WHAT'S THE BIOBUZZ?
A journal for students by students

Can Neurotoxins Affect Plant Growth?

Key Terms

Receptor:
Chemical signals need a receptor, which can be thought of as a port in which they can dock. Once a chemical 'docks' in a receptor, the receiving cell begins a biological response. Each chemical can begin a different type of response.

Glutamate:
Glutamate is a chemical that causes a neuron to become excited when it docks in a receptor. When the neuron becomes excited, it is more likely to "fire", and release a mix of chemicals to the next neuron.

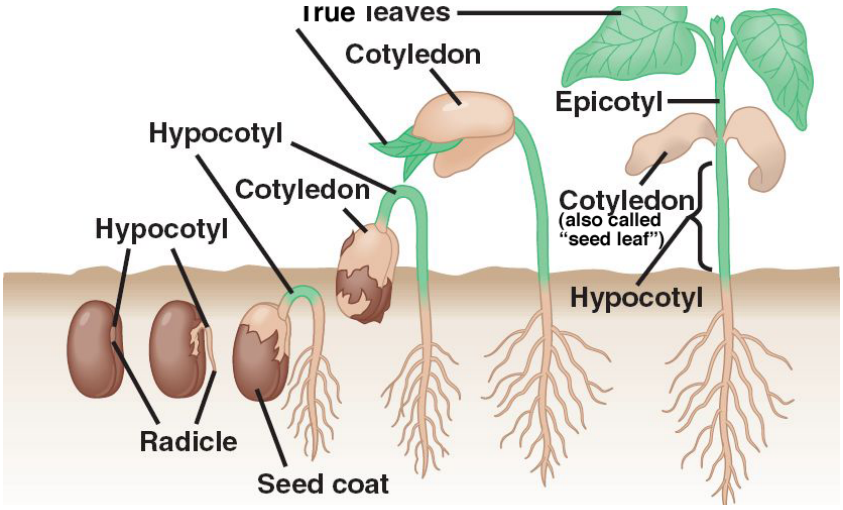
Hypocotyl:
The stem of the plant.

Cotyledon:
A leaf that is stored in a seed. When the seed sprouts, the cotyledons are the first leaves that the plant has.

Phenotype:
The observable physical properties of an organism.

Germination:
Germination refers to the process by which an organism grows from a seed. The most common form of germination includes a seed sprouting to form a seedling.

µM (micromolar):
Molarity is a measurement of the concentration of a solution in terms of the amount of substance per unit volume of solution. You would need 1,000,000 micromolar to make 1 molar.



ABSTRACT

Plants are alive, but do they have brains? Plant cells, and also brain cells, can communicate using chemical and electrical signals. One chemical signal, called **glutamate**, is very similar in both plants and animals. In humans, glutamate plays an important role in learning and memory. The neurotoxin BMAA is a harmful chemical that can attach to glutamate receptors and plays a role in brain disorders such as Alzheimers and Parkinson's dementia.

The purpose of this study is to find out what effects BMAA might have on plants, rather than animals. The plant used in this study, Arabidopsis, has glutamate **receptors** that are similar to those in animals. When used on Arabidopsis seeds during the early stages of growth, BMAA caused an increase in the length of the plant's **hypocotyl**, but stopped the sprouting of its **cotyledon**. These changes only happened when the seeds were grown in the light. One interesting fact is that the effect of BMAA on Arabidopsis can be reversed by the addition of glutamate.

By testing the effects of BMAA on Arabidopsis development, we can learn more about the function of glutamate receptors in plants. The results of this study bring us one step closer to finding a cure to degenerative brain diseases in humans.

INTRODUCTION

Cells in the brain need to work together in order for the body to function. To do this, they "talk" to each other through chemical signals. These signals are received by receptors, which initiate a biological response. Glutamate, or Glu, is the chemical signal that plays a role in learning and memory. Some diseases in human brains, such as Alzheimers and Parkinsons, may be caused by a chemical called BMAA that is very similar to glutamate, and acts in a way that takes over the glutamate pathway in the brain. BMAA does not occur naturally in humans, but enters the body through certain plants that we can eat.

What are model organisms?

A model organism is a non human species that has been widely studied because it is easy to maintain and breed in a laboratory, and has particular experimental advantages. Arabidopsis is a model organism because of its short life cycle, small plant size, and efficient reproduction through self-pollination. Arabidopsis is known to be useful for studying plant biology and genetics.

METHODS

In order to study the function of glutamate receptors in plants, scientists treated Arabidopsis plants with BMAA to analyze the effect on their development. These plants were divided into groups based on the environment they grew in, such as light or dark conditions, and were treated with different concentrations of BMAA. By testing the effects of BMAA on Arabidopsis development, we can better understand the function of the chemicals, the receptors, and the resulting biological processes that play a role in brain diseases. In the future, this research can help scientists create treatments and cures for these diseases.

RESULTS

The goal of this study is to determine if BMAA has any effect on the function of the Arabidosis glutamate receptor. The scientists grew Arabidopsis seedlings, both with and without BMAA, then observed and compared the **phenotypes** of the two groups. They discovered that the BMAA-treated plants had longer hypocotyls and a smaller angle of cotyledon separation compared to the untreated group. **Figure 1** shows the difference between the BMAA treated (top) and the control (bottom) Arabidopsis seedlings.

As shown in **Figure 2**, this study discovered that when the seeds were treated with BMAA and grown in the dark, there was no change in phenotype, proving that BMAA only has an effect when plants are grown in the light. This study also found that with increasing amounts of Glutamate, the effects of BMAA were reversed.

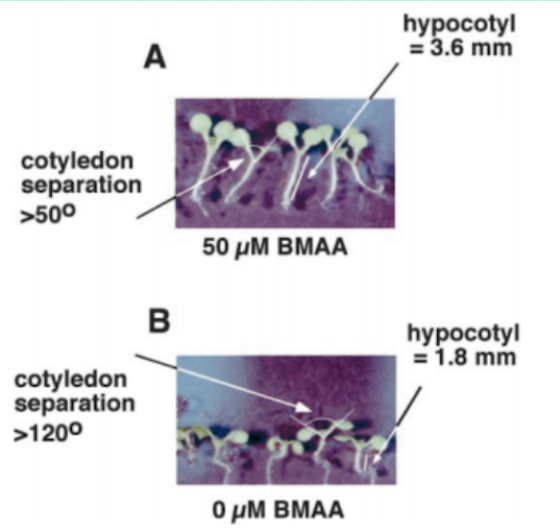


FIGURE 1: Compared to the plants containing 0 µm of BMAA, the plants treated with 50 µM of BMAA had a longer hypocotyl, but a smaller angle of cotyeldon separation

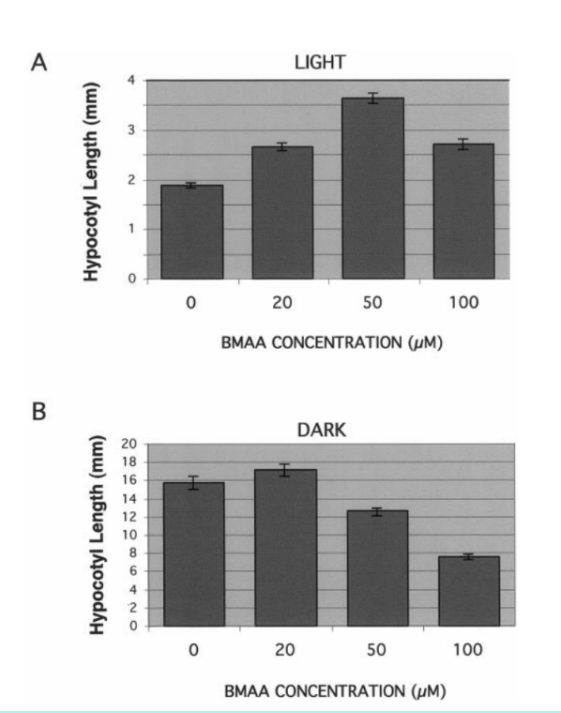


FIGURE 2: Light-grown Arabidopsis had an increase in hypocotyl length as more BMAA was added, while dark-grown Arabidopsis plants had a gradual decrease in hypocotyl length as more BMAA was added.

DISCUSSION

- The study showed that BMAA was able to change the early development of Arabidopsis plants. It promoted the hypocotyl length and inhibited cotyledon opening in the light. In animals, chemicals like BMAA that enter the body are potentially dangerous and cause damage to the brain.

- In a normally functioning brain, glutamate binds with receptors, but at some point, these receptors stop responding. This process is called desensitization, where the receptors no longer recognize glutamate and stop signaling a biological response. This process is necessary for normal functioning of the brain.

- In a brain where BMAA is present, the receptors that are supposed to bind with glutamate bind with BMAA instead, and they do not become desensitized to the chemical. In other words, BMAA overexcites the glutamate pathway.

- Interestingly, this study found that the effects of BMAA on Arabidopsis development were reversed when they added glutamate. The reason that glutamate is able to reverse the effects of BMAA is because it competes with BMAA at the binding site and takes over to restore normal receptor desensitization and function.

- High levels of BMAA have been found in the tissues of certain plants. This has led researchers to believe that BMAA may be produced naturally in plants to act as a toxin against predators. Many studies also suggest that chemicals like BMAA which are found in plants may not only serve to deter predators, but also act as molecules that signal for certain developmental processes to occur. For example, hypocotyl elongation.

- The role that BMAA plays in plants compared to animals is an important finding, because scientists can use this information to discover new therapeutic treatments for neurological disorders that are related to BMAA and receptor dysfunction

Adapted from Arabidopsis Mutants Resistant to S(1)-b-Methyl-a,b-Diaminopropionic Acid, a Cycad-Derived Glutamate Receptor Agonist1 by Eric Brenner *et al.*, Plant Physiology, 2000