Application of Technology in The Cultivation of Medicinal Plants

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Abstract

Technology can be applied in the cultivation of medicinal plants to improve efficiency, productivity, and crop quality. Through the application of appropriate technology, it is expected that the medicinal plant cultivation sector can develop more rapidly and sustainably, and be able to meet the increasing needs of domestic and international markets. This paper aims to explore the knowledge of several technologies that can be used in the cultivation of medicinal plants, to obtain maximum and high quality results. The application of technology in the cultivation of medicinal plants has brought significant changes in terms of efficiency, productivity and quality of yield. By utilizing biotechnology, smart irrigation, vertical farming, IoT, drones, LED lighting technology, and precision fertilization systems, the medicinal plant industry can grow more rapidly and sustainably. The implementation of these technologies not only supports the sustainability of medicinal plant production, but also maintains a balance between human needs for natural medicines and environmental preservation.

***Keywords**:* Technology, Medicinal Plants, Cultivation

Introduction

Technology is a tangible manifestation of the application of science, tools, techniques, or systems to solve problems, improve efficiency, or facilitate various human activities. A broader definition of technology can be stated that technology includes all forms of tools and methods that are created and used to help meet their needs. The technology applied ranges from simple ones such as wheels to more complex systems such as computers and the internet.

Medicinal plants have long been recognized as a source of natural ingredients used in both traditional and modern medicine. Currently, public awareness of the importance of herbal medicine and the increasing demand for natural products, medicinal plant cultivation is one of the growing agricultural sectors. Data from the Ministry of Agriculture for 2021-2023 shows that the demand for local medicinal plants is increasing, one of which is Patchouli with an increase in selling value of more than 20%. In addition, there are priority medicinal plants, namely ginger and turmeric with export destinations of Bangladesh, Pakistan, Malaysia, Singapore and Argentina [1]. Medicinal plants such as ginger, turmeric, temulawak, and sambiloto not only have high economic value, but also an important role in maintaining public health naturally. However, despite the huge potential of medicinal plants, the cultivation process still faces various challenges, such as limited land, pest attacks, climate change, and reliance on traditional methods that are often less efficient.

In this modern era, technology has brought significant changes in various sectors, including agriculture. The application of technology in the cultivation of medicinal plants is a solution to

overcome various problems faced by farmers, while increasing the productivity and quality of medicinal plants. Technologies such as biotechnology, smart irrigation, vertical farming, Internet of Things (IoT), and drones have opened up new opportunities to maximize yields and maintain the sustainability of medicinal plant cultivation.

In addition, improving the quality of active ingredients in medicinal plants through proper cultivation techniques is increasingly becoming a focus in the pharmaceutical industry. Therefore, the integration of technology in the cultivation of medicinal plants is not only important to meet the growing market demand, but also to ensure that the products produced meet the quality standards required by the pharmaceutical and healthcare industries.

However, the application of technology in medicinal plant cultivation still faces various obstacles, especially among smallholder farmers who still use conventional methods. Constraints such as lack of access to modern technology, high initial investment costs, and lack of knowledge on how to implement these technologies pose a challenge. Therefore, proper education and assistance are needed so that farmers can adapt to new technologies and maximize the benefits they offer. As done by Amrul, one of the biofarming technologies can be used in medicinal plant cultivation practices [2].

It is important to further explore how various technologies can be applied in medicinal plant cultivation to improve efficiency, productivity and crop quality. Through the application of appropriate technology, it is expected that the medicinal plant cultivation sector can develop more rapidly and sustainably, and be able to meet the increasing needs of domestic and international markets. This paper aims to explore the knowledge of several technologies that can be used in the cultivation of medicinal plants, to obtain maximum yield and high quality.

Literature Review

Medicinal Plants

Medicinal plants are an important part of cultural heritage around the world, including Indonesia, which is rich in biodiversity. These plants have been used for thousands of years as raw materials for traditional medicine to cure various diseases. Some popular medicinal plants in Indonesia include ginger, turmeric, temulawak, and sambiloto, which are known to have various health benefits, ranging from anti-inflammatory, antimicrobial, to immune system booster. Various ethnicities in Indonesia use various types of plants as medicinal raw materials. For example, the Batak parmalim community uses approximately 77 types of plants as raw materials for traditional medicine[3]. Karo people use approximately 85 types of medicinal plants that are around their home gardens [4].

In modern medicine, medicinal plants are important raw materials in the manufacture of herbal and pharmaceutical drugs. The active compounds contained in them, such as flavonoids, alkaloids, and essential oils, have scientifically proven therapeutic potential. In addition, medicinal plants are also a desirable source of alternative medicine because they are considered more natural and have fewer side effects than synthetic drugs. Research in the Daya Bakumpai community illustrates that one plant has different benefits, such as kecapi because it contains flavonoid compounds and is capable as a medicine and also as beneficial in the environment[5].

In this modern era, technology has brought significant changes in the cultivation of medicinal plants. Techniques such as biotechnology, automated irrigation, as well as the use of hydroponics and vertical farming systems help improve the production and quality of medicinal plants. Thus, medicinal plants not only act as a natural health solution, but also as a promising economic resource in the future. The great benefits offered by medicinal plants require more attention, especially in the preservation and development of sustainable cultivation. With the

right approach, medicinal plants can continue to be a source of natural health for the community, as well as contribute to the global pharmaceutical industry.

Technology

Technology in a broad sense can refer to the skills and processes used to create and utilize tools and systems that facilitate or improve human life. It is also a form of applying scientific knowledge for practical purposes, especially in industry. It can involve the use of some equipment, machines, techniques and methods to solve a problem or achieve a specific goal. Technology covers a wide range of areas such as information, communication, manufacturing, transportation and continues to evolve with scientific advancement and innovation.

Agricultural technology has undergone rapid development in recent decades, transforming the way farmers manage land, increase crop yields, and support environmental sustainability. In the face of global challenges such as climate change, population growth, and land limitations, technological innovation in agriculture is key to meeting the world's food needs in an efficient and environmentally friendly way. Agricultural technology is very diverse from very simple metose as well as advanced technology. Agricultural technology is the application of engineering knowledge in agricultural production activities. It is incorporated in activities from upstream to downstream. From the cultivation process to the marketing of these agricultural products[6].

Problem Solving Analysis

Medicinal plants have become an important part of traditional and modern medicine. Along with the development of science, technology has been applied to improve quality, productivity and efficiency in the cultivation of medicinal plants. Modern technology not only speeds up the cultivation process, but also ensures that medicinal plants can be grown with high quality standards and sustainably. Here are some of the technologies that have been applied in medicinal plant cultivation:

1. **Biotechnology for Superior Variety Development**
   Biotechnology plays a major role in improving the quality of medicinal plants through plant breeding and genetic engineering. With techniques such as tissue culture, plants can be developed under sterile and disease-free conditions. In addition, genetic engineering allows the development of plant varieties that are more resistant to pests and diseases, and are able to produce higher bioactive compounds, such as alkaloids, flavonoids, and phenolic compounds used in the pharmaceutical industry. The development of biotechnology in the field of agriculture is carried out to assemble superior varieties such as rice and annual crops that are very helpful in providing food needs in Indonesia. The development of biotechnology gives different reactions, some are worrying but also have a beneficial impact on society [7].

2. **Smart Irrigation Technology**
   Efficient water management is essential in the cultivation of medicinal plants, especially in water-scarce areas. Smart irrigation technologies, such as drip irrigation controlled by soil moisture sensors, allow farmers to apply water precisely according to the needs of the plants. This not only saves water, but also prevents excess water that can cause root rot and deterioration of active ingredients in medicinal plants. Research conducted by Water use efficiency in agricultural land can be optimized through the use of proper irrigation techniques. Irrigation technology is one of the important components to increase the efficiency and production of agricultural products based on soil conditions, plant needs and microclimate. In certain periods during the dry season, open channel irrigation systems tend to be less efficient because plant roots only absorb 10 percent of the water given and the rest is wasted through percolation, evaporation and others. Drip irrigation has an efficiency value

of 80-95 percent compared to bulk and surface irrigation. Providing water in small and continuous volumes through drip irrigation aims to maintain soil moisture and avoid losses such as percolation and runoff so that water availability for plants is fulfilled [8].

3. **Vertical Farming and Hydroponics**
   In an effort to overcome land constraints, vertical farming and hydroponic technologies are gaining popularity. Vertical farming allows the cultivation of medicinal plants in a limited space by using a multilevel system. Hydroponics, on the other hand, allows plants to grow without soil, using a rich nutrient solution. This technology ensures an optimal growing environment, allowing medicinal plants to grow faster and healthier without the risk of soil contamination. Vertical farming, as an innovative agricultural approach, promises to address some of the challenges faced by traditional farming. At its core, vertical farming involves the cultivation of plants in layers stacked vertically or on an inclined surface, usually in a controlled environment such as a greenhouse or vertical tower [9]. The use of vertical and hydroponic systems is very appropriate in areas with little agricultural land or in urban areas[10].

4. **IoT-based Monitoring and Automation System**
   The Internet of Things (IoT) has introduced a new way of monitoring and controlling agricultural conditions. With IoT sensors, farmers can monitor parameters such as soil moisture, temperature, and pH in real-time. The data collected can be processed to make better decisions regarding fertilization, watering, and pest control. In addition, the automation system allows farmers to remotely control irrigation, lighting, and temperature, thereby increasing efficiency and productivity. Research using IoT to monitor the cultivation process is one of them in the vertical garden method [11].

5. **Use of Drones for Land Monitoring**
   Drones have begun to be used in agriculture to monitor land and crop conditions. In medicinal plant cultivation, drones equipped with spectral and thermal cameras can help farmers detect plant health problems early, such as pest or disease attacks. Thus, preventive measures can be taken immediately to protect medicinal plants from greater losses. The use of drones in agriculture has begun to be widely used, especially for large agricultural land. This makes it very easy for farmers to control especially changes in their environment such as temperature, humidity and others [12].

6. **Utilization of LED Technology for Lighting**
   LED technology is now being used as an artificial lighting source in the cultivation of medicinal plants, especially in environments that lack natural light. These energy-efficient LED lights are designed to provide an optimal light spectrum for plant growth, which can increase biomass production and the concentration of active compounds in the medicinal plants. This technology is particularly effective in indoor cultivation or in areas with low sunlight intensity. This lighting system is also used in the plant factory concept. The plant factory utilizes fluorescent or LED lights as the source of light energy for plant growth. In addition, all components of plant growth factors such as temperature, humidity, carbon dioxide levels, and plant nutrients are supported by artificial technology that can be adjusted to the growing requirements of plants. So that crop production can achieve maximum value both in terms of quality and quantity. The construction conditions of this plant factory are closed so there is very little possibility of external environmental influences on the environment inside the plant factory. This makes it possible to build this type of plant factory in places where certain commodities cannot be grown due to extreme conditions such as snowy environments or very dry environments [13].

7. Precision Fertilization System

Precision fertilization is an approach that uses data from soil and crop sensors to deliver the exact amount of fertilizer that the crop needs. This can reduce the overuse of fertilizers, which not only saves costs but also protects the environment from pollution due to excess chemical residues. With the application of this technology, the content of active ingredients in medicinal plants can be optimized without damaging the balance of the ecosystem.

Conclusion

The application of technology in the cultivation of medicinal plants has brought about significant changes in terms of efficiency, productivity, and yield quality. By utilizing biotechnology, smart irrigation, vertical farming, IoT, drones, LED lighting technology, and precision fertilization systems, the medicinal plant industry can develop more rapidly and sustainably. In the future, it is expected that more technological innovations will be implemented to optimize the potential of medicinal plants in providing high-quality raw materials for the health and pharmaceutical industries. The implementation of these technologies not only supports the sustainability of medicinal plant production, but also maintains a balance between human needs for natural medicines and environmental preservation.

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