UNIVERSITI PUTRA MALAYSIA

EFFECTS OF AMBIENT OZONE (O3) CONCENTRATIONS ON THE GROWTH PERFORMANCE OF RICE (*ORYZA SATIVA* VAR. MR 219) TREATED WITH DIFFERENT NUTRIENT REGIMES IN THE MUDA AREA, MALAYSIA

SHARIFAH AZLINA BT. ALI

FPAS 2007 4

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By

SHARIFAH AZLINA BT. ALI

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

January 2007

DEDICATION

This thesis is especially dedicated to:

My mother and father,

Thanks for the never-ending love

My brother and sisters,

Hope the future holds something wonderful for all of you

All my relatives,

Your help and encouragement has been so valuable to me

All my friends,

I'll never get this far without your support, thanks for the friendship…

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SHARIFAH AZLINA ALI

January 2007

Chairman : Associate Professor Ahmad Makmom Hj. Abdullah, PhD

Faculty : Environmental Studies

Ozone (O_3) is a secondary gaseous pollutant produced through photochemical reaction known to have substantial impacts on agricultural production in North America and Western Europe. In Malaysia, emissions of O_3 precursors such as non-methane hydrocarbons and nitrogen dioxide are rapidly increased due to urbanization, industrialization and the increasing number of motor vehicles. Furthermore climatic condition in the country is frequently favourable for the formation of high concentration of O_3. It can threaten the rice production which is important to the country as it is the staple food for the vast majority of the population.

In this study, different nutrient regimes were employed to assess the impact of ozone on the growth and yield of variety of local rice (*Oryza sativa* L.) at Muda area in three different ambient ozone (O_3) concentrations. A controlled experiment involving ambient ozone (non-filtered air) and filtered air treatment in

open top chambers demonstrated protective effects of nutrient against ozone. The study found that ozone significantly reduced the growth of rice plant by inhibiting photosynthetic rate, stomatal conductance, transpiration, tiller number and biomass. The result also demonstrated that the growth of rice plant was significantly increased when adding 25% of nutrient regime from normal practices. The relationship between grain dry weight, ozone dosage (AOT40) and the optimum nutrient regime expressed through a fitting linear model produced the following equation: Grain Yield Weight (N_{125}) = (-0.00045*AOT40)+(124.3953).

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

KESAN KEPEKATAN OZON (O_3) UDARA KASA KE ATAS PRESTASI PERTUMBUHAN PADI (*ORYZA SATIVA* VAR. MR219) DENGAN RAWATAN REJIM NUTRIEN BERBEZA DI KAWASAN MUDA, MALAYSIA

Oleh

SHARIFAH AZLINA ALI

Januari 2007

Pengerusi : Profesor Madya Ahmad Makmom Hj. Abdullah, PhD

Fakulti : Pengajian Alam Sekitar

Ozon (O_3) adalah gas pencemar kedua yang terhasil melaui tindakbalas fotokimia yang diketahui dapat memberi kesan ke atas pengeluaran pertanian di Amerika Utara dan Eropah Barat. Di Malaysia, pelepasan bahan perintis O_3 seperti hidrokarbon bukan metana dan nitrogen dioksida meningkat dengan cepat disebabkan oleh proses urbanisasi, perindustrian dan peningkatan jumlah kenderaan bermotor. Tambahan lagi, keadaan iklim di negara ini adalah amat sesuai untuk penghasilan ozon yang tinggi. Keadaan ini boleh mengancam pengeluaran padi dalam negara yang merupakan makanan ruji bagi kebanyakan masyarakat.

Dalam kajian ini, rejim nutrien berbeza diaplikasikan untuk menilai kesan ozon ke atas pertumbuhan dan hasilan padi tempatan (*Oryza sativa* L.) di kawasan MADA pada tiga kepekatan ozon udara kasa (O_3) yang berbeza. Eksperimen kawalan yang melibatkan ozon udara kasa (udara tidak bertapis) dan udara bertapis di dalam kebuk fumigasi terbuka menunjukkan kesan perlindungan

nutrien daripada serangan terhadap ozon. Kajian ini membuktikan bahawa ozon memberi kesan pengurangan yang signifikan terhadap pertumbuhan pokok padi dengan mengganggu kadar fotosintesis, rintangan stomata, transpirasi, bilangan tangkai dan biojisim. Hasil kajian juga menunjukkan bahawa pertumbuhan pokok padi meningkat dengan signifikan apabila rejim nutrien ditambahkan sebanyak 25% melebihi daripada amalan pengurusan biasa. Hubungan di antara berat kering padi, dos ozon (AOT 40) dan rejim baja optimum ditunjukkan melalui model garis lurus yang menghasilkan persamaan berikut: Berat kering hasilan padi (N_{125}) = (-0.00045*AOT40)+(124.3953).

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I wish to thank especially to other personnel especially on their contribution to this work. These include the rice farmers at the Kg. Sungai Baru Tengah A and officers from MADA in PPK I 11 Kuala Sungai, Alor Star.

Last but not least, I would like to express a very special thanks to my beloved family especially my father and friends especially to Mohd. Hafiz, Hilyati, Asimi, Nurul Azzura and Norliyati whom assist me in completing this project. Thanks for being with me all this time.

I certify that an Examination Committee has met on 18th January 2007 to conduct the final examination of Sharifah Azlina Bt. Ali on her Master of Science thesis entitled "Effects of Ambient Ozone (O_3) Concentrations on the Growth Performance of Rice (*Oryza sativa* Var. MR 219) Treated with Different Nutrient Regimes in the Muda Area, Malaysia" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee are as follows:

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Date: 10 MAY 2007

DECLARATION

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

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SHARIFAH AZLINA ALI

Date: 15 MARCH 2007

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LIST OF ABBREVIATIONS

AOT 40	Accumulated O_3 concentration above a threshold of 40 ppb
AQMS	Air Quality Monitoring System
ASMA	Alam Sekitar Malaysia
ANOVA	Analysis of Variance
BMP	Best Management Practices
B	Boron
CH_2	Carbohydrates
CO_2	Carbon dioxide
Ca	Calsium
CF	Charcoal filtered
Cu	Copper
DAP	Day After Planting
DRIS	Diagnosis and Recommendation Integrated System
DOE	Department of Environment
EPA	Environmental Protection Agency
Fe	Ferum
FAO	Food and Agriculture Organisation
H_2O	Hidrogen dioxide
IRPA	Intensification of Research in Priority Area
K	Kalium
Mg	Magnesium
MR	Malaysian rice

MMS	Malaysia Meteorological Station
MT	Metric tonne
MADA	Muda Agricultural Development Authority
Nm	Nanometer
N	Nitrogen
NOx	Nitrogen oxides
NF	Non filtered
OTC	Open Top Chamber
O_3	Ozone
ppm	Part per million
ppb	Part per billion
PPK	Pertubuhan Peladang Kawasan
PAR	Photosynthetically Active Radiation
PFD	Photon Flux Density
P_{max}	Photosynthetic capacity
α	Photosynthetic efficiency
P	Potassium
RH	Relative humidity
RGR	Relative growth rate
gs	Stomatal conductance
SO_2	Sulfur dioxide
E	Transpiration rate
TDW	Total dry weight
USA	United States of America

VPD	Vapour pressure deficit
VOCs	Volatile organic compounds
Zn	Zink

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CHAPTER 1

INTRODUCTION

1.1: Background information of research

There is an approved record of air pollution damaging crops in the world. In particular, ozone has historically been regarded as the principal urban and regional air quality problem in the United States and studies to determine the extent of its harmful effects on both human and environment have been ongoing for decades. However, ozone is not an emitted pollutant and is instead formed in the atmosphere from other pollutants. Therefore, its regulation has focused on controlling the emissions of its precursors that contribute to its synthesis. Major sources of ozone precursors are coal-fired utilities, many of which are located in the Midwestern United States. Recently, disputes between regions over emerging evidence of the long-distance transport of ozone across states has prompted the USEPA and state regulatory agencies to begin addressing the transport problem through cooperative efforts. Tropospheric O_3 is currently viewed as a widespread and growing problem that suppresses crop productivity on a large scale (USEPA, 1996; Mauzerall and Wang 2001; Fuhrer and Booker 2003). Ozone interferes with the ability of plants to produce and store food, making them more susceptible to disease, insects, other pollutants, and harsh weather. Exposure to ozone causes visible effects of ozone injury to plants such as bleached or light flecks or stipples (small clusters of dead cells) on the upper surface of leaves. Matured leaves are the most easily damaged (USEPA, 1998).