The Use of Hydroponic Robots to Promote Sustainable Agriculture

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Abstract: This article explains the significance of agriculture to society. It also proves that many of the problems the world is facing with agriculture are due to the kinds and quality of the soil. Hydroponics is a system of agriculture that utilizes nutrient-laden water rather than soil for plant nourishment (Bridgewood, 2003). It provides more sustainable farming. Nevertheless, the hydroponic system might need to undergo some improvements to attain a level of efficiency like never before. The integration of robotics can facilitate this process of enhancement. The technology of color and heat sensors can be introduced to a robot's system, therefore preserving nutrients and delivering them in the right amounts and timing. This method can actually take agriculture to the next level. Perhaps one day you might hear of hydroponic robots on the surface of the moon.

Keywords: agriculture, hydroponics, soil, nutrients, sensors

Introduction

For decades, agriculture has been associated with the production of essential food crops. At present, agriculture above and beyond farming includes forestry, dairy, fruit cultivation. Today, processing, marketing, and distribution of crops and livestock products are all acknowledged as part of current agriculture. ("The Importance of Agriculture," 2016)[1]. According to M. S. Swaminathan (2002), if agriculture goes wrong, nothing else will have the chance to go right in the country. If efficient agriculture took place, not only will starvation and poverty be reduced at a noticeable rate, but also incomes and earnings would likely increase. Problems in agriculture have been growing profusely. They include land conversion and habitat loss, soil erosion and degradation, pollution, and climate change. ("Environmental impacts of farming," n.d.)[2]

For that, individuals and farmers are currently pursuing sustainable agriculture, as well as they are seeking the use of advanced technology, which was put to help improve and fix inefficiencies like self-driving tractors, they can till, crop, fertilize a plant on their own, or the fruit-picking Agbot that picks one fruit per second without damaging the fruit or the tree (Koehler, 2017)[3]. One other way that technology helped in the uplift of agriculture is hydroponics. Hydroponics is one way that scientists use to partially eradicate such problems. According to Roberts, Lary (Nov 2000), hydroponic farming reduces the amount of water and nutrient requirements, increases the crop yields, and allows more plant growth in the same space as farming, because it allows plants to be grown one over another. However, the hydroponic theory needs some improvements to attain efficiency and sustainability. With the use of an advanced robot, hydroponics will be taken to the next level. We decided to develop this idea further and come up with a robot that can 1) purify and make sure the water that is used is controlled, 2) check that the amounts of nutrients being used are sufficient and check for the purity of the nutrients, 3) last but not least the robot will be the host of the plant and make it transformable.

Literature review

Many robots were invented to contribute in improving agriculture, robots that are used in automated harvesting systems like the Cucumber Harvester and the WP5, robots that are used for weed control like the AgBot II, and robots that are used for navigation in the field like the Rowbot or the Hamster Bot (Calin, 2015)[4]. Our robot will be hosting the plant and it will also test and control the water used, it will provide the seed with the efficient amount of nutrients. When the solution of water and nutrients is subjected to heat, which can be dangerous, the robot will move to a cooler spot and initiate the cooling system. A plant will try to supply

[1] http://agriculturegoods.com/the-importance-of-agriculture/

[2] http://wwf.panda.org/what_we_do/footprint/agriculture/impacts/

[3] http://www.redbull.com/en/stories/1331835446349/robotic-technology-in-agriculture

[4] https://www.intorobotics.com/35-robots-in-agriculture/

more nutrients to its younger leaves than to its older ones. When nutrients are mobile within the plant, symptoms of any deficiency become apparent first on the older leaves. However, not all nutrients are equally mobile. Nitrogen, phosphorus, and potassium are mobile nutrients while the others have varying degrees of mobility. When a less-mobile nutrient is deficient, the younger leaves suffer because the nutrient does not move up to them but stays in the older leaves. This phenomenon is helpful in determining which nutrients a plant may be lacking. The most common solution is the Hoagland solution, developed by D. R. Hoagland in 1933. The solution consists of all the essential nutrients in the correct proportions necessary for most plant growth. Our robot will have sensors (color and camera) to read and solve any nutrient deficiency, as well as thermal sensors that can detect heat and temperature to signal the robot to change position. It will also have an aerator which is used to prevent an anoxic event or hypoxia. Hypoxia can affect nutrient uptake of a plant because, without oxygen present, respiration becomes inhibited within the root cells. Another thing our robot can include is the nutrient film technique, it is a hydroponic technique in which the roots are not fully submerged. This allows for adequate aeration of the roots, while a "film" thin layer of nutrient-rich water is pumped through the system to provide nutrients and water to the plant. ("Plant nutrition," 2017)[5]. "In the past, we would use a pair of pliers, a crescent wrench, and a welder. Now we're using this thing called a computer," said Gregg Halverson (Muller, 2015)[6]. Agriculture, as well known, is the backbone of any country. There is no doubt that agriculture plays a crucial role in the overall growth of most countries and so it is necessary to ensure its development. Special attention should be given to this sector so that farmers use the latest technology for agriculture that results in higher yield. Better the agriculture, higher will be the growth of the nation. Agriculture is important because it provides livelihood to the people, it helps in economic development, it offers food security, and it enforces international trade (imos, 2016). Professor Simon Blackmore agrees: "Precision is the key to efficient agriculture." He is the director of the newly founded National Centre for Precision Farming (NCPF). And raising efficiency has become exceedingly necessary and to meet this, manufacturers have already begun working on a vast array of high-performance machines, "Robots will have considerable effects on agriculture", says David Dorhout. Basic concepts such as crop rows might become unnecessary and not a single square inch will remain unobserved. Blackmore says: "In 20 years robotics will have revolutionized agriculture." Crop Science's technology expert, Peter Dahmen agrees: "We don't know what the future looks like. But it is quite conceivable that robots will help us to increase the productivity of farming in a more sustainable and environmentally compatible way.("Robots and autonomous super tractors will make farming more efficient," 2016)[7]

Concept and Design:

Robots can be built suiting hydroponic characteristics. The robot will detect any deficiency in the nutrients or water using sensors and filters, and fix that problem to make sure a successful hydroponic process is performed. Such robots must contain plastic pipes constructed with holes to fit the plants. A watery, hydroponic solution including the main nutrients (Nitrogen, Phosphorus, Potassium, Calcium, and Magnesium) must be supplied to the plants at regular intervals and with the correct amounts. The importance of water, starting with healthy water is the basis for a successful hydroponics experience. Basically, what you want to know is if you have very hard or very soft water. Hard water has lots of mineral content and calcium carbonate in particular. If you see calcium buildup (white residue) on your faucets, you probably have hard water. Soft water has low mineral content, which is preferable. (But you cannot use water that has gone through a water softener system for hydroponics, it's way too salty). If you find out that you have really poor water, (greater than 300 ppm total solids), consider installing an RO (reverse osmosis) water filter. (Stella, n.d.)[8] Our robot will include this filter and keep water pure and filtered. The quality of your water can have a major impact upon the management of your system. Freedom from insoluble matter and pathogens is an obvious requirement for a hydroponic water supply. The type and quantity of dissolved solids in raw water are just as important as pathogens and insoluble matter. When considering dissolved solids there are two basic types, those which are nutrients and those which aren't. The nutrient ions, which are in the water, should be allowed for in your fertilizer formulations if their concentration is significant.

[5] https://en.wikipedia.org/wiki/Plant_nutrition

[6] https://www.forbes.com/sites/joannmuller/2015/07/09/forbes-agtech-summit-smarter-tractors-robots-make-farming-more-efficient/#1d6d04177c06

[7] http://www.farmingfutures.org.uk/blog/robots-and-autonomous-super-tractors-will-make-farming-more-efficient

[8] http://www.hydroponics-simplified.com/hydroponic-solution.html

There are several traps to avoid. The iron content in water supplies is much more of a problem than a benefit because it oxidizes quickly to rust and so is of no use as a nutrient. Much more of a problem, especially in Australia, is high levels of sodium chloride. While chloride is a micronutrient, and perhaps sodium also, their required levels are far lower than 1 ppm. Individual crops have different degrees of tolerance to sodium chloride. Sodium chloride becomes a major problem when either the sodium and/or the chloride are present at higher levels than the plants can take up, and hence build up in the system. A similar problem in some countries, but rarely in Australia, is water with too high a boron content. In practice, the major problems occur within closed systems where the build up can continue until reaching toxic levels. Reverse osmosis (RO) equipment uses semi-permeable membranes, which allow the passage of water but not dissolved solids. Hence, it totally removes all ions including the problem ones, giving a stream of virtually pure water. (Donnan, 2014)[9]. The hydroponics process is so dependent on proper nutrition. In hydroponics, you take soil away from the plant, so you must supply perfectly balanced and complete nutrition for it. just remember, plants do not need soil they need nutrients. Plants need large amounts of 6 macro-nutrients: Nitrogen (N), Phosphorus (P), and Potassium (K) The other 3 macros are calcium, sulfur, and magnesium. All 6 are provided in the proper ratio in all hydroponics solutions. Plants also need micro-nutrients (minute traces of other elements) in order to thrive, hydroponic fertilizer contains the major necessary elements as well as traces of iron, boron, manganese, zinc, molybdenum, copper, cobalt, chlorine, selenium and silicon.(Stella, n.d.)[10]. Without nitrogen, plants have no ability to produce leaves. It's responsible for a lot of the core functions of a plant's growth: leaf growth, leaf color, amino acid, proteins, nucleic acid, and chlorophyll synthesis You can tell your plants have enough nitrogen when their leaves have a vibrant green color and their growth rate isn't slow. Phosphorus is essential for the proper synthesis of a plant's DNA and RNA. It's also necessary for the proper development of many parts of your plants: Stems, Roots, Flowers, Seeds. The main role of potassium in a plant's life is to synthesize both proteins and carbohydrates. It also plays a role in the development of flowers, roots, and stems to a smaller degree. (Kevin, 2016)[11]. Hydroponics is better than normal gardening because hydroponics saves water, only a small percentage of the water is used by the plant. Hydroponics solves this problem by using what is called a recirculating nutrient reservoir this means that a plant's roots will only take up the amount of water they need at any one time and leave the rest in the reservoir for later this allows the same amount of water that was used to water a plant in soil for a day to water a plant in a hydroponics setup for days or weeks at a time. You can save around 90% of the water used in soil gardening simply by switching to a hydroponic setup. No weeding is necessary because no soil means no weeds and fewer pests and diseases. Eliminating soil also eliminates a lot of the different soil-borne diseases and pests that plague traditional gardening. (Kevin, 2017)[12]

Suggested Nutrient Solutions for Various Crops					
Crop	N	P	K	Ca	Mg
Concentration in mg/l (ppm)					
Tomato	190	40	310	150	45
Cucumber	200	40	280	140	40
Pepper	190	45	285	130	40
Strawberry	50	25	150	65	20
Melon	200	45	285	115	30
Rose	170	45	285	120	40

Table 1: shows the approximate nutrients intake by various types of plants.[13]

Implementation:

To conclude, our robot will have the correct equipment and nutrients to make sure a successful hydroponics process takes place. Issues concerning

[9] http://www.hydroponics.com.au/how-important-is-water-quality-in-hydroponics/

[10] http://www.hydroponics-simplified.com/hydroponic-fertilizer.html

[11] http://www.epicgardening.com/hydroponic-nutrients-guide/

[12] http://www.epicgardening.com/hydroponics-vs-soil/

[13] http://www.smart-fertilizer.com/articles/hydroponic-nutrient-solutions

different nutrients often appear through a unique pattern or change in the color of plants' leaves (usually yellow). Robots can use their cameras and color sensors to detect any change in a plant's color due to an imbalance in nutrient supply. Moreover, the robot will supply the correct plant with the correct amount of nutrients by concentrating or diluting the hydroponic solution subjected to the roots. Eventually, agriculture, as well as hydroponics, will be taken to the next level, a satisfying level of sustainability[14]. Hydroponics will be a mobile process because the nutrient solution must be kept cool, or it will "cook" the tender roots (Stella, n.d.)[15]. Thus the robot will host and make sure the plant grows more efficiently without wasting water and without dealing with the deficiencies of soil. Lots of companies rely on the annual crop harvest like Nestle: "We source millions of tons of agricultural raw materials, and millions of farmers depend on our business for their livelihoods. All our suppliers are required to meet our high standards"[16] and if any damage is to take place to the crops the yearly production will be compromised maybe even delayed and for that having a successful hydroponics process is essential to big companies and that can be done by our robot.

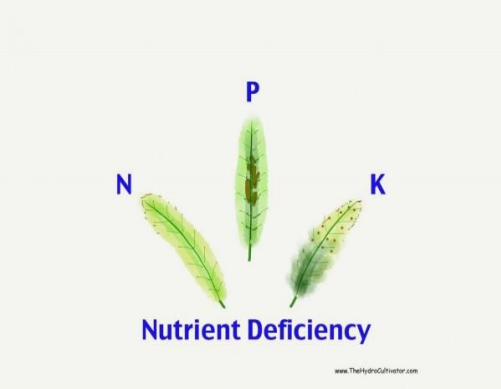

Figure 1: describes how the nutrient deficiencies appear on plants leaves.

A very important aspect that we considered is the mobility of our hydroponic robot. Mobility allows the attainment of more efficient and sustainable results in the hydroponic field by simply facilitating plantation in uncultivable areas, as well as it assists the process of transporting rare plants worldwide and reduces the risks involved with that sort of matter. If the robot's system was mobile, agriculture can take place in harsh habitats like the dessert and Antarctica. The thermal sensors will allow the robot to determine whether it is healthy for the plants to maintain their position, or if the robot should move to a cooler/warmer spot. On the other hand, if the plants were grown by an indoor controlled system in a harsh environment that whole system can melt out or even freeze due to uncontrolled climatical characteristics. That fact increases the risks people might take in case they tend to apply that concept. Transporting plants takes place almost every year, thus it plays a crucial role in research and the discovery of current diseases. Approximately 7,000 medical compounds prescribed by Western doctors are derived from plants. Only 1 percent of the known plant and animal species have been thoroughly examined for their medicinal potentials. Scientists estimate that, at the accelerating rate at which rainforests are now being destroyed, as much as 20 or 25 percent of the world's plant species will be extinct by the year 2000. ("Medicinal Treasures of the Rainforest," n.d.)[17] Nevertheless, the imperative process of extracting cures from wild plants will perpetuate as our hydroponic mobile robot will have the ability to preserve and transport the plants safely, almost free of risks. For that to happen, our robot, as mentioned, will contain various types of sensors, cameras, and advanced safety mechanisms in order to assist the robot as it accomplishes its task.

Transferring the concept of our hydroponic robot to the moon would likely seem impossible if the system was immobile; therefore, mobility can be considered necessary and basic to implement our idea. Taking hydroponics to the moon will definitely initiate cultivation on its surface, which will accordingly allow scientists and astronauts to maintain a certain level of stability as well as it will provide a better opportunity for research. Eventually, it would be possible for us to start a civilization where life was once impossible.

[14] http://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.2001413
https://www.quora.com/Robotics-How-do-color-sensors-work

[15] http://www.hydroponics-simplified.com/disadvantages-of-hydroponics.html

[16] http://www.nestle.com/csv/environmental-sustainability/product-life-cycle/raw-materials

[17] http://www.adventure-life.com/amazon/articles/medicinal-treasures-of-the-rainforest

Conclusion:

Hydroponics is an important process that allows you to plant without soil, our robot will be equipped with the right tools to purify and control the water and cure it of any deficiency. It will also make sure the correct amount and type of nutrients are being used to have the plant grow more efficiently. Last but certainly not least it'll be a moveable process and that’s better because if the heat rises and the nutrients start heating up the robot can move to a cooler place and it can also start a cooling system. It's also good for it to be a moveable system because one day we might be able to take this process to the moon and start planting there.