Could Ents Be More Than Fiction?

In the well-known series of *Lord of the Rings* told by J. R. R. Tolkein there are intelligent talking tree-like creatures called Ents. The Ents distinguish themselves from trees, but what if trees were more similar to them than we thought? Plants have been considered inferior and lacking in the basic intelligence that most other life has, but with new research scientists have found that plants are far more complex than we thought. As more is discovered concerning plants, the idea of plant sentience becomes more tangible. Some of the questions on plant sentience are how and why plants communicate, whether there is a plant brain or even a need for its existence, and plants having consciousness. In displaying and explaining several of the modes of plant communication the complexity and sentience become apparent.

Firstly, one must understand what is meant by plant communication. What is involved? What is the purpose? Günther Witzany (2006) wrote in "Plant Communication from Biosemiotic Perspective" that plant communication is defined as "active coordination and active organization—conveyed by signs… Chemical molecules are used as signs. They function as signals, messenger substances, information carriers and memory medium in either solid, liquid or gaseous form" (p. 169). Similar to how humans use sound to communicate "there's a snake in my boot," plants use chemicals to communicate distress. The array of chemicals available for plants to utilize in communication is equal in diversity to human vocalizations. Some of these include plant hormones, secondary metabolites, volatile organic compounds, and pheromones. These diverse modes of plant communication make plants much more complex than they were originally thought to be. The previous assumptions that plants were inferior and lacking in the ability to have experiences, which is a component of sentience, need to be addressed. The idea of sentience is the capacity to be positively and negatively affected along with the ability to have experiences. In the case of animals, sentience is being used to argue for their moral protection because if they can feel and have experiences then they can suffer. Plants are capable of much more than we thought and their ability to communicate, feel, and remember make them also eligible for moral protection.

In order for plants to be able to communicate they must have some sort of message transportation system like how animals have a nervous system. Scientists have found that plants have structures similar to the nervous system of animals, in particular the neuron. As stated by Rainer Hendrich et al. (2016) in "Electrical Wiring and Long-Distance Plant Communication," the plant neuron has components "just like the axon interior, the sieve tube cytoplasm is dominated by an electrolyte of approximately 100 mM K^+, separated from the exterior (approximately 1 mM K^+) by the plasma membrane. Analogous to the glial cells that provide support and protection for neurons, the sieve elements are accompanied by companion cells" (p. 377). Having similar structure and function to an animal nervous system makes learning and understanding the plant version that much simpler. We can use what is already known about animals and apply it to plants, while also taking the newly acquired knowledge of plants to use elsewhere. An example of applied knowledge of animals to the real world is The Eastgate Centre in Zimbabwe, which is a shopping center where the air conditioning system is replaced by a system of fans and channels that draw air in from the bottom where it is either heated or cooled by the surrounding concrete. It then circulates throughout the building until it exits out the top (Doan, 2012). The termites which this building is modeled after regulate the temperature of their mound by opening and closing various vents (Doan, 2012). Humans have already modeled the Eastgate Centre in Zimbabwe after termite mounds to have more efficient heating and cooling (Doan, 2012) and may one day model many more useful things after plants.

Although plants have many similarities to other creatures, it is uncertain if they have a central nervous system which contains a brain-like functioning area. It would make sense that, in order to organize all of the information collected and sort out what is important or not, some sort of controlling organ would preside over all of it. There would be a part of the plant that is deciding whether to react to a signal it receives or not, and also how the individual is going to act. In Charles Darwin's (1880) book *The Power of Movement in Plants*, he introduces the possibility of part of the root apex containing a brain-like area that determines where the root will grow in which he claims, "It is hardly an exaggeration to say that the tip of the radicle thus endowed, and having the power of directing the movements of the adjoining parts, acts like the brain of one of the lower animals…" (p. 573). Conflicting opinions on the existence of a plant brain have also led to hiccups in the developing research of this subject. Scientists have gone back and forth on whether or not a brain-like feature is needed in order for plants to carry out all of the different things they do. Scientists Rob DeSalle and Ian Tattersall (2012) claim that comparing plant systems to animal nervous systems is "simply a case of discussing similarities," and should not necessarily be taken literally. Plant neurobiology is a term that has scientists split because some think that plants may actually have a nervous system, but then others think that the systems found in plants used for communication are only comparable to animals and do not have to have all of the same traits and features. Whether plants do have a central nervous system, roots that function as a brain, or have a different brain-like area that allows for plants to interpret the diversity of information that they receive, it cannot be denied that in some way they are able to interpret stimuli similar to how humans and animals do.

Since plants have a means to relay a message there remains the question of why. Is there a logical reason for plants to communicate with each other, even though there may be costs sometimes? An emitter plant will release chemicals, either willing or unwilling, into the surroundings which are then picked up by other receiver plants that can then defend against the attack or stress event. The benefit for the receiver plant is obvious since it is able to prepare itself and thus preserve more of its tissues. The benefit for the emitter plant is less obvious since warning its neighbors could potentially give its competitors the upper hand, but there are several components that can make communicating for the emitter plant worthwhile. A plant benefits when its surrounding neighbors are close relatives due to limited dispersal, so warning them ensures that the family tree lives on. Emitter plants also benefit when releasing volatile organic compounds, which helps to warn other parts of the same individual of incoming attack so that it can prepare. With this in mind, Martin Heil and Richard Karban (2010) further explain in their article "Explaining Evolution of Plant Communication by Airborne Signals" that the "discovery of within-plant signaling by VOCs provides an attractive explanation for the evolutionary origin of the physiological machinery that is needed to perceive volatile signals and to translate this information into purportedly adaptive responses," (p. 142). Since the emitter plant has a clear benefit to release volatile organic compounds, then the use of these chemicals for communication is sensible.

The emitter plant is positively affected in another way when warning other plants of attack by helping create a barrier of healthy plants around it. When a plant is attacked it can warn others by releasing volatile organic compounds or along the network of mycorrhizal fungus that it is in a mutual relationship with. This signal composed of plant hormones and secondary metabolites is sent along the common mycorrhizal network by diffusion across the cell membrane, dissolving in the water on the outside of the hyphae, or inside cords formed from hyphae. All of these different modes of transportation allow for both hydrophobic and hydrophilic substances to travel, which means a larger variety of chemicals can reach more neighboring plants quicker. The emitter plant is able to reach a greater amount of neighboring plants because mycorrhizal fungi tend to partner up or interact with more than one host plant in order to ensure its better fitness. By being in contact with more mutualistic partners, the fungi is maximizing the amount of carbon intake it receives which is its primary source of energy. Having this extensive network allows for more signals to reach more plants which will protect a damaged plant. In "Fungal Superhighways: Do Common Mycorrhizal Networks Enhance Below Ground Communication?" Barto, Weidenhamer, Cipollini, and Rillig (2012) explain that the "benefits of plant defense signaling through CMNs may counterbalance the competitive costs of plants growing in close proximity, because induction of defenses in surrounding plants could insulate the inducer from further attack by creating a shield of healthy plants around it" (p. 634). This helps explain why dense groups of plants would benefit from chemical distress signals originating from other plants.

One of the most controversial modes of plant communication is their use of acoustics. It is acknowledged that cell processes produce sound all the time as found in "Green Symphonies: A Call for Studies on Acoustic Communication in Plants," where Monica Gagliano (2013) states that "sound waves of many different frequencies and sources constantly travel back and forth through the environment we live in and tell us a great deal about the surrounding world," (p. 790). This sound is commonly caused by the movement of the cytoskeleton which produces very low frequency wavelengths (Gagliano, 2013, p. 791). Another common source of sound in plants is cavitation of the xylem which is when drought stress causes collapsing of the xylem. Scientists Mayr and Zublasing (2010) found that "conifer axes exposed to drought stress and freeze–thaw events typically emit UAE during freezing…"

(p. 39) which suggests that plants that are stressed will release ultrasonic acoustic emissions to inform other plants of the stressful event. There is again the question of whether this warning signal is voluntary or not. In this scenario, it seems that the plant emitting the ultrasonic acoustic emissions is doing so involuntarily as a result of cavitation being a physical response out of its control. There can be no question though that using sound is incredibly beneficial because it travels faster and does not take as much energy to produce as chemicals do. It would also be reasonable to assume that plants would be able to recognize different sounds so that sounds produced in one part of an individual can be spread to other parts to ensure the entire organism is on the same page. More research is needed before we can know the extent of plant communication with sound.

Although it is unknown how a plant detects sound and interprets it exactly, they can distinguish between different sound waves and even magnetic waves. In a study done by Gagliano, Grimonprez, Depczynski, and Renton (2017), it was discovered that the roots of a plant could differentiate between sound waves and magnetic waves in which they proposed "that acoustic gradients enable roots to broadly detect a water source at a distance and conceivably, establish the most direct and cost-effective route to that source prior to encountering the associated moisture gradient" (p. 157). The roots grew towards the sound of water running played from a speaker, but away from the speaker that was on and not playing any sounds. This suggests that the roots could distinguish between the desirable sound of water and the unfamiliar magnetic waves produced by the speaker. Discovery of the complex ways that plants communicate gives more and more evidence toward plant sentience.

Plant communication shows how complex plants are and demonstrates how they are impacted negatively and positively. Since it is acknowledged that plants do have the capacity to be affected negatively and positively and are aware, then the question of whether plants are sentient lies in their ability to have experiences. In their study with the *Mimosa pudica* plant, which is well known for its tendency to curl up its leaves when it feels threatened, Monica Gagliano et al. (2014) found that "*Mimosa* can acquire an enduring memory of a past event, whereby the plant recognizes and generalizes the learned stimulus" (p. 69) after subjecting the plant to different stimuli over short and long periods of time. Somehow these plants are able to remember experiences and thus can change their response to stimuli accordingly. They are able to learn, remember, and have experiences which are all characteristic of intelligence and sentience. Arguments against sentience of plants on the basis of their inability to have experiences are unsound.

Despite that the sentience of plants is becoming better known, there are some that would argue plants are not sentient. The idea that plants can feel, have experiences, and communicate seems like science fiction to many people. There are those that do not necessarily care too much about plants' well-being, but there are many more who just do not know the full extent of their complexity. Part of what is assumed to be an aspect of sentience is the possession of a nervous system that allows for consciousness, but this type of system in plants is a new idea that must be tested and proven. This leads into another issue; the consciousness of plants or animals cannot definitively be proven. Skeptics would argue that since there is no evidence for plant consciousness then they cannot be sentient, but the consciousness of animals cannot be proven either. Animal sentience is widely accepted and hopefully, given time and more research, plant sentience will also be accepted.

The advancement of research in plant communication has come a long way, but it still has a long way to go. Knowledge about the mechanisms of plant communication provides evidence for plant sentience. There are still many things that remain unknown like whether plants have a brain, the extent of acoustic communication, and the consciousness of plants. Knowledge of such things will broaden our view of plants and sentience itself. As more research and studies are done, there is more proof that plants do communicate in complex ways. Plants communicate via chemicals in the air, chemicals transported by the underground mycorrhizal fungus network, and also by sound waves. They are not inferior just because they cannot move from where they are planted, but rather have many complex tools that they use to better their survival and the survival of others around them through communication. These advancements made in our knowledge of plant communication show the complexity, intelligence, and sentience of plants. Ents and plants as we know them today are not so different after all. They are both intelligent and sentient with memories, beings which should be respected. Plants should have the same moral protection and rights as animals since they also have the ability to remember, feel, and thus suffer.

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