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Have we Found the Key to Sustainable Farming? Microbial Communities and Crops

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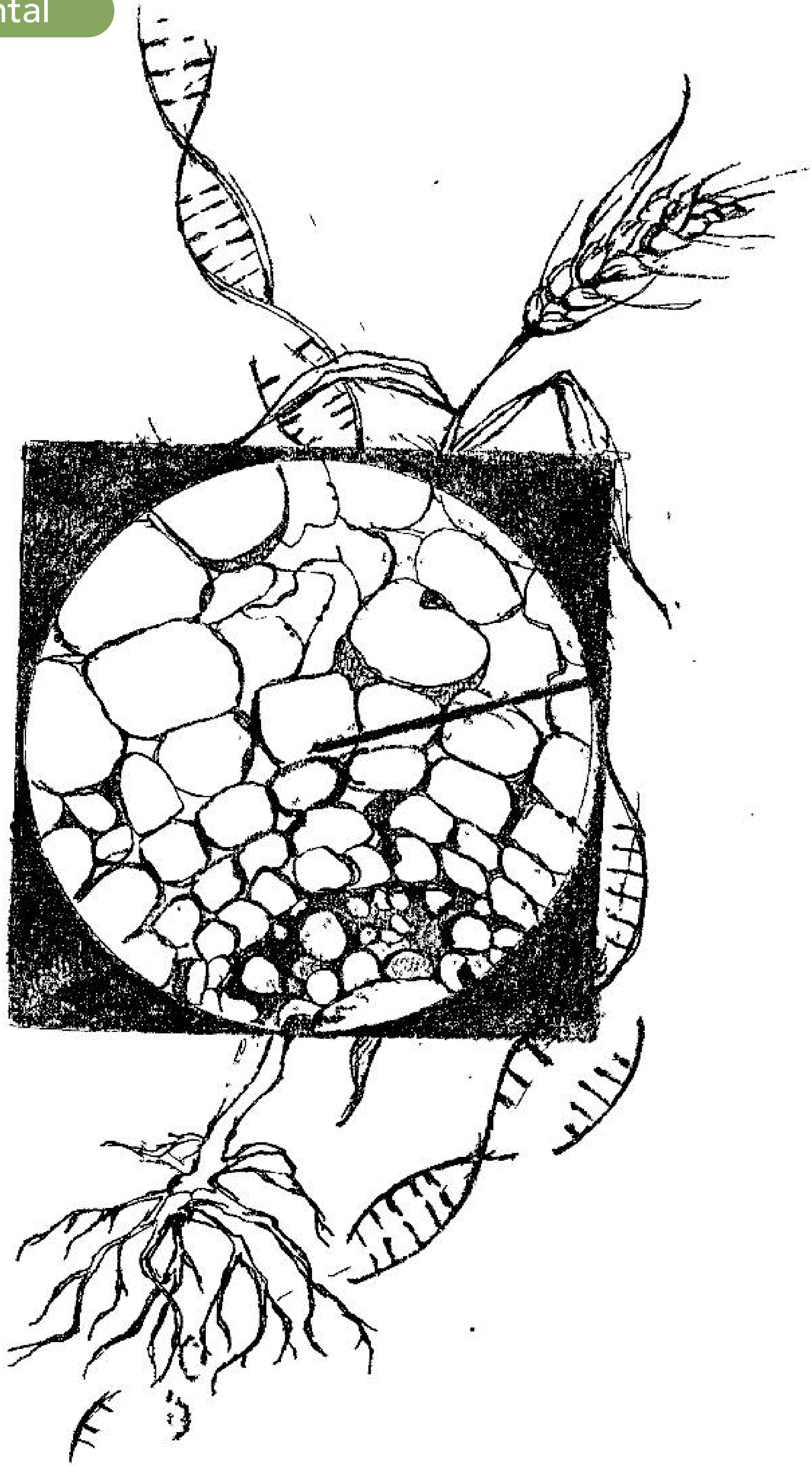

Have we Found the Key to Sustainable Farming?

Microbial Communities and Crops

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There is no doubt that the United States agriculture system is not perfect. From monoculture to workers rights to the use of fertilizers, it is clear that there needs to be a change in the practices that are currently implemented for U.S. farming.

For fertilizers, in particular, which are heavily used in agriculture, half of their nitrogen is lost to the environment leading to eutrophication, water and air pollution, and hypoxic dead zones. The loss of nitrogen on this scale is detrimental to the fight for environmental protection. Furthermore, farmers lose, on average, $200 billion each year as a result of nitrogen loss and pollution. Fertilizers as we know them need an overhaul both environmentally and economically. Microbial communities may be the key to making such changes.

Microbes and microbial communities are complex and emerging areas of biology. Furthermore, soil microbes have recently taken center stage in sustainable farming. The microbes are called diazotrophs – bacteria that are classified as having biological nitrogen fixation (BNF). In short, the necessary steps to incorporate BNFs into farming would be to simply place it in the soil. When fertilizer is applied, the microbes bind to the nitrogen in the fertilizer, converting it to a more usable substance like ammonia, which benefits the soil. This would subvert the negative ecological effects as the nitrogen would not leach out into water and other environments. Furthermore, farmers would not have to spend as much money on fertilizers. Currently, research being done on the application and use of diazotrophs uses cereal

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crops as the model organism. A recent study, Enabling Biological Nitrogen Fixation for Cereal Crops in Fertilized Fields, explores the relationship of diazotrophs and cereal crops. If these microbes are so great and are beneficial to the environment as well as farmers' profits, why have they not been used yet? There are a couple reasons. The main one being that a majority of these BNF diazotrophs operate in low nitrogen environments. They activate their nitrogen fixation whenever there is a lack of nitrogen. During a study at the South Dakota State University, they measured the wheat with four different nitrogen applications: zero pounds, 50 pounds, 100 pounds, and 150 pounds. Nitrogen fixation is very energetically taxing for the bacteria because it requires a lot of ATP. As a result, diazotrophs tightly control when they fix nitrogen as it is not prudent for them to do it often. Finding these bacteria that fixed nitrogen in high-nitrogen soil proved to be especially difficult. It was found that the number of BNF diazotrophs found was significantly less when more nitrogen was applied. Unfortunately, most crops are bred in high-nitrogen soils, which causes several issues. However, the use of genetic editing is a solution to the problem.

Since BNF diazotrophs found in high-nitrogen environments are scarce, they need to be genetically altered. A contributing explanation for the recent uptick in soil microbial research is that the technology to genetically alter microbes is available. In the ACS research study, they took a bacteria that was operating in a high-nitrogen environment, Klebsiella variicola, and genetically altered it. The DNA was changed so that it would activate and fix nitrogen even if it was in a high-nitrogen environment. Wen and Havens found increased nitrogen fixation activity by 122-fold when compared to its wild-type counterpart. Overall, though this process is time consuming and extremely complicated, the results support that this method still produced high yields for crops and it minimized nitrogen loss. In fact, Wen and Havens believe that the use of BNF diazotrophs could create a great shift in agriculture, as the Haber-Bosch process did over a century ago. The Harber-Bosch process converts nitrogen to ammonia and led to the global use of fertilizer and a spike in crop production. The microbes' possess a remarkable ability to be edited and sold to farmers.

Though great progress has been made, further studies need to be conducted in order to fully implement this new technology and method. There are currently very few peer-reviewed studies surrounding nitrogen-fixing soil microbes. An explanation as to why so few articles have been published is because gene edited microbes that operate in high-nitrogen environments carry the risk of being susceptible to human pathogens. In order for these microbes to be released, there needs to be extensive biosafety parameters for future experiments. Furthermore, it is a new method of farming that will naturally be met with resistance and skepticism. However, despite the risks, this emerging field of biology has fascinating possibilities for sustainable farming and agriculture in general. If we can ensure that using these microbes are safe and efficient, there is a bright future for agriculture around the world. • • •