of this study are discussed in relation to various previously completed literature. It was identified that the development of rapidly growing global pollution and climate changes have impacted the growth and environmental stress of plants. The growth of plants can be significantly reduced by the formation of negative environmental conditions (Wink, 2018). To resolve these issues plants use a wide variety of defense strategies. Among these strategies, the neurotransmission of chemical impulses become very vital for plant growth by reducing stress of the environment.

In figure 2, the role of plant-based NTs and the growth of plants can be understood properly. It shows four different developments of plants which are controlled by different types of NTs. The growth of these plants are identified as various plant organs such as pollen stem, stem etc (Ramesh *et al*. 2015). On the other hand, figure 3 shows the role of neurotransmitters in plant response to environmental stress. It was found that NTs such as GLRs have the ability to create a significant impact on the environmental stress response of a plant by controlling the dose Ca channel.

VI. FUTURE DIRECTIONS

It was identified from this entire research investigation, that the role and impact of plant based neurotransmitters are very significant for their growth and environmental stress response. There are multiple neurotransmitters are present which have the ability to regulate plant growth and environmental stress response (Rabiei, Z. and Rabiei, 2017). In most of the previously completed research papers' the findings were observed as secondary analysis not primary (Hodo *et al*. 2020). Only a few researchers have completed clinical laboratory based research, using plant samples. Because of these reasons, the formation of this study's future direction should be focused on the formation of clinical research using plant samples.

VII. CONCLUSION

Throughout this entire research study, the identification of plant-based neurotransmitter's role in the growth of plants are described properly. Also, this study holds the understanding of the relationship between the environmental stress response of plants and NTs. A well-structured literature review was conducted in this study based on the previously completed research paper linked to this research area. This literature review becomes very important to understand vital concepts such as neurotransmitters, their classifications, plant-based neurotransmitters and their roles etc. After that the data collection and analysis methods of this research are mentioned. The use of a secondary data analysis procedure was implemented in this research to find out about the roles of plant-based neurotransmitters for their growth and environmental stress response. It was found that NTs such as acetylcholine, GLRs and serotonin have a significant impact on plant growth. Also, different types of chemical channels regulated by NTs can create responses to environmental stress.

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