UNIVERSITI PUTRA MALAYSIA

THE INFLUENCES OF WATER AVAILABILITY AND VESICULAR-ARBUSCULAR MYCORRHIZAL (VAM) FUNGI ON GROWTH AND PHYSIOLOGICAL PROCESSES OF TOMATO (LYCOPERSICON ESCULENTUM MILL.) IN SOILLESS CULTURE

PUTERI EDAROYATI BINTI MEGAT WAHAB

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By

PUTERI EDAROYATI BINTI MEGAT WAHAB

Thesis Submitted in Fulfilment of the Requirements for the Degree of Master of Agricultural Science in the Faculty of Agriculture, Universiti Putra Malaysia

May 1999

Special dedicated

To

Haji Megat Wahab Bin Megat Ahmad
And
Hajjah Siti Noriah Bt. Haji Abdullah

..... lead from the unreal to the real ..
..... from darkness to light and from death to immortality

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In the name of Allah The Beneficial and The Compassionate

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Abstract of thesis submitted to the Senate of Universiti Putra Malaysia in fulfilment of the requirements of the degree of Master of Agricultural Science.

INFLUENCE OF WATER AVAILABILITY AND VESICULAR AND ARBUSCULAR MYCORRHIZAL (VAM) FUNGI ON GROWTH AND PHYSIOLOGICAL PROCESSES OF TOMATO (*LYCOPERSICON ESCULENTUM* Mill.) UNDER SOILLESS CULTURE

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Chairmain: Associate Professor Mohd Razi Ismail, Ph.D

Faculty: Agriculture

A study was conducted to determine the influence of water availability and vesicular-arbuscular mycorrhizal (VAM) inoculation on growth and physiological changes of tomato. Two-week old tomato seedlings were transferred to cultivation slab (120 cm x 30 cm) containing 6 kg of coconut coir dust mixture (CD-Mix) media and allowed to grow for two weeks before uniform plants were chosen for treatment. The experiment was a single factor experiment arranged in a Complete Randomized Design (CRD) with different levels of VAM inoculated at 0, 10, 20, 30 and 40 g per plant with four replications. Data was collected at one week after treatment and subsequently at by-weekly interval until the 7th week.

Plants inoculated with the highest level of inoculum (40 g) resulted in significant higher vegetative growth (as measured by shoot and stem dry weight) and physiological processes (relative water content and stomatal conductance). There was a significant linear relationship between the number of fruits (y=234.094 + 1.215x) and the total soluble solids (y=5.603 + 0.038x) with the rate of inoculum used.

VAM at 40 g per plant was further evaluated using a split plot arrangement in Randomized Completely Block Design (RCBD), with water availability (WA) as main-plot (100%, 75%, 50% and 25% of moisture content: based on substrate water holding capacity) and VAM inoculation (MI) as sub-plot. Data was collected at weekly interval (4 weeks) after treatment.

At the end of the experiment (4 weeks), plant vegetative growth response and physiological processes were significantly affected with reduction in WA. There was significant interaction between WA and MI on growth as measured by leaf area and root, shoot and stem dry weight. Inoculated tomato plants showed higher root shoot ratio and the difference was significant as compared to uninoculated plant. VAM inoculation with higher relative water content significantly affected the crop physiology. The number of fruits, fruit dry weight and yield (fresh weight per plant) were significantly reduced when WA was depleted. However, inoculated plants showed a significant effect on these

parameters. As total soluble solid increase, the number of fruits decreased. Soil characteristics (bulk density, particle density and total pore space) were improved in the presence of the VAM. Therefore, WA at 75% MC was sufficient for growth and physiological responses. This was improved in the presence of VAM.

Abstrak tesis dikemukan kepada Senat Universiti Putra Malaysia untuk memenuhi keperluan Ijazah Master Sains Pertanian

PENGARUH KEDAPATAN AIR DAN KULAT MIKORIZA VESIKUL-ARBUSKUL (MVA) TERHADAP PERTUMBUHAN DAN PROSES FISIOLOGI TANAMAN TOMATO (*LYCOPERSICON ESCULENTUM* MILL.) DALAM KULTUR TANPA TANAH

Oleh

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Mei 1999

Pengerusi: Profesor Madya Mohd Razi Ismail, Ph.D

Fakulti: Pertanian

Satu kajian telah dijalankan untuk menentukan pengaruh kedapatan air dan inokulasi kulat mikoriza vesikular-arbuskular (MVA) terhadap perubahan pertumbuhan dan fisiologi tanaman tomato. Anak benih tomato yang berumur dua minggu diubah ke tapak penanaman berukuran 120 cm x 30 cm yang mengandungi 6 kg campuran habuk sabut kelapa (CD-Mix). Pemilihan dibuat selepas 2 minggu untuk diberikan rawatan. Kajian satu faktor ini disusun secara rekabentuk penuh rawak (CRD) pada 4 kadar inokulasi iaitu 0, 10, 20, 30 dan 40 g per pokok dengan 4 replikasi. Data diambil pada minggu pertama selepas rawatan dan seterusnya pada selang satu minggu hingga minggu ke tujuh.

Pokok yang dirawat dengan inokulum yang tinggi (40 g) memberikan kesan yang bererti pada pertumbuhan vegetatif (seperti yang diukur oleh berat kering daun dan batang) dan proses fisiologi (diukur oleh kandungan air relatif dan konduktiviti stomata). Terdapat kaitan linear yang bererti di antara bilangan buah (y= 234.094 + 1.215x) dan kandungan pepejal terlarut (y= 5.603 + 0.038x) dengan kadar inokulum yang digunakan.

Kulat mikoriza pada kadar 40 g per pokok digunakan untuk kajian seterusnya, disusun secara plot pecahan dalam rekabentuk penuh rawak lengkap (RCBD) dengan kedapatan air (WA) (100%, 75%, 50% dan 25% kandungan lembapan: berasaskan kepada kapasiti pegangan air substrat) sebagai plot utama dan inokulasi kulat mikoriza sebagai subplot. Data diambil pada selang satu minggu (selama 4 minggu) selepas rawatan.

Di akhir kajian (minggu ke-4 selepas rawatan), tindakbalas pertumbuhan vegetatif pokok dan proses fisiologi telah memberi kesan yang bererti apabila pengurangan pada kedapatan air. Terdapat interaksi yang bererti di antara kedapatan air dan inokulasi mikoriza terhadap pertumbuhan pokok seperti yang diukur oleh luas daun dan berat kering daun, akar dan batang. Pokok tomato yang diinokulasi telah menunjukkan nisbah akar:pucuk yang lebih baik dan bererti. Inokulasi mikoriza dengan kandungan air relatif yang tertinggi memberikan kesan yang beerti terhadap fisiologi tanaman. Bilangan buah, berat kering buah dan hasil (berat basah buah per pokok) telah menurun secara berkesan apabila kedapatan air berkurangan. Apabila kandungan pepejal terlarut meningkat, bilangan buah per pokok pula berkurangan. Ciri-ciri fizikal tanah (ketumpatan pukal, ketumpatan partikel dan jumlah ruang udara) telah meningkat dengan kehadiran mikoriza. Oleh yang demikian, kedapatan air pada 75% kandungan kelembapan adalah mencukupi untuk tindakbalas pertumbuahn dan fisiologi yang didapati meningkat dengan kehadiran kulat mikoriza.

CHAPTER I

INTRODUCTION

Crop cultivation under protected environment is always subjected to root and aerial environment stresses due to the change in plant microclimatic factors. One of the main limitations to crop production is water availability where the problems arise from limitation of water source or availability of low quality water. Ismail and Fauzi (1995) demonstrated that under glasshouse condition, over watering is essential for melon plants grown in soilless culture where midday temperature often exceed 40°C.

It is a well-known fact that water deficiency affects plant growth and development (Ismail *et al.,* 1993). Basic information on plant responses to water availability should be understood in order to maximize production through efficient use of water and nutrients. Reduced water availability can be a significant factor affecting growth and plant development, grown in soilless substrate. Though, growth and productivity of plants in a protected environment is governed by water availability, there is a need to improve water use efficiency of plants subjected to reduce water availability. It is well documented that incorporation of vesicular arbuscular mycorrhizal (VAM) fungi can improve root growth. Through many assessments in microbiological fertilizer, a particular VAM fungus might be used to improve crop production. Plant response to VAM fungi is dependent on the interactions between fungus-host plant and environmental conditions (Barea and Azcon-Aquilar, 1983). The occurrence of VAM fungi under glasshouse conditions is influenced also by several eco-physiological factors, which affect the development and efficiency of VAM on several tropical plants. However, VAM is common in areas where water is limiting. There are reports suggesting the beneficial effects of VAM on water relations in droughted plants through the mechanism that increased root length density and rooting depth (Kothari *et al.,* 1990); enhanced water extraction (Allen, 1982; Kothari *et al.,* 1990; Faber *et al.,* 1991) and alteration in root morphology (McCully, 1995). However, it has not been shown whether VAM are ultimately beneficial to growth and final crop productivity of water stressed plants.

Objectives of the Study

The overall objective of this study is to understand the growth and physiological processes of tomato plants in response to water availability and VAM fungi inoculation under soilless culture system for improvement of growth under limited water regimes.

CHAPTER II

LITERATURE REVIEW

Vegetable Production in Malaysia: An Overview

Malaysia's National Agriculture Policy (NAP) (1993) proclaimed to develop modern and commercial agriculture sector and increase production of horticultural crops, especially vegetables, as part of the strategy for diversity and revitalize agriculture's contribution to the economic development of Malaysia. Agriculture has always played a dominant role in Malaysian economy, but with the advent of technology-push industrialization, the principle role of agriculture has been relegated. Thus premium land available for food production, especially vegetables, has decreased. Unfortunately, with the sudden occurrence of the regional economic and currency crisis at the end of 1997, the government had to cut back on import food accounting to more than RM11 billion, to stabilize the national economy.

Local production of vegetables is insufficient to meet the domestic demand both currently and in the future by the growing human population in Malaysia. This imbalance in demand and supply is itself a stimulus for expansion in the production of vegetable crops. Total cost of imported vegetables for local use was estimated at RM596 million in 1996 (Mahmud, 1997). Karim (1992) noted that the demand for vegetable showed an increasing trend and will continue to the year 2000 and beyond. Hence, the government has embarked on an aggressive campaign to increase the local vegetable production.

Soilless Culture System: Protected Environment Agriculture (PEA)

There has been an important evolution towards a new cultivation technology in the crop production system. One of the technologies used in increasing vegetable production is the soilless culture system under protected environment agriculture (PEA). This system not only can produce vegetables, especially tomatoes, in a short period of time compared to the conventional method, but can produce also farm products of high quality and free of pesticide residue, which is considered to be harmful to the environment and consumers. This has certainly lead to an even more artificial cultivation while irrigation system has changed to fertigation, application of water and nutrient to more specific water supply. However, phytopathological problems can occur in artificial substrates and soilless culture. Van Assche *et al.* (1991) found that the more artificial the culture, the greater the risks for pathogen problems. Several investigations have been carried out and the importance of using soilless culture, which is a pathogen-free substrate,