IMPLEMENTING PLANT FACTORY INNOVATIONS TO CANNABIS CULTIVATION IN THAILAND

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Abstract: The Narcotic Drugs Act (No. 7) B.E. 2562 allows marijuana to be used for medical purposes and research studies. There must be a control of production process, drug contamination and quality screening of cannabis cultivation as prescribed. Authorized manufacturers are permitted to adopt Plant Factory technology or revolution covering plant growing system which can control climate, temperature, amount of carbon dioxide and nutrient solution. It helps getting high quality products with consistent output. The advantage of planting with the Plant Factory system will be receiving high quality products. The disadvantage will derive from high production cost. However, the planting system has 3 options for growers, namely 1) Plant Factory with Sunlight, 2) Plant Factory with Sunlight and Supplemental Light, and 3) Plant Factory with Fully Artificial Light. Each option will be suitable for planting in different areas and different planting costs. Quality will be also depending planting form.

Keywords: Plant Factory, innovation, cannabis

I. Introduction

Plant Factory is a factory that produces plants. It is a plant growing system that controls the cultivation environment such as light, temperature, humidity, carbon dioxide content, and elemental solution. It helps achieving high quality output and consistent yields. Plant Factory uses the Soilless Culture technique in growing plants. For example, hydroponics is to grow plants with roots immersed directly in the solution. The nutrient solution flows through the plant trough using a pump to suck the solution to flow through the trough to the roots of the plant and circulates back to the tank. The difference between the Plant Factory and a Hydroponics System is that the Plant Factory system can grow plants vertically in multiple tiers, possibly up to 10, which is the best use of space suitable for places with limited areas. The types of crops suitable for growing with the Plant Factory system are staple food crops such as rice, wheat, potatoes and sugar cane, healthy crops such as vegetables and herbs and flowers. Plant Factory is divided into 3 categories; 1) Plant Factory with Sunlight, 2) Plant Factory with Sunlight and Supplemental Light, and 3) Plant Factory with Fully Artificial Light. Regarding the 3 types of Plant Factory, the growers can choose to use according to their goals and capital. Now in the center, there are three types of crops, each with different purpose and markets. The results will be the same to produce consistent output, reduce labor costs, and change the plants to be planted continuously (Tawida Sirisamphan, 2021).

Thailand has adopted Plant Factory technology to grow cannabis in both closed and open systems as cannabis is a new economic crop that has been allowed to grow for medical use. It has caused many people and agencies to plant cannabis with many different methods and
Innovations. In addition, it has been found from academic evidence supporting both Thai traditional and modern medicine that cannabinoids (THC, CBD) in cannabis can relieve chronic pain and multiple sclerosis. Outdoor cultivation from seed results in plants with different genetic composition and the amount of active ingredient is uncertain due to uncontrollable growth environment. Cultivating cannabis in the soil results in the cannabis plant to have tendency for cross-pollination. This will reduce the quantity and quality of cannabinoids. It also increases the risk of contamination with pesticides, heavy metals, mold, bacteria and microorganisms in the fungi group that are dangerous to humans. Moreover, using soil for planting will cause different plants to absorb different amounts of fertilizer and minerals resulting in low yields and unstable yield quality. Therefore, the cannabis cultivation trend has started from many places in every corner of the world. For example, according to New Leaf Data Services, LLC. All right reserved, there is the tendency of cannabis markets collected following the cultivation pattern (during January-February 2021), it was found that planting indoor would have the most market value compared to Greenhouse and Outdoor planting. For example, as of January 1, 2021, the market value of indoor cannabis planting was $2,000, Greenhouse was $1,343, and Outdoor was $952. Meanwhile, the February data showed that on February 5, 2021, the Indoor planting value was $1,942, Greenhouse was $1,297, and Outdoor was $829. On February 12, 2021, the Indoor planting value was $1,971, Greenhouse was $1,306, and Outdoor was $800. The market value of planting in various systems affects the selection of cannabis exports in each country (Krungthep Turakij, 2021).

Cannabis cultivation in glasshouse with root spa watering system will make the cannabis plants get the same amount of absorbed fertilizer and minerals. Because of the ability direct absorption with the adjusted electrical conductivity (EC) and pH to be suitable level for continual plant growth at all time. This can eliminate pesticide residue and will rendering manufacturing process in pharmaceutical industry for future. The research team of Medical Cannabis Research and Experiment Center, Faculty of Agricultural Innovation, Rangsit University, has studied and developed the formula of cannabis hydroponic plant nutrient solution for each stage of growth. A total of 4 cannabis nutrient solution formulations were developed by the research team for all stages of the cannabis plant’s maturation phase; S1 for the 1st week to the 4th week which is the stem and foliar stage, S2 for the 5th week to the 6th week which is the flowering pre-stage, S3 for the 7th week to the 12th week which is the flowering stage, S4 for the 13th week to the 15th week which is the pre-harvest stage. Formulated with cannabis hydroponics plant nutrient solution combined with root spa watering cannabis cultivation system will result in medical cannabis, i.e. cannabis flowers are of consistent quality and quantity to be referred to the College of Pharmacy to produce good medicine (Rangsit University, 2021).

Therefore, bringing innovation in cannabis cultivation and production in Plant Factory whether Indoor, Outdoor, or Greenhouse systems promotes cannabis to be an alternative medicinal plant for medical benefits to farmers. Therefore, it is an appropriate approach and can be allocated according to the law. This research paper will present the model how to grow cannabis in the Plant Factory system for medical use. This will benefit the agencies that operate cannabis cultivation or farmers who grow cannabis and wants it to become a revenue-growing, commercial and legal commodity as well as having a market to support the purchase of agricultural products.
II. Cannabis production technology in the Plant Factory system

Plant production technology in the Plant Factory system is the plant growing system which almost all environment is controlled to be suitable for growth and crop yield over time by using devices such as artificial light sources, air conditioner, and the system to increase the amount of carbon dioxide. Thus, it has the high ability to produce quality crops in all locations and conditions. Plant factory will allow rare exchange to external environments. This system is used widely in Japan, Korea, Taiwan and the United States for commercial purposes initially in the past. The important limitation of this technology is leverage at initial cost and higher operating expenses than growing in the outdoor house and plots. However, at present, many of the devices used in the system become cheaper and their efficiency is much more increased than that can be used to produce many types of high value crops commercially (Siriwat Sakornwasee, 2020).

The Plant Factory concept or growing vegetables and fruits in the indoor system or in a greenhouse will help promoting agricultural value chains that have a wide impact on farmers, consumers, exporters, especially the cultivation of medicinal plants or high-value plants. The innovation is brought together with agricultural technology to solve problems and develop a higher quality agricultural system in terms of quantity and quality. By being able to control the production in the Indoor system where the water, air and humidity factors are controlled at the right amount with a sensor system makes them economical as natural resources and environmentally friendly. The crops are quantitatively certain in each cycle up to 95% and are free from chemicals that are harmful to consumer’s health. In addition, Smart Farm technology can be applied to reduce the size of the farmland, which can be distributed into the community in any area without restrictions. Even in the city, it can also be built to reduce transportation costs keeping the quality of produce to be fresh. The labor problems and product damage can be reduced. Furthermore, physical data is also stored for crops and consumer’s data in the form of Big Data to develop crops by using more accurate data storage.

There are a number of agencies in Thailand that grow plants and cannabis in the indoor system. In most cases, it was found that the yield was higher than the outdoor planting or the ground planting. The agencies that cultivate cannabis with the indoor system are as follows:

1. Faculty of Science and Technology, Rajamangala University of Technology Phra Nakhon in cooperation with Thai Canatech Innovation Co., Ltd. has studied cannabis cultivation for medical and commercial purposes under the “Research project to create production technology (planting) for medical grade cannabis” to develop Thai cannabis strains. It is a cannabis strain that has special features of providing high doses of active medicinal substances and for use in seed production. The important database is built for the country as a source for cannabis research studies with the public and private sectors in order to create the products to be used for medical and commercial purposes. The experiments were conducted in the indoor system, greenhouse system, and outdoor system. The results revealed that the Indoor system provided the most standardized cannabis and it was the planting system that the global market needs. It begins with the cultivation, extraction, distillation, harvesting and making of cannabis extracts. CBD is 99% pure and THC does not exceed 0.01 by weight. CBD in this condition will be the only CBD to be exempted from being narcotic and can be used in medicine, food, beverage, and cosmetics. This makes cannabis and cannabis extracts meet international standards. In addition, the research has found that cannabis cultivation in the indoor system can control the environment, temperature, light and humidity resulting in quality cannabis. Meanwhile, the risk of pest infestation can be alleviated. The productivity is high in both quantity and quality. The stability of the yield can be
controlled both in terms of substance and yield. Importantly, planting and harvesting can be planned all year round (Krungthep Turakij, 2021). Therefore, in order to promote cannabis cultivation, the indoor system should be employed and an expert understands the nature of cannabis is required. Growing cannabis for standardized medical and commercial use must be careful. After this, Rajamangala University of Technology Phra Nakhon will create a platform for education and transfer to the community and villagers to understand how each type of planting works and how the implementation of technology and innovation can help (Krungthep Turakij, 2021).

2. Phayao University and Apinya Medical Co., Ltd. integrated collaboration between private sectors and educational institutes in the development of research and development for the extraction of substances and pharmaceuticals from cannabis and hemp. For the medical benefit of Phayao University, the area was visited to inspect the construction of the house to plan for estimating the construction period and system management in accordance with building construction standards based on the agreement and operating guidelines following the Memorandum of Understanding in terms of assessing the quality of the house, environmental, space adjustment, utilities, water and electricity. The construction of cannabis and hemp cultivation houses for research and development of extracts for medical benefits received cooperation from Research Management Division by Vice President for Research and Innovation, Assoc. Prof. Dr. Samer Thanoi, in coordinating for researches. At the same time, the cooperation was also received from Assistant Rector, Dr. Chatchawan Wongchai and Director of the Premises Division in facilitating and supervising the construction of such houses. By studying and developing the growing and improving processes of cannabis and hemp varieties, the high amounts of important substances can be obtained to be extracted and analyzed developed into a product from cannabis and hemp extracts to get registered for further medical and commercial use (Phayao University, 2021).

3. Drug Research Center, College of Public Health Sciences, Chulalongkorn University, collaborated with Healthcare Group or THG to raise standards for development and production of cannabis extract for medical use. Research is ready to provide comprehensive support covering upstream, midstream, and downstream from the development of the breed, support of farmers to cultivate, establishment of extraction plant, testing lab, mixing and production technology, distribution as well as promoting educational institutes for continuous academic development. It covers from the development of good species, cultivation, to the extraction of important substances. The use of extracts for the production of standardized pharmaceuticals is an important step leading to cooperation in knowledge exchange and support of cultivation, research, extraction and analysis to obtain medical grade quality products that can be used for medical purposes and for commercial sale. It also encourages the development of more hemp and cannabis education. The first stage was successful in bio-cultivation to control factors affecting cannabis cultivation and development of cannabis strains that can be cultivated outdoors under the humid climate. This includes experimenting with different forms of cannabis cultivation both indoor cultivation and Greenhouse cultivation as well as the study to improve the species suitable for various types of cultivation and methods of storing various important extracts. It is to produce quality products aiming for Medical Grade for maximum medical benefit innovation and linking information/knowledge at both local and international levels on drug problems, including related effects and important health implications. The ‘Drug Research Center’ has expanded its operations to the Chula-Saraburi Land Development Project under the Cannabis Research Project: Social, Scientific and Legal Approaches according to the National
Security Strategy. The project was funded by the Office of the Narcotics Control Board (ONCB). It originated the cannabis research to develop species suitable for medical use, biological cultivation including the creation of system, methods, monitoring and control of cannabis.

4. Chaophya Abhaibhuberj Hospital grows cannabis in the indoor system. The advantages of this planting system are suitability for hybrid species and the plants are not very tall. They can be planted 3-4 times a year (16 Chemdawg species produce approximately 4,700 grams of oil). The using Aeroponics and Deep water culture (DWC) processed were used to control the planting conditions including wind, humidity, light, windproof, and insect proof. There were high yields per plant with good quality, tight, and safe. However, there are limitations that the cost was higher than planting in plots and greenhouse systems. At present, Chao Phraya Abhaibhubhejhr Hospital grows cannabis in 3 forms; indoor system, Green house system, and outdoor system. Each model has different advantages and disadvantages. Cannabis cultivation at Chao Phraya Abhaibhubhejhr Hospital uses 3 Plant Factory systems, namely (Satathan Suriyachai, 2021).

1. For planting cannabis in the indoor system, Chaophya Abhaibhubhejhr Hospital initially experimented in growing the cannabis in the containers. However, it was found that the containers were small and were difficultly managed. Then, the cannabis were changed to be planted in the bigger house with the improved function-controlled system. At present, the cultivation of the new indoor system has been developed to support various functions better. The advantage is that the cannabis can be planted 3-4 times a year (16 Chemdawg species produce approximately 4,700 grams of oil). The using Aeroponics and Deep water culture (DWC) processed were used to control the planting conditions including wind, humidity, light, windproof, and insect proof. There were high yields per plant with good quality, tight, and safe. However, there are limitations that the cost was higher than planting in plots and greenhouse systems.

2) For planting cannabis in the Green house, Chaophya Abhaibhubhejhr Hospital grows the cannabis in 2 Green houses. The emphasis is on planting for comparing the produce and substance of the cannabis between Hydroponics planting and organic agricultural systems. It was found that organic farming is a suitable approach that can share knowledge with farmers in the future. Chaophya Abhaibhubhejhr Hospital grows Charlotte’s Angel cannabis strain, characterized by its high CBD content of 15%, THC as low as 0.7%, suitable for general therapeutic purposes.

3) Chaophya Abhaibhubhejhr Hospital grows cannabis in an outdoor system by laying a foundation to prevent weeds and pathogens from the soil. Growing Thai cannabis species by bringing the branches obtained from the mother plant cuttings, Chaophya Abhaibhubhejhr Hospital planted cannabis varieties of Charlotte’s Angel to use the female flowers without males in the area because of the risk of infecting the seeds in the cherry blossom angel flowers in the female flowers resulting in the reduction of important substances in the inflorescence. The important substances are transferred from the inflorescence area to the seeds instead. Cannabis cultivation in Chaophya Abhaibhubhejhr Hospital’s Greenhouse system is being developed to be more suitable for growing cannabis by designing to solve the problem of heat in the factory with Evap system. The fans are installed to reduce heat and increase humidity for greenhouses during maturity. In the outdoor system, Chaophya Abhaibhubhejhr Hospital focuses on growing Thai cannabis species, such as Hawthorn cannabis species. They are planted with seeds, roots, leaves, stems used as materials in the production of Thai medicinal formulas. There are advantages of planting this system including low cost and good yields. Chaophya Abhaibhubhejhr Hospital grows Charlotte’s Angel cannabis strain characterized by its high CBD content of 15%, THC as low as 0.7%, suitable for general therapeutic purposes.
experimented with growing cannabis in containers and it was found that the containers were small and difficult to be managed. Therefore, it was switched to growing cannabis in a larger room which the control system can be placed to work better. At present, the cultivation of a new indoor system has been developed to support various functions better. From the study of the movement in applying Plant Factory technology to cannabis cultivation by agencies in Thailand, it was found that agencies that move and operate quickly are universities with the cooperation from private sector to carry out cultivation and marketing to plan the distribution of cannabis cultivation as a commercial crop. The planting is expanded to the community in order to create innovations in planting and expanding to become economic crops at the national level. From the results of cannabis cultivation by the aforementioned agencies, it was found that planting with the indoor system would give the most market value.

III. Implementing IoT technology in the planting part of Plant Factory

The IoT system is a system for measuring, displaying, and controlling the quantity and various environmental factors in the planting section of the Plant Factory in the cannabis cultivation. It is designed to be easy to use via an application on the smartphone. The system consists of (applied from the concept of Siriwat Sakornwasi, 2020):

1) IoT sensor system for measuring various planting factors in the planting cabinet consists of sensors measuring temperature and relative humidity, air, light sensor, volume sensor, Carbon Dioxide concentration and Electrical Conductivity (EC) sensor. The devices of all sensors transmit a signal to the Unit Control Center installed in the control room and connect to the gateway device by sending/sending data to the cloud computing system to display and store in the database.

2) Applications for display Real-time factors inside the cabinet receive the values from the cloud server and display the factors in the indoor system through the Dashboard. The application has a function for controlling factors get through the device like a smartphone and functions for work automatically. There is a messaging system to alert the operator via the Line application when there is a new setting or an error of the working data of the equipment inside the cabinet. The data measured from the vegetable growing cabinet can be brought out to plot the graph to see the past. All developed IoT systems will greatly facilitate and reduce the use. The workforce in the cannabis growing system is doing well. The cannabis yield from the indoor system is classified as a premium product that can be sold at a high price because it is a product free from chemical pesticides and can be eaten immediately without washing. The age after harvesting is also longer due to less microbial contamination than other current systems. This developed system can yield approximately 150 g of cannabis per plant which is relatively low. This is compared to normal planting in outdoor plots. The business model for selling fresh produce only thus may still be difficult to do. However, this system can be part of the business. It is used to create a distinctive feature that attracts people to places such as shopping centers, restaurants or coffee shops. The containers equipped with indoor prototype and IoT system were for fresh cannabis cultivation. This concept has been applied to a wide range of crops, for example, strawberry cultivation with the indoor system of the Faculty of Engineering and Agro-Industry, Maejo University, Chiang Mai Province. The strawberries in the size compared to ten baht coin obtained from the indoor system are used to make drinks or snacks such as smoothies, waffles or cakes for selling to visitors who will make profits for entrepreneurs. The research team is currently focusing on developing this system to produce more cannabis than before in order to support the sales business model of fresh fruits in the future. The prototype plant of Maejo University and IoT
system for cannabis cultivation are housed in a 25-square meter container, partly powered by solar cells, located at the Faculty of Engineering and Agro-Industry, Maejo University, Chiang Mai (Siriwat Sakornwasi, 2020).

IV. Conclusion

Medical use of cannabis is a cellular therapy. Cannabis has the potential to help cells work better. If cannabis becomes an innovation, it will be able to add value. The problem of the educational institute is to create cannabis innovations in the dimension of alternative medicine and modern medicine. It can be used in medicine, food, beverage, and cosmetics. Every process will receive great importance in order to make cannabis and cannabis extract meet international standards. The commercial cultivation should take into account the target audience to choose to use. Although the food and drink markets are the most popular uses of cannabis, to be sustainable, cannabis should be innovative to take the cannabis extract directly to the treatment of any disease such as chronic non-communicable diseases, Office Syndrome or will be used in the spa business. The clear target audience and problem solving are required. More importantly, cannabis must be standardized from planting, harvesting, extracting and creating products. In order not to lose the opportunities of cannabis, businessmen have to get serious about standards and the cannabis standard needs to be set on the national agenda (Rangsit University, 2021).

The implementation of Plant Factory concept for cannabis cultivation in Thailand and technology development for cannabis cultivation, it is necessary to provide farmers with the tools to facilitate and develop knowledge to increase both quantitative and qualitative yields. Therefore, looking for ways to help farmers, it should be considered by looking from the upstream (manufacturing sector) to the downstream (marketing sector, consumers, pharmaceutical industry, cosmeceutical industry, etc.) to create a new network of farmers that can eliminate the cause of poverty. The Thai produce that can be cultivated in the Plant Factory can be used for cannabis cultivation, especially planting in the indoor system and housing system. It will get the most value and value in sales. The Plant Factory technology is a new agricultural innovation that can control basic production factors such as water, air, temperature, humidity, carbon dioxide, fertilizer, lighting and wind by using the Internet of Things (IOT) system together with the control sensor system. These factors are balanced and efficient. Finally, the Plant Factory is a system that can grow crops anytime, anywhere. Apart from saving space and energy, it also saves water and planting factors and most importantly is to store information in a digital format. This will cause the data to be collected upstream (cultivation), midstream (transportation), and downstream (consumer) systematically leading to Big Data that is used for analyzing and summarizing the results of the cultivation of each type of plant as well.

V. Recommendations

Practical recommendations
1) The operation area are divided into 12 different zones as according to the Ministry of Health Department. Each of which provides a comprehensive integration of cannabis operation. In that area, there is at least one upstream, cannabis planting area, in the middle at least one cannabis processing facility in that area. For the downstream, there is at least one cannabis dispensary in each province to create a comprehensive integration of assistance in that area.
2) In the dispensing of cannabis, despite a lot of modern medicine, Thai traditional medicine, and folk healers have been trained, there is very little use of legal cannabis and there is a lot of illegal
cannabis use. Therefore, to be able to fix it, in a province that has 1 legal cannabis dispensing, there must be an integration or close cooperation of modern medicine, Thai traditional medicine, and folk healers. For example, they should stay in the same place or nearby areas where the patients can be referred or they can consult one another in a timely manner. Patients do not waste time having to travel to many places. In addition, the modern medicine, Thai traditional medicine, and folk healers should be trained and attend the training meeting altogether. The emphasis should be on training modern medicine, Thai traditional medicine, and folk healers with a positive attitude towards cannabis use to have knowledge to work altogether on cannabis seriously and sincerely.

3) There has to be an idea of cannabis and hemp operations legally. Various rules to control the cannabis and hemp operations have to try to find a solution or relief or amendment on the regulations to be in line with real and practical cannabis operations to maximize benefits to the general public. Cannabis cultivation practices at the sub-district level is the cannabis operation that is closest to the people. This expands the cannabis operations closest to households and it is the cannabis operation that has the most people involved. Therefore, in each of the 12 districts, even if it can be done on upstream, midstream, and downstream, if any sub-district is ready to undertake planting at the sub-district level (hospital), they should be able to provide an opportunity for action at the sub-district level in order to have the largest number of districts following the guidelines of cannabis cultivation projects at the sub-district level which are separately written into specific projects.

4) To make the operation of cannabis and hemp comprehensive and beneficial both medically and economically in each district, every province should be assigned to have at least one Health and Wellness Tourism system as an example of other tourist attractions to continue this matter. It will promote the country’s economy and promote tourism as well as promoting good health and good quality of life of the people.

5) To promote the economy in every household or every village, the hemp cultivation must be promoted in each district for the economy and for health. The hemp will be removed from the drug list. However, as hemp contains CBD which is used for medicine, health, beauty, food, etc., the hemp cultivation should be promoted to extract CBD for sale or sale of seeds or others for economic purposes. Therefore, each district that processes cannabis has to innovate to work on hemp as well. At the same time, those involved in the legislation, regulations, rules of hemp to facilitate people to grow hemp for economic purposes will be able to operate legally and have to issue regulations soon as well.

Policy recommendations
1) One place should be provided as planting site (upstream). It is possibly a university, a provincial hospital, a community hospital, or a government facility that has enough space for producing cannabis for use in the whole province.

2) One place should be provided for medicinal cannabis processing (midstream) either a university or a community hospital that has received WHOGMP for cannabis from the planting site to be processed and distribute to the whole district.

3) The places should be provided of cannabis dispensaries (downstream) to distribute cannabis whether modern, traditional, Thai, folk healers in the same place or close to one another (so that patients can travel conveniently and all 3 types of doctors can refer to consult one another). There should be at least 1 place to dispense medicine (if there are 7 provinces, there must be 7
4) At the sub-district level which is the closest link to villages and people’s houses, cannabis should be grown as an example of cultivation, processing and dispensing with the participation of local healers for villagers who are sick and need cannabis. At least one sample per province or one sub-district promoting hospital must be made using the form in line with the project attached hereto.

5) The hemp should be promoted for the economy. Every region should have hemp planted in every province, one place per province. The hemp may be planted in large plots or may be sub-planted in each family for 1-10 rai. There should be cannabis processing plant and market for buying hemp products at least one per district in order to create a comprehensive hemp economy in each district as well.

6) The economy and Health and Wellness Tourism in each province should be promoted. There should be an extensive cultivation of cannabis and hemp by the villagers, 1 place per province. The comprehensive health tourism attraction should be provided at least 1 source or 1 place per province which will have a full range of accommodation, massage, spas, herbs, examples of cannabis and hemp cultivation, CBD food, CBD cosmetics, etc.

References


