PC-BASED PID NUTRIENT MIXING PROCESS FOR FERTIGATION SYSTEM

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Dengan nama Allah yang Maha Pemurah lagi Maha Pengasih.
To my beloved, supportive wife Ainun Munirah Kamaruddin,
and my daughter Nurhana Safiyya

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ABSTRAK

Fertigasi merupakan satu teknik bagi membekalkan tanaman dengan baja melalui kaedah pengairan. Ia merupakan teknik pertanian yang moden bagi memaksimumkan hasil dan mengurangkan pencemaran alam sekitar melalui pengawalan penggunaan baja yang cekap seterusnya meningkatkan pulangan ke atas baja yang dilaburkan. Dengan menggunakan teknik fertigasi, masa, jumlah dan kepekatan baja yang digunakan dapat dikawal. Keperluan nutrien tanaman sangat bergantung kepada peringkat biologi pertumbuhan. Ia berbeza dari peringkat pembenihan sehingga menuai. Matlamat projek ini adalah untuk mereka bentuk, memberikan keboleharapan dan mengekalkan proses pencampuran baja fertigasi set A dan set B pada nilai yang diperlukan dengan menggunakan pengawal, PID. Pam kadar aliran yang tepat digunakan untuk menyuntik kedua-dua baja set A dan set B pada kekonduksian elektrik (KE) tertentu, diikuti dengan kadar pengambilan nutrien tumbuhan berdasarkan sistem pengairan berjadual. Kerintangan elektrik campuran baja dijadikan sebagai proksi kepada kebolehubahan nutrien. Keberkesanan sistem diuji melalui eksperimen. Oleh itu prototaip sistem fertigasi berasaskan komputer dibina bagi mengumpul dan menganalisis data pengukuran, (KE). Maklumat sebenar digunakan sebagai bandingan untuk mengesahkan kejituan sistem kawalan PID. Kajian menunjukkan proses pencampuran baja set A, set B dan air menggunakan pengawal PID dapat meningkatkan kecekapan pencampuran baja merujuk kepada nilai yang dikehendaki.

ABSTRACT

The practice of supplying crops in the field with fertilizers via the irrigation water is called fertigation. It is a modern agro-technique which provides an excellent opportunity to maximize yield and minimize environmental pollution by increasing fertilizer use efficiency, minimizing fertilizer application and increasing return on the fertilizer invested. In fertigation, timing, amounts and concentration of fertilizers applied are easily controlled. The nutrient requirement of crops is very much dependent on the biological stage of growth, varying from seeding to harvest. The goal of this project is to design, provide reliable and maintain a mixing process of fertilizer set A and set B at set point using PID controller. The precise proportional flow rate pump is used to inject both fertilizers set A and set B at predecided electrical conductivity (EC) value followed by plant nutrient uptake rate on a time-base irrigation system. Electrical resistivity of the mixing fertilizer liquid is to be considered as a proxy for the variability of nutrient properties. Validation of a model is determined by experiment. Therefore a prototype of fertigation system based on PC-based is built to collect and analyse the measurement data of EC. The result shows that the mixing process of fertilizers set A, set B and water using PID controller has been able to increase the efficiency of mixing fertilizer level according to the set point.

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LIST OF SYMBOLS

V	-	Voltage
I	-	Current
R	-	Resistance of the solution
κ	-	Conductivity in S/cm
G	-	Electrical conductance
K	-	Cell constant in cm^{-1}
C	-	Salt Concentration in water
A	-	Factor composition of the particular concentrated solution
f	-	Injection rate of the stock solution dispensers in *1/s*.
V_n	-	Volume of nutrient solution for total number of plant
Q	-	Pump Flow Rate
n	-	Total number of plant in irrigation pipeline
Vi	-	Total volume of nutrient solution injected to each plant
T_{pump}	-	ON period of pump in seconds
P_{out}	-	Proportional term of output
K_p	-	Proportional gain
K_i	-	Integral gain
K_d	-	Derivative gain
P_{cr}	-	Period of oscillations
T_i	-	Integral Time of PID controller
T_d	-	Derivative Time of PID controller
K_{cr}	-	Critical value of PID sustained oscillations

LIST OF ABBREVIATIONS

A/D	-	Analog to Digital Converter
CV	-	Control Variable
DAS	-	Data Acquisition System
DIT	-	Drip Irrigation technique
DFT	-	Deep Flow Technique
D/A	-	Digital to Analog Converter
D.C	-	Direct Current
EC	-	Electrical Conductivity
EC_w	-	Current Electrical Conductivity
EC_d	-	Desired Electrical Conductivity
EFT	-	Ebb and Flow Technique
GFT	-	Gravel Flow Technique
GUI	-	Graphical User Interface
MV	-	Manipulated Variable
NFT	-	Nutrient Film Technique
pH	-	Power of Hydrogen
P	-	Proportional Controller
PI	-	Proportional + Integral Controller
PV	-	Process Value
PID	-	Proportional + Integral + Derivative Controller
PWM	-	Pulse Width Modulation
RMT	-	Root Mist Technique
SP	-	Set Point
SAT	-	Static Aerated Technique.
USB	-	Universal Serial Bus
ZN	-	Zigler Nichols

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CHAPTER 1

INTRODUCTION

This chapter discusses on the definition of the fertigation system, the purpose and the importantce of the project. The objectives of project, scope of project and thesis outline will also be presented in this chapter.

1.6 Overview of the Fertigation System

There are many techniques in vegetable cultivation. Figure 1.1 shows the three major techniques used in Malaysia which are conventional, organic farming and hydroponic. Hydroponic techniques grow from day to day replacing existing methods.

Hydroponic is the process of growing plants in media such as coco peat, rock wool, gravel, or liquid, with added nutrients but without soil. There are many methods as shown in Figure 1.1. One of the famous techniques is fertigation which is the technique of supplying fertilizer to crops through an irrigation system by injection. In fertigation technique, it has two sets of fertilizer. Both of fertilizers must be mixed and stirred with the ratio 1:1 respectively into water. The illustration of this system is shown in Figure 1.2. The nutrient of the solution will be measured by the EC measurement device to make sure the level of nutrient is not more than the crop requirement.

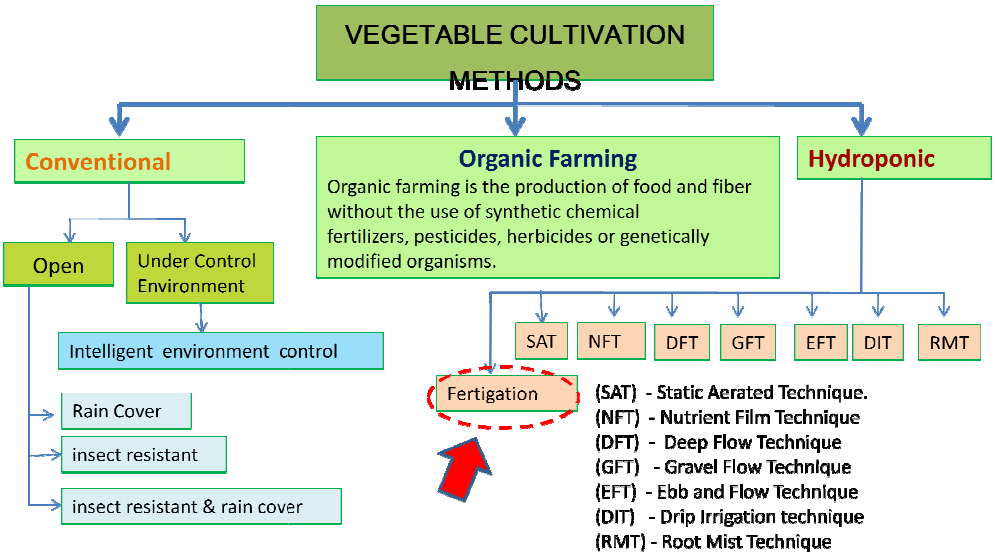

Figure 1.1: Type of vegetable cultivation method

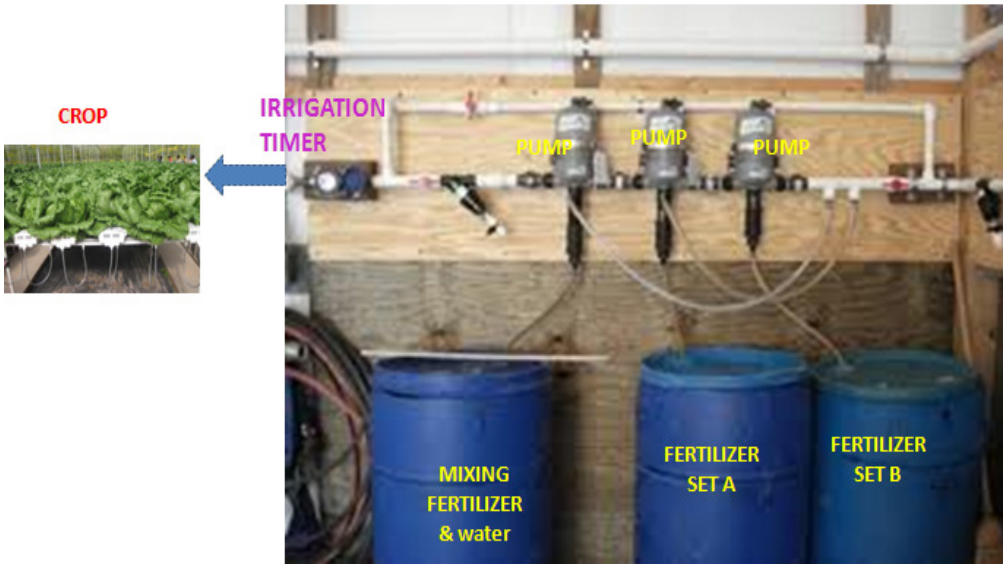

Figure 1.2: Traditional automatic fertigation system

The advantages of supplying mineral nutrients to crop roots using fertigation include:

i. Reduced delivery costs (no need to broadcast fertilizers, leading to less soil compaction in the inter-row areas, less fuel usage and lower labor requirements).
ii. Greater control over where and when nutrients are delivered, leading to the greater fertilizer use efficiency.
iii. More control over crop behavior through targeted application of specific nutrients during particular stages of crop development.
iv. Potential to reduce fertilizer losses (due to immobilization within or leaching below the root zone) by supplying small amounts constantly.

Disadvantages of supplying mineral nutrients to crop roots using fertigation include:

i. Greater capital costs associated with the equipment needed to dissolve and inject the fertilizer into the irrigation water.
ii. Higher operating costs associated with using technical grade fertilizers as opposed to agricultural grade fertilizers.
iii. Chemical reactions between some types of fertilizers when mixed, potentially causing significant equipment blockages.

1.7 Objectives of the Project

The aims of this project are to design, provide reliable and maintain a mixing process of fertilizers set A and set B at set point using PID controller. Specifically the objectives of this project are:

i. To study on the process of mixing fertilizers set A and set B in the fertigation system
ii. To establish the relationship between electrical conductivity, salinity of mixture of fertilizer set A and set B and design an EC sensor using carbon probe.
iii. To design and develop a low cost PID controller for the mixing process of fertilizer set A and set B to determine certain level of EC.

1.8 Scope of the Project

This project is divided into two parts, which are:

Part 1: Hardware development

Firstly, literature studies on the concept of automatic fertigation techniques are revised. Microcontroller Arduino Mega 2560 is used to interface with the actuator and sensor. The simple and low cost Electrical Conductivity sensor (EC) will be proposed to measure the EC in the solution tank. The correlation between actual value of EC vs salinity is determined experimentally using conductivity probe. The data are used as a calibration of the EC sensor.

Part 2: Software Development

This project focused on PID controller design using Ardino-LabVIEW. Microcontroller type Arduino Mega 2560 is used to interface with the actuator and

sensor. A model of fertigation system based on a PC-based will be built to evaluate the performance of PID controller.

1.9 Project Planning

This project was implemented based on the project planning schedule. The project started from Sept 2013 and ended in May 2014. The project planning schedule is presented in Appendix A.

1.10 Thesis Outline

Chapter 1 presents the overview of the automatic fertigation system, the objectives of the project, project schedule and thesis outline.

Chapter 2 covers the literature review on the fertigation technique, the principles of fertigation hardware and software and PID controller system.

Chapter 3 describes in details the development of PC-based PID nutrient mixing process on fertigation system methodology, and also hardware and software development.

Chapter 4 presents the results of the experiments and measurements. All the results will be discussed in details.

Chapter 5 discusses the overall conclusions and suggestions for future work.

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