RESPONSES OF EGGPLANT (Solanum melongena L. cv MTe 2) TOWARDS SALINITY AND DEVELOPMENT OF PLANT GROWTH ENHANCER IN REDUCING SALT STRESS

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By

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Salinity is the second most widespread soil problem affecting large areas of world cultivated land and is considered as a serious constraint to increase crop production. Seed germination and seedling growth are both important stages in agronomical aspect of crop establishment and both stages are sensitive towards salt stress. Currently, no study has been done regarding salt tolerance of eggplant (*Solanum melongena* L. var MTe 2). Thus, the present work aimed to compare the effects of different types of salts on seed germination capability, early seedling growth and seed anatomy of the eggplant (*S. melongena* var. MTe 2) and also to develop liquid formulation to enhance germination and growth of salt-stressed MTe 2 seeds. Ten sterilized Mte 2 seeds were treated with 5 ml of 25, 50, 100, 150 and 200 mM of NaCl, KCl, $MgCl_2$ and $MgSO_4$ in Petri dish with deionized water as control. After 10 days, the germination performance and early seedling growth were evaluated with their parameters, respectively. The ungerminated seed were transferred to distilled water for percent recovery test and also for histological study. Seeds showed highest tolerance and germination performance in KCl followed by NaCl, $MgCl_2$ and $MgSO_4$. The germination percentage, germination rate, relative salt injury rate, seed vigor, salt tolerance, seedling height and biomass were significantly affected by interaction effect between type of salt and concentration of salt. Treatment with 25 mM KCl was found to enhance the germination performance and early seedling growth of MTe 2 seeds. The seeds were unable to germinate even at the lowest concentration of $MgCl_2$ and $MgSO_4$. Percent recovery test revealed that while NaCl and KCl imposed an osmotic stress onto MTe 2 seeds, $MgCl_2$ and $MgSO_4$ imposed a specific ion toxicity that affects the germination performance. The histological study further revealed that osmotic stress induced a state of dormancy which prevented the protusion of radicle from the testa while specific ion toxicity disrupted cell membrane integrity, interfered with metabolism of germinating seeds and caused a cell death to seed embryo. In this study, potassium chloride (KCl), potassium nitrate (KNO_3) and indole-butyric-acid (IBA) were tested for the effectiveness as a liquid enhancer towards salt stressed MTe 2 seeds. MTe 2 seeds were haloprimed with 200 mM NaCl to induce a salt-stress state to the seeds. The seeds were then dried, surface-sterilized and treated with different

combinations of KCl, KNO_3 and IBA, respectively. After ten days, the germination performance and early seedling growth were evaluated. Results found that the mixture of 25 mM KCl with 6 ppm IBA significantly produced seedlings with the highest seed vigor and seedling length among all other treatments in compared to control. In conclusion, the salt tolerance of eggplant MTe 2 at germination and early growth stages are as follows: NaCl>KCl>$MgCl_2$>$MgSO_4$. The mixture of 25 mM KCl and 6 ppm IBA were found to enhance the germination performance and early seedling growth of salt-stressed eggplant MTe 2.

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

TINDAK BALAS TERUNG (*Solanum melongena* cv. MTe 2) TERHADAP KEMASINAN DAN PEMBANGUNAN CECAIR PENGGALAK PERTUMBUHAN UNTUK MENGURANGKAN TEKANAN GARAM

Oleh

FATEEN KHALIESSA BINTI MOHD ARIFIN

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Kemasinan merupakan masalah kedua utama yang meliputi sebahagian besar tanah di seluruh dunia dan dianggap sebagai kekangan yang serius untuk meningkatkan pengeluaran tanaman. Percambahan biji benih dan pertumbuhan anak benih adalah peringkat penting dalam aspek agronomi untuk penubuhan tanaman dan kedua-dua peringkat tumbesaran tersebut sensitif terhadap tekanan garam. Terkini, tiada lagi kajian telah dilakukan mengenai kadar toleransi terung (*Solanum melongena* cv. MTe 2) terhadap jenis garam yang berbeza. Oleh itu, kajian ini dijalankan bertujuan untuk membandingkan kesan garam yang berbeza terhadap percambahan biji benih, pertumbuhan benih awal dan anatomi biji benih terung (*S. melongena* cv. MTe 2) dan membangunkan formulasi cecair yang boleh meningkatkan percambahan dan pertumbuhan biji benih terung MTe 2 dalam keadaan persekitaran yang ada kemasinan. Sepuluh biji benih MTe 2 diletakkan dalam bekas petri yang telah diletakkan 5 mL 25, 50, 100, 150 dan 200 mM NaCl, KCl, $MgCl_2$ dan $MgSO_4$ dan air ternyahion sebagai kawalan. Selepas 10 hari, prestasi percambahan dan pertumbuhan anak benih terung Mte 2 dinilai menggunakan parameter masing-masing. Benih yang tidak bercambah dalam masa 10 hari dalam rawatan dipindahkan ke air suling untuk kajian pemulihan peratus yang selanjutnya dan juga untuk kajian histologi. Benih menunjukkan prestasi toleransi dan percambahan tertinggi di dalam rawatan KCl, diikuti oleh NaCl, $MgCl_2$ dan $MgSO_4$. Peratusan percambahan, kadar percambahan, relatif kecederaan garam, kesegaran benih. Toleransi garam, panjang anak benih dan biomas telah terkesan secara signifikan oleh kadar kepekatan dan jenis garam yang berbeza. Rawatan dengan 25 mM KCl pula didapatai meningkatkan percambahan dan pertumbuhan benih Mte 2. Tiada percambahan biji benih terung Mte 2 dalam $MgCl_2$ dan $MgSO_4$, walaupun pada kepekatan yang terendah. Ujian pemulihan peratus mendedahkan bahawa walaupun NaCl dan KCl mengenakan tegasan osmotik ke atas biji benih terung MTe 2, $MgCl_2$ dan $MgSO_4$ mempunyai ketoksikan tertentu yang mempengaruhi prestasi percambahan biji benih tersebut. Kajian histologi seterusnya mendedahkan bahawa tekanan osmosis menyebabkan keadaan dorman pada biji benih dan seterusnya menghalang pengeluaran radikal manakala ketoksikan ion tertentu mengganggu integriti sel membran, mengganggu metabolisme dan menyebabkan kematian sel kepada embrio benih. Dalam kajian ini, KCl,

KNO_3 dan IBA telah diuji untuk keberkesanan sebagai formula cairan. Biji benih terung MTe 2 telah direndam terlebih dahulu dalam 200 mM NaCl untuk memberi tekanan garam kepada biji benih. Kemudian, biji benih dikeringkan, melalui proses sterilasi dan dirawat pula dengan campuran KCl, KNO_3 dan IBA untuk 10 hari. Selepas 10 hari, prestasi percambahan dan pertumbuhan anak benih dinilai. Keputusan mendapati bahawa campuran 25 mM KCl dan 6 ppm IBA secara signifikannya telah menghasilkan benih terpanjang dan terbaik berbanding semua rawatan lain termasuklah rawatan kawalan. Kesimpulannya, toleransi biji benih terung MTe 2 dalam garam yang berbeza adalah seperti berikut: NaCl>KCl>$MgCl_2$>$MgSO_4$. Campuran 25 mM KCl and 6 ppm IBA secara signifikan telah menambah baik percambahan biji benih dan pertumbuhan awal terung MTe 2 yang telah menerima tekanan garam.

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This thesis was 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 were as follows:

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NaCl	sodium chloride
KCl	potassium chloride
$MgCl_2$	magnesium chloride
$MgSO_4$	magnesium sulphate
$CaSO_4$	calcium sulphate
$CaCl_2$	calcium chloride
Na_2SO_4	sodium sulphate
$NaHCO_3$	sodium bicarbonate
KNO_3	potassium nitrate
IBA	indole-butyric acid
MTe 2	*Malaysia varieti terung 2*
mM	milimolar
ppm	part per million
EC	electrical conductivity
dS/m	deciSiemens per meter
EC_e	electrical conductivity of saturated paste extract
mg L^{-1}	milligram per liter
NaClO	sodium hypochlorite
GP	germination percentage
GR	germination rate
RIR	relative injury rate
ST	salt tolerance of seed
SHR	seedling height reduction

CHAPTER 1

INTRODUCTION

1.1 Background Study

Abiotic stresses are serious issues concerning agricultural production worldwide for the ability of reducing average yields of major crop plants by more than 50%. These stresses have an adverse effects on plants by triggering a series of morphological, physiological, biochemical, and molecular changes in crop plants, hence affecting the growth and reducing the crop productivity. Among these stresses, salinity gives a remarkable impact on farmlands worldwide (FAO & ITPS, 2015). Globally, approximately 25% of the agricultural land is saline and it continues to be a major problem in the arid and semi-arid regions (Karan & Subudhi, 2012).

Seed germination is a critical and decisive phase of a plant life cycle as the survival and continuity of a species depends on the ability of the plant to germinate and establish itself as a seedling in its environment (Deng et al., 2014). A delayed and reduced in seed germination and later seedling emergence may lead to non-uniform stand establishment and reduced yield. (Wojtyla, Lechowska, Kubala & Garnczarska, 2016). Salinity stress is a well-known, major abiotic factor that provokes disorders in seeds and in its entirety affects the germination, seedling development, crop growth and productivity by disrupting homeostasis in water potential, water uptake and ion distribution. Often, secondary stress might develop as the consequence of these primary effects and result in oxidative damage through ion toxicity to the metabolic machinery (Zhang et al., 2014; Chaparzadeh & Hosseinzad-Behboud, 2015).

Eggplant (*Solanum melongena* L.) is an important non-tuberous crop which belongs to the nightshade family of vegetables. It is one of the most common crop grown in India, Pakistan, China, Philippines, Bangladesh and many Asian countries. Besides low in calories and fats, eggplant is also a good source of vitamins and minerals and rich in amide proteins, free reducing sugars and total water soluble sugars. The purple colour of the fruit comes from anthocyanin pigment, an antioxidant that has been found to prevent brain damages and serve as anti-tumoral activities, alongside with other health benefits (Lim, 2013).

1.2 Problem Statement and Justification of Study

Various salts occur worldwide yet, many research only focused on the salinity effects of NaCl on plant. Agricultural soil composition and irrigation water consists combinations of anions and cations of magnesium, potassium, chloride and sulphate. Currently, the effects of various concentrations and types of salt stress on Malaysian variety of eggplant, MTe 2 are not fully understood and no research has been done before. Though previous studies stated that it is moderately sensitive (Demir et al., 2003; Akinci et al, 2004; Shaheen, Naseer, Ashraf & Akram, 2013), the knowledge of salt tolerance of this vegetable plant and how their growth and development are affected by salt stress are outdated and scarce. The response differs depends on the variety, developmental stage, genotype and environment on which the eggplant is being cultivated. Knowledge on the tolerance of eggplant MTe 2 under salt stress may later contribute in minimizing the impact of salinity and thus increase the efficiency of eggplant MTe 2 production in salt-affected soils in Malaysia.

Besides that, the interaction between dormant salt-stressed seed and plant growth regulators on eggplant MTe 2 has never been studied before. The alleviation of salt stress by liquid growth enhancer that is formulated from plant growth regulators may serve as an alternative to reduce loss due to salinity stress on crop production.

1.3 Objectives

Hence the objectives of the present work are as follows:

1. To compare the effects of different concentrations of salts on germination, seedling growth and anatomy of eggplant (*Solanum melongena* L. cv. MTe 2).
2. To develop a liquid growth enhancer to mitigate the effects of salt stress on eggplant seed (*Solanum melongena* L. cv. MTe 2).

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