UNIVERSITI PUTRA MALAYSIA

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BY

HAMIDEH NOURI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of Requirement for Degree of Master of Science

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Dedicated to

From the depth of my hearth I dedicated this thesis to my beloved father Mohammad Ali Nouri, mother Zohreh Safi, husband Sattar Chavoshi Boroujeni, and siblings Hamed, Bahareh and Behnaz.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science

Effect of Nitrogen Fertigation by Sprinkler Irrigation Sugar Beet Crop Performance

By

Hamideh Nouri

February 2009

Chairman: Prof. Ir. Mohd Amin Mohd Soom, PhD

Faculty: Faculty of Engineering

It is crucial to make field management strategy by understanding of spatial and temporal variability of effective elements such as soil, water and plant properties. The impact of nitrogen fertigation by sprinkler irrigation would be a valuable step in support of environmental preservation and natural resources conservation. This research has focused on the spatial and temporal distribution of N fertigation by sprinkler irrigation and its effect on soil and plant properties to determine the relationship among fertigation distribution pattern and crop performance. The field variability study was carried out in the Fesaran village in east part of Esfahan city in Esfahan Province, Iran. Geostatistical sampling method was selected for an accurate interpolation by kriging to produce spatial and temporal variability maps. A total of 162 soil samples and 81 plant samples were collected and locations recorded using Differential Global Positioning System (DGPS). To describe the variability of soil and plant status, soil and plant nutrient response to the nitrogen fertilizer application

by sprinklers was studied by analyzing 7 soil elements including N, P, K, CEC, OM, EC, and PH under two conditions, pre-treatment (before fertigation) and post-treatment (after fertigation). The sugar beet crop performance was based on 6 crop properties that include leaf N content, tuber moisture content, tuber sugar content, tuber weight, number of tubers in each square meter and yield. Variability maps were obtained using Geographical Information System (GIS) and Geostatistical statistics (GS+) software. Statistical analysis, geostatistical analysis and spatial analysis were employed to analyze the data. Data statistical analysis consist of descriptive analysis, T-Test (Pairwise two-tail), correlation (Pearson two-tail) and ANOVA (Duncan and SNK) and regression were derived from Statistical Package for the Social Sciences (SPSS) and Statistical Analysis System (SAS) software. The impact of N fertigation through sprinkler irrigation on spatial and temporal pattern of soil properties and spatial variability of sugar beet crop performance was studied through statistical analysis and visualization of spatial variability maps. The results show that the highest variability in available P (CV_{af} =89.7 %) and K (CV_{af} =53.26 %) between selected soil properties. It could be related to non-uniform fertilization of potash and phosphate pre-plant that were applied manually. The least variability was seen in soil pH (CV_{af} =0.97 %) and soil OM (CV_{af} =3.04 %).That is an evidence of very low variability of soil pH and OM through and across the study area. Low variability of soil N (CV_{bf} =12.44 %, CV_{af} =14.7 %) would be a key point to encourage farmers to replace fertigation by sprinkler irrigation instead of current methods.

The highest variability of crop properties belonged to tuber weight (CV=44.8 %) while the least variability was in tuber moisture content (CV=6.04 %) and tuber sugar content (CV=6.38 %) which points out the low variability of sugar and moisture content of tubers. Crop properties such as yield, tuber sugar content, tuber numbers, tuber moisture content and N leaf content have low variability (CV $\leq$ 25 %), except tuber weight with moderate variability. Spatial variability map displays concentration of the higher yield was seen in central area compared to least yield in the north west of the study area. Fewer tubers in the north and east of the study area compared to more tubers in the south and west. Interestingly, for those areas which have heavier tubers, the map shows fewer numbers of tubers. Plant performance analysis shows a negative significant correlation of leaf N content with sugar content of tuber at 95 % confidence. Tuber weight has a negative correlation to the number of tubers but positive correlation to the tuber moisture content. It indicates the higher moisture content causes heavier tuber but the grid which has more number of tubers has the lighter tubers. There is a negative correlation of tuber weight and number of tubers but positive significant correlation of number of tubers and sugar content. It indicates that more tubers with lighter weight have higher sugar content. Surprising result shows the negative correlation of leaf N content and sugar content.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

Kesan Fertigasi dengan Mengguna Pengairan Perenjis terhadap Variasi Ruang dan Masa bagi dan Prestasi Tanaman Ubi Putih

Oleh

Hamideh Nouri

Febuari 2009

Pengerusi: Prof. Ir. Mohd Amin Mohd Soom, PhD

Fakulti: Fakulti Kejuruteraan

Pemahaman tentang pengurusan variasi ruang dan masa bagi elemen-elemen penting seperti tanah, air dan tanaman adalah sangat penting untuk mengurangkan keraguan tentang bidang pengurusan berdasarkan konsep pertanian presis. Kesan dari fertigasi Nitrogen dengan mengguna pengairan perenjis akan menjadi satu langkah yang amat berharga bagi menyokong pengawetan alam sekitar dan pemuliharaan sumbur semulajadi. Kajian ini bertumpu kepada pertaburan secara ruang dan masa bagi fertigasi N melalui pengairan perenjis dan kesannya terhadap ciri-ciri tanah dan tanaman untuk mengetahui sekiranya terdapat sebarang hubungan di antara corak pertaburan fertigasi dan prestasi tanaman. Kawasan kajian variasi yang dipilih adalah di kampung Fesaran yang terletak di bahagian Timur Bandar Esfahan, Iran. Kaedah pensampelan *Geostatistics* telah dipilih bagi mendapat penyisipan yang tepat melalui *kringing* untuk menghasilkan peta variasi ruang dan masa. Jumlah daripada 162

sampel tanah dan 81 sampel tumbuhan telah diambil dan lokasi sampel telah direkodkan mengguna *Differential Global Positioning System (DGPS).* Untuk menerangkan status variasi tanah dan tanaman, reaksi nutrein dalam tanah dan pokok terhadap pembahagian baja nitrogen melalui perenjis air telah dikaji dengan menganalisis 7 elemen tanah termasuk N, P, K, CEC, OM, EC dan pH pada dua keadaan, rawatan awal (sebelum proses fertigasi) dan rawatan susulan (selepas proses fertigasi). Prestasi tanaman ubi putih berasaskan 6 ciri-ciri tanaman termasuk kandungan N dalam daun, kandungan kelembapan pada ubi, kandungan gula pada ubi, berat ubi, bilangan ubi bagi setiap kaki persegi, dan hasil tanaman. Peta variasi diperolehi menggunakan perisian *Geostatistical Information System (GIS)* dan *Geostatistical Statistic (GS+).* Analisis statistik, analisis *geostatistical* dan analisis *spatial* digunakan untuk menganalisis data. Analisis statistik data terdiri daripada analisis deskriptif, T-Test (*Pairwise two-tail*), *correlation (Pearson two-tail)*, dan *ANOVA (Duncan and SNK)* manakala regresi dilakukan daripada perisian *Statistical Package for the Social Sciences (SPSS)* dan *Statistical Analysis System (SAS)*. Kesan fertigasi N melalui pengairan perenjis terhadap corak ruang dan masa bagi ciri-ciri tanah dan variasi ruang bagi prestasi tanaman ubi putih dipelajari menerusi analisis statistik dan penggambaran peta variasi ruang. Keputusan menunjukkan kepelbagaian variasi tertinggi dilihat pada P (CV = 89.7%) dan K (CV = 53.26%) berbanding kalangan ciri-ciri lain yang terpilih. Ia boleh dikaitkan dengan ketidakseragaman baja potash dan phosphate yang diberi secara manual sebelum penanaman. Variasi yang terendah boleh dilihat dalam pH tanah (CV_{af} = 0.97%) dan OM tanah (CV_{af} = 3.04%). Ini adalah satu bukti yang menunjukan bahawa variasi pH

dan OM tanah terdapat seluruh kawasan kajian. Variasi yang rendah bagi N tanah (CV = 14.7%) boleh menjadi sebab utama untuk menggalakkan petani menggantikan fertigasi dengan pengairan perenjis berbanding dengan kaedah semasa yang diguna pakai. Variasi yang tertinggi bagi cirri-ciri tanaman menjadi milik berat ubi (CV = 44.8%) manakala variasi yang terendah adalah bagi kandungan kelembapan pada ubi (CV = 6.04%) dan kandungan gula pada ubi (CV = 6.38%) yang mana ia menunjuk variasi yang rendah bagi kandungan gula dan kelembapan pada ubi. Ciri-ciri tanaman seperti hasil, kadungan gula pada ubi, bilangan ubi, kandungan kelembapan pada ubi dan kandungan N dalam daun terdapat variasi yang rendah ($CV \leq 25\%$), melainkan berat ubi dengan variasi yang sederhana. Peta variasi ruang mempamerkan kepekatan hasil yang tinggi terdapat di kawasan tengah berbanding hasil yang terendah di kawasan utara barat dalam kawasan kajian. Bilangan ubi yang sedikit terdapat di kawasan utara dan timur dalam kawasan kajian berbanding bilangan ubi yang banyak yang terdapat di kawasan selatan dan barat. Yang mengasyikan, bagi kawasan-kawasan yang ubinya lebih berat, ia menunjukan lebih rendah bilangan ubi diatas peta. Analisis pretasi pokok menunjukan bahawa terdapat correlation yang negatif diantara kandungan N dalam daun dengan kandungan gula pada ubi di tahap kepercayaan 95%. Terdapat correlation yang negatif diantara berat ubi dan bilangan ubi tetapi terdapat correlation yang positif terhadap kandungan kelembapan pada ubi. Ia menunjukan bahawa kandungan kelembapan yang lebih tinggi mengakibatkan ubi lebih berat tetapi kawasan yang ada lebih banyak bilangan ubi terdapat lebih ringan berat ubi. Terdapat correlation yang negatif bagi berat ubi dan bilangan ubi tetapi terdapat correlation yang positif bagi bilangan ubi dan kandungan gula. Ia

menunjukan bahawa lebih banyak ubi yang lebih ringan terdapat kandungan gula yang tinggi. Dalam kata lain, correlation yang negatif bagi kadungan kelembapan dan kandungan gula telah di pantau. Hasil kajian yang menakjubkan iaitu terdapat correlation yang negatif bagi kandungan N dalam daun dengan kandungan gula.

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Finally, I wish to record my thanks and gratitude to all those who have assisted me directly and indirectly in carrying out this study; farmers, lab assistants, surveyor and etc.

Approval Sheet 1

I certify that an Examination Committee has met on ……. to conduct the final examination of **Hamideh Nouri** on her master degree thesis entitled **"Effect of N Fertigation by Sprinkler Irrigation on the Spatial and Temporal Variability of Soil Properties and Crop Performance"** is accordance with Universiti Putra Malaysia Regulation 1981. The committee recommends that the student be awarded the Master of Science.

Members of the Examination Committee were as follows:

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of master. The members of Supervisory Committee were as follows:

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Date: June 2009

DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or any other institutions.

Hamideh Nouri

3 Nov 2008

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INTRODUCTION

1.1 Introduction

Environmental preservation and protection is a growing concern in the industrial and agricultural sectors. Due to the importance of natural resources conservation for next generations, a delicate overlook has been defined to water, soil and plant relationship. As the most important concern in environmental pollution, chemical products such as fertilizers, herbicides, etc should be applied at optimum level to the field, with respect to approved rules and standards. As the agriculture pollution is nonpoint sources, its management is an international challenge. According to Annadale (1991), there is an increasing need in farming for the fertility management system that conserves natural resources, minimizes the degradation of environmental quality and reduces production costs.

To decrease the uncertainty of field management, it is crucial to have a better understanding of spatial and temporal variability management of effective elements such as soil and plant properties.

Sustainable agriculture as a vital solution to increase utilization efficiency of plant nutrients and to decrease the losses which made undesirable changes in the environment has important role in natural sources conservation. To maximize the efficiency of utilization, it is essential to control the input-output relations of

nutrients in the crop and observe the factors and processes that set limits to the utilization of the nutrients. Higher utilization efficiency of nutrient in a crop rotation would be possible by analyzing input-output relations over several years (Vos, 1996).

Nitrogen as the most fertigated elements due to high plant nutrient needs is an increasing concern in environmental pollution. Because the additional nitrogen that is not utilized by crop possibly will move(in nitrate form) with soil water from the root zone to groundwater aquifers or drainage systems that discharge to surface water (Li et al., 2005). Suitable temporal and spatial distribution of nutrient application would be a helpful in applying precise amount with uniform distribution of fertilizer to avoid surplus.

In recent decades researchers conducted studies on determination of proper amount of nutrients depending on environmental and economical factors but not much attention has been given to distribution pattern of nutrient application. This research has focused on the impact of fertigation by sprinkler irrigation on spatial and temporal variability of selected soil properties and crop performance. In another word, this study tries to establish relationship between fertigation distribution pattern and crop properties.

1.2 Problem Statement

Due to low rate and non-uniform distribution of rainfall and scarcity of other water resources in Esfahan Province (experimental site), farmers receive governmental

loan to install pressurized irrigation systems. Huge investment on implementation, installation and maintenance of pressurized irrigation systems in most provinces of Iran provides the ideal situation for applying fertilizers through sprinkler system. Adding soluble fertilizer to the irrigation water is an effective delivery method both in terms of labor utilization and control of crop development in various growth stages. More often farmers apply other types of fertilizer with less efficiency and higher cost such as spinner spreader, boom spreader and application with planting machines simultaneously. Fertigation can reduce labor cost and in some cases may improve effectiveness and timeliness of application. Therefore, this research was conducted on the fertigation through sprinkler irrigation (solid set system with removable sprinklers) with underground piping which is the common type of pressurized irrigation system in Esfahan Province. To decrease the uncertainty of field management, it is crucial to have a better understanding of spatial and temporal variability management of effective factors such as soil and plant properties. This study focused on the impact of nitrogen fertigation on spatial and temporal variability of selected soil properties and the relationships between fertigation distribution pattern and crop performance.