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(HANDBOOK)

MECHATRONIC FERTIGATION

By:

Muhammad Arif Farhan bin Mohd Zohri

Amirul Mukminin bin Nor Akbar

MRSM BALIK PULAU
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ABSTRACT

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Muhammad Arif Farhan bin Mohd Zohri, Amirul Mukminin bin Nor Akbar

MRSM Balik Pulau, Penang, Malaysia

The implementation of Movement Control Order (MCO) during the COVID-19 pandemic in 2020-2021 has affected the production process of agricultural produce due to labour shortage. Agricultural workers were unable to come to work to care for crops. At the same time, the MCO has also given opportunities for budding farmers who began to show interest in gardening and making profit. Starting from mid-2020, our school has established a small farm using fertigation farming to generate income. Fertigation, formed by two words - fertilization and irrigation; is a concept that relies on using the present irrigation line operating in existing field to inject plants with the desired fertilizers. From this idea, we have designed and proposed an automatic plant watering system, an innovative technology to make farmers work more efficiently and yield more profit. The irrigation technics currently applied in farms are **inefficient and causing excessive volume of water wastage**. Artificial intelligence system that is applied in agriculture; also known as precision farming, may **help farmers to efficiently control water usage thus produce a profitable crop**. Our project on automatic plant watering system named *Mechatronic Fertigation*, is a device system that **transmits data from soil-moisture sensor** to inform decisions about watering schedules besides supporting the efficiency of fertilizers in mass production of agriculture. If moisture in the soil is considered at the **optimum amount**, plants can wealthily absorb water. The data obtained from the Mechatronic Fertigation helps farmers to **increase their profit** by learning how to take care of their crops and **determining the ideal amount of water and fertilizer to use.** By allowing **humans to grow food** in urban areas, this technology may have the capacity to **reduce deforestation.**

CATEGORY: ENGINEERING

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First and foremost, all of praises are due to Allah the Almighty who gave us guidance, ability, and patience, complete our thesis. Here we would like to express our deep gratitude to the following people who made this research possible.

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1.0 INTRODUCTION

Agriculture is by far the thirstiest consumer of water globally, accounting for 70 per cent of water withdrawals worldwide. By 2050, world agriculture will need to produce 60% more food globally, and one hundred per cent more in developing countries. Considering demand of industrial and domestic water, the ways of efficient water use must be practiced in irrigated agriculture.

1.2 Problem Statement

Increasing agricultural productivity and sustainable food production are crucial to help alleviate the perils of hunger in number two sustainable development goal. Fertigation techniques improves the agricultural productivity; it allows precise irrigations and fertilization in a controlled system at the root system. Irrigation techniques nowadays are a time-based method which uses only a timer as a switch to turn on and off the water pump. This causes the water pump to pump an excessive amount of water and sometimes may exceed the needs of the plants for example during rainy and humid days. These irrigation technics applied in farm are **inefficient and waste excessive volume of water**. Excessive of water may also spread plant diseases through water contact with the foliage. Easily working fertigation system may benefit farmers to work efficiently and productively.

1.3 Objective

- reduce wastage of water during irrigation therefore helps in saving the precious water resource
- saving time, reducing energy cost and labour charges for commercial agricultural industry.
- To make the gardener works easily, the automatic plant watering system is created, innovative technology for efficient use of water and fertilizers in agriculture.
- Using artificial intelligence system to produce *Mechatronic Fertigation* device – a precision farming device for farmers to efficiently control water usage thus produce a profitable crop

2.0 LITERATURE REVIEW

2.1 What is Irrigation?

Irrigation is the process of applying water to the crops artificially to fulfil their water requirements. Nutrients may also be provided to the crops through irrigation. The various sources of water for irrigation are wells, ponds, lakes, canals, tube-wells and even dams. Irrigation offers moisture required for growth and development, germination and other related functions. The frequency, rate, amount and time of irrigation are different for different crops and also vary according to the types of soil and seasons. For example, summer crops require a higher amount of water as compared to winter crops. Let us have a look at different types of irrigation and the methods used for irrigation.

2.1.1 Types of Irrigation

There are different types of irrigation practised for improving crop yield. These types of irrigation systems are practised based on the different types of soils, climates, crops, and resources. The main types of irrigation followed by farmers include:

Surface Irrigation

In this system, no irrigation pump is involved. Here, water is distributed across the land by gravity.

Localized Irrigation

In this system, water is applied to each plant through a network of pipes under low pressure.

Sprinkler Irrigation

Water is distributed from a central location by overhead high-pressure sprinklers or from sprinklers from the moving platform.

Drip Irrigation

In this type, drops of water are delivered near the roots of the plants. This type of irrigation is rarely used as it requires more maintenance.

Centre Pivot Irrigation

In this, the water is distributed by a sprinkler system moving in a circular pattern.

Sub Irrigation

Water is distributed through a system of pumping stations gates, ditches and canals by raising the water table.

Manual Irrigation

This a labour intensive and time-consuming system of irrigation. Here, the water is distributed through watering cans by manual labour.

2.2. What is Traditional Irrigation Method

In this method, irrigation is done manually. Here, a farmer pulls out water from wells or canals by himself or using cattle and carries to farming fields. This method can vary in different regions. The main advantage of this method is that it is cheap. But its efficiency is poor because of the uneven distribution of water. Also, the chances of water loss are very high. Some examples of the traditional system are pulley system, lever system, chain pump. Among these, the pump system is the most common and used widely.

2.3 What is Modern Irrigation Method

The modern method compensates the disadvantages of traditional methods and thus helps in the proper way of water usage. The modern method involves two systems:

- Sprinkler system
- Drip system

2.4 What is Fertigation?

Fertigation is a concept that relies on using the present irrigation line operating in an exceedingly field to inject plants with the desired fertilizers. Fertigation has been developed after a process called chemigation that also relies on the prevailing irrigation line to supply nutritious chemicals to the produce.

Although chemigation and fertigation are used interchangeably from time to time, the very fact is that chemigation is solely associated with the employment of chemicals like fungicides, insecticides, and herbicides.

In fertigation, however, the sole additions made to the water within the irrigation line is that the addition of nutritious fertilizers. As fertigation relies on the liquid application of nutrients on to the roots of the plants, it is seen to be simpler than traditional agricultural practices.

2.5 Fertigation Agriculture in Malaysia

In Malaysia, fertigation of vegetables like chillies, cucumbers and tomatoes, still as high-valued fruits like rock melons are widely practiced. Crop yields of up to five times per unit area are achieved and this has contributed to its increasing public interest and appeal. MARDI plays a crucial role in generating innovative techniques that are tailored to suit requirements of local food crops, also as utilizing the benefits of fertigation system to expand into cultivating non-local food crops that might rather be difficult to grow through conventional methods.

One of these advantages is in addressing the requirements to avoid soil-borne diseases and nomadic cultivation in limited highland areas that still negatively affect production of high-value local ginger (Zingiber officinale Roscoe). MARDI developed a way to cultivate ginger rhizomes in lowland areas with a rise in yield from 0.9 kg to 5.4 kg per clump. Furthermore, research was also done to develop techniques to substitute locally available by-products like coconut husk (coco-peat)

and rice husk as growing media. These alternative media aren't only relatively cheaper, but also provide solutions for utilizing unused agricultural wastes.

2.6 Fertigation Agriculture in the World

The U.S. Department of Agriculture (USDA) will support additional fertilizer production for American farmers to handle rising costs, including the impact of Putin's price hike on farmers, and spur competition. USDA will make available $250 million through a brand new grant program this summer to support independent, innovative and sustainable American fertilizer production to produce American farmers. Additionally, to deal with growing competition concerns within the agricultural supply chain, USDA will launch a public inquiry seeking information regarding seeds and agricultural inputs, fertilizer, and retail markets.

Fertilizer prices have over doubled since last year because of many factors including Putin's price hike, a limited supply of the relevant minerals and high energy costs, high global demand and agricultural commodity prices, reliance on fertilizer imports, and lack of competition within the fertilizer industry.

2.7 Water Conservation and Fertigation Agriculture

Water is that the hidden ingredient in our agricultural system. quite anything, it's what determines what quantity food we will grow in any given region, and the way sustainably we are able to grow it. Since agriculture uses more water than the other industry (more than 90% of total water use in some U.S. states) conserving water in agriculture can have net positive effects throughout the environment and therefore the economy.

According to the USDA's Natural Resources Conservation Service, "Agricultural water is emerging as a critical natural resources issue. Irrigated agriculture is crucial in meeting our food and fibre production needs." And consistent with the U.N., "There is enough water available for our global future needs, but this world picture hides large areas of absolute water scarcity which affects billions of individuals."

By conserving water throughout the agricultural industry, growers can spend less money irrigating their crops, investors and lenders can feel more confident in their land deals, and organizations can mitigate the results of water scarcity on their supply chains. Ultimately, conserving water in agriculture is one among the foremost important tools available to confirm a secure and reliable food supply, and harden the worst effects of temperature change

2.8 Problem Faces by Farmers during Fertigation.

1. **Inefficient soil moisture management**

   Water is a vital component of farming and natural ecosystems. Inefficiently managing the moisture in soil can lead to poor crop yields and increased runoff. In cropland, poor yields could be attributed to an insufficiency of soil moisture instead of inadequate rainfall.

Soybeans in Navasota, Texas

2. Inefficient use of irrigation water

If irrigation water is not stored, delivered, scheduled, or applied effectively, then it may not be used as efficiently as possible. In addition, aquifer depletion or drought can lead to low levels of surface or groundwater.

The result of too much water in a soybean field in DeValls Bluff, Arkansas

3. Water depletion

Water depletion can occur in both surface water (ponds, lakes, pools from precipitation runoff, etc.) and groundwater. If water from either of these sources is used more quickly than it can be replenished, natural resources can be impacted, and land may not be unusable for its intended purposes.

Example of water depletion in a pond

4. Use of naturally available moisture

Soil moisture impacts plant growth, soil settling, susceptibility to compaction, ease of excavation, and installation of conservation practices. Soil moisture can be influenced by many factors including precipitation, temperature, wind, and

more. Naturally available moisture should be managed to help support land use goals and ecological processes.

A rain-swollen stream flows through a farm in La Crosse, Wisconsin.

5. Ponding and flooding

Excess water in soil can cause issues such as ponding, flooding, and other drainage issues. If left untreated, these issues can make it impossible to grow vegetation or crops and make buildings or structures more prone to flooding.

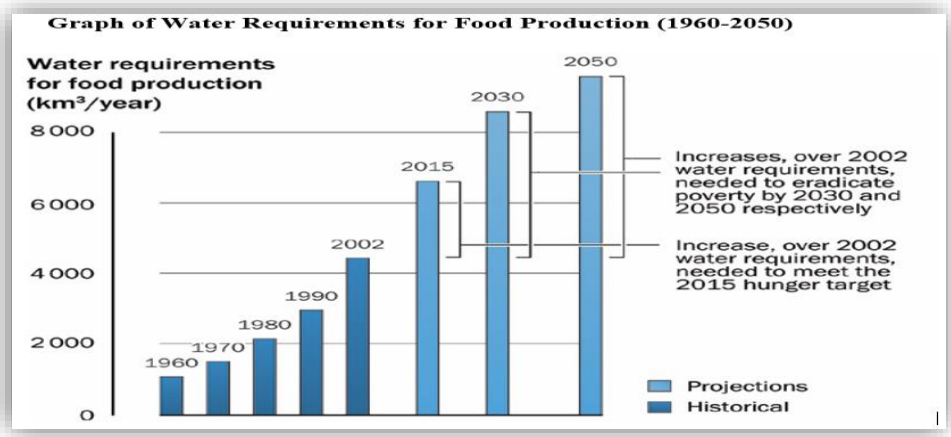
Flooding in North Dakota

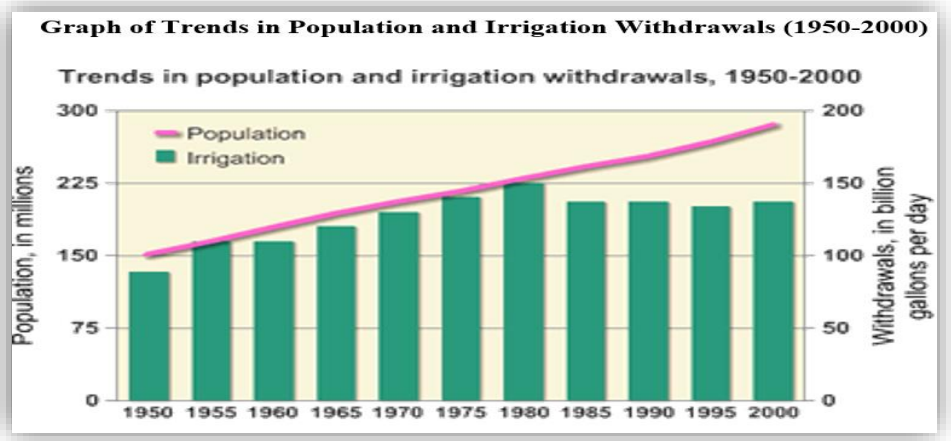
6. Water seeps

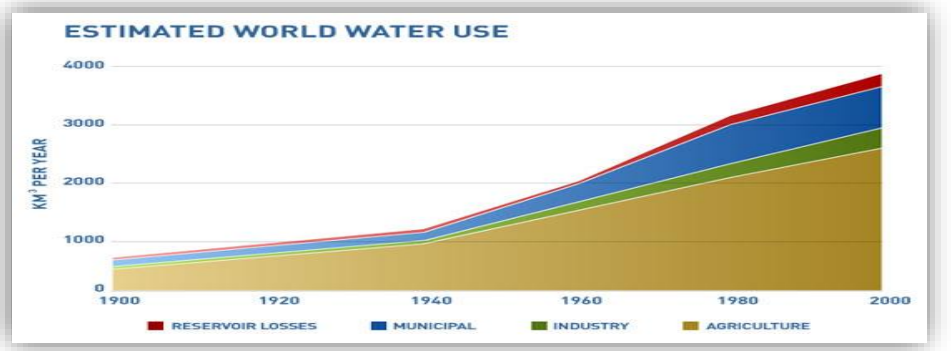
Seeps occur when subsurface water gradually reaches the earth's surface creating areas of moisture on land. Water seeps can restrict plant growth, degrade water resources, cause damage in or around buildings, among other problems.

Example of a water seep

Figures related







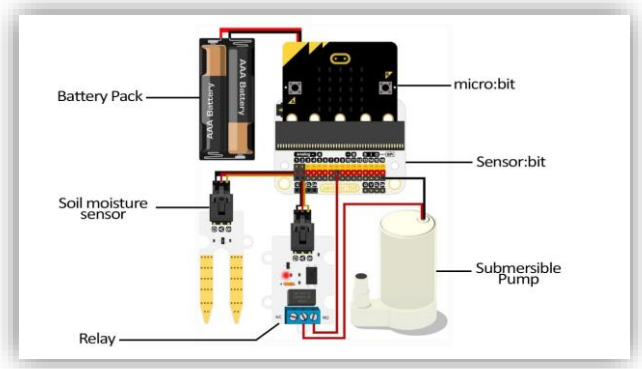
3.0 Future Agriculture- Mechatronic Fertigation

The irrigation technics applied in farm are inefficient and waste excessive volume of water. Artificial intelligence system applied to agriculture; also known as precision farming may help farmers to efficiently control water usage thus produce a profitable crop. Our project is about automatic plant watering system. Mechatronic Fertigation is a device system that transmit data from soil- moisture

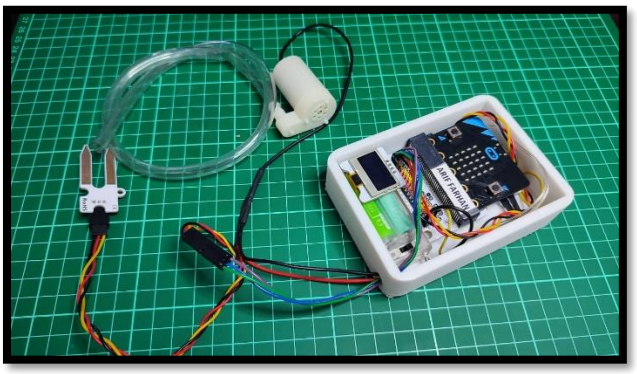
sensor to informed decisions about watering schedules besides support the efficiency of fertilizers in mass production of agriculture. If moisture in the soil is at the considered optimum amount, plants can wealthily absorb water. The data obtain from the Mechatronic Fertigation helps farmers to increase their yields by learning how to take care of their crops and determine the ideal amount of water and fertilizer to use. This technology may have the capacity to reduce deforestation by allowing humans to grow food in urban areas.

3.0 Water Filter Design (Development)

3.1 Mechatronic Fertigation Prototype



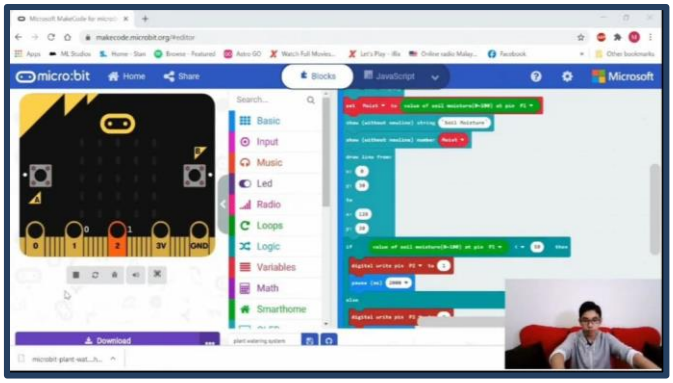
3.2 Water Filter Design (Final product)



4.0 METHODOLOGY

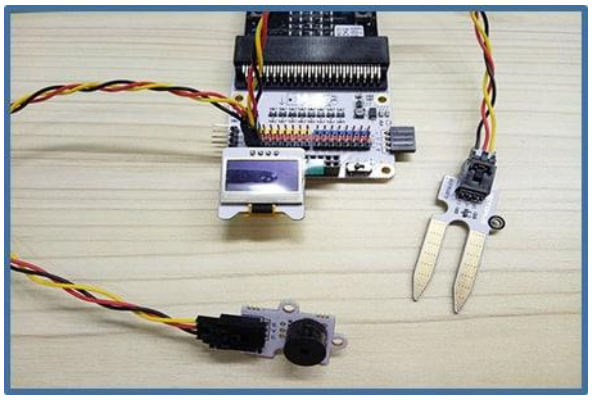
4.1 Programming The System

Program code for this system is based on Micro: Bit language. If dryness level is high, moisture level is low. At that time, the water pump is switched ON to supply water to the plant and is automatically OFF when the soil moisture reaches to the minimum threshold



4.2 Installation of The System

In this project, the submersible water pump as pumping unit is constructed by using a small DC motor. An integrated OLED screen is also used for real time display of data acquired from the sensor and the status of the various devices.



4.3 Testing and Evaluating

At this stage, all parameters being tested and evaluated to make sure all the devices were successfully linked to the system.

5.0 COSTING

5.1 Material Cost

No.	Material	Quantity	Cost per Unit (RM)	Total (RM)
1	Moisture Sensor	100	15	1500
2	Submersible Pump	100	3.9	390
3	Durable Silicone Tube	100	4.5	450
4	OLED Screen	100	25	2500
5	Relay	100	5	500
6	Micro:bit board	100	72	7200
7	Sensor:bit	100	39	3900
8	Male to female jumper wire	100	16	1600
9	AAA Battery 1.5V	100	2	200
10	Battery holder	100	3	300
Total				18540

5.2 Wages Cost

No. Workers	Worktime (hours)	Hourly Wage Rate (RM)	No. Day	Wages Cost (RM)
1	2	5	10	100

Wages Cost = No. Workers x Worktime x Hourly Wage Rate x No. Day

5.3 Overhead Cost

Aspect	Cost per Day (RM)	No. days	Total (RM)
Electric Bill	2	10	20
Water Bill	0	0	0
Total			20

Total (RM) = Cost per Day x No. days

5.4 Total Cost

Material Cost (RM)	Wage Cost (RM)	Overhead Cost (RM)	Total Cost(RM)
18540	100	20	18660

Quantity	Total Cost(RM)	Production Cost per Unit (RM)
100	18660	186.60

Total Cost (RM) = Material Cost (RM) + Wage Cost (100) + Overhead Cost (RM)
Production Cost per Unit (RM) = Total Cost (RM) / Quantity

5.5 Sales Cost

Production Cost per Unit (RM)	Profit Percentage (%)	Profit (RM)	Sales Cost (RM)
186.6	10%	18.66	205.26

Sales Cost (RM) = Production Cost per Unit (RM) + Profit (RM)

5.6 Comparison Saving Plan Data

AUTO FERTIGATION SYSTEM (10000 SQMETER PLANTATION)

ype of xpences	NO	ITEMS	QTY	UOM	UNIT PRICE	TOTAL
	1	Automation system	1	UNIT	200.00	200.00
	2	Water Pump	1	UNIT	400.00	400.00
investment	3	Water/fertilizer container	2	UNIT	150.00	300.00
	4	20mm polypipe	200	meter	1.50	300.00
	5	4mm micro polytube	1	roll	78.00	78.00
	6	Joiner	100	unit	0.10	10.00
					TOTAL	1,278.00
nonthly xpences	1	workers	1	HC	1,200.00	1,200.00

TOTAL EXPENCES (MYR) 2,488.00
SAVING PER MONTH FOR WORKERS (MYR) 2,400.00
RETURN OF INVESTMENT (MONTH) 0.53

TRADITIONAL SYSTEM FOR (10000 SQMETER PLANTATION)

type of expences	NO	ITEMS	QTY	UOM	UNIT PRICE	TOTAL
investment						
month expences	1	workers	3	HC	1200	3,600.00

TOTAL EXPENCES (MYR) 3,600.00

6.0 RESULTS

This proposed system mainly focused on automation of the drip irrigation and fertigation process using Micro Bit. Fertigation is an agricultural technique and application together with water and fertilizer to soil and/or plants. By releasing the exact amount of fertilizer and water to the crop in all phases balances the plant nutrient and reduces the soil erosion. The proposed system greatly preserve water than traditional irrigation methods ensuring optimal growth in low cost, high reliability, and accuracy.

It increases both yield and fertilizer use efficiency; therefore, leaching of nutrients is prevented.
The implementation automatic fertigation system can be able to save irrigation water from 30% up to 50% in case it is properly designed, installed, and operated compared to traditional irrigation, and it can also enable increasing crop yields and crop quality.

7.0 DISCUSSION & CONCLUSION

7.1 Advantages of Mechatronics Fertigation

In addition, by implementing the system can eliminate many diseases that are spread through water contact with the foliage. The best benefit is that it reduces the wastage of water during irrigation and helps in saving the precious water resource. Another are saving time, reducing energy cost and labour charges for commercial agricultural industry.

8.0 Applications and Future Values

By introducing Mechatronic Fertigation system to the students, we can encourage them to learn subjects such as computer science, biology, chemistry, accounting, engineering, and maths as it is the core subject in conducting the system of this technology. This is because agriculture or farming needs skills and hands-on more than learning it on books for the students to experience. Furthermore, this will lead to nurturing future entrepreneur among the new generations on the industry 4.0.

Users can configure these systems to manage irrigation on demand, for example, when a particular land area is too dry and starting an irrigation routine or to stop irrigation when a particular saturation point is met because a soil moisture level has been reached. This system can also be customized by users by adding more sensors and Internet of Things (IoT) features which can be controlled and monitored by smart phone. With a simple programming skill, now everyone can farm from their homes, garden or office.

As the automatic plant watering system has a user-friendly design so it can be used by the household users as well as the commercial user. Our Goal to increase involvement of the community, housewife to generate extra income by doing farming to increase the

household income at the same time enjoying the precious time with family. Target 1 family to have one farming product and gain extra income with automation farming by 2025.

Our concept to promote the idea at school so that the concept can be adopted at home and spread the good new concept to the next society of the students and community. This will develop and believe the farming for food can be the road for millionaire and reduce the dependency for import for food. We can produce locally and feed local. Farmers around the globe are adopting various agriculture irrigation techniques to be safe against weather uncertainties. Through auto watering system, farmers can also extend growing seasons. Water management solutions offer a significant economic advantage for farmers. With technological advances, new agricultural auto irrigation and fertigation technique has been proposed to boost productivity and maintain a competitive edge. This system will transform many regions from food importers to major food exporters. This system also plays a huge role to our social, in boosting food security to feed millions of people.

8.1 The Implementation of Mechatronics Fertigation in our school IBWS MRSM Balik Pulau

In middle 2020, our school has established a small farm to gain more income from the crops. In response to the COVID-19 pandemic, the federal government of Malaysia implemented Movement Control Order (MCO). Due to this, our gardeners are not able to come to work, as usual, to take care of the crops.

In conjunction with this, we designed and proposed an automatic plant watering system, a new technology to make the gardener works easier. It was successfully established and tested. The technology can eliminate many diseases that are spread through water contact with the foliage besides reducing the wastage of water usage and helps in saving precious water resources. Plus, it can also save time, reducing energy costs and labour charges for the commercial agricultural industry.

9.0 ATTACHMENT

Chilli, Cucumber, Eggplant Plantation in MRSM Balik Pulau, Penang, Malaysia

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