Rhizobium bacteria are associated with the nitrogen fixation process in legume plants. Much is known about what rhizobia do on a biological level, but questions concerning the evolution and uses for the bacteria still exist. Through an experiment done by Marta Marchetti, evidence suggests that rhizobia started as a plant pathogen and through natural selection of a regulatory gene, evolved into legume symbiont. Studies done by Elena Beyhaut and S. Rodríguez-Echeverría have shown the ability for rhizobia to not only help in prairie restoration, but also revegetation and soil rehabilitation projects as well. Rhizobia have also been seen to promote growth in legumes and at the same time increase defense against predators according to a study done by Sylvia Thamer. By sharing this symbiosis with legumes, rhizobia are able to rehabilitate land, but also to accomplish what artificial fertilizers do, but at a lesser cost to the environment and to the farmers growing the crops. The aim of this review is to provide a general overview of how Rhizobium bacteria may have evolved, and what steps should be taken next to use Rhizobium in restoration projects, defense against predators, and a sustainable nitrogen source for crops.

Introduction

The mutualism between plants and nitrogen-fixing fungi go back to the first land plants millions of years ago. Mycorrhizae, as the symbiosis, is known for its ability to help bring in nutrients to 90% of vascular plants currently inhabiting the world. Benefits and advantages of the fungi include: Greater stress resistant plants, less pesticides used as the initial growing process, increased drought resistance, and the ability to increase pathogen resistance and protection. Mycorrhizae have shown promise to the field of agriculture and have stood the test of time. While mycorrhizae have the ability to form symbiotic relationships with 90% of land plants, that still leaves a need for nitrogen unaccounted for.

Rhizobium, nitrogen-fixing bacteria, is associated with the nitrogen fixation process in legume plants. While mycorrhizae have a broad range of plants it is able to effect, rhizobia are tailored to legume plants only. Although some research has been done to improve our knowledge on this subject, not much is known about how the Rhizobium bacteria evolved, or what it can be used for on a larger scale. Similar to its counterpart, rhizobia have been shown to improve plant growth, defense, and have even been found to aid in restoration in prairies. Rhizobia have also had the ability to replace manufactured fertilizers in crops as well. After reviewing multiple studies and analyzing the experimental outcomes of many studies, the aim of this study is to provide a general overview of how Rhizobium evolved and expand the knowledge of its multiple uses in agriculture.

Research Questions

What opportunities do Rhizobium give to the agriculture field?

What research has been done to show the effectiveness of Rhizobium in agriculture?

What next steps should be taken in order to implement Rhizobium into agricultural practices?

Abstract

Rhizobium bacteria are associated with the nitrogen fixation process in legume plants. Much is known about what rhizobia do on a biological level, but questions concerning the evolution and uses for the bacteria still exist. Through an experiment done by Marta Marchetti, evidence suggests that rhizobia started as a plant pathogen and through natural selection of a regulatory gene, evolved into legume symbiont. Studies done by Elena Beyhaut and S. Rodríguez-Echeverría have shown the ability for rhizobia to not only help in prairie restoration, but also revegetation and soil rehabilitation projects as well. Rhizobia have also been seen to promote growth in legumes and at the same time increase defense against predators according to a study done by Sylvia Thamer. By sharing this symbiosis with legumes, rhizobia are able to rehabilitate land, but also to accomplish what artificial fertilizers do, but at a lesser cost to the environment and to the farmers growing the crops. The aim of this review is to provide a general overview of how Rhizobium bacteria may have evolved, and what steps should be taken next to use Rhizobium in restoration projects, defense against predators, and a sustainable nitrogen source for crops.

Rhizobium Evolution

During the research Marta Marchetti conducted on R. solanacearum and the chimeric Rhizobium, she discovered that the inactivation of the hrpS structural gene of the type III secretion system allowed nodulation and early infection to take place” (Marchetti 2010). In Figure 1, you can see the stages of root nodulation and the root hairs entering and infecting after the inactivation of the hrpS gene. She also found that “the inactivation of the master virulence regulator hrpG allowed intracellular invasion of nodules” (Marchetti 2010). In Figure 2, you can see the intracellular invasion of nodule cells after the inactivation of the hrpG gene. Without the natural selection of inactivation of these genes, we would not have nodulation or intracellular invasion in legumes that we have today.

Promoting Growth and Defense

The experiment showed that the rhizobia not only increased above ground biomass, shoot length, and leaf number, but also altered and improved the plants defense against herbivores within the 5 weeks of being cultivated. See Figure 3 and Figure 4 for tables. The effects of rhizobia on the legume plant conclude that the bacteria can be used for alternate means of securing and growing plants for the future, as well as aid in defense.

Conclusion

This study was conducted in order to inform of the many useful possibilities of Rhizobium bacteria in the field of agriculture. In farming practices, nitrogen is an essential part of successful plant growth, and because of this, society has turned to using manufactured fertilizer to aid in this part of the process, as well as pesticides to keep herbivores from consuming the crops. Manufactured fertilizer and pesticides are not only harmful to the environment, but they are also harmful to those who consume the crops. Nitrogen was found to accumulate in edible parts of the plants, while pesticides have been shown to cause harm to the farmers who might be using them, ultimately causing health issues later on. The use of rhizobia bacteria would not only fix the current situations, but would also provide higher crop yield. Rhizobia can be used in multiple situations in agriculture including restoration, plant growth, and defense as we have seen through this study.

Next steps in starting this process would be to introduce rhizobia to situations where crops may not be producing anymore due to lack of nitrogen and overuse of the soil. By doing this, rhizobia could "restart" the biological components of the soil and in turn provide more fertile land after the course of a few years, as well as new vegetation into the area. After vegetation has been restored, the continued use of inoculation in new crops would promote growth, but also aid in defense, eliminating the need for manufactured fertilizer and pesticides.

Once these processes show promise, research on genetically enhanced crops could one day be a part of the future. By continuing the research on the evolution of rhizobia, scientists may be able to unlock and genetically implant these genes into new crops, allowing them to complete nitrogen fixation on their own. Microbiology is the way to successful farming and crop yields in the future, and steps to ensure the plants future should be taken now.

References


