ANALYSIS OF EMBRYOGENIC CALLUS INDUCTION AND REGENERATION OF INDICA RICE VARIETY OF MALAYSIA

SURAIYA BINTE MOSTAFIZ

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Doctor of Philosophy

Faculty of Science
Universiti Teknologi Malaysia

MARCH 2019

DEDICATION

I humbly dedicate this thesis to:
My beloved family for their endless support and motivation

ACKNOWLEDGEMENT

First and foremost, I am very much thankful to Allah SWT, Who has spared my life and guided me through the academic and non-academic periods and also gave me the understanding, strength and motivation to bear and endure all the eventualities on post-graduate life and challenges.

I would like to express my sincere gratitude to my supervisor Dr. Alina Wagiran for commencing this research project and for her continuous consolations guidance, and prayers during the study period. Without her support I could not have completed this PhD. I also wish to acknowledge for her time, advice, patient teaching, reading and critically commenting on my thesis in different stages.

I wish to thank the Ministry of Higher Education, Malaysia (MOHE) Tier 1. GUP Q.J.130000.2545.09H22 and the Universiti Teknologi Malaysia for experimental support and International Doctoral Fellowship (IDF) of University technology Malaysia for financial support. My sincere gratitude goes to all the lecturers of Plant Biotechnology group under Bioscience at Universiti Teknologi Malaysia for their beneficial advices, suggestions and criticisms. I also wish to acknowledge to all the staffs of Department of Biosciences, Universiti Teknologi Malaysia for kindly helping me with complete laboratory instruments and preparing the facilities for setting up this research project.

I also wish to tender my sincere appreciations to my lab collogues, Dr. Bashir Abu Bakar, Miss Ng Ja Ming, Mrs Hazwani, Miss Nurfadhila, Mr Sulaiman Mohammad for their numerous support, constructive suggestions and advices in any matters throughout the project. Finally, The most important persons whom I be obliged more than thanks to my family members who include my father Dr. Mostafizur Rahman, my mother Rehana Akther and my siblings for their moral support.

Last but not least, my deepest gratitude goes to my husband Dr. Eng. Mizanur Rahman for his guidance of my research work. I could not continue this research without his support, continuous encouragement and patience. This achievement is for my two children, Saifullah Tawsif and Tasfia Nuzhat who have encouraged me and always giving a lovely support in finishing this research.

ABSTRACT

Rice is the main food-crop for more than half of the global population and its demand is increasing due to population growth. Different abiotic and biotic stresses are among the major reasons that lower the yield. Development of new rice varieties through *in vitro* somatic embryogenesis not only contributes to enhance the yield but also improves the quality of rice. However, exact timing of maintenance of embryogenic competent callus was yet to be established for *indica* rice, which is considered as a main barrier in genetic modification. Somatic embryogenesis receptor kinase (SERK1) gene is extensively used as an embryogenic marker in many plant species, which is expressed specifically in embryogenic callus. To obtain high callus induction, effect of plant growth regulators (i.e. 2,4-D and NAA), carbon sources (i.e. sucrose, maltose and sorbitol), basal media (i.e. MS, N_6 and LS), and pre-heat treatments (i.e. 35°C, 40°C, 45°C and 50°C) with different imbibition periods (3 days, 5 days and 7 days) were investigated for four Malaysian *indica* rice varieties (i.e. MR220, MR220-CL2, MR232 and Bario). SERK1 gene was quantified by real time PCR in differential stages of callus (14 days, 21 days, 28 days, 35 days and 42 days), different PGR (2,4-D, NAA, NAA+ 2,4-D), and pre-heat treatment. Plant regeneration was also optimised by using different concentrations of plant growth regulators. After regeneration, agronomic studies was carried out between control plant and treatment plant for all varieties. In the present study, highest percentage of callus induction was obtained for MR220 (96%), MR220-CL2 (100%) MR232 (100%) and Bario (95.7%) on MS media with 3 mg/L 2, 4-D and 3% maltose after 21 days of culture of pre-heat treated seed at 45°C for 3 days. The characteristics of embryogenic callus were found to be embryogenic from SEM and histology. Amplification of SERK1 cDNA was referred as detection of the gene of aged 21-days was successfully amplified in all four varieties. The phylogenetic tree analysis showed that SERK1 gene of all varieties were similar to the SERK1 of *Oryza sativa Japonica*. The Real Time PCR analysis revealed that SERK1 transcript was significantly higher at 21 days old callus on MS media with 2,4-D at 45°C pre-heat treated callus for all four varieties. Further, regeneration was tested for 21 days old callus, where the regeneration frequency were found to be 72%, 89%, 71% and 50% in MR220, MR220-CL2, MR232 and Bario respectively in optimised regeneration media (2mg/L BAP+ 2mg/L Kinetin+0.5mg/L NAA). Regenerated plants grew easily in the glasshouse with 90 –95% survival rate. Agronomic studies did not show any morphological variation but grain weight of *in vitro* raised plant was significantly higher than control plant in all tested varieties. These findings establish a suitable protocol for *in vitro* regeneration system to be used in genetic modification studies in *indica* rice in future.

ABSTRAK

Padi merupakan tanaman makanan utama kepada lebih daripada separuh populasi global dan permintaannya semakin meningkat disebabkan oleh peningkatan populasi. Persekitaran negatif abiotik dan biotik yang berbeza merupakan antara sebab utama yang mengurangkan hasil pokok padi. Penghasilan padi varieti baru melalui embriogenesis somatik *in vitro* bukan sahaja menyumbang kepada mempertingkatkan hasil tetapi juga memperbaiki kualiti beras. Walau bagaimanapun, masa yang tepat bagi pengendalian potensi kalus embriogeni untuk padi *indica* belum lagi ditentukan, yang dianggap sebagai halangan utama dalam pengubahsuaian genetik. Gen Kinase penerima embriogenesis somatik (SERK1) digunakan secara meluas dalam kebanyakan spesis pokok sebagai penanda embriogeni sel. Bagi mendapatkan induksi kalus embriogen yang tinggi, kesan pengawalatur pertumbuhan pokok (2,4-D dan NAA), sumber karbon (sukrosa, maltosa dan sorbitol), media basal (MS, N_6 and LS), dan prapemanasan (35°C, 40°C, 45°C dan 50°C) dengan tempoh berbeza (3, 5 dan 7 hari) diselidik bagi padi *indica* Malaysia variti MR220, MR220-CL2, MR232 dan Bario. Menggunakan kaedah PCR masa sebenar, kandungan gen SERK1 dari umur kalus yang berbeza (14 hari, 21 hari, 28 hari, 35 hari dan 42 hari), kesan pra pemanasan, PGR (2,4-D, NAA, NAA+ 2,4-D) dan tempoh prapemanasan dianalisa. Pertumbuhan semula pokok dioptimumkan menggunakan pengawal atur pertumbuhan pokok dengan kepekatan yang berbeza. Selepas itu, agronomi pokok direkodkan diantara rawatan kawalan dan pokok yang dibesarkan secara *in vitro* untuk kesemua varieti. Peratusan induksi kalus 3 minggu yang tertinggi diperoleh untuk MR220 (96%), MR220-CL2 (100%) MR232 (100%), dan Bario (95.7%) dalam media MS dengan 3 mg/L 2, 4-D dan 3% maltosa selepas eksplan didedahkan kepada suhu 45°C selama 3 hari. Ciri-ciri kalus didapati embriogeni daripada SEM dan histologi. Amplifikasi gen SERK1 telah diperolehi dengan jayanya daripada cDNA kalus yang berusia 21 dari kesemua empat varieti. Analisis pokok filogenetik menunjukkan gen SERK1 bagi kesemua varieti serupa dengan gen SERK1 *Oryza sativa Japonica*. Dari analisis masa sebenar PCR mendedahkan bahawa transkrip SERK1 meningkat dengan ketara bagi kalus berusia 21 hari apabila dikultur atas media MS dengan 2,4-D pada suhu prapemanasan 45°C bagi kesemua empat varieti. Seterusnya, regenerasi kalus berusia 21 hari ini menunjukkan peratus pertumbuhan masing-masing sebanyak 72%, 89%, 71% dan 50% dalam MR220, MR220-CL2, MR232 dan Bario dalam media regenerasi optimum (2mg/L BAP+2mg/L Kinetin+0.5mg/L NAA). Pokok seterusnya tumbuh dengan kadar kemandirian 90–95%. Kajian agronomi tidak menunjukkan sebarang perbezaan morfologi tetapi berat bijian pokok dari sumber *in vitro* ketara lebih tinggi daripada pokok kawalan dalam kesemua varieti yang diuji. Kajian ini membuktikan protokol yang dibangunkan adalah sesuai untuk digunakan bagi kajian pengubahsuaian genetik pada masa akan datang.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVATIONS

ANOVA	-	Analysis of Variance
BAP	-	Benzoapyrene
BBM		Baby Boom
BLAST	-	Basic Local Alignment Search Tool
bp	-	Base Pair
cDNA	-	complementary DNA
CIP	-	Callus Induction Percentage
cm	-	Centimetre
CTAB	-	Cetyltrimethylammonium Bromide
cps	-	Counts Per Second
Ct	-	Threshold Cycle
DEPC	-	Diethyl Pyrocarbonate
dH2O	-	Deionized Water
DNA	-	Deoxyribonucleic Acid
DNase 1	-	Deoxyribonuclease 1
dNTP	-	Deoxynucleotide Triphosphates
EC	-	Embryogenic Callus
EDTA	-	Ethylenediaminetetraacetatic Acid
EtBr	-	Ethidium Bromide
g	-	Gram
HCl	-	Hydrochloride Acid
hr	-	Hours
i.e.	-	that is
K	-	Potassium
k	-	Kilo
kb	-	Kilobase

KOH	-	Potassium Hydroxide
L	-	Litre
LS		Linsmaier and Skoog
MgCl2	-	Magnesium Chloride
MgSO4	-	Magnesium Sulphate
MEGA		Molecular Evolutionary Genetics Analysis
min	-	Minute
Ml	-	Millilitre
mm	-	Millimetre
mM	-	Millimolar
MMLV-RT	-	Maurine Moloney Leukemia Virus Reverse Transcriptase
mRNA	-	Messenger RNA
MS		Murasighe and Skoog
NaCl	-	Sodium Chloride
NaOH	-	Sodium Hydroxide
NE	-	Non-Embryogenic Callus
NAA		1-Napahthaleneacetic acid
ng	-	Nanogram
nt	-	Nucleotide
O2	-	Oxygen
OD	-	Optical density
OS	-	*Oryza sativa*
PAGE	-	Polyacrylamide Agarose Gel Electrophoresis
PCR	-	Polymerase Chain Reaction
pmol	-	Picomole
qRT-PCR	-	Quantitative Real-Time Polymerase Chain Reaction
RM	-	Regeneration Media
RNA	-	Ribonucleic Acid
RNase	-	Ribonuclease

RT	-	Room Temperature
SD	-	Standard Deviation
SDS	-	Sodium Dodecyl Sulphate
sec	-	Seconds
SE	-	Standard Error
SEM	-	Standard Error of the Mean
SERK	-	Somatic Embryogenesis Receptor Kinase
SPSS		Statistical Package for the Social Sciences
T	-	Thiamine
TAE	-	Tris-Acetate-EDTA

LIST OF SYMBOLS

%	-	Percentage
α	-	Alpha
β	-	Beta
λ	-	Lambda
°C	-	Degree Celsius
µg	-	Microgram
µl	-	Microliter
µM	-	Micromolar

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Rice *(Oryza sativa* L.) is an important food-crop among 70 species and 11 genera of tribe Oryzaeae. It is the second most widely cultivated crop in the world after wheat (Sandhu and Kumar, 2017) and is a model monocot system for genetic and functional genomics. Rice (*Oryza sativa* L.) belongs to the large and economically important Gramineae family, which includes a variety of species such as *japonica, javanica,* and *indica* (Azizi et al, 2015). These rice species are found throughout the tropical and temperate regions while *indica* subspecies is the most widely cultivated in South and Southeast Asian countries (Khush, 2005).

Rice is consumed by more than half (i.e. 70%) of the world population as their major source of energy. Total annual rice production of the world was 758.9 million tonnes on 165 million hectares in 2016 with a fluctuating trend during the last five years (FAO Statistics Division, 2017). Similar to other South Asian countries, rice is the staple food-crop in Malaysia. It is estimated that 97% population of Malaysia take rice as a major source of their carbohydrate. In Malaysia, the production of rice was 3.1 million tonnes on 695 hectares of land in 2017. Domestic consumption of rice in Malaysia is projected to increase from 2.75 million tonnes in 2016/17 to 2.8 million tonnes in 2017/18 according to the increasing population growth (Wahab, 2017).

Malaysian rice is grown both in wetland and upland areas of the country. Although the yield of wetland rice is comparatively higher than upland rice, upland rice is advantageous due to its low-cost of production and low-irrigation requirements (Fageria and Baligar, 2003). The upland rice Bario is also beneficial for its sticky texture, fine elongated grains, mild pleasant aroma and exquisite taste (Wong et al., 2009) and could be promoted as a health food for its low glycaemic index (Nicholas et al., 2014). For increasing yield, Malaysian Agricultural Research and Development Institute (MARDI) has released several hybrid rice varieties including MR220, MR220-CL2, and MR232. These hybrid rice varieties are prime in terms of their quality and comparatively higher yields. Even though, these varieties are said to be high-yielding, but their plants are susceptible to flooding, drought, and low resistance to diseases and pests (Libin et al, 2012; Kevin et al, 2007; Naeg, 2012).

Malaysia sets to achieve food security up to 80% by 2020, which eventually increases the food demand. Several measures have been taken by the government to stabilize the rice supply, however, the food security only reached to 72% as of 2017. Nearly 700 hectares of paddy field were flooded which had affected reaching the self-sufficiency target (80%) (Shabery, 2017). Furthermore, the area of land available for cultivation of crop is decreasing rapidly because of urbanization as well as decreasing the area of fertile land (Kumar, 2017). Previous reports showed that rice production has been adversely affected by abiotic stress and high vulnerability to weather changes (Bzour et al, 2018; Azmi et al., 2012; Zulkarnain et al, 2013; FAO Statistics Division, 2017; Wahab, 2017). The increasing demand for rice earnestly requires increasing the yield to bridge the gap between demand and production.

In order to ensure food security, the country needs to develop new high yielding rice varieties (FAO, 2015) through available options such as molecular breeding and biotechnology (Thuy and Saitoh, 2017). Conventional breeding, genetic engineering and *in vitro* tissue culture methods usually used to develop new rice varieties (Gosal and Kang, 2012). Although conventional breeding methods improve rice variety, their progress rates are very slow (Wang et al, 2011).

In vitro method is known to be an efficient method for developing improved rice variety (Kalhori et al, 2017; Kumar et al, 2010). New varieties through genetic engineering plants with resistance to various stresses, both biotic and abiotic, require a detail understanding of the cellular and functional features of the plant's genes (Lin et al, 2017). However, the lack of efficient tissue culture protocols is also one of the main barriers to breeding improvement and biotechnological studies. One of the main objectives of plant genetic modification is cultivar development, which can be accomplished through plant regeneration by using somatic embryogenesis (Azizi et al, 2015). Therefore, the availability of an efficient *in vitro* regeneration protocol is an essential requisite prior to genetic modification program.

The recalcitrance of *indica* rice has been attributed to low callusing and regenerating abilities (Silva, 2010) compared to *japonica* subspecies (Kalhori et al, 2017) in particular to various conditions of *in vitro* tissue culture. Eventually, within *indica* subspecies, significant variation was also found with *in vitro* culture response in different genotypes (Rahman et al, 2010). However, the lack of potential tissue culture method in certain rice species to regenerate the healthy plantlets remains the main hindrance for genetic modification of a wide range of plant species (Uddain, 2015).

The earliest stage of *in vitro* callus induction draws attention due to the determination of embryonic cells, which provides us the information of the mechanism about cell development as well as the regeneration potential that are used in plant biotechnology (Zimmerman, 1993; Wójcikowska and Gaj, 2017). Thus, the information of exact timing of maintenance of embryogenic callus and its effect on embryogenic quality are inadequate of all types of *indica* rice varieties. Therefore, marker base studies could be an alternative solution for evolving a new protocol. Molecular and morphological marker production of embryogenic competent cell in certain developmental ages could support to develop new regeneration protocol of Malaysian *indica* rice for most of the genotypes.

Molecular changes of somatic embryogenesis involve different gene expression patterns which are triggered by a series of signal cascades. Five somatic embryogenesis receptor kinase gene (SERK) types have been identified in

Arabidopsis, which are responsible for development, stress tolerance and organ differentiation (Salaj et al, 2008). So, it is important to identify the specific gene which is involved in the molecular regulation of somatic embryogenesis in plant species (Talapatra et al, 2013). Among all the gene involved in the procurement of embryogenic potential, somatic embryogenesis receptor kinase1 (SERK1) gene has been used as a marker of somatic embryogenesis in different plant species (Hu et al, 2005; Talapatra et al, 2013; Podio et al, 2014).

Knowledge of the molecular mechanisms that operate in the signal transduction pathway of cellular response to somatic embryogenesis of Malaysian *indica* rice is still quite unavailable. This project has performed a comprehensive study on SERK1 to identify the certain-stage embryogenic callus induction which is potential for regeneration. Although several plant species including *japonica* and wild rice were studied and SERK1 was identified as an embryogenic marker. However, SERK1 was not yet studied in Malaysian *indica* rice cultivar. This study conducts to identify putative SERK1 homologs from the embryogenic callus and its expression as a potential embryogenic marker for selected Malaysian *indica* rice.

1.2 Problem Statement

To ensure the sufficient rice production and meet up the demand of rice consumption, several new varieties had been developed and introduced to the farmers in Malaysia through the breeding technology. Hence, to fulfill the self-sufficiency in rice production, Malaysia still had to imports rice from neighboring countries such as Thailand, Vietnam, China, Pakisthan and India.

Though MR220, MR232, and MR220-CL2 are newly developed rice varieties, they do not fulfill the expected predicted yields due to their vulnerability to environmental stress and adverse soil condition. In addition, Bario is popular upland rice variety in Sarawak. However, its production is very low due to soil salinity, narrow range of genetic variability and lack of sufficient information to improve the quality and yield of rice (Hoang et al, 2016). Therefore, new hybrid rice variety by

improving their quality and yield through genetic modification techniques and technologies can meet the targeted demand for rice in Malaysia.

The major drawbacks of *in vitro* culture of *indica* rice are low percentage of callus induction, somatic embryogenesis and plant regeneration compared to *japonica* rice variety (Hoque and Mansfield, 2004; Abiri et al, 2017). These issues are considered as the main barriers in the genetic modification of *indica* rice (Azizi et al, 2015). Additionally, limited information was found on the exact age of maintenance of embryogenic callus and its effect on embryogenic quality. The expressions of SERK1 gene by real time PCR during SE were yet not determined in Malaysian rice callus produced for different varieties such as MR220, MR220-CL2, and MR232 and Bario rice cultivars.

Based on the above research problems, the present study determines the high callus induction and regeneration performance of MR220, MR232, Bario and MR220-CL2 on these growth media which are better than control treatment. Expression of SERK1 gene during somatic embryogenesis of four *indica* rice varieties was evaluated using different plant growth regulators, different age callus, pre-heat treatment. Therefore, using this information, the understanding of the fundamental molecular events that trigger somatic embryogenesis, which guides the development of propagation practises, for those plants that are recalcitrant to *in vitro* somatic embryogenesis. In addition, the present study proposed the prediction three-dimensional structures of *Oryza sativa* SERK1 using bioinformatics tools. These would broaden the horizon of biotechnological advancements in the field of crop science.

1.3 Objectives

The objectives of this research are stated below:

(a) To determine the effects of different basal media and plant growth regulators, pre-heat treatments on callus induction.

(b) To characterize SERK1 gene based on the structure and phylogenetic relationship.

(c) To quantify the expression of SERK1 gene in different varieties and their developmental ages, pre-heat treatment, and plant growth regulators.

(d) To determine the effects of pre-heat treatment on regeneration.

1.4 Scope of the Study

Establishment and optimization parameters affect somatic embryogenesis (callus induction of different basal media and plant growth regulators, carbon sources, gelling agent, and pre-heat treatment) of wetland rice varieties (MR220, MR220-CL2, MR232) and upland *indica* rice variety of Bario. For callus induction, seed were cultured on MS media, N_6 media, and LS media supplemented with different concentration of plant growth regulator (auxin) such as 2,4-dichlorophenoxyacetic acid (2,4-D), α- Naphthaleneacetic Acid (NAA) alone or in combination. The morphology of embryogenic and non-embryogenic callus was observed and recorded (callus percentage). Then, the ultrastructure and cell composition were examined through scanning electron microscopy (SEM) and histology respectively.

RNA extraction was employed and reverse transcriptase polymerase chain reaction (RT-PCR) was conducted to synthesize the complementary DNA (cDNA). The *Oryza sativa* was subsequently authenticated using the BLASTn and Neighbor-

joining (NJ) tree analysis in software MEGA 6 (Tamura et al, 2013). The expression of the gene was quantified by real-time PCR (Rotor- gene-Q, Qiagen). Quanti Nova SYBR gene PCR kit was used for real-time PCR. Fold change of the gene were quantified by using the Bioinformatics software of Gene Globe (Qiagen).

The present study was also conducted regeneration work from callus of these rice varieties by using different combinations of plant growth regulators (cytokinin and auxin) such as 6-Benzylaminopurine, benzyl adenine (BPA), Kinetin (Kin), and NAA. Germination test was conducted and seed weight from the *ex-vitro* plants was evaluated. The evaluation was compared from control plant and *ex-vitro* plant.

1.5 Significance of the Study

The success in establishing a standard callus induction and regeneration method for some important Malaysian *indica* rice varieties such as MR220, MR220-CL2, MR232 and Bario will assist in overcoming the issues of insufficiency of regeneration method for variety development which is extensively used in genetic modification research.

This study has focused on getting highly efficient callus induction media for Malaysian *indica* rice. The molecular studies were therefore intended on identifying the SERK1 gene during somatic embryogenesis in MR220, MR232, MR220-CL2, and Bario. Moreover, the expression of SERK1 gene from different developmental ages of somatic embryogenesis were not yet identified in MR220, MR220-CL2, MR232 and Bario cultivar. This project has performed a comprehensive study on SERK1 to identify the certain age of embryogenic callus induction which is potential for regeneration. Besides, to my best knowledge, pre-heat treatment of rice seeds contributed to high throughput callus induction had not yet studied in detail.

Therefore, this study helps to formulate a new approach for regenerating of *indica* rice. Additionally, the knowledge of SERK1 gene as embryogenic marker could widen the specific target of competency callus before establishment of any

REFERENCES

Abdollahi, M.R., Darbandi, M., Hamidvand, Y. and Majdi, M. (2015). The Influence of Phytohormones, Wheat Ovary Co-Culture, and Temperature Stress on Anther Culture Response of Watermelon (*Citrullus lanatus* L.). *Brazilian Journal of Botany*, 38(3), pp.447–456.

Abe, T. and Futsuhara, Y. (1986). Genotypic Variability for Callus Formation and Plant Regeneration in Rice (*Oryza sativa* L.). *Theoretical and Applied Genetics*, 72(1), pp.3–10.

Abiri, R., Maziah, M., Shaharuddin, N.A., Yusof, Z.N.B., Atabaki, N., Hanafi, M.M., Sahebi, M., Azizi, P., Kalhori, N. and Valdiani, A. (2017). Enhancing Somatic Embryogenesis of Malaysian Rice Cultivar MR219 Using Adjuvant Materials in a High-Efficiency Protocol. *International Journal of Environmental Science and Technology*, 14(5), pp.1091–1108.

Abu K, M. (2017). Role of Explants and NAA on Callus Induction of Potato. *American Journal of Life Sciences*, 5(5), p.140.

Abubakar, B.M. (2014). *Isolation of High Quality Ribonucleic Acid and Complementary Deoxyribonucleic Acid from Oryza sativa*. Malaysia: Universiti Teknologi Malaysia.

Afele, J.C. (1992). Increased Induction of Microspore Embryos Following Manipulation of Donor Plant Environment and Culture Temperature in Corn (Zea mays L.). *Plant Cell, Tissue and Organ Culture*, 28(1), pp.87–90.

Ahmad, F.I., Johan, N.S. and Wagiran, A. (2013). Effect of 2,4-D on Embryogenic Callus Induction of Malaysian *Indica* Rice (*Oryza sativa* L.) Cultivars MR123 and MR127. *Jurnal Teknologi*, 64(2), pp.42-48.

Alagarsamy, K., Pandian, S. and Ramesh, M. (2009). High Frequency Plant Regeneration from Embryogenic Callus of Popular Indica Rice (*Oryza sativa* L.). *Physiology and molecular biology of plants : an international journal of functional plant biology*, 15, pp.371–5.

Alam, M.M., Sharmin, S., Nabi, Z., Mondal, S.I., Islam, M.S., Nayeem, S.B. Shoyaib and M., Khan, H. (2010). A Putative Leucine-Rich Repeat Receptor-Like Kinase of Jute Involved in Stress Response. *Plant Molecular Biology Reporter*, 28(3), pp.394–402.

Alhasnawi, A.N. (2016). Impact of Exogenous Ascorbic Acid on Biochemical Activities of Rice Callus Treated with Salt Stress. *AIP Conference Proceedings*, 1784(1), p.020005.

Amin, A.M., Rahman, Z.A., Musa, M.H. and Abdullah, S.N.A. (2016). Variation in Nitrogen Uptake Efficiency in Upland Rice Landraces as Influenced by P Fertilization. *Australian Journal of Crop Science*, 10(12), pp.1608–1613.

Andi Brisibe, E., Miyake, H., Taniguchi, T. and Maeda, E. (1992). Callus Formation and Scanning Electron Microscopy of Plantlet Regeneration in African Rice (*Oryza glaberrima Steud*). *Plant Science*, 83(2), pp.217–224.

Arzate-Fernández, A.-M., Nakazaki, T., Okumoto, Y. and Tanisaka, T. (1997). Efficient Callus Induction and Plant Regeneration from Filaments with Anther in Lily (*Lilium longiflorum* Thunb.). *Plant Cell Reports*, 16(12), pp.836–840.

Ascough, G.D. and Fennell, C.W. (2004). The Regulation of Plant Growth and Development in Liquid Culture. *South African Journal of Botany*, 70(2), pp.181–190.

Azizi, P., Rafii, M.Y., Mahmood, M. and Abdullah, S.N.A. (2015). Differential Gene Expression Reflects Morphological Characteristics and Physiological Processes in Rice Immunity Against Blast Pathogen *Magnaporthe Oryzae*. *Plos One*, 10(5), p.e0126188.

Azizi, P., Rafii, M.Y., Mahmood, M., Abdullah, S.N.A., Hanafi, M.M., Latif, M.A., Sahebi, M. and Ashkani, S. (2017). Evaluation of Rna Extraction Methods in Rice and Their Application in Expression Analysis of Resistance Genes Against *Magnaporthe Oryzae*. *Biotechnology & Biotechnological Equipment*, 31(1), pp.75–84.

Azizi, P., Rafii, M.Y., Mahmood, M. and Hanafi, M.M. (2015). Highly Efficient Protocol for Callogenesis, Somagenesis and Regeneration of *Indica* Rice Plants. *Comptes Rendus Biologies*, 338(7), pp.463–470.

Azmi, M., Azlan, S., M Yim, K., V George, T. and E Chew, S. (2012). Control of Weedy Rice in Direct-Seeded Rice Using the Clearfield Production System in Malaysia. *Pakistan Journal Weed Science Research*, 18.

Ball, S., Zhou, H. and Konzak, C. (1993). Influence of 2,4-D, Iaa, and Duration of Callus Induction in Anther Cultures of Spring Wheat. *Plant Science*, 90(2), pp.195–200.

Basu, D. and Veluthambi, K. (2016). Partial Desiccation of Scutellum-Derived Rice Callus Improves Agrobacterium- Mediated Transformation. *Journal of Bio Innovation*, 5(5), pp.632–642.

Bec, S. (1998). Comparative Histology of Microprojectile-Mediated Gene Transfer to Embryogenic Calli in Japonica Rice (*Oryza sativa* L.): Influence of the Structural Organization of Target Tissues on Genotype Transformation Ability. *Plant Science*, 138(2), pp.177–190.

Bevitori, R., Popielarska-Konieczna, M., dos Santos, E.M. and Grossi-de-Sa, M.F. (2014). Morpho-anatomical characterization of mature embryo-derived callus of rice (*Oryza sativa* L.) suitable for transformation. *Protoplasma*, 251(3), pp.545–554.

Biswas, A. and Mandal, A.B. (2007). Plant Regeneration in Different Genotypes of *Indica* Rice. *Indian Journal of Biotechnology*, 6(4), pp.532–540.

Blackhall, N.W., Jotham, J.P., Azhakanandam, K., Power, J.B., Lowe, K.C., Cocking, E.C. and Davey, M.R. (1999). Callus Initiation, Maintenance, and Shoot Induction in Rice. *Methods in Molecular Biology (Clifton, N.J.)*, 111, pp.19–29.

Bustin, S.A. and Nolan, T. (2004). Pitfalls of Quantitative Real-Time Reverse-Transcription Polymerase Chain Reaction. *Journal of Biomolecular Techniques*, 15(3), pp.155–166.

Bzour, M.I., Zuki, F.M. and Mispan, M.S. (2018). Introduction of Imidazolinone Herbicide and Clearfield® Rice Between Weedy Rice—Control Efficiency and Environmental Concerns. *Environmental Reviews*, pp.1–18.

Canhoto, J.M., Rama, S.C. and Cruz, G.S. (2006). Somatic Embryogenesis and Plant Regeneration in Carob (*Ceratonia siliqua* L.). *In Vitro Cellular & Developmental Biology-Plant*, 42(6), pp.514–519.

Chaar, M., Pinker, I., Grieger, P. and Boehme, M. (2012). The Effect of Flower Bud Size and Pre-Treatment on Callus Induction and Plant Regeneration in Anther Culture of Petunia "Purple Wave." In: Geelen, D., (ed.) *Vii International Symposium on in Vitro Culture and Horticultural Breeding*. *International Society Horticultural Science*, Leuven 1, pp. 375–382.

Chand, S. and Kumar Sahrawat, A. (2001). Stimulatory Effect of Partial Desiccation on Plant Regeneration in Indica Rice (*Oryza sativa* L). *Journal of Plant Biochemistry and Biotechnology*, 10(1), pp43-47.

Chauhan, B.S. and Singh, K. (2016). Weedy Rice: An Emerging Threat for Direct-seeded Rice Production Systems in India. *Rice Research: Open Access*, 4(1), pp.1–6.

Chen, R., Shen, L.-P., Wang, D.-H., Wang, F.-G., Zeng, H.-Y., Chen, Z.-S., Peng, Y.-B., Lin, Y.-N., Tang, X., Deng, M.-H., Yao, N., Luo, J.-C., Xu and Z.-H., Bai, S.-N. (2015). A Gene Expression Profiling of Early Rice Stamen Development That Reveals Inhibition of Photosynthetic Genes by OSMADAS58. *Molecular Plant*, 8(7), pp.1069–1089.

Chu, C.C., Wang, C.C., Sun, C.S., Hsu, C., Yin, K.C., Chu, C.Y. and Pi, F.Y. (1975). Establishment of an Efficient Medium for Anther Culture of Rice Through Comparative Experiments on the Nitrogen Sources. *Scientia Sinica*, 18(5), pp.659–668.

Datta, S.K. (2004). Rice Biotechnology: A Need for Developing Countries. Food and Agriculture Organization, Rome, Italy.

Delporte, F., Pretova, A., Jardin, P. du and Watillon, B. (2014). Morpho-Histology and Genotype Dependence of in Vitro Morphogenesis in Mature Embryo Cultures of Wheat. *Protoplasma*, 251(6), pp.1455–1470.

Dewi, I., Purwoko, B., Aswidinnoor, H., Somantri, I., Chozin, M. (2009). Plant Regeneration from Anther Cultures of Several Genotypes of Indica Rice Tolerant to Aluminium Toxicity. *Indian Journal of Agricultural Science*, 2, pp.1–5.

Diaguna, R., Suwarno, F.C. and Surahman, M. (2017). Testing Method for Salinity Tolerance at Germination Stage on Rice Genotypes. *International Journal of Applied Science and Technology*, 7(3), p.8.

Dievart, A., Perin, C., Hirsch, J., Bettembourg, M., Lanau, N., Artus, F., Bureau, C., Noel, N., Droc, G., Peyramard, M., Pereira, S., Courtois, B., Morel, J.-B. and Guiderdoni, E. (2016). The Phenome Analysis of Mutant Alleles in Leucine-Rich Repeat Receptor-Like Kinase Genes in Rice Reveals New Potential Targets for Stress Tolerant Cereals. *Plant Science*, 242, pp.240–249.

Elhiti, M., Stasolla, C. and Wang, A. (2013). Molecular Regulation of Plant Somatic Embryogenesis. *In Vitro Cellular & Developmental Biology-Plant*, 49(6), pp.631–642.

Fageria, N.K. and Baligar, V.C. (2003). Methodology for Evaluation of Lowland Rice Genotypes for Nitrogen Use Efficiency. *Journal of Plant Nutrition*, 26(6), pp.1315–1333.

Fahliani, R.A., Khodambashi, M., Houshmand, S. and Arzani, A. (2010). Estimation of the Heritability of Agro-Morphological Traits in Rice (*Oryza sativa* L.) Using F2:3 Families. *African Journal of Agricultural Research*, 5(11), pp.1297–1303.

Fang, C., Xu, T., Ye, C., Huang, L., Wang, Q. and Lin, W. (2014). Method for RNA Extraction and cDNA Library Construction from Microbes in Crop Rhizosphere Soil. *World Journal of Microbiology & Biotechnology*, 30(2), pp.783–789.

FAO (2015). *FAOSTAT*. Food and Agriculture Organization, Rome, Italy.

FAO Statistics Division (2017). *FAOSTAT*, Food and Agriculture Organization, Rome, Italy.

Fu, X., Yang, S. and Bao, M. (2008). Factors Affecting Somatic Embryogenesis in Anther Cultures of Chinese Pink (Dianthus chinensis). *In Vitro Cellular & Developmental Biology - Plant*, 44(3), pp.194–202.

Gamborg, O.L., Miller, R.A. and Ojima, K. (1968). Nutrient Requirements of Suspension Cultures of Soybean Root Cells. *Experimental Cell Research*, 50(1), pp.151–158.

Ge, X.J., Chu, Z.H., Lin, Y.J. and Wang, S.P. (2006). A Tissue Culture System for Different Germplasms of *indica* Rice. *Plant Cell Reports*, 25(5), pp.392–402.

Ghobeishavi, H., Uliaie, E.D., Alavikia, S.S. and Valizadeh, M. (2014). The Effect of Plant Growth Regulators on Embryogenic Callus Induction and Regeneration from Coleoptile in Rice. *International Journal of Bioscience*, 5(2), pp.144–150.

Gonzalez, M.W. and Pearson, W.R. (2010). Homologous over-extension: a challenge for iterative similarity searches. *Nucleic Acids Research*, 38(7), pp.2177–2189.

Gosal, S.S. and Kang, M.S. (2012). Plant Tissue Culture and Genetic Transformation for Crop Improvement. In: Tuteja, N., Gill, S.S., Tiburcio, A.F. and Tuteja, R., (eds.) *Improving Crop Resistance to Abiotic Stress*. Wiley-VCH Verlag GmbH & Co. KGaA, pp. 357–397.

Hanafi, M., Hartinie, A., Shukor, J. and Mohamed, M. (2009). Upland Rice Varieties in Malaysia: Agronomic and Soil Physico-Chemical Characteristics. *Pertanika Journal of Tropical Agricultural Science*, 32, pp.1511–3701.

Haq, I.-U., Chang-Xing, Z., Mukhtar, Z., Jaleel, C.A. and Azooz, M.M. (2009). Effect of Physical Desiccation on Plant Regeneration Efficiency in Rice (*Oryza sativa* L.) Variety Super Basmati. *Journal of Plant Physiology*, 166(14), pp.1568–1575.

Haque, M., Islam, S.M.S. and Subramaniam, S. (2017). Effects of Salt and Heat Pre-Treatment Factors on Efficient Regeneration in Barley (*Hordeum vulgare* L.). *3 Biotech*, 7(1), p.63.

Harun, R. (2017). *Policies and Economic Development of Rice Production in Malaysia*. Economic and Technology Management Research Centre, MARDI. FFTC Agricultural Policy Platform, MARDI-UPM, Selangor, Malaysia.

Hecht, V., Vielle-Calzada, J.-P., Hartog, M.V., Schmidt, E.D.L., Boutilier, K., Grossniklaus, U. and de Vries, S.C. (2001). The *Arabidopsis* Somatic Embryogenesis Receptor Kinase 1 Gene Is Expressed in Developing Ovules and Embryos and Enhances Embryogenic Competence in Culture. *Plant Physiology*, 127(3), pp.803–816.

Hegazi, E.S.S., Atif, A.M.A.A. and Abd Elraof, O.A. (2017). Effect of Growth Regulators on Callus Induction and Somatic Embryogenesis in Olive. *Research Journal of Pharmaceutical Biological and Chemical Sciences*, 8(4), pp.274–280.

Hiei, Y. and Komari, T. (2008). Agrobacterium-Mediated Transformation of Rice Using Immature Embryos or Calli Induced from Mature Seed. *Nature Protocols*, 3(5), pp.824–834.

Hirano, M., Sato, N. and Abe, K. (1999). Characterization of *Ribes rubrum* Callus Cultured under Low Temperature. *Journal of Bioscience and Bioengineering*, 88(4), pp.416–420.

Hoang, T.M.L., Tran, T.N., Nguyen, T.K.T., Williams, B., Wurm, P., Bellairs, S. and Mundree, S. (2016). Improvement of Salinity Stress Tolerance in Rice: Challenges and Opportunities. *Agronomy*, 6(4), p.54.

Hooghvorst, I., Ramos-Fuentes, E., López-Cristofannini, C., Ortega, M., Vidal, R., Serrat, X. and Nogués, S. (2018). Antimitotic and Hormone Effects on Green Double Haploid Plant Production Through Anther Culture of Mediterranean Japonica Rice. *Plant Cell, Tissue and Organ Culture*, 134(2), pp.205–215.

Hoque, M.E. and Mansfield, J.W. (2004). Effect of Genotype and Explant Age on Callus Induction and Subsequent Plant Regeneration from Root-derived Callus of *indica* Rice Genotypes. *Plant Cell, Tissue and Organ Culture*, 78(3), pp.217–223.

Hou, P., Xie, Z., Zhang, L., Song, Z., Mi, J., He, Y. and Li, Y. (2011). Comparison of Three Different Methods for Total RNA Extraction from Fritillaria Unibracteata: A Rare Chinese Medicinal Plant. *Journal of Medicinal Plants Research*, 5(13), pp.2834–2838.

Htwe, N.N., Maziah, M., Ling, H.C., Zaman, F.Q. and Zain, A.M. (2011). Responses of Some Selected Malaysian Rice Genotypes to Callus Induction Under *in vitro* Salt Stress. *African Journal of Biotechnology*, 10(3), pp.350–362.

Hu, H., Xiong, L. and Yang, Y. (2005). Rice SERK1 Gene Positively Regulates Somatic Embryogenesis of Cultured Cell and Host Defense Response Against Fungal Infection. *Planta*, 222(1), pp.107–117.

Huang, S., Hill, R.D., Wally, O.S.D., Dionisio, G., Ayele, B.T., Jami, S.K. and Stasolla, C. (2014). Hemoglobin Control of Cell Survival/Death Decision Regulates in Vitro Plant Embryogenesis. *Plant Physiology*, 165(2), pp.810–825.

Huang, X., Lu, X.-Y., Zhao, J.-T., Chen, J.-K., Dai, X.-M., Xiao, W., Chen, Y.-P., Chen, Y.-F. and Huang, X.-L. (2010). MaSERK1 Gene Expression Associated with Somatic Embryogenic Competence and Disease Resistance Response in Banana (*Musa* spp.). *Plant Molecular Biology Reporter*, 28(2), pp.309–316.

Ibrahim, M.B., Juraimi, A.S., Hakim, M.A., Aslani, F., Karim, S.M.R. and Alam, M.A. (2017). Residual Effect of Imidazolinone Herbicide Used in Clearfield Rice. *Bangladesh Journal of Botany*, 46(1), pp.335–341.

Ikeuchi, M., Sugimoto, K. and Iwase, A. (2013). Plant Callus: Mechanisms of Induction and Repression. *The Plant Cell*, 25(9), pp.3159–3173.

Ismail, M., Suroto, A. and Abdullah, S. (2015). Response of Malaysian Local Rice Cultivars Induced by Elevated Ozone Stress. *Environment Asia*, 8(1), pp.86–93.

Ito, Y., Eiguchi, M. and Kurata, N. (1999). Expression of Novel Homeobox Genes in Early Embryogenesis in Rice1. *Biochimica et Biophysica Acta (BBA) - Gene Structure and Expression*, 1444(3), pp.445–450.

Ito, Y., Takaya, K. and Kurata, N. (2005). Expression of SERK Family Receptor-Like Protein Kinase Genes in Rice. *Biochimica et Biophysica Acta (BBA) - Gene Structure and Expression*, 1730(3), pp.253–258.

Jaligot, E., Hooi, W.Y., Debladis, E., Richaud, F., Beule, T., Collin, M., Agbessi, M.D.T., Sabot, F., Garsmeur, O., D'Hont, A., Alwee, S.S.R.S. and Rival, A. (2014). DNA methylation and expression of the egdef1 gene and neighboring retrotransposons in mantled somaclonal variants of oil palm. *Plos One*, 9(3), p.e91896.

Jun-jie, Z., Yue-sheng, Y., Meng-fei, L., Shu-qi, L., Yi, T., Han-bin, C. and Xiao-yang, C. (2017). An Efficient Micropropagation Protocol for Direct Organogenesis from Leaf Explants of an Economically Valuable Plant, Drumstick (*Moringa oleifera* Lam.). *Industrial Crops and Products*, 103, pp.59–63.

Juturu, V.N., Mekala, G.K., Garladinne, M., Reddy, P.C.O. and Sekhar, A.C. (2016). Optimization of in Vitro Regeneration Protocol for a Popular Indica Rice (*Oryza sativa* L. Cv Swarna). *Annals of Plant Sciences*, 5(08), pp.1395–1401.

K Rai, M., Shekhawat, N., Harish, Gupta, A., M, P., Ram, K. and Jaiswal, U. (2011). The role of abscisic acid in plant tissue culture – a review of recent progress. *Plant Cell Tissue and Organ Culture*, 106, pp.179–190.

Kadhimi, A.A., Zain, C.R.C.M., Alhasnawi, A.N., Isahak, A., Ashraf, M.F., Mohamad, A., Doni, F., Yusoff, W.M.W., Ibrahim, K., Badri, K.H., Jumali, M.H.H., Noorani, M.S.M., Ibrahim, N., Rasol, N.H.A., Yaacob, W.Z.W. (2016). Impact of Gamma Rays Exposure and Growth Regulators on *Oryza sativa* L. c.v MR269 Callus Induction. *AIP Conference Proceedings*, 1784(1), p.020006.

Kalhori, N., Nulit, R., Go, R., Zulkifly, S., Azizi, P. and Abiri, R. (2017). Selection, Characterizations and Somatic Embryogenesis of Malaysian Salt-Tolerant Rice (*Oryza sativa* cv. MR219) Through Callogenesis. *International Journal of Agriculture and Biology*, 19(01), pp.157–163.

Karami, O., Aghavaisi, B. and Mahmoudi Pour, A. (2009). Molecular Aspects of Somatic-to-Embryogenic Transition in Plants. *Journal of Chemical Biology*, 2(4), pp.177–190.

Karlova, R., Boeren, S., van Dongen, W., Kwaaitaal, M., Aker, J. and Vervoort, J., de Vries, S. (2009). Identification of in Vitro Phosphorylation Sites in the *Arabidopsis* Thaliana Somatic Embryogenesis Receptor-Like Kinases. *Proteomics*, 9(2), pp.368–379.

Kevin, M.T.S., Ahmed, O.H., Asrina, W.Y.W., Rajan, A. and Ahzam, M. (2007). Towards Growing Bario Rice on Lowland Soils: A Preliminary Nitrogen and Potassium Fertilization Trial. *American Journal of Agricultural and Biological Sciences*, 2(2), pp.99–105.

Khaleda, L. and Al-Forkan, M. (2006). Genotypic Variability in Callus Induction and Plant Regeneration Through Somatic Embryogenesis of Five Deepwater Rice (*Oryza sativa* L.) Cultivars of Bangladesh. *African Journal of Biotechnology*, 5(16).

Khatun, R., Islam, S.M.S., Ara, I., Tuteja, N. and Bari, M.A. (2012). Effect of Cold Pretreatment and Different Media in Improving Anther Culture Response in Rice (*Oryza sativa* L.) in Bangladesh. *Indian Journal Biotechnology*, p.6.

Khush, G.S. (2005). What It Will Take to Feed 5.0 Billion Rice Consumers in 2030. *Plant Molecular Biology*, 59(1), pp.1–6.

Kiviharju, E. and Pehu, E. (1998). The Effect of Cold and Heat Pretreatments on Anther Culture Response of *Avena Sativa* and A. Sterilis. *Plant Cell, Tissue and Organ Culture*, 54(2), pp.97–104.

Kırdök, E., Ekinci, H. and Çiftçi, Y.Ö. (2016). Cryopreservation of Somatic Embryos of Ornamental Plants. In: Mujib, A., (ed.) *Somatic Embryogenesis in Ornamentals and Its Applications*. Springer India, New Delhi, pp. 121–139.

Koleva-Gudeva, L.R., Spasenoski, M. and Trajkova, F. (2007). Somatic Embryogenesis in Pepper Anther Culture: The Effect of Incubation Treatments and Different Media. *Scientia Horticulturae*, 111(2), pp.114–119.

Körbes, A.P. and Droste, A. (2005). Carbon Sources and Polyethylene Glycol on Soybean Somatic Embryo Conversion. *Pesquisa Agropecuária Brasileira*, 40(3), pp.211–216.

Kumar, A., Sood, A., Palni, L.M.S. and Gupta, A.K. (2015). *In Vitro* Propagation of Gladiolus Hybridus Hort.: Synergistic Effect of Heat Shock and Sucrose on Morphogenesis. *Plant Cell, Tissue and Organ Culture*, 57(2), pp.105–112.

Kumar, G.P., Subiramani, S., Govindarajan, S., Sadasivam, V., Manickam, V., Mogilicherla, K., Thiruppathi, S.K. and Narayanasamy, J. (2015). Evaluation of Different Carbon Sources for High Frequency Callus Culture with Reduced Phenolic Secretion in Cotton (*Gossypium hirsutum* L.) Cv. Svpr-2. *Biotechnology Reports*, 7, pp.72–80.

Kumar, S. (2017). Phytochemistry and Functional Food: The Needs of Healthy Life. *Journal of Phytochemistry and Biochemistry 2017*, 1(1), p.3.

Kumar, S., Singh, R., Kalia, S., Sharma, S.K. and Kalia, A.K. (2016). Recent Advances in Understanding the Role of Growth Regulators in Plant Growth and Development *in vitro* -I. Conventional Growth Regulators. *Indian Forester*, 142(5), pp.459–470.

Kumar, S., Arul, L. and Talwar, D. (2010). Generation of Marker-Free Bt Transgenic Indica Rice and Evaluation of Its Yellow Stem Borer Resistance. *Journal of Applied Genetics*, 51(3), pp.243–257.

Kumar, S.M. and Nandi, S.C. (2015). High Frequency Plant Regeneration with Histological Analysis of Organogenic Callus from Internode Explants of Asteracantha Longifolia Nees. *Journal of Genetic Engineering and Biotechnology*, 13(1), pp.31–37.

Kumlay, A.M. and Ercisli, S. (2015). Callus Induction, Shoot Proliferation and Root Regeneration of Potato (*Solanum tuberosum* L.) Stem Node and Leaf Explants Under Long-Day Conditions. *Biotechnology & Biotechnological Equipment*, 29(6), pp.1075–1084.

Latiff, N.A., Alam, S.A.Z., Hanapi, S.Z., Supari, N., Javed, M.A., Tin, L.C. and Sarmidi, M.R. (2017). Evaluation of Antioxidant Activity and Total Polyphenols Content on Upland Rice. *Journal of Natural Product and Plant Resources*, 7(2), pp.1–6.

Lau, A., Siedlecki, J., Anleitner, J., Patterson, G., Caplan, F. and Moore, R. (1993). Inhibition of Reverse-Transcriptase Activity by Extracts of Cultured Blue-Green-Algae (*Cyanophyta*). *Planta Medica*, 59(2), pp.148–151.

Lee, S.-T. and Huang, W.-L. (2013a). Cytokinin, Auxin, and Abscisic Acid Affects Sucrose Metabolism Conduce to De Novo Shoot Organogenesis in Rice (*Oryza sativa* L.) Callus. *Botanical Studies*, 54.

Lee, S.-T. and Huang, W.-L. (2013b). Osmotic Stress Stimulates Shoot Organogenesis in Callus of Rice (*Oryza sativa* L.) Via Auxin Signaling and Carbohydrate Metabolism Regulation. *Plant Growth Regulation*, 73(2), pp.193–204.

Li, Y., Li, Q., Guo, G., He, T., Gao, R., Faheem, M., Huang, J., Lu, R., Liu, C., Li, Y., Li, Q., Guo, G., He, T., Gao, R., Faheem, M., Huang, J., Lu, R. and Liu, C. (2018). Transient Overexpression of HvSERK2 Improves Barley Resistance to Powdery Mildew. *International Journal of Molecular Sciences*, 19(4), p.1226.

Libin, A., King, P.J.H., Ong, K.H., Chubo, J.K., Sipen, P. (2012). Callus Induction and Plant Regeneration of Sarawak Rice (*Oryza sativa* L.) Variety Biris. *African Journal of Agricultural Research*, 7(30), pp.4260–4265.

Lin, Y., Zhao, Z., Zhou, S., Liu, L., Kong, W., Chen, H., Long, W., Feng, Z., Jiang and L., Wan, J. (2017). Top Bending Panicle1 Is Involved in Brassinosteroid Signaling and Regulates the Plant Architecture in Rice. *Plant Physiology and Biochemistry*, 121, pp.1–13.

Linsmaier, E.M. and Skoog, F. (1965). Organic Growth Factor Requirements of Tobacco Tissue Cultures. *Physiologia Plantarum*, 18(1), pp.100–127.

Liu, B., Su, S., Wu, Y., Li, Y., Shan, X., Li, S., Liu, H., Dong, H., Ding, M., Han, J. and Yuan, Y. (2015). Histological and Transcript Analyses of Intact Somatic Embryos in an Elite Maize (*Zea mays* L.) Inbred Line Y423. *Plant Physiology and Biochemistry*, 92, pp.81–91.

Liu, Y.M., Diao, F.Q., Zhang, L., Huang, M.J. and Wu, N.H. (2005). Cloning and characterization of DcLEA1, a new member of carrot LEA gene family. *Progress in Natural Science*, 15(3), pp.220–228.

Livak, K.J. and Schmittgen, T.D. (2001). Analysis of Relative Gene Expression Data Using Real-Time Quantitative PCR and the 2(-Delta Delta C(t)) Method. *Methods (San Diego, Calif.)*, 25(4), pp.402–408.

Londo, J.P., Chiang, Y.-C., Hung, K.-H., Chiang, T.-Y. and Schaal, B.A. (2006). Phylogeography of Asian Wild Rice, *Oryza Rufipogon*, Reveals Multiple Independent Domestications of Cultivated Rice, *Oryza sativa*. *Proceedings of the National Academy of Sciences*, 103(25), pp.9578–9583.

Lu, B.-R., Cai, X. and Xin, J. (2009). Efficient Indica and Japonica Rice Identification Based on the Indel Molecular Method: Its Implication in Rice Breeding and Evolutionary Research. *Progress in Natural Science*, 19(10), pp.1241–1252.

Ma, J., He, Y., Hu, Z., Xu, W., Xia, J., Guo, C., Lin, S., Cao, L., Chen, C., Wu, C. and Zhang, J. (2012). Characterization and Expression Analysis of AcSERK2, a Somatic Embryogenesis and Stress Resistance Related Gene in Pineapple. *Gene*, 500(1), pp.115–123.

Maeda, E. and Radi, S.H. (1991). Ultrastructural Aspects of Rice Scutellum as Related to Seminal Root Cultures. In: Bajaj, P.D.Y.P.S., (ed.) *Rice*. Biotechnology in Agriculture and Forestry. *Springer Berlin Heidelberg*, pp. 78–91.

Mahmod, I.F., Barakbah, S.S., Osman, N. and Omar, O. (2014). Physiological Response of Local Rice Varieties to Aerobic Condition. *International Journal of Agricultural Biology*, 16(4), pp.7-17.

Makerly, H., Rahmat, Z. and Wagiran, A. (2012). Potential Use of Partial Desiccation Treatment for Regeneration System of Malaysian Indica Rice (*Oryza sativa* L.). *Jurnal Teknologi (Sciences and Engineering)*, 59, pp.97–100.

MANCHID. (2015), *Malaysian National Committee on Irrigation and Drinage* [Online]. Available at: http://www.mancid.org.my/ [Accessed: 7 July 2018].

Meneses, A., Flores, D., Munoz, M., Arrieta, G. and Espinoza, A.M. (2005). Effect of 2,4-D, Hydric Stress and Light on *Indica* Rice (*Oryza sativa*) Somatic Embryogenesis. *Revista De Biologia Tropical*, 53(3–4), pp.361–368.

Meng, X., Chen, X., Mang, H., Liu, C., Yu, X., Gao, X., Torii, K.U., He, P. and Shan, L. (2015). Differential Function of *Arabidopsis* SERK Family Receptor-Like Kinases in Stomatal Patterning. *Current Biology*, 25(18), pp.2361–2372.

Mohd Din, A.R.J., Iliyas Ahmad, F., Wagiran, A., Abd Samad, A., Rahmat, Z. and Sarmidi, M.R. (2016). Improvement of Efficient in Vitro Regeneration Potential of Mature Callus Induced from Malaysian Upland Rice Seed (*Oryza sativa* Cv. Panderas). *Saudi Journal of Biological Sciences*, 23(1, Supplement), pp.69–S77.

Morcillo, F., Gallard, A., Pillot, M., Jouannic, S., Aberlenc-Bertossi, F., Collin, M., Verdeil, J.L. and Tregear, J.W. (2007). EgAP2-1, an AINTEGUMENTA-like (AIL) Gene Expressed in Meristematic and Proliferating Tissues of Embryos in Oil Palm. *Planta*, 226(6), pp.1353–1362.

Mornkham, T., Wangsomnuk, P.P., Fu, Y.-B., Wangsomnuk, P., Jogloy, S. and Patanothai, A. (2013). Extractions of High Quality Rna from the Seeds of Jerusalem Artichoke and Other Plant Species with High Levels of Starch and Lipid. *Plants* , 2(2), pp.302–316.

Mujib, A., Ali, M., Tonk, D., Isah, T. and Zafar, N. (2016). Embryogenesis in Ornamental Monocots: Plant Growth Regulators as Signalling Element. In: Mujib, A., (ed.) *Somatic Embryogenesis in Ornamentals and Its Applications*. Springer India, New Delhi, pp. 187–201.

Murashige, T. and Skoog, F. (1962). A Revised Medium for Rapid Growth and Bio Assays with Tobacco Tissue Cultures. *Physiologia Plantarum*, 15(3), pp.473–497.

Naeg, D. (2012). *Bario Rice – a Rare Grain* [Online]. Available at: http://www.theborneopost.com/2012/01/29/bario-rice-a-rare-grain/ [Accessed: 9 May 2017].

Naik, N., Rout, P., Umakanta, N., Verma, R.L., Katara, J.L., Sahoo, K.K. and Singh, O.N., Samantaray, S. (2017). Development of Doubled Haploids from an Elite *indica* Rice Hybrid (BS6444G) Using Anther Culture. *Plant Cell, Tissue and Organ Culture* , 128(3), pp.679–689.

Naqvi, S.M.S., Sultana, R. and Rasheed, H. (2005). Tissue Culture Studies in Oryza sativa L. cvs. Basmati 385 and Super Basmati. *Pakistan Journal of Biotechnology*, 37(4), pp.823–828.

Narciso, J.O. and Hattori, K. (2010). Genotypic Differences in Morphology and Ultrastructures of Callus Derived from Selected Rice Varieties. *Phillippine Science Letters*, p.7.

Naz, S., Siddiqui, Mum.F.F. and Raza, S. (2018). Effect of Different Growth Regulators on in Vitro Propagation of *Brassica Napus* L. *African Journal of Biotechnology*, 50(5), pp.1871–1876.

Nazuri, N.S. and Man, N. (2016). Acceptance and Practices on New Paddy Seed Variety Among Farmers in MADA Granary Area. *Academic Journal of Interdisciplinary Studies*, 5(2), p.105.

Nic-Can, G.I. and Loyola-Vargas, V.M. (2016). The Role of the Auxins During Somatic Embryogenesis. In: *Somatic Embryogenesis: Fundamental Aspects and Applications*. *Chemistry*, pp. 171–182.

Nicholas, D., Hazila, K.K., Chua, H.P. and Rosniyana, A. (2014). Nutritional Value and Glycemic Index of Bario Rice Varieties. *Journal of Tropical Agriculture and Food Science*, 42(1), pp.1–8.

Nishi, T., Yamada, Y. and Takahashi, E. (1968). Organ Redifferentiation and Plant Restoration in Rice Callus. *Nature*, 219(5153), pp.508–509.

Nolan, K.E., Irwanto, R.R. and Rose, R.J. (2003). Auxin up-Regulates MtSERK1 Expression in Both Medicago Truncatula Root-Forming and Embryogenic Cultures. *Plant Physiology*, 133(1), pp.218–230.

Nolan, K.E., Kurdyukov, S. and Rose, R.J. (2009). Expression of the Somatic Embryogenesis Receptor-Like Kinase1 (SERK1) Gene Is Associated with Developmental Change in the Life Cycle of the Model Legume Medicago Truncatula. *Journal of Experimental Botany*, 60(6), pp.1759–1771.

De Oliveira Santos, M. (2005). Characterisation of the Cacao Somatic Embryogenesis Receptor-Like Kinase (SERK) Gene Expressed During Somatic Embryogenesis. *Plant Science*, 168(3), pp.723–729.

Pandey, D.K. and Chaudhary, B. (2014). Role of Plant Somatic Embryogenesis Receptor Kinases (SERKs) in Cell-to-Embryo Transitional Activity: Key at Novel Assorted Structural Subunits. *American Journal of Plant Sciences*, 05(21), pp.3177–3193.

Panjaitan, S.B., Abdullah, S.N.A., Aziz, M.A., Meon, S., Omar, O. (2009). Somatic Embryogenesis from Scutellar Embryo of *Oryza sativa* L. Var. MR219. P*ertanika Journal of Tropical Agricultural Science*, 32(2), p.185-194.

Park, H.S., Ryu, H.Y., Kim, B.H., Kim, S.Y., Yoon, I.S. and Nam, K.H. (2011). A Subset of Osserk Genes, Including OsBAKI1, Affects Normal Growth and Leaf Development of Rice. *Molecules and Cells*, 32(6), pp.561–569.

Pearson, W.R. (2013). An Introduction to Sequence Similarity ("Homology") Searching. *Current protocols in bioinformatics / editoral board, Andreas D. Baxevanis.*

Pereira, W.J., Bassinello, P.Z., Brondani, C., Vianello, R.P., Pereira, W.J., Bassinello, P.Z., Brondani, C. and Vianello, R.P. (2017). An Improved Method for Rna Extraction from Common Bean Seeds and Validation of Reference Genes for Qpcr. *Crop Breeding and Applied Biotechnology*, 17(2), pp.150–158.

Perez-Nunez, M.T., Souza, R., Saenz, L., Chan, J.L., Zuniga-Aguilar, J.J. and Oropeza, C. (2009). Detection of a SERK-Like Gene in Coconut and Analysis of Its Expression During the Formation of Embryogenic Callus and Somatic Embryos. *Plant Cell Reports*, 28(1), pp.11–19.

Pilarska, M., Popielarska-Konieczna, M., Slesak, H., Kozieradzka-Kiszkurno, M., Góralski, G., Konieczny, R., Bohdanowicz, J. and Kuta, E. (2014). Extracellular Matrix Surface Network Is Associated with Non-Morphogenic Calli of Helianthus Tuberosus Cv. Albik Produced from Various Explants. *Acta Societatis Botanicorum Poloniae*, 83, pp.67–73.

Podio, M., Felitti, S.A., Siena, L.A., Delgado, L., Mancini, M., Seijo, J.G., González, A.M., Pessino, S.C., Ortiz, J.P.A. (2014). Characterization and Expression Analysis of Somatic Embryogenesis Receptor Kinase (SERK) Genes in Sexual and Apomictic Paspalum notatum. *Plant Molecular Biology*, 84(4–5), pp.479–495.

Popielarska-Konieczna, M., Ślesak, H. and Góralski, G. (2006). Histological and Sem Studies on Organogenesis in Endosperm-Derived Callus of Kiwifruit (*Actinidia deliciosa* Cv. Hayward). *Acta biologica Cracoviensia. Series botanica*, 48(2), pp.97–104.

Raemakers, C.J.J.M., Jacobsen, E. and Visser, R.G.F. (1995). Secondary Somatic Embryogenesis and Applications in Plant Breeding. *Euphytica*, 81(1), pp.93–107.

Rahman, Z.A., Roowi, S. and Subramaniam, W.Z.W.S. and Sreeraramanan (2010). Regeneration of Malaysian Indica Rice (*Oryza sativa*) Variety MR232 Via Optimised Somatic Embryogenesis System. *Journal of Phytology*, 2(3), pp.30–38.

Rajamoorthy, Y., Rahim, K. b A. and Munusamy, S. (2015). Rice Industry in Malaysia: Challenges, Policies and Implications. *Procedia Economics and Finance*, 31, pp.861–867.

Reddy, B., Karmakar, J., Roychowdhury, R. and Dey, N. (2013). Optimization of Callus Induction and Callus Multiplication in Rice (*Oryza sativa* L.) Landraces. *Research in Plant Biology*, 3, pp.41–44.

Reddy, V.S., Leelavathi, S. and Sen, S.K. (1985). Influence of Genotype and Culture Medium on Microspore Callus Induction and Green Plant Regeneration in Anthers of *Oryza sativa*. *Physiologia Plantarum*, 63(3), pp.309–314.

Reis, R.S., Vale, E. de M., Heringer, A.S., Santa-Catarina, C. and Silveira, V. (2016). Putrescine Induces Somatic Embryo Development and Proteomic Changes in Embryogenic Callus of Sugarcane. *Journal of Proteomics*, 130(2), pp.170–179.

Rekik, I., Elleuch, A., Kriaa, W. and Drira, N. (2013). Molecular Cloning and in Silico Analysis of Three Somatic Embryogenesis Receptor Kinase mRNA from Date Palm. *Genetika*, 45(3), pp.837–853.

Repalli, S.K., Geda, C.K., Nsn, P. and Gjn, R. (2017). Regeneration Enhancement in Tissue Culture of Indica Rice's through Partial Desiccation and Chemical Supplements. *Journal of Plant Biochemistry & Physiology*, 5(03)pp 229-238.

Rocha, D.I. (2015). Cellular and Molecular Changes Associated with Competence Acquisition During Passion Fruit Somatic Embryogenesis: Ultrastructural Characterization and Analysis of Serk Gene Expression. *Protoplasma*, 253(2), pp.595–609.

Roly, Z.Y., Islam, M.M., Shaekh, M.P.E., Arman, M.S.I., Shahik, S.M., Das, D., Haamem, M.M.E. and Khalekuzzaman, D.M. (2014). In Vitro Callus Induction and Regeneration Potentiality of Aromatic Rice (*Oryza sativa* L.) Cultivars in Differential Growth Regulators. *International Journal of Applied Sciences and Biotechnology*, 2(2), pp.160–167.

Rossin, C.B. and Rey, M.E.C. (2011). Effect of Explant Source and Auxins on Somatic Embryogenesis of Selected Cassava (*Manihot esculenta* crantz) Cultivars. *South African Journal of Botany*, 77(1), pp.59–65.

Rueb, S., Leneman, M., Schilperoort, R.A. and Hensgens, L. A. M. (1994). Efficient Plant Regeneration Through Somatic Embryogenesis from Callus Induced on Mature Rice Embryos (*Oryza sativa* L.). *Plant Cell, Tissue and Organ Culture*, 36(2), pp.259–264.

Sabana, A.A., Antony, G., Rahul, C.U. and Rajesh, M.K. (2018). In silico identification of micro RNAs and their targets associated with coconut embryogenic calli. *Agri Gene*, 7, pp.59–65.

Sah, S.K., Kaur, A. and Sandhu, J.S. (2014). High Frequency Embryogenic Callus Induction and Whole Plant Regeneration in Japonica Rice Cv. Kitaake. *Rice Research, 2(125)*pp*1*75-180.

Sah, S.K., Kaur, G. and Kaur, A. (2014). Rapid and Reliable Method of High-Quality Rna Extraction from Diverse Plants. *American Journal of Plant Sciences*, 05(21), pp.3129–3139.

Sahoo, K.K., Tripathi, A.K., Pareek, A., Sopory, S.K. and Singla-Pareek, S.L. (2011). An Improved Protocol for Efficient Transformation and Regeneration of Diverse *Indica* Rice Cultivars. *Plant Methods*, 7, p.49.

Saito, K., Asai, H., Zhao, D., Laborte, A.G. and Grenier, C. (2018). Progress in Varietal Improvement for Increasing Upland Rice Productivity in the Tropics. *Plant Production Science*, 21(3), pp.145–158.

Salaj, J., von Recklinghausen, I.R., Hecht, V., de Vries, S.C., Schel, J.H.N. and van Lammeren, A.A.M. (2008). AtSERK1 Expression Precedes and Coincides with Early Somatic Embryogenesis in *Arabidopsis Thaliana*. *Plant Physiology and Biochemistry*, 46(7), pp.709–714.

Sandhu, N. and Kumar, A. (2017). Bridging the Rice Yield Gaps Under Drought: Qtls, Genes, and Their Use in Breeding Programs. *Agronomy*, 7(2), p.27.

Sankepally, S.S.R. and Singh, B. (2016). Optimization of Regeneration Using Differential Growth Regulators in *indica* Rice Cultivars. *3 Biotech*, 6(1), p.19.

Sawardekar, S. (2018). Effect of Acetosyringone and Age of Callus on Agrobacterium- Mediated Transformation of Rice (*Oryza sativa* L.) Calli. , 6(3), pp.82–88.

Schmidt, E.D.L., Guzzo, F., Toonen, M. a. J. and deVries, S.C. (1997). A Leucine-Rich Repeat Containing Receptor-Like Kinase Marks Somatic Plant Cells Competent to Form Embryos. *Development*, 124(10), pp.2049–2062.

Schwessinger, B. and Rathjen, J.P. (2015). Changing SERKs and Priorities During Plant Life. *Trends in Plant Science*, 20(9), pp.531–533.

Seldimirova, O.A., Titova, G.E. and Kruglova, N.N. (2016). A Complex Morpho-Histological Approach to the in Vitro Study of Morphogenic Structures in a Wheat Anther Culture. *Biology Bulletin*, 43(2), pp.121–126.

Shabery, A. (2017). *Rice production at 72% of self-sufficiency level: Ahmad Shabery* [Online]. Available at: http://www.thesundaily.my/news/2017/09/26/rice-production-72-self-sufficiency-level-ahmad-shabery.

Shahsavari, E. (2010). Evaluation and Optimizations of Media on the Tissue Culture System of Upland Rice. *Intenational Journal of Agricultural Biollogy*, 12(4), pp.5-15.

Shahsavari, E., Maheran, A.A., M. M. Hanafi and Akmar, S.N. (2010). The Effect of Plant Growth Regulators on Optimization of Tissue Culture System in Malaysian Upland Rice. *African Journal of Biotechnology*, 9(14), pp.2089–2094.

Shanthi, P., Jebaraj, S., Geetha, S. and Aananthi, N. (2010). Effect of Growth Regulators on Callus Induction in Rice Embryo Culture. *Electronic Journal of Plant Breeding*, 1(4), pp.1200–1207.

Shen, H.S., Sundstøl, F., Eng, E.R. and Eik, L.O. (1999). Studies on Untreated and Urea-Treated Rice Straw from Three Cultivation Seasons: 3. Histological Investigations by Light and Scanning Electron Microscopy. *Animal Feed Science and Technology*, 80(2), pp.151–159.

Shimada, T., Hirabayashi, T., Endo, T., Fujii, H., Kita, M. and Omura, M. (2005). Isolation and Characterization of the Somatic Embryogenesis Receptor-Like Kinase Gene Homologue (CitSERK1) from *Citrus unshiu* Marc. *Scientia Horticulturae*, 103(2), pp.233–238.

Shu, C., Sun, S., Chen, Jieling, Chen, J. and Zhou, E. (2014). Comparison of Different Methods for Total RNA Extraction from Sclerotia of *Rhizoctonia Solani*. *Electronic Journal of Biotechnology*, 17(1), pp.50–54.

Siddique, A.B., Ara, I., Islam, S.M.S. and Tuteja, N. (2014). Effect of Air Desiccation and Salt Stress Factors on *in vitro* Regeneration of Rice (*Oryza sativa* L.). *Plant Signaling & Behavior*, 9(12).

Silva, A.T., Barduche, D., do Livramento, K.G., Ligterink, W. and Paiva, L.V. (2014). Characterization of a Putative SERK-Like Ortholog in Embryogenic Cell Suspension Cultures of *Coffea Arabica* L. *Plant Molecular Biology Reporter*, 32(1), pp.176–184.

Silva, T.D. (2010). *Indica* Rice Anther Culture: Can the Impasse Be Surpassed? *Plant Cell Tissue and Organ Culture*, 100(1), pp.1–11.

Sindhujaa, V., Gnanaraj, M., Viji, M., Karuppanapandian, T. and Manoharan, K. (2018). Induction of High Frequency Somatic Embryogenesis and Analysis of Developmental Stagewise Expression of Serk1 Gene During Somatic Embryogenesis in Cultures of *Vigna Radiata* (l.) R.wilczek. *Indian Journal of Experimental Biology*, 10(3)pp.14-21.

Singh, A. and Khurana, P. (2017). Ectopic Expression of Triticum Aestivum Serk Genes (TaSERKs) Control Plant Growth and Development in *Arabidopsis*. *Scientific Reports*, 7(1), p.12368.

Singh, P. (2010). *Cereal processing | Britannica.com* [Online]. Available at: https://www.britannica.com/technology/cereal-processing [Accessed: 11 October 2018].

Singla, B., Khurana, J.P. and Khurana, P. (2008). Characterization of Three Somatic Embryogenesis Receptor Kinase Genes from Wheat, *Triticum Aestivum*. *Plant Cell Reports*, 27(5), pp.833–843.

Singla, B., Khurana, J.P. and Khurana, P. (2009a). Structural Characterization and Expression Analysis of the SERK/SERL Gene Family in Rice (*Oryza sativa*). *International Journal of Plant Genomics*, 2009, pp.1–8.

Smertenko, A. and Bozhkov, P.V. (2014). Somatic Embryogenesis: Life and Death Processes During Apicalbasal Patterning. *Journal of Experimental Botany*, 65(5), pp.1343–1360.

Sohrabi, M., Rafii,Y., M., Hanafi, M.M., Akmar, A.S.N. and M.A. Latif (2012). Genetic Diversity of Upland Rice Germplasm in Malaysia Based on Quantitative Traits. *Scientific World Journal.*, 2012:416291.

Somleva, M.N., Schmidt, E.D.L. and Vries, S.C. de. (2002). Embryogenic Cells in *Dactylis Glomerata* L. (Poaceae) Explants Identified by Cell Tracking and by Serk Expression. *Plant Cell Reports*, 19(7), pp.718–726.

Sucharitakul, K., Rakmit, R., Boonsorn, Y., Leelapon, O., Teerakathiti, T., Bunnag, S. and Chanvivattana, Y. (2014). Isolation and Expression Analysis of a Somatic Embryogenesis Receptor-Like Kinase (SERK) Gene in Curcuma alismatifolia Gagnep. *Journal of Agricultural Science*, 6(10), p.p207.

Suen, K. and Choi, J. (1991). Isolation and Sequence-Analysis of a cDNA Clone for a Carrot Calcium-Dependent Protein-Kinase - Homology to Calcium Calmodulin-Dependent Protein-Kinases and to Calmodulin. *Plant Molecular Biology*, 17(4), pp.581–590.

Summart, J., Panichajakul, S., Prathepha, P. and Thanonkeo, P. (2008). Callus Induction and Influence of Culture Condition and Culture Medium on Growth of Thai Aromatic Rice, Khao Dawk Mali 105, Cell Culture. ,10(3) pp.6-12.

Supari, N., Hanapi, S.Z., Alam, S.A.Z., Javed, M.A., Din, A.R.J.M., Tin, L.C., Rashid, S.N.A.A., Annuar, N.A.S. and Sarmidi, M.R. (2014). Microbial Effects on Seed Germination in Malaysian rice (*Oryza sativa* L.). *Proceedings of the Asia-Pacific Advanced Network*, 37(0), pp.42–51.

Talapatra, S., Ghoshal, N. and Raychaudhuri, S.S. (2013). Molecular Characterization, Modeling and Expression Analysis of a Somatic Embryogenesis Receptor Kinase (SERK) Gene in *Momordica Charantia* L. During Somatic Embryogenesis. *Plant Cell, Tissue and Organ Culture*, 116(3), pp.271–283.

Talbot, M.J. and White, R.G. (2013). Methanol Fixation of Plant Tissue for Scanning Electron Microscopy Improves Preservation of Tissue Morphology and Dimensions. *Plant Methods*, 9, p.36.

Talib, R. bt and Kadir, Z.A. b. (2014). Situation Breeding and Production of Rice in Malaysia, *Japan Association for Techno-Innovation in Agriculture, Forestry and Fisheries*, Hanoi, Vietnam.

Tamura, K., Stecher, G., Peterson, D., Filipski, A. and Kumar, S. (2013). MEGA6: Molecular Evolutionary Genetics Analysis version 6.0. *Molecular Biology and Evolution*, 30(12), pp.2725–2729.

Tamura, S. (1968). Shoot Formation in Calli Originated from Rice Embryo. *Proceedings of the Japan Academy*, 44(6), pp.544–548.

Tan, L.W., A. Rahman, Z., Goh, H.-H., Hwang, D.-J., Ismail, I., Zainal, Z. (2017). Production of Transgenic Rice (indica 1 cv. MR219) Overexpressing Abp57 Gene through Agrobacterium-Mediated Transformation. *Sains Malaysiana*, 46(5), pp.703–711.

Tassi, F., Maestri, E., Restivo, F. and Marmiroli, N. (1992). The Effects of Carbon Starvation on Cellular-Metabolism and Protein and RNA-Synthesis in Gerbera Callus-Cultures. *Plant Science*, 83(2), pp.127–136.

Tenhola-Roininen, T., Tanhuanpaa, P. and Immonen, S. (2005). The Effect of Cold and Heat Treatments on the Anther Culture Response of Diverse Rye Genotypes. *Euphytica*, 145(1–2), pp.1–9.

Terano, R., Mohamed, Z. and Din, N.S.Z. (2016). Determinants of Farmers' Adoption of Clearfield Production System in Malaysia. *Agriculture and Agricultural Science Procedia*, 9, pp.103–107.

Thomas, C., Meyer, D., Himber, C. and Steinmetz, A. (2004). Spatial Expression of a Sunflower SERK Gene During Induction of Somatic Embryogenesis and Shoot Organogenesis. *Plant Physiology and Biochemistry*, 42(1), pp.35–42.

Thuy, T.L. and Saitoh, K. (2017). Responses of Fourteen Vietnamese Rice (Oryza sativa L.) Cultivars to High Temperatures During Grain Filling Period Under Field Conditions. *Agronomy*, 7(3), p.57.

Tichopad, A., Dzidic, A. and Pfaffl, M.W. (2002). Improving Quantitative Real-Time RT-PCR Reproducibility by Boosting Primer-Linked Amplification Efficiency. *Biotechnology Letters*, 24, pp.2053–2056.

Tiwari, A., Shamim, M., Prakash Saxena, R. and Singh, K. (2012). Plant Regeneration Efficiency of Two Scented *indica* Rice Varieties Pusa Basmati 1 and Kalanamak. *Plant Tissue Culture & Biotechnology*, 8(4)pp16-22.

Toorn, M., Albrecht, C. and de Vries, S. (2015). On the Origin of SERKs: Bioinformatics Analysis of the Somatic Embryogenesis Receptor Kinases. *Molecular Plant*, 8(5), pp.762–782.

Torres, L.F., Cardamone Diniz, L.E., Do Livramento, K.G., Freire, L.L. and Paiva, L.V. (2015). Gene Expression and Morphological Characterization of Cell Suspensions of *Coffea Arabica* L. Cv. Catigua Mg2 in Different Cultivation Stages. *Acta Physiologiae Plantarum*, 37(9)pp200-209.

Touraev, A., Indrianto, A., Wratschko, I., Vicente, O., Heberle-Bors, E. (1996). Efficient Microspore Embryogenesis in Wheat (*Triticum aestivum* L.) Induced by Starvation at High Temperature. *Sexual Plant Reproduction*, 9(4), pp.209–215.

Uddain, J. (2015). Efficient Plant Regeneration of Malaysian Aromatic Rice (*Oryza sativa* L.) Through Somatic Embryogenesis. *Emirates journal of Food and Agriculture*, 27(11), pp.857–863.

Ullah, H., Ullah, I., Jadoon, S.A. and Rashid, H. (2007). Tissue Culture Techniques for Callus Induction in Rice. *Sarhad Journal of Agriculture*, 23(1), p.6.

Upadhyaya, G., Sen, M. and Roy, A. (2015). In Vitro Callus Induction and Plant Regeneration of Rice (*Oryza sativa* L.) Var. 'sita', 'rupali' and 'swarna Masuri.' ,8(6)pp.4.

Vasil, I. (2012). *Plant Regeneration and Genetic Variability*, India. Elsevier Publisher.

Vega, R., Vásquez, N., Espinoza, A.M., Gatica, A.M. and Valdez-Melara, M. (2009). Histology of Somatic Embryogenesis in Rice (*Oryza sativa* cv. 5272). *Revista de Biología Tropical*, 57, pp.141–150.

Vennapusa, A.R., Vemanna, R.S., H, R.R.B., Babitha, K.C., Kiranmai, K., Nareshkumar, A. and Sudhakar, C. (2015). An Efficient Callus Induction and Regeneration Protocol for a Drought Tolerant Rice Indica Genotype AC39020. *Journal of Plant Sciences*, 3(5), p.248.

Verma, D., Joshi, R., Shukla, A. and Kumar, P. (2011). Protocol for in Vitro Somatic Embryogenesis and Regeneration of Rice (*Oryza Sativa* L.). *Indian Journal of Experimental Biology*, 49(12), pp.958–963.

Vibhuti, V., Shahi, C., Bargali, K. and Bargali, S. (2015). Seed Germination and Seedling Growth Parameters of Rice (*Oryza sativa* L.) Varieties as Affected by Salt and Water Stress. *Indian Journal of Agricultural Sciences*, 85 (2), pp.102–108.

Visarada, K.B.R.S., Sailaja, M. and Sarma, N.P. (2002). Effect of Callus Induction Media on Morphology of Embryogenic Calli in Rice Genotypes. *Biologia Plantarum*, 45(4), pp.495–502.

Wagiran, A., Ismail, I., Zain, C.R.C.M. and Abdullah, R. (2008). Improvement of Plant Regeneration from Embryogenic Suspension Cell Culture of Japonica Rice. *Journal of Biological Sciences*, 8(3), pp.570–576.

Wahab, A.G. (2017). *Grain and Feed Annual_kuala Lumpur Malaysia*, Global Agricultural Information Network, Kuala Lumpur, Malaysia.

Waheed, A., Ahmad, H. and Abbasi, F.M. (2012). Different Treatment of Rice Seed Dormancy Breaking, Germination of Both Wild Species and Cultivated Varieties (*Oryza sativa* L.). *Journal of Materials and Environmental Science*, 3(3), pp.551–560.

Wang, C.-H., Zheng, X.-M., Xu, Q., Yuan, X.-P., Huang, L., Zhou, H.-F., Wei, X.-H. and Ge, S. (2014). Genetic Diversity and Classification of *Oryza sativa* with Emphasis on Chinese Rice Germplasm. *Heredity*, 112(5), pp.489–496.

Wang, L., LIN, G., ZHAO, D., WANG, F. and CHEN, J. (2011). Tissue Culture System for Different Hybrid of *Indica* Rice. *Journal of Northeast Agricultural University (English edition)*, 18(2), pp.13–17.

Wang, X., Fang, G., Li, Yang, Ding, M., Gong, H., Li. and Yangsheng. (2013). Differential Antioxidant Responses to Cold Stress in Cell Suspension Cultures of Two Subspecies of Rice. *Plant Cell, Tissue and Organ Culture*, 113(2), pp.353–361.

Wisniewska, A., Grabowska, A., Pietraszewska-Bogiel, A., Tagashira, N., Zuzga, S., Woycicki, R., Przybecki, Z., Malepszy, S. and Filipecki, M. (2012). Identification of Genes up-Regulated during Somatic Embryogenesis of Cucumber. *Plant Physiology and Biochemistry*, 50, pp.54–64.

Wójcikowska, B. and Gaj, M.D. (2017). Expression Profiling of Auxin Response Factor Genes During Somatic Embryogenesis Induction in *Arabidopsis*. *Plant Cell Reports*, 36(6), pp.843–858.

Wong, S.C., Yiu, P.H., Bong, S.T.W., Lee, H.H., Neoh, P.N.P. and Rajan, A. (2009). Analysis of Sarawak Bario Rice Diversity Using Microsatellite Markers. *American Journal of Agricultural and Biological Sciences*, 4(4), pp.298–304.

Wu, X., Li, F., Zhang, C., Liu, C. and Zhang, X. (2009). Differential Gene Expression of Cotton Cultivar CCRI24 During Somatic Embryogenesis. *Journal of Plant Physiology*, 166(12), pp.1275–1283.

Xin-min, W., Xian, R., Gui-xiang, Y., Ke, W., Jia-rui, L., Li-pu, D., Hui-jun, X. and Xing-guo, Y. (2014). Effects of Environmental Temperature on the Regeneration Frequency of the Immature Embryos of Wheat (*Triticum aestivum* L.). *Journal of Integrative Agriculture*, 13(4), pp.722–732.

Xu, C., Zhao, L., Pan, X. and Šamaj, J. (2011). Developmental Localization and Methylesterification of Pectin Epitopes during Somatic Embryogenesis of Banana (*Musa* spp. AAA). *Plos One*, 6(8), p.e22992.

Yang, X., Wang, L., Yuan, D., Lindsey, K. and Zhang, X. (2013). Small RNA and degradome sequencing reveal complex miRNA regulation during cotton somatic embryogenesis. *Journal of Experimental Botany*, 64(6), pp.1521–1536.

Yaqoob, D., Janp, B., Kaul, T. and Ahmad Nawchoop, I. (2016). Tissue culture of Rice: Problems, Progress and Prospects. I*nternational Journal of Innovative Science, Engineering & Technology*, 3(6) 581-613.

Yin, C.-C., Ma, B., Wang, W., Xiong, Q., Zhao, H., Chen, S.-Y. and Zhang, J.-S, (2016). RNA Extraction and Preparation in Rice (*Oryza sativa*). In: *Current Protocols in Plant Biology*. John Wiley & Sons, Inc. 411-418.

Yu, D., Tang, H., Zhang, Y., Du, Z., Yu, H. and Chen, Q. (2012). Comparison and Improvement of Different Methods of Rna Isolation from Strawberry (fragria * Ananassa). *Journal of Agricultural Science*, 4(7), p.51.

Zhai, L., Xu, L., Wang, Y., Zhu, X., Feng, H., Li, C., Luo, X., Everlyne, M.M. and Liu, L. (2016). Transcriptional Identification and Characterization of Differentially Expressed Genes Associated with Embryogenesis in Radish (*Raphanus sativus* L.). *Scientific Reports*, 6, p.21652.

Zhang, L., Li, W., Han, S., Yang, W. and Qi, L. (2013). cDNA Cloning, Genomic Organization and Expression Analysis During Somatic Embryogenesis of the Translationally Controlled Tumor Protein (tctp) Gene from Japanese Larch (*Larix leptolepis*). *Gene*, 529(1), pp.150–158.

Zhao, W., Zheng, S. and Ling, H.-Q. (2011). An efficient regeneration system and Agrobacterium-mediated transformation of Chinese upland rice cultivar Handao297. *Plant Cell, Tissue and Organ Culture*, 106(3), p.475.

Zimmerman, J. (1993). Somatic Embryogenesis: A Model for Early Development in Higher Plants. *The Plant Cell*, 5(10), pp.1411–1423.

Zulkarnain, W.M., Ismail, M.R., Saud, H.M., Othman, R., Habib, S.H. and Kausar, H. 2013. Growth and Yield Response to Water Availability at Different Growth Stages of Rice. *Journal of Food Agriculture and Environment*, 11(2), pp.540–544.

Zuo, S., Zhou, X., Chen, M., Zhang, S., Schwessinger, B., Ruan, D., Yuan, C., Wang, J., Chen, X. and Ronald, P.C. (2014). OsSERK1 Regulates Rice Development but Not Immunity to *Xanthomonas oryzae* Pv. *Oryzae* or *Magnaporthe oryzae*. *Journal of Integrative Plant Biology*, 56(12), pp.1179–1192.

Zuraida, A.R., Naziah, B., Zamri, Z. and Sreeramanan, S. (2011). Efficient Plant Regeneration of Malaysian *indica* Rice MR 219 and 232 Via Somatic Embryogenesis System. *Acta Physiologiae Plantarum*, 33(5), pp.1913–1921.