NUTRIENT SOLUTION MANAGEMENT FOR GREENHOUSE TOMATOES: A MULTIPLE-CASE STUDY

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Name of Candidate: Minhua Xu ID Number: 03212688

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Thesis Title: Greenhouse Tomato Systems Nutrient Waste Management

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Abstract

Nutrient solution released from hydroponic greenhouse operations has been considered as a potential pollution source by New Zealand regional authorities. *The Management of Nutrient Solutions Released from Greenhouses: A Code of Practice* (COP) is designed to assist New Zealand greenhouse growers in managing nutrient solution release in hydroponic systems to comply with The Resource Management Act 1991 (RMA) and regional resource plans prepared by regional authorities to ensure that their constituents act appropriately.

A multiple-case study was designed to investigate the nutrient solution management and disposal practices of New Zealand hydroponic greenhouse tomato growers and, further, to investigate whether or not these practices meet the guidelines set out in *The Management of Nutrient Solutions Released from Greenhouses: A Code of Practice.*

Three hydroponic greenhouse properties that represent the current New Zealand greenhouse tomato industry were selected as case studies. How the greenhouse growers manage nutrient solution in these greenhouses was investigated by interviewing the growers. The results show that none of the case study growers fully met the guidelines given in the COP. However, recirculating growers manage nutrient solution better than do the run-to-waste grower in terms of reducing nutrient solution discharge frequency. They release less volume of nitrogen into the environment per 1000 kg of tomato produced in their recirculating growing systems. The research results indicate that high-technology recirculating grower could better satisfy the requirements set out in the COP. Low-technology run-to-waste growers are unlikely to meet those requirements due to their system design. Therefore, adopting a recirculating growing system is considered as a trend of the industries in the future.

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1. Introduction

1.1 Background

Greenhouse systems can efficiently produce high-quality products for consumers. As a result, in the last decade, worldwide commercial greenhouse production has expanded rapidly (RIRDC, 2001). These systems are found predominantly in affluent countries that have discerning consumers or countries that have access to such markets (RIRDC, 2001). New Zealand is one of these countries. Major crops in greenhouses include tomatoes, cut flowers, strawberries, capsicums, cucumbers, and lettuces (MAF, 2002).

Tomatoes are a significant greenhouse crop in New Zealand. In 2004, tomatoes were ranked number one in terms of household spending in *Statistics New Zealand's Ranking of Household Expenditure* for the top 30 fresh vegetables (Vegfed, 2005). Consumers spend $118 million on tomatoes annually. This was more than double the 1996 figure ($55.5 million) (Vegfed, 2005). Similarly, New Zealand's export of greenhouse tomatoes has also increased. In 2002, the value of export greenhouse tomatoes was $1.4 million. By 2003, it had increased more than three times to $4.9 million and by 2005 to $7.5 million (Ivicevich, 2005). In 2005, 40,000 tonnes of greenhouse tomatoes were supplied to the domestic market (worth $97.5 million) and 2,000 tonnes were exported (HortNZ, 2006). Most of the fresh market tomatoes in New Zealand are produced in greenhouses (HortNZ, 2006). In 2005, 375 commercial growers produced tomatoes from 120 hectares of greenhouses (HortNZ, 2006). The majority of these are located in the North Island, and one-third in the Auckland region (HortNZ, 2006).

In the last decade in this scene of expanding consumption and export, New Zealand greenhouse growers' production technology has significantly improved. This has been represented by improvements in growing systems and hence in increased yield. Traditionally, greenhouse properties in New Zealand have been small (0.5-1.0 hectare) family-run greenhouses. Some growers produced tomatoes in soil (Vegfed, 2004). In the

1990s the average greenhouse tomato annual yield in the whole country was 28 kg/m^2 (Singgih, 1999). But now the situation has changed-the majority of New Zealand fresh market tomato growers produce their crops in hydroponic or semi-hydroponic systems; only a few of them still grow in soil (Vegfed, 2004). The average greenhouse size has increased. The largest growers now have up to 20 hectares in production under glass (Vegfed, 2004). As greenhouse growers have adopted more sophisticated technology and moved to more intensive systems, the tomato yield has also significantly increased. By 2005 the average greenhouse tomato annual yield was 45-50 kg/m^2 (HortNZ, 2006). However, although the greenhouse property sizes are increasing, the total number of greenhouse tomato growers has declined from 560 in 2002 to 375 in 2005 (HortNZ, 2006). The main reason is that growers with low-technology small-scale greenhouses can not drive their performance to enable them to survive without advanced technology, high investment, skilled management and sufficient profit (HortNZ, 2006).

As mentioned above, almost all the fresh market tomatoes in New Zealand are produced in greenhouse hydroponic growing systems. The advantage of a hydroponic growing system is that nutrients can be supplied in a more efficient and controlled manner (Jones, 2004). However, one of the characteristics of hydroponic growing is that from time to time surplus nutrient solution has to be discharged. When disease occurs or the salinity level is too high, or when the system needs to be cleaned between crops, a proportion of the nutrient solution is discharged to waste (Tuzel, Tuzel, Gul, Meric, Yavuz, & Eltez, 2001).

The surplus nutrient solution from a hydroponic system has a high concentration of nutrients, particularly nitrogen, phosphorus, and potassium (Hochmuth & Sweat, 1999). For large-scale greenhouses, the quantities of surplus nutrient solution can be huge (Martin, 2004). If disposal of the surplus nutrient solution is not carried out carefully it can have an adverse impact on the environment by polluting surface and groundwater (ARC, 2005c). Therefore, greenhouse nutrient solution management has been considered as one of the critical factors in greenhouse management.

Previously in New Zealand the emphasis on greenhouse tomato production was on increasing yields and improving fruit quality. But now sustainability and the environment have become important concerns for farmers and growers (PCE, 2004). The Resource Management Act 1991 (RMA) is an important piece of legislation that the government has developed to ensure the sustainability of the ecosystem. Regional councils set their local regulations and policies about resource management within the framework of the RMA. Some regional councils (e.g., the Auckland Regional Council) are concerned that many greenhouses are discharging nutrient solution to the environment in a way that is potentially harmful to the environment and inconsistent with sustainable management (ARC, 2005c). Therefore, management practices associated with reducing the environmental impacts of greenhouse nutrient solution release have recently been highlighted by regional authorities.

In order to assist the greenhouse growers to comply with the RMA and regional resource plans, *The Management of Nutrient Solutions Released from Greenhouses: A Code of Practice* (COP), which was funded by the Ministry of Agriculture and Forestry's Sustainable Farming Fund, Vegfed's Tomato Sector, Veg-Gro Supplies Ltd, Auckland Regional Council, Fertiliser Manufacturers' Research Association and Northern Flower Growers Association, has been developed and launched in 2006.

1.2 Problem Statement

In New Zealand, the tomato greenhouse industry has expanded rapidly during the past decade. In recent years the nutrient solution released from greenhouse operations has been considered as a potential pollution source by regional authorities. "*The Management of Nutrient Solutions Released from Greenhouses: A Code of Practice*" (COP) is designed to assist New Zealand greenhouse growers in managing the nutrient solution release in hydroponic systems to comply with the RMA and regional resource plans prepared by regional authorities to ensure that their constituents act appropriately. However, in New Zealand's greenhouse industry, production systems and greenhouse growers' level of

technical expertise vary. Little is known about the nutrient solution management and disposal practices of New Zealand hydroponic greenhouse tomato growers. Similarly, there is a paucity of information about the extent to which these growers follow guidelines provided in *The Management of Nutrient Solutions Released from Greenhouses: A Code of Practice* (COP).

1.3 Objective of the Study

The main objective of this research was to investigate the nutrient solution management and disposal practices of New Zealand hydroponic greenhouse tomato growers and, further, to investigate whether these practices meet the guidelines set out in *The Management of Nutrient Solutions Released from Greenhouses: A Code of Practice* (COP).

Specific objectives of the research are:

1). To obtain an in-depth understanding of the theory of nutrient solution management and disposal in hydroponic systems by reviewing the literature.

2). To investigate the nutrient solution management and disposal practices used by New Zealand hydroponic greenhouse tomato growers.

3). To compare the growers' nutrient solution management and disposal activities with the guidelines provided in the COP and the literature.

1.4 Thesis Structure

There are seven chapters in this thesis. Chapter One is the introduction. In this chapter the background of this research, including an overview of New Zealand's greenhouse tomato industry and the environmental concerns developing in relation to greenhouse nutrient

solution discharge, the research problem statement, and the research objectives, are outlined.

Chapter Two is the literature review. In this chapter, the theories of nutrient solution management and disposal in hydroponic systems and the guidelines for reducing impacts of the nutrient solution discharge on the environment are reviewed. Chapter Three is the research methodology. Chapter Four is the case study report. In this chapter, the details of the nutrient solution management and disposal activities used by the selected case studies are described. Chapter Five is the cross-case analysis. In this chapter, the results obtained in the case studies are compared with each other. Chapter Six is the discussion. In this chapter, the results from the cross-case analysis are compared to the general theories found in the literature and the guidelines given in the COP. Chapter Seven is the conclusion. The main findings from the research, the implications of the findings, an assessment of the research method, and future research suggestions are summarised in this chapter.