Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; SP4: 29-31

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(Special Issue- 4)
National Seminar
“Role of Biological Sciences in Organic Farming”
(March 20, 2019)

Emerging technologies in agriculture: A review

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Abstract
Technology is truly transforming every aspect of human lives, and farming is no exception. Agriculture technology will become ever more computerized in the decades ahead. The demand for innovative farm technology is high, and when inventors show results, modern farmers automatically show willingness to embrace those inventions and new techniques. Soil water sensors can detect moisture and nitrogen levels, and the farmer can use this information to determine when to water and fertilize rather than rely on a predetermined schedule. That results in more efficient use of resources and lowered costs, but it makes farm more environment friendly by conserving water, limiting erosion and reducing fertilizer levels in local rivers and lakes. Weather tracking technology can give farmers enough advanced notice of frost, hail and other weather that they can take precautions to protect the crops or at least mitigate losses to a significant degree. Satellite imagery, images in resolutions of 5-meter-pixels and even greater let a farmer examine crops closely. Even reviewing images on a weekly basis can save a farm a considerable amount of time and money. Vertical farming a component of urban agriculture is the practice of producing food in vertically stacked layers. This offers many advantages, most obvious is the ability to grow within urban environments and thus have fresher foods available faster and at lower costs. Hence, agriculture is entering into world of technology at greater pace.

Keywords: Emerging technologies, agriculture, Soil water sensors.

Introduction
With onset of modern era, agriculture has also emerged as a high-tech subject. Earlier farmers had to face harsh effects of sudden weather hazards, but now with the invention of weather tracking devices, the farmer life has seen amazing positive effects of such gadgets. Herein are discussed few emerging farm technologies in detail.

Soil moisture sensors
Soil moisture sensors are devised to measure the volumetric water content in soil. Soil moisture sensors measure the volumetric water content indirectly by using properties such as electrical resistance, dielectric constant, or interaction with neutrons, as a proxy for the moisture content. The relation between the measured property and soil moisture is calibrated and may vary depending on environmental factors such as soil type, temperature, or electric conductivity. Reflected microwave radiation is affected by the soil moisture and is used for remote sensing in hydrology and agriculture. Portable probe instruments are used by farmers or gardeners. Soil moisture sensors are sensors that estimate volumetric water content. Another type of sensors measure another property of moisture in soils called water potential; these sensors are usually referred to as soil water potential sensors and include tensiometers and gypsum blocks.

Soil water sensors have been used for irrigation and water management in agriculture for many years, but with limited success overall. Nonetheless, the use of soil water sensors is increasing as water scarcity increases and also problems associated with over irrigation increase. Common problems with soil water sensing include sensor failure, problems with wiring, or failure of data telemetry, inaccurate data, lack of timely data, high labour requirements and interference from dynamic soil temperature and bulk electrical conductivity changes. There are many sensors available, but mainly four main technologies: neutron thermalization, resistance blocks, capacitance sensing (frequency domain sensing), and travel time sensing (time domain reflectometry and time domain transmission modes).

Weather forecasting

Weather forecasting is the application of current technology to predict the state of the atmosphere for a future time at a given location. Weather forecasts are made by collecting enough data about the present state of the atmosphere, which includes temperature, humidity, wind, and the understanding of atmospheric processes to determine how the atmosphere will evolve in coming weeks. They receive data from number of sources – including local weather observations, weather balloons, weather stations, satellites, and now drones. Climate forecasts can be grouped into two broad categories—statistical and physical. Statistical techniques depend on historical climate data to establish relationships between different time periods.

Agriculture satellites are used around the world to help assess crop health, yield, and facilitate environmental analysis to ensure farmers have all the details they need to best manage their farms. Imaging systems like Normalized Difference Vegetation Index are effectively special visual sensors pointing down at the ground. The different colors in the image tell a different story about what is happening with a farmer's crops. Already, agriculture-ready drones are popping up for purchase, for the farmer who wants to use technology to gather information on his crops. A drone called the Honey Comb makes use of the same exact NDVI technology normally found on satellites.

Now, drones are flown into the atmosphere to uncover meteorological secrets critical to improving weather forecasts. These drones could sample the atmosphere in difficult to reach, remote locations where weather data is scarce. The data received could then be integrated into prediction models, improving their resolution and reliability. Research facilities at multiple agencies and universities have been testing methods for using drones in meteorological data collection for years, but operational drones for weather analysis have only started flying recently.

The Earth's atmosphere has layers like a cake. Forecasting the weather is more accurate if information comes from a lot of sources and from all of those layers. That is why we have weather satellites, high-flying drones and weather balloons, all operating at different altitudes. Scientists at Oklahoma State University are developing new drones that will help forecasters operate at all the different levels, which should increase the quality of computer models that are tracking local weather patterns. Atmospheric measurements provided by radar, weather balloons and towers are good for forecasting a few days ahead, but not so good at predicting dynamic, hour-to-hour weather changes. Drone flights can be extremely important in places prone to sudden, violent storms.

Vertical Farming

Vertical farming is the practice of producing food on vertically inclined surfaces. Instead of farming vegetables and other foods on a single level, such as in a field or a greenhouse, this method produces foods in vertically stacked layers commonly integrated into other structures like a skyscraper, shipping container or repurposed warehouse. Using Controlled Environment Agriculture (CEA) technology, this modern idea uses indoor farming techniques. The artificial control of temperature, light, humidity, and gases makes producing foods and medicine indoor possible.

In many ways, vertical farming is similar to greenhouses where metal reflectors and artificial lighting augment natural sunlight. The primary goal of vertical farming is maximizing crops output in a limited space.

Advantages of Vertical Farming

Having greater output from a small cultivation area is not the only advantage of vertical farming. Following are some of the major benefits of vertical farming:

Preparation for Future: By 2050, around 80 percent of world population is expected to live in urban areas, and the growing population will lead to an increasing demand for food. The efficient use of vertical farming may perhaps play a significant role in preparing for such a challenge.

Increased in Crop Production: Vertical farming allows us to produce more crops from the same square footage of growing area. In fact, 1 acre of an indoor area offers equivalent production to at least 4-6 acres of outdoor capacity. According to an independent estimate, a 30-story building with a basal area of 5 acres can potentially produce an equivalent of 2,400 acres of conventional horizontal farming. Additionally, year-round crop production is possible in a controlled indoor environment which is completely controlled by the vertical farming technologies.

Less Use of Water in Cultivation: Vertical farming allows us to produce crops with 70-95 percent less water than required for normal cultivation. Hence, it aims to conserve water.

Not Affected By Unfavorable Weather Conditions: Crops in a field can be adversely affected by natural calamities such as torrential rains, cyclones, flooding or severe droughts — events which are becoming increasingly common as a result of global warming. Indoor vertical farms are less likely to feel the brunt of the unfavorable weather, providing a greater certainty of harvest output throughout the year.

Increased Production of Organic Crops: As crops are produced in a well-controlled indoor environment without the use of chemical pesticides, vertical farming allows us to grow pesticide-free and organic crops.

Human and Environmentally Friendly: Indoor vertical farming can significantly decrease the occupational hazards associated with traditional farming. Farmers are not exposed to hazards related to heavy farming equipment, diseases and poisonous chemicals and so on. As it does not disturb animals and trees land areas, hence it is good for biodiversity as well.

Limitations of Vertical Farming

Vertical farming has both pros and cons. Sometimes the pros of vertical farming are highlighted and not the cons. Following are the major limitations of vertical farming:

No Established Economics: The financial feasibility of this new farming method remains uncertain. The cost of building skyscrapers for farming, combined with other costs such as lighting, heating, and labor, can easily outweigh the benefits we can get from the output of vertical farming. For a 60 hectare vertical farm, the building cost can be well over $100 million. And while vertical farms will be attractive to locate close to cities, the high price of real estate will impede the financial viability of urban locations. The financial situation is changing, however, as the industry matures and technologies improve. For example, New Jersey-based indoor-farming startup Bowery announced in December 2018 that it had raised $90 million in fresh funding. In 2017, Plenty, a West Coast vertical grower, announced a $200 million investment from Softbank.

Difficulties in Pollination: Vertical farming takes place in a controlled environment without the presence of insects. As such, the pollination process needs to be done manually, which will be labour intensive and costly.

Labour Costs: As high as energy costs are in vertical farming, labor costs can be even higher due to their concentration in urban centers where wages are higher, as well as the need for more skilled labor. Automation in vertical farms, however, may lead to the need for fewer workers. Manual pollination may become one of the more labor-intensive functions in vertical farms. Too Much Dependency on Technology: The development of better technologies can always increase efficiency and lessen costs. But the entire vertical farming is extremely dependent on various technologies for lighting, maintaining temperature, and humidity. Losing power for just a single day can prove very costly for a vertical farm. Many believe the technologies in use today are not ready for mass adoption.

Methodology

Soil moisture sensors

Soil moisture sensors measure the water content in soil. A soil moisture probe is made up of multiple soil moisture sensors. One common type of soil moisture sensors in commercial use is a Frequency domain sensor such as a capacitance sensor. Another sensor, the neutron moisture gauge, utilize the moderator properties of water for neutrons.

Soil moisture content may be determined via its effect on dielectric constant by measuring the capacitance between two electrodes implanted in the soil. Where soil moisture is predominantly in the form of free water (e.g., in sandy soils), the dielectric constant is directly proportional to the moisture content. The probe is normally given a frequency excitation to permit measurement of the dielectric constant. The readout from the probe is not linear with water content and is influenced by soil type and soil temperature. Therefore, careful calibration is required and long-term stability of the calibration is questionable.

Satellite Imagery

Satellites are like any other vehicle and they have two main parts: the generic vehicle itself and the specific thing it carries (the payload) to do its unique job. The "vehicle" part of a satellite is called the bus, and it includes the outer case, the solar panels and batteries that provide power, telemetry (a remote-controlled system that sends monitoring data from the satellite to Earth and operational commands back in the other direction), rocket thrusters to keep it in position, and reflective materials or other systems ("heat pipes") to protect it from solar radiation and dissipate heat. The payload might include transponders for a communications satellite, computers and atomic clocks to generate time signals for a navigation satellite, cameras and computers to images back to digital data for a photographic satellite, and so on.

How Vertical Farming Works

There are four critical areas in understanding how vertical farming works: 1. Physical layout, 2. Lighting, 3. Growing medium, and 4. Sustainability features. Firstly, the primary goal of vertical farming is producing more foods per square meter. To accomplish this goal, crops are cultivated in stacked layers in a tower life structure. Secondly, a perfect combination of natural and artificial lights is used to maintain the perfect light level in the room. Technologies such as rotating beds are used to improve the lighting efficiency. Thirdly, instead of soil, aeroponic, aquaponic or hydroponic growing mediums are used. Peat moss or coconut husks and similar non-soil mediums are very common in vertical farming. Finally, the vertical farming method uses various sustainability features to offset the energy cost of farming. In fact, vertical farming uses 95 percent less water.

Conclusion

Vertical farming technologies are still relatively new. Companies are yet to successfully produce crops at scale and make it economically feasible to meet the growing food. It is worth noting, however, that technologies developed for vertical farms are also being adopted by other segments of the $300 billion indoor farming sector, such as greenhouses, which can utilize natural sunlight, albeit requiring much more real estate and longer routes to market. Also, sensors sometimes do not work efficiently and also required skilled people to access the data. But on a whole, new technology is making farming a interesting occupation so that young farmhands can use the new skills to enhance crop yields. Hence, the future farming is aimed to help farmers in a positive way.

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