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EFFECT OF HEAT STRESS AND PLANTING DATE ON YIELD, GRAIN QUALITY AND FERTILIZER UPTAKE OF RICE CULTIVARS (*Oryza sativa L.*)

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By

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In the first experiment, high temperature tolerance, in terms of transplanting dates (1st May, 21st May and 10th June) was tested on six Iranian rice cultivars. The response of rice cultivars and transplanting dates for the morphological, and yield components showed the crop sown on 1st and 21st May had better growth and yield components which resulted higher grain yield (6625 kg ha^{-1}) of Neda cultivar.

The second experiment was glass house conducted to evaluate the effects of high temperature (38±2°C) stress and normal temperature (32±2°C) on seven rice cultivars. The results showed the greater weight of 1000 grains (26.97 g) observed in Neda grown in normal condition. The maximum grain yield (51.3 g pot^{-1}) was noted in MR219 planted in normal condition.

In third experiment, the effect of normal and heat stress temperatures were tested on four rice cultivars (Fajr, Hashemi and Hovaze as exotic and MR219 as indigenous). The main effects of heat stress and growth stage were significant in all parameters except on effective tillers. The lowest grain yield per pot was observed in Hashemi (6.8 g pot^{-1}) at flowering stage during heat stress condition and the highest was found in MR219 (42- 45d g pot^{-1}) during normal condition. In conclusion, the major reason for yield reduction of all cultivars was enhancement of sterile and aborted spikelets numbers when plants exposed to heat stress during booting and flowering phases.

The last experiment was conducted on the rice cultivars from previous experiment to evaluate the effect of normal temperature and heat stress using Potassium fertilizer, nitrogen, and Meister-20 (polymer coated urea). The grain yield was significantly higher (25.9 g pot^{-1}) in the plants grown in normal condition and fertilized with Meister-20 at 160 kg N ha^{-1}. In the heat stress condition, the grain yield ranged between 15.3 to 17.9 g pot^{-1} in the N fertilized plants which is also considered satisfactory as compared to unfertilized plants in the heat stress condition.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor of Falsafah

KESAN TEKANAN HABA DAN TARIKH PENANAMAN TERHADAP HASIL TUAIAN, KUALITI BERAS DAN PENYERAPAN BAJA OLEH KULTIVAR-KULTIVAR PADI (*Oryza sativa L.*)

Oleh

MOHAMMAD TAGHI KARBALAEI AGHAMOLKI

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Dalam eksperimen pertama, toleransi suhu yang tinggi, dari segi pengalihan tarikh (1hb Mei, 21hb Mei dan 10hb Jun) telah diuji pada enam kultivar padi Iran. Tindakbalas daripada kultivar padi dan pengalihan tarikh bagi morfologi , dan komponen-komponen hasil menunjukkan tanaman dicambah pada 1 dan 21 Mei mempunyai komponen pertumbuhan yang lebih baik dan penghasilan beras yang lebih tinggi (6625 kg ha^{-1}) daripada kultivar Neda.

Percubaan kedua ialah rumah kaca yang dijalankan untuk menilai kesan daripada tekanan suhu tinggi (38±2°C) dan suhu biasa (32±2°C) ke atas tujuh kultivar padi. Keputusan menunjukkan lebihan berat terhadap 1000 beras (26.97 g) yang diperhatikan pada Neda tumbuh dalam keadaan normal. Hasil beras maksimum (51.3 g /pasu-1) dicatatkan pada MR219 yang ditanam dalam keadaan normal.

Dalam eksperimen ketiga, kesan daripada suhu biasa dan suhu tekanan haba telah diuji pada empat kultivar padi (Fajr, Hashemi dan Hovaze sebagai eksotik dan MR219 sebagai pribumi). Kesan utama tekanan haba dan peringkat pertumbuhan adalah penting dalam semua parameter kecuali pada bilangan anak padi. Kesan haba telah menurunkan penghasilan pada peringkat bunting, debunga dan pengisian beras, sebaliknya tetapi tiada perbezaan yang signifikan diperhatikan pada peringkat kematangan padi berbanding dengan pertumbuhan biasa. Kesan utama peringkat pertumbuhan dan tekanan haba adalah signifikan dalam semua parameter kecuali pada bilangan anak padi. Hasil beras yang terendah sepasu diperhatikan pada Hashemi (6.8 g/pasu-1) di peringkat debunga semasa keadaan tekanan haba dan penghasilan suhu biasa. Kesimpulannya, sebab utama penurunan hasil semua kultivar ialah peningkatan bilangan spikelets yang gugur apabila tumbuhan terdedah kepada tekanan kepanasan semasa difasa bunting dan debunga.

Percubaan terakhir telah dijalankan ke atas kultivar beras dari eksperimen sebelumnya untuk menilai kesan suhu biasa dan tekanan suhu dengan menggunakan baja potassium, nitrogen dan Meister-20 (polimer yang bersalut urea). Hasil padi adalah jauh lebih tinggi (25.9 g periuk-1) dalam tumbuh-tumbuhan yang ditanam dalam keadaan normal dan fertilized dengan Meister-20 pada 160 kg N ha-1. Dalam keadaan tekanan haba, kadar hasil bijirin adalah

antara g 15.3 hingga 17.9 periuk-1 pada N tumbuh-tumbuhan yang dibaja juga dianggap memuaskan berbanding dengan tumbuh-tumbuhan yang tidak dibaja berada dalam keadaan tekanan haba.

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LIST OF ABBREVIATIONS

BC	Before Christ
M	Metric
°C	Centigrade
CO_2	Carbon dioxide
g	Gram
RH	Relative humidity
ROS	Reactive oxygen species
SOD	superoxide dismutase
CAT	Catalase
POD	Peroxidise
N	Nitrogen
K	Potassium
NO	Nitric oxide
SCU	Sulfur coated urea
H_3Po_4	Phosphoric acid
$Fe(OH)_3$	Iron(III) oxide-hydroxide
Fe_2O_3	Iron(III) oxide
PO_4^{3-}	Phosphate
SeM	Selene methionine
GPX	Glutathione Peroxidase
TRXR	Thioredoxin Reductase
PRI	The European reference intake
RDI	Recommended dietary intakes
DMRT	Duncan Multiple Range Test
EC	Electrical Conductivity
MOP	Muriate of potash
K_2O	Potassium oxide
$HClO^{4-}$	Perchloric acid
HNO^{3-}	Nitric acid
LSD	Least Significant Difference
$\mu g\ g^{-1}$	micro gram per gram
$mg\ g^{-1}$	milligram per gram
$mg\ kg^{-1}$	milligram per kilogram
$kg\ ha^{-1}$	Kilogram per hectare
H	heat

μM	Micro Molar
mM	Milli molar
$\mu g\ m^{1-}$	microgram per metre
RCBD	Randomized complete block design
CEC	Cation Exchange Capacity
ANOVA	Analysis of variance
HI	Harvest index
OM	Organic matter

CHAPTER ONE

INTRODUCTION

Rice crop is an annual cereal which has a C3 metabolism belonging to the botanical family of Poaceae. There are two cultivated species of rice *Oryza sativa* L. (Asian rice) and *Oryza glaberrina* Steud (African rice), were correspondingly domesticated about 2500 B.C. in the Niger inland delta in Mail (MacNeish and Libby, 1995) and 10000 BC in China. There are two major genetic groups of *O. sativa* called Japonica. This group has short grain and grows in temperate lowlands and tropical rice uplands. On the other group, Indica with long grains belongs to tropical and generally lowland rice areas.

During the last 50 years, the production of rice in the world is at least three times more and average yield increased to more than doubled and reached to 4.3 tons per hectare in 2010 (Australia was the most rice productive with 10.8 t/ha and China the largest producer of rice with 197.2 M tons (FAOSTAT, 2012). When it comes to fertilizer inputs and management, irrigated flooded systems are intensive and reach higher yields compared to other systems of rice. Developed countries having highest yields, such as Japan, Korea, Australia and the United States grow absolutely under irrigated conditions (Seck *et al.*, 2012). In the world, increasing rice production would be originated from production intensification (accordingly rising sustainable grain yields where they are low now) and through decreasing the yield gap (thus achieving the locally potential and attainable yield). In order to accomplish food security, this must be achieved in the context of climate change, which is an ambitious goal to development community and the global rice research (Lal *et al.*, 1998).

It takes about 3 months for the germinated rice crop to be matured, depending on the environmental factors and variety (Yoshida, 1981). This cycle has three main phases, that is, the vegetative, reproductive and grain filling or maturation phases. The first phase (vegetative phase) begins at germination and its characteristic is known when the roots are developed and for resource acquisition the leaf area is needed, and tillering which puts the possible amount of panicles to be matured (Yoshida, 1981).

The second phase (reproductive) starts when the panicle appears, it starts developing inside the sheath, and stops when anthesis begins. During the reproductive growth stage, internodes elongation, spikelets development and pollen formation are followed by heading (emergence of panicle from the sheath) and flowering (or anthesis) stage. A panicle is a composition of a base spotted by a bulge (neck node), a primary axis (rachis) that is used for primary and secondary of stems, keeping the pedicels at the end of which are the spikelets.

About one month before heading (depending on the environmental and climate conditions), the panicle primordium starts the initiation and when the pollen is completely matured, the difference between panicles ends (Yoshida, 1981). However, the panicle is still surrounded by the sheath and is placed at the lowest part of the canopy. Then by the help of internodes elongation, it is derived up to near the head of the canopy, especially the top of the internodes.

Nowadays, intensive climate change researches indicated that increasing temperature may intensify flooding, storms and other severe climate and weather events around the world, and ultimately affect production of food. The model projects of climate indicated that air temperatures of the world may increase by averagely 4–5.8 °C in the upcoming few decades (Solomon *et al.*, 2007). Temperature elevation will probably decrease the likely benefits of increasing the global CO_2 concentration on crop growths and development. Seed crops are most affected by rising temperature compared to cultivated plants for vegetative- part production such as forage plants. Rice as a globally important food crop provides food security for many countries. In the future, the rice yield would be declined due to the environmental climatic conditions (high temperature) of growing season in many rice-growing areas (Abiko *et al.*, 2005;Nagarajan *et al.*, 2010; Welch *et al.*, 2010). Based on a research done by Matsui et al. (2001b), if future predications about severe climate are correct, rice yields could be totally disappear from the current paddy fields.

High temperature is considered to disrupt normal movement of ion, water, and organic solute across membranes of a plant, which intervenes with respiration and photosynthesis. When the plant exposed to high temperatures, electrolyte may leak from leaves (Halford, 2009). The cell membrane thermal stability is regarded to be positively performed in the yield. Temperature is one of the main controlling factors for photosynthesis reactions of crops, but high temperatures can caused a sharply reduction in crops photosynthesis and dry matter allocation of shoots and roots. The high temperature adversely affects not only the aboveground portion of rice but also the below-ground parts of crops due to increasing the soil and water temperature.

1.1 Justification

The current study highlights the rice importance in globe, the high temperature effects regard to the world climate change on rice growth, yield and yield components and quality of rice grains. Therefore there is necessary for future research planes.

1.2 Hypothesis

Heat stress tolerance at various rice growth stages is a complicated feature in morphological characters and yield parameters. The rice response determination to this increasing heat-stressed problem needs integrated and practical strategies for affected regions to maintain and improve rice yield. Thus, this research tries to investigate the Malaysian and Iranian rice cultivars' growth and yield responses.

1.3 Objectives

1) To evaluation of high temperature impacts on growth, yield and quality of six selected rice cultivars.
2) To characterize the effect of heat stress on yield parameters of seven selected rice cultivars at growth and reproductive stages.
3) To identify of tolerant and sensitive of four rice cultivars to heat stress during reproductive stage.
4) To determine the influence of heat stress on nitrogen and potassium fertilizers on the growth and yield of MR219 rice cultivar.

BIBLIOGRAPHY

Abiko, M., Akibayashi, K., Sakata, T., Kimura, M., Kihara, M., Itoh, K., Asamizu, E., Sato, S., Takahashi, H., and Higashitani, A. (2005). High-temperature induction of male sterility during barley (Hordeum vulgare L.) anther development is mediated by transcriptional inhibition. *Sexual Plant Reproduction, 18*(2), 91-100.

Akhtar, N., Nazir, M., Rabnawaz, A., Mahmood, T., Safdar, M., Asif, M., and Rehman, A. (2011). Estimation of heritability, correlation and path coefficient analysis in fine grain rice (*Oryza sativa L.*). *The Journal of Animal & Plant Sciences, 21*(4), 660-664.

Akita, S., Parago, F., and Coronel, V. (1987). Physiological response of rice to light and nitrogen. *Weather and Rice. Int. Rice Res. Inst., Los Baños, the Philippines*, 81-91.

Ali, A., Xu, J., Ismail, A., Fu, B., Vijaykumar, C., Gao, Y., Domingo, J., Maghirang, R., Yu, S., and Gregorio, G. (2006). Hidden diversity for abiotic and biotic stress tolerances in the primary gene pool of rice revealed by a large backcross breeding program. *Field Crops Research, 97*(1), 66-76.

Amtmann, A., Hammond, J. P., Armengaud, P., and White, P. J. (2005). Nutrient sensing and signalling in plants: potassium and phosphorus. *Advances in Botanical Research, 43*, 209-257.

Andersen, M. N., Jensen, C., and Lösch, R. (1992). The interaction effects of potassium and drought in field-grown barley. I. Yield, water-use efficiency and growth. *Acta Agriculturae Scandinavica B-Plant Soil Sciences, 42*(1), 34-44.

Awan, T., Ahmad, M., Ali, I., Anwar, M., and Manzoor, Z. (2007). Contribution of tillers within a rice plant to yield and yield components. *Journal of Agricultural Research, 45*.

Baker, J., Allen Jr, L., and Boote, K. (1992). Response of rice to carbon dioxide and temperature. *Agricultural and Forest Meteorology, 60*(3), 153-166.

Bashir, M. U., Akbar, N., Iqbal, A., and Zaman, H. (2010). Effect of different sowing dates on yield and yield components of direct seeded coarse rice (Oryza sativa L). *Pakistan Journal of Agricultural Sciences, 47*(4), 361-365.

Bendixen, R., Gerendás, J., Schinner, K., Sattelmacher, B., and Hansen, U. P. (2001). Difference in zeaxanthin formation in nitrate-and ammonium-grown Phaseolus vulgaris. *Physiologia Plantarum, 111*(2), 255-261.

Bo, S., and Taigui, L. (1996). An appraisal on the resistance of rice rarieties to heat stress. *Seed, 6*, 005.

Boote, K. J., Allen, L. H., Prasad, P. V., Baker, J. T., Gesch, R. W., Snyder, A. M., Pan, D., and Thomas, J. M. (2005). Elevated temperature and CO2 impacts on pollination, reproductive growth, and yield of several globally important crops. *Journal of Agricultural Meteorology, 60*, 469-474.

Bouyoucos, G. J. (1962). Hydrometer method improved for making particle size analyses of soils. *Agronomy Journal, 54*(5), 464-465.

Bremner, J. (1960). Determination of nitrogen in soil by the Kjeldahl method. *The Journal of Agricultural Science, 55*(01), 11-33.

Cao, Y.-Y., Duan, H., Yang, L.-N., Wang, Z.-Q., Liu, L.-J., and Yang, J.-C. (2009). Effect of High Temperature During Heading and Early Filling on Grain Yield and Physiological Characteristics in Indica Rice. *Acta Agronomica Sinica, 35*(3), 512-521.

Cao, Y.-Y., Duan, H., Yang, L.-N., Wang, Z.-Q., Zhou, S.-C., and Yang, J.-C. (2008). Effect of heat stress during meiosis on grain yield of rice cultivars differing in heat tolerance and its physiological mechanism. *Acta Agronomica Sinica, 34*(12), 2134-2142.

Ceccarelli, S., Grando, S., Maatougui, M., Michael, M., Slash, M., Haghparast, R., Rahmanian, M., Taheri, A., Al-Yassin, A., and Benbelkacem, A. (2010). Plant breeding and climate changes. *The Journal of Agricultural Science, 148*(06), 627-637.

Chandra, D., Lodh, S., Sahoo, K., and Nanda, B. (2013). Effect of date of planting and spacing on grain yield and quality of scented rice (Oryza sativa) varieties in wet season in coastal Orissa. *The Indian Journal of Agricultural Sciences, 67*(3).

Chang, T., Seshu, D., and Khush, G. (1988). *The rice seed exchange and evaluation programs of IRRI.* Paper presented at the Rice Seed Health: Proceedings of the International Workshop on Rice Seed Health, 16-20 March 1987.

Chaudhary, T., and Chopra, U. K. (1983). Effect of soil covers on growth and yield of irrigated wheat planted at two dates. *Field Crops Research, 6*, 293-304.

Cheng, W., Sakai, H., Yagi, K., and Hasegawa, T. (2009). Interactions of elevated CO2 and night temperature on rice growth and yield. *Agricultural and Forest Meteorology, 149*(1), 51-58.

Chuan, H.-s., and Kraus, R. A. (1975). Mid-Ch'ing rice markets and trade: East Asian Research Center, Harvard University; distributed by Harvard University Press.

Cooper, N., Siebenmorgen, T., and Counce, P. (2008). Effects of nighttime temperature during kernel development on rice physicochemical properties. *Cereal Chemistry, 85*(3), 276-282.

Counce, P., Bryant, R., Bergman, C., Bautista, R., Wang, Y.-J., Siebenmorgen, T., Moldenhauer, K., and Meullenet, J.-F. (2005). Rice milling quality, grain dimensions, and starch branching as affected by high night temperatures. *Cereal chemistry, 82*(6), 645-648.

Cruz, N. D., and Khush, G. (2000). Rice grain quality evaluation procedures. *Aromatic Rices*, 15-28.

Cruz, R., and O'Toole, J. (1984). Dryland rice response to an irrigation gradient at flowering stage. *Agronomy Journal, 76*(2), 178-183.

De Datta, S. (1984). Availability and management of nitrogen in lowland rice in relation to soil characteristics.

De Datta, S. K. (1981). *Principles and Practices of Rice Production*: Int. Rice Res. Inst.

Dehghan, A. (2007). The effect of delayed planting date on grain yield and yield components of three sorghum in Khouzestan. *The Scientific Journal of Agriculture, 30*(30), 123-132.

Dinesh Chandra, S. B. L., K. M, Sahoo, and B. B. Nanda. (1997). Effect of date of planting and spacing on grain yield and quality of scented rice (*Oryza sativa*) varieties in wet season in coastal Orissa. *The Indian Journal of Agricultural Sciences 67*(3), 93-97.

Dobermann, A. R. (2005). Nitrogen use efficiency–state of the art.

Dupuis, I., and Dumas, C. (1990). Influence of temperature stress on in vitro fertilization and heat shock protein synthesis in maize (Zea mays L.) reproductive tissues. *Plant Physiology, 94*(2), 665-670.

Ekanayake, I., Steponkus, P., and De Datta, S. (1990). Sensitivity of pollination to water deficits at anthesis in upland rice. *Crop Science, 30*(2), 310-315.

El-Hadi, A., Ismail, K., and El-Akabawy, M. (1997). Effect of potassium on the drought resistance of crops in Egyptian conditions. *Food security in the WANA region, the essential need for balanced fertilization*, 26-30.

EnayatGholizadeh, M., Bakhshandeh, A., Shoar, M. D., Ghaineh, M., Saeid, K. A., and Sharafizadeh, M. (2012). Effect of source and seed size on yield component of corn S. C704 in Khuzestan. *African Journal of Biotechnology, 11*(12), 2938-2944.

Fageria, N., and Baligar, V. (2001). Lowland rice response to nitrogen fertilization. *Communications in Soil Science and Plant Analysis, 32*(9-10), 1405-1429.

Fan, X., Jiang, D., Dai, T., Jing, Q., and Cao, W. (2005). Effects of nitrogen rates on activities of key regulatory enzymes for grain starch and protein accumulation in wheat grown under drought and waterlogging from anthesis to maturity. *Scientia Agricultura Sinica, 38*(6), 1132-1141.

FAOSTAT, F. (2012). Statistics Division. : Food and Agriculture Organization of the United Nations.

Farrell, T., Fox, K., Williams, R., and Fukai, S. (2006). Genotypic variation for cold tolerance during reproductive development in rice: screening with cold air and cold water. *Field Crops Research, 98*(2), 178-194.

Farrell, T., Fox, K., Williams, R., Fukai, S., and Lewin, L. (2003). *Avoiding low temperature damage in Australia's rice industry with photoperiod sensitive cultivars.* Paper presented at the Proceedings of the 11th Australian Agronomy Conference. Deakin University, Geelong (Feb. 2-6), Victoria, Australia.

Faust, M., and Christians, N. (1999). AB-DTPA and Mehlich III soil tests unable to predict copper available to creeping bentgrass 1. *Communications in Soil Science & Plant Analysis, 30*(17-18), 2475-2484.

Fukai, S., and Cooper, M. (1995). Development of drought-resistant cultivars using physiomorphological traits in rice. *Field Crops Research, 40*(2), 67-86.

Ghosh, D., and Singh, B. (1998). Crop growth modelling for wetland rice management. *Environment and Ecology, 16*(2), 446-449.

Gornall, J., Betts, R., Burke, E., Clark, R., Camp, J., Willett, K., and Wiltshire, A. (2010). Implications of climate change for agricultural productivity in the early twenty-first century. *Philosophical Transactions of the Royal Society B: Biological Sciences, 365*(1554), 2973-2989.

Goto, S. G., and Kimura, M. T. (1998). Heat-and cold-shock responses and temperature adaptations in subtropical and temperate species Drosophila. *Journal of Insect Physiology, 44*(12), 1233-1239.

Guilioni, L., Wery, J., And Tardieu, F. (1997). Heat stress-induced abortion of buds and flowers in pea: is sensitivity linked to organ age or to relations between reproductive organs? *Annals of Botany, 80*(2), 159-168.

Habibullah, N., Shah, H., and Iqbal, F. (2007). Response of rice varieties to various transplanting dates. *Pakistan Journal of Agricultural Sciences, 13*(1), 1-4.

Halford, N. G. (2009). New insights on the effects of heat stress on crops. *Journal of experimental botany*, page311.

HalJ, A. E. (1992). Breeding for heat tolerance. *Plant breeding reviews*, 129.

Hall, W. (2005). *Benefits of enhanced-efficiency fertilizers for the environment.* Paper presented at the IFA International Workshop on Enhanced-Efficiency Fertilizers. June.

Hayat, K., Awan, I. U., and Hassan, G. (2003). Impact of seeding dates and varieties on weed infestation, yield and yield components of rice (*Oryza sativa L.*) under direct wet seeded culture. *Pakistan Journal of Weed Sciences Research, 9*(1/2), 59-65.

Houston, D. F. (1972). Rice: chemistry and technology (Vol. 4): American Association of Cereal Chemists St Paul, MN.

Huang, Z.-A., Jiang, D.-A., Yang, Y., Sun, J.-W., and Jin, S.-H. (2004). Effects of nitrogen deficiency on gas exchange, chlorophyll fluorescence, and antioxidant enzymes in leaves of rice plants. *Photosynthetica, 42*(3), 357-364.

Huber, D. M., and Thompson, I. A. (2007). Nitrogen and plant disease. *Mineral nutrition and plant disease. St. Paul*, APS Press.

Islam, M., and Morison, J. (1992). Influence of solar radiation and temperature on irrigated rice grain yield in Bangladesh. *Field Crops Research, 30*(1), 13-28.

Jagadish, S., Craufurd, P., and Wheeler, T. (2007). High temperature stress and spikelet fertility in rice (*Oryza sativa L.*). *Journal of eExperimental Botany, 58*(7), 1627-1635.

Jagadish, S., Muthurajan, R., Oane, R., Wheeler, T. R., Heuer, S., Bennett, J., and Craufurd, P. Q. (2010). Physiological and proteomic approaches to address heat tolerance during anthesis in rice (*Oryza sativa L.*). *Journal of Experimental Botany, 61*(1), 143-156.

Jeng, T., Tseng, T., Wang, C., Chen, C., and Sung, J. (2003). Starch biosynthesizing enzymes in developing grains of rice cultivar Tainung 67 and its sodium azide-induced rice mutant. *Field crops research, 84*(3), 261-269.

Jones Jr, J. B. (2001). *Laboratory guide for conducting soil tests and plant analysis*: CRC press.

Juliano, B. (1971). Simplified assay for milled-rice amylose. *Cereal Science Today*.

Juraimi, A. S., Saiful, A. M., Uddin, M. K., Anuar, A., and Azmi, M. (2011). Diversity of weed communities under different water regimes in bertam irrigated direct seeded rice field. *Australian Journal of Crop Science, 5*(5), 595-604.

Kafkafi, U. (1990). *The functions of plant K in overcoming environmental stress situations.* Paper presented at the Proceedings of the 22nd colloq of the International Potash Institute, Berne, Switzerland.

Kariali, E., and Mohapatra, P. K. (2007). Hormonal regulation of tiller dynamics in differentially-tillering rice cultivars. *Plant Growth Regulation, 53*(3), 215-223.

Kato, M. C., Hikosaka, K., Hirotsu, N., Makino, A., and Hirose, T. (2003). The excess light energy that is neither utilized in photosynthesis nor dissipated by photoprotective mechanisms determines the rate of photoinactivation in photosystem II. *Plant and Cell Physiology, 44*(3), 318-325.

Kato, T., and Takeda, K. (1996). Associations among characters related to yield sink capacity in space-planted rice. *Crop Science, 36*(5), 1135-1139.

Khakwani, A. A., Zubair, M., Mansoor, M., Naveed, K., Shah, I. H., Wahab, A., Ilyas, M., and Ahmed, I. (2006). Agronomic and Morphological Parameters of Rice Crop as Affected by Date of Transplanting. *Journal of Agronomy, 5*(2), 248-250.

Khalifa, A. (2009). Physiological evaluation of some hybrid rice varieties under different sowing dates. *Australian Journal of Crop Science, 3*(3), 178-183.

Kim, H. Y., Horie, T., Nakagawa, H., and Wada, K. (1996). Effects of elevated CO_2 concentration and high temperature on growth and yield of rice. 2. The effect on yield and its components of Ahihikari rice. *Japanese Journal of Crop Science, 65*(4), 644-651.

Kim, J.-K., and Krishnan, H. B. (2002). Making rice a perfect food: Turning dreams into reality. *Journal of crop production, 5*(1-2), 93-130.

Kobata, T., and Uemuki, N. (2004). High temperatures during the grain-filling period do not reduce the potential grain dry matter increase of rice. *Agronomy Journal, 96*(2), 406-414.

Krause, G., and Santarius, K. (1975). Relative thermostability of the chloroplast envelope. *Planta, 127*(3), 285-299.

Laborte A., A. N., K. Jagadish, J. Aunario, A. Sparks, C. Ye and E.D. Redona (2012a). Rice feels the heat. Rice Today *International Rice Research Institute* (pp. 30-31). Philipine.

Laborte, A. G., de Bie, K. C., Smaling, E. M., Moya, P. F., Boling, A. A., and Van Ittersum, M. K. (2012b). Rice yields and yield gaps in Southeast Asia: past trends and future outlook. *European Journal of Agronomy, 36*(1), 9-20.

Lack, S., Marani, N. M., and Mombeni, M. (2012). The effects of planting date on grain yield and yield components of rice cultivars. *Advances in Environmental Biology*, 406-414.

Lal, M., Singh, K., Rathore, L., Srinivasan, G., and Saseendran, S. (1998). Vulnerability of rice and wheat yields in NW India to future changes in climate. *Agricultural and Forest Meteorology, 89*(2), 101-114.

Li, W.-B., Wang, H., and Zhang, F.-S. (2005). Effects of silicon on anther dehiscence and pollen shedding in rice under high temperature stress. *Acta Agronomica Sinica, 1*, 025.

Liang, K., Lin, W., Chen, Z., Li, Y., Liang, Y., Guo, Y., He, H., and Chen, F. (2003). Heterosis and genetic correlation analysis of rice (*Oryza sativa L.*) grain weight development under different environmental conditions]. *Ying yong sheng tai xue bao= The journal of applied ecology/Zhongguo sheng tai xue xue hui, Zhongguo ke xue yuan Shenyang ying yong sheng tai yan jiu suo zhu ban, 14*(12), 2200.

Lin, W., Ziska, L. H., Namuco, O. S., and Bai, K. (1997). The interaction of high temperature and elevated CO2 on photosynthetic acclimation of single leaves of rice in situ. *Physiologia Plantarum, 99*(1), 178-184.

Lisle, A., Martin, M., and Fitzgerald, M. (2000). Chalky and translucent rice grains differ in starch composition and structure and cooking properties. *Cereal Chemistry, 77*(5), 627-632.

Lu, C., Wang, C., Zong, S., Zhao, L., and Zhou, J. (2002). Effects of temperature on fertility and seed set in intersubspecific hybrid rice. *International Rice Research Notes, 27*.

Lur, H.-S., Wu, Y.-C., Chang, S.-J., Lao, C.-L., Hsu, C.-L., and Kondo, M. (2009). *Effects of high temperature on yield and grain quality of rice in Taiwan.* Paper presented at the Proceeding of the MARCO Symposium. National Institute for Agro-Environmental Sciences, Tsukuba, Japan.

Mackill, D. J., Ismail, A. M., Pamplona, A. M., Sanchez, D. L., Carandang, J. J., and Septiningsih, E. M. (2010). Stress tolerant rice varieties for adaptation to a changing climate. *Crop, Environment and Bioinformatics, 7*, 250-259.

MacNeish, R. S., and Libby, J. G. (1995). *Origins of rice agriculture: the preliminary report of the Sino-American Jiangxi (PRC) Project SAJOR*: University of Texas at El Paso.

Marschner, H. (1995). Mineral Nutrition of HigherPlants. (2nd ed). Horst Marschner Press, page 108.

Matsui, T., and Kagata, H. (2003). Characteristics of Floral Organs Related to Reliable Self-pollination in Rice (*Oryza sativa L.*). *Annals of Botany, 91*(4), 473-477.

Matsui, T., and Omasa, K. (2002). Rice (*Oryza sativa L.*) cultivars tolerant to high temperature at flowering: anther characteristics. *Annals of Botany, 89*(6), 683-687.

Matsui, T., Omasa, K., and Horie, T. (1997). High temperature-induced spikelet sterility of Japonica rice at flowering in relation to air temperature, humidity and wind velocity conditions. *Japanese Journal of Crop Science, 66*(3), 449-455.

Matsui, T., Omasa, K., and Horie, T. (2001a). Comparison between Cultivais wi. *Production Science, 4*(1), 36-40.

Matsui, T., Omasa, K., and Horie, T. (2001b). The difference in sterility due to high temperatures during the flowering period among japonica-rice varieties. *Plant Production Science-Tokyo-, 4*(2), 90-93.

Matsushima, S., and Tanaka, T. (1960). Analysis of developmental factors determining yields and its application to yield prediction and culture improvement of lowland rice. 55. Early discrimination of non-fertilized rice-grains. *Nihon Sakumotsugaku Kai Kiji= Proceedings of the Crop Science Society of Japan, 28*(4), 365-366.

Mengel, K., Kosegarten, H., Kirkby, E. A., and Appel, T. (2001). *Principles of plant nutrition*: Springer.

Mittler, R. (2002). Oxidative stress, antioxidants and stress tolerance. *Trends in plant science, 7*(9), 405-410.

Morita, S., Shiratsuchi, H., Takahashi, J., and Fujita, K. (2004). Effect of high temperature on grain ripening in rice plants: analysis of the effects of high night and high day temperatures applied to the panicle and other parts of the plant. *Japanese Journal of Crop Science (Japan)*.

Murata, Y. (1976). Productivity of rice in different climatic regions of Japan. *International Rice Research Institute (Los Baños, Filipinas). Climate and rice. Los Baños*, 449-469.

Nagarajan, S., Jagadish, S., Prasad, A., Thomar, A., Anand, A., Pal, M., and Agarwal, P. (2010). Local climate affects growth, yield and grain quality of aromatic and non-aromatic rice in northwestern India. *Agriculture, ecosystems & environment, 138*(3), 274-281.

Nakagawa, H., Horie, T., Matsui, T., Mew, T., Brar, D., Peng, S., Dawe, D., and Hardy, B. (2003). *Effects of climate change on rice production and adaptive technologies.* Paper presented at the Rice science: innovations and impact for livelihood. Proceedings of the International Rice Research Conference, Beijing, China, 16-19 September 2002.

Nishiyama, I., and Blanco, L. (1980). Avoidance of high temperature sterility by flower opening in the early morning [of rice plant]. *Japan Agricultural Research Quarterly, 14*.

O'Toole, J., and Namuco, O. (1983). Role of panicle exsertion in water stress induced sterility. *Crop Science, 23*(6), 1093-1097.

Oh-e, I., Saitoh, K., and Kuroda, T. (2007). Effects of high temperature on growth, yield and dry-matter production of rice grown in the paddy field. *Plant Production Science, 10*(4), 412-422.

Ohta, S., and Kimura, A. (2007). Impacts of climate changes on the temperature of paddy waters and suitable land for rice cultivation in Japan. *Agricultural and Forest Meteorology, 147*(3), 186-198.

Okada, M., Iizumi, T., Hayashi, Y., and Yokozawa, M. (2011). Modeling the multiple effects of temperature and radiation on rice quality. Environmental Research Letters, 6(3), 034031.

Olson, R. A., and Kurtz, L. (1982). Crop nitrogen requirements, utilization, and fertilization. *Nitrogen in AgriculturalSsoils*(nitrogeninagrics), 567-604.

Osada, A., Sasiprapa, V., M. Rahong, S., Dhammanuvong, And Chakrabandhu, H. (1973). Abnormal occurrence of empty grains of indica rice plants in the dry, hot season in Thailand. *Japanese Journal of Crop Science 42*(1), 103-109.

Perez, C. (1979). Gel consistency and viscosity of rice. Paper presented at the Proceedings of the Workshop on Chemical Aspects of Rice Grain Quality. International Rice Research Institute, Manila, Philippines.

Porter, J. R. (2005). Rising temperatures are likely to reduce crop yields. *Nature, 436*(7048), 174-174.

Porter, J. R., and Semenov, M. A. (2005). Crop responses to climatic variation. *Philosophical Transactions of the Royal Society of London B: Biological Sciences, 360*(1463), 2021-2035.

Posmyk, M., and Janas, K. (2007). Effects of seed hydropriming in presence of exogenous proline on chilling injury limitation in Vigna radiata L. seedlings. *Acta Physiologiae Plantarum, 29*(6), 509-517.

Prasad, P., Boote, K., Allen Jr, L., Sheehy, J., and Thomas, J. (2006a). Species, ecotype and cultivar differences in spikelet fertility and harvest index of rice in response to high temperature stress. *Field Crops Research, 95*(2), 398-411.

Prasad, P., Boote, K. J., and Allen Jr, L. H. (2006b). Adverse high temperature effects on pollen viability, seed-set, seed yield and harvest index of grain-sorghum *Sorghum bicolor (L.)* Moench are more severe at elevated carbon dioxide due to higher tissue temperatures. *Agricultural and Forest Meteorology, 139*(3), 237-251.

Reddy, K. S., and Reddy, B. B. (1992). Effect of transplanting time, plant density and seedling age on growth and yield of rice. *Indian Journal of Agronomy, 37*(1), 18-21.

Resurreccion, A. P., Hara, T., Juliano, B. O., and Yoshida, S. (1977). Effect of temperature during ripening on grain quality of rice. *Soil Science and Plant Nutrition, 23*(1), 109-112.

Rice, Chaudhary, R. C. (1996). *Standard Evaluation System for Rice*: IRRI, International Rice Research Institute.

Ristic, Z., and Cass, D. D. (1992). Chloroplast structure after water and high-temperature stress in two lines of maize that differ in endogenous levels of abscisic acid. *International Journal of Plant Sciences*, 186-196.

Safdar, M. E., Ali, A., Muhammad, S., Sarwar, G., and Awan, T. H. (2008). Effect of transplanting dates on paddy yield of fine grain rice genotypes. *Pakistan Journal of Botany, 40*(6), 2403-2411.

Saini, H. S. (1997). Effects of water stress on male gametophyte development in plants. *Sexual Plant Reproduction, 10*(2), 67-73.

Saini, H. S., and Westgate, M. E. (1999). Reproductive development in grain crops during drought. *Advances in Agronomy, 68*, 59-96.

Sangakkara, U., Frehner, M., and Nösberger, J. (2001). Influence of soil moisture and fertilizer potassium on the vegetative growth of mungbean (*Vigna radiata L.* Wilczek) and cowpea (Vigna unguiculata L. Walp). *Journal of Agronomy and Crop Science, 186*(2), 73-81.

Sarr, B. (2012). Present and future climate change in the semi-arid region of West Africa: a crucial input for practical adaptation in agriculture. *Atmospheric Science Letters, 13*(2), 108-112.

Sarr, B., S. Traore and S. Salack. (2007). *Evaluation of the impact of climate change on yields of cereal crops in Sudano-Sahelian. International Conference for the reduction of the vulnerability of natural systems to economical esociaux. West Africa Climate Change, (In French).* Paper presented at the International Conference for the reduction of the vulnerability of natural systems to economical esociaux, West Africa Climate Change, Ouagadougou.

Satake, T., and Yoshida, S. (1978). *High temperature-induced sterility in indica rices at flowering.* Paper presented at the Proceedings of the Crop Science Society of Japan.

Sato, S., Kamiyama, M., Iwata, T., Makita, N., Furukawa, H., and Ikeda, H. (2006). Moderate increase of mean daily temperature adversely affects fruit set of Lycopersicon esculentum by disrupting specific physiological processes in male reproductive development. *Annals of Botany, 97*(5), 731-738.

Savin, R., Stone, P. J., and Nicolas, M. E. (1996). Responses of grain growth and malting quality of barley to short periods of high temperature in field studies using portable chambers. *Crop and Pasture Science, 47*(3), 465-477.

Seck, P. A., Diagne, A., Mohanty, S., and Wopereis, M. C. (2012). Crops that feed the world 7: rice. *Food Security, 4*(1), 7-24.

Shabala, S., and Pottosin, I. I. (2010). Potassium and potassium-permeable channels in plant salt tolerance *Ion Channels and Plant Stress Responses* (pp. 87-110): Springer.

Shah, F., Huang, J., Cui, K., Nie, L., Shah, T., Chen, C., and Wang, K. (2011). Impact of high-temperature stress on rice plant and its traits related to tolerance. *Journal of Agricultural Science, 149*, 545-556.

Shahzad, M., Sahi, S., Khan, M., and Ahmad, M. (2007). Effect of sowing dates and seed treatment on grain yield and quality of wheat. *Pakistan Journal of Agricultural Sciences (Pakistan)*.

Shrestha, S., Asch, F., Dingkuhn, M., and Becker, M. (2011). Cropping calendar options for rice–wheat production systems at high-altitudes. *Field Crops Research, 121*(1), 158-167.

Siebenmorgen, T., Nehus, Z., and Archer, T. (1998). Milled Rice Breakage Due to Environmental Conditions 1. *Cereal Chemistry, 75*(1), 149-152.

Singh, N., Singh, H., Kaur, K., and Bakshi, M. S. (2000). Relationship between the degree of milling, ash distribution pattern and conductivity in brown rice. *Food Chemistry, 69*(2), 147-151.

Singletary, G. W., Banisadr, R., and Keeling, P. L. (1994). Heat stress during grain filling in maize: effects on carbohydrate storage and metabolism. *Functional Plant Biology, 21*(6), 829-841.

Slaton, N. A. (2001). Rice production hand book. Misc. Publ., 192. (pp. 281): Arkansas Coop. Ext. Service, University of Arkansas.

Snider, J. L., Oosterhuis, D. M., and Kawakami, E. M. (2010). Genotypic differences in thermotolerance are dependent upon prestress capacity for antioxidant protection of the photosynthetic apparatus in Gossypium hirsutum. *Physiologia Plantarum, 138*(3), 268-277.

Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K., Tignor, M., and Miller, H. (2007). *climate change 2007: the physical science basis*. Paper presented at the IPCC, 2007. Contribution of Working Group I to the fourth assessment report of the Intergovernmental Panel on Climate Change.

Souroush, H., Mesbah, M., and Hossain, Z. A. (2004). A study of relationship between grain yield and yield components in rice. *Iranian Journal of Field Crop Science, 35*(4), 11.

Stevenson, F. J. (1982). Crop nitrogen requirements, utilization, and fertilization. American Society of Agronomy.

Sung, D.-Y., Kaplan, F., Lee, K.-J., and Guy, C. L. (2003). Acquired tolerance to temperature extremes. *Trends in plant science, 8*(4), 179-187.

Tang, R.-S., Zheng, J.-C., Jin, Z.-Q., Zhang, D.-D., Huang, Y.-H., and Chen, L.-G. (2008). Possible correlation between high temperature-induced floret sterility and endogenous levels of IAA, GAs and ABA in rice (*Oryza sativa* L.). *Plant Growth Regulation, 54*(1), 37-43.

Tao, L. X., Tan, H. J., Wang, X., Cao, L. Y., and Cheng, S. H. (2007). Effects of high temperature stress on super hybrid rice Guodao 6 during flowering and filling phases. *Chinese Journal of Rice Science, 5*, 014.

Tao, L.-X., Tan, H.-J., Wang, X., CAO, L.-Y., Song, J., and Cheng, S.-H. (2008). Effects of High-Temperature Stress on Flowering and Grain-Setting Characteristics of Guodao 6. *Acta Agronomica Sinica, 34*(4), 609-674.

Tashiro, T., and Wardlaw, I. (1991). The effect of high temperature on kernel dimensions and the type and occurrence of kernel damage in rice. *Crop and Pasture Science, 42*(3), 485-496.

Tian, X., Tsutomu, M., Li, S., and Lin, J. (2007). High temperature stress on rice anthesis: research progress and prospects]. *Ying yong sheng tai xue bao= The* *journal of applied ecology/Zhongguo sheng tai xue xue hui, Zhongguo ke xue yuan Shenyang ying yong sheng tai yan jiu suo zhu ban, 18*(11), 2632.

Trenkel, M. E., and Association, I. F. I. (1997). *Controlled-release and stabilized fertilizers in agriculture* (Vol. 11): International fertilizer industry association Paris.

Umemoto, T., and Terashima, K. (2002). Research note: Activity of granule-bound starch synthase is an important determinant of amylose content in rice endosperm. *Functional plant biology, 29*(9), 1121-1124.

Vange, T. and Obi, I. (2006). Effect of planting date on some agronomic traits and grain yield of upland rice varieties at Makurdi, Benue state, Nigeria. *Journal of Sustainable Development in Agriculture and Environment, 2*(2), 1-9.

Verhoeven, A. S., Demmig-Adams, B., and Adams III, W. W. (1997). Enhanced employment of the xanthophyll cycle and thermal energy dissipation in spinach exposed to high light and N stress. *Plant Physiology, 113*(3), 817-824.

Vollenweider, P. G. M. (2005). Diagnosis of abiotic and biotic stress factors using the visible symptoms in foliage. *Environmental Pollution, 137*, 455-465.

Wahid, A., Gelani, S., Ashraf, M., and Foolad, M. (2007). Heat tolerance in plants: an overview. *Environmental and Experimental Botany, 61*(3), 199-223.

Wang, W., Vinocur, B., Shoseyov, O., and Altman, A. (2004). Role of plant heat-shock proteins and molecular chaperones in the abiotic stress response. *Trends in Plant Science, 9*(5), 244-252.

Waraich, E., Ahmad, R., Halim, A., and Aziz, T. (2012). Alleviation of temperature stress by nutrient management in crop plants: a review. *Journal of Soil Science and Plant Nutrition, 12*(2), 221-244.

Waraich, E. A., Ahmad, R., and Ashraf, M. (2011). Role of mineral nutrition in alleviation of drought stress in plants. *Australian Journal of Crop Science, 5*(6), 764.

Wardlaw, I., and Wrigley, C. (1994). Heat tolerance in temperate cereals: an overview. *Functional Plant Biology, 21*(6), 695-703.

Wassmann, R., Jagadish, S., Sumfleth, K., Pathak, H., Howell, G., Ismail, A., Serraj, R., Redona, E., Singh, R., and Heuer, S. (2009). Regional vulnerability of climate change impacts on Asian rice production and scope for adaptation. Advances in Agronomy, 102, 91-133.

Watanabe, T., and Kume, T. (2009). A general adaptation strategy for climate change impacts on paddy cultivation: special reference to the Japanese context. *Paddy and Water Environment, 7*(4), 313-320.

Welch, J. R., Vincent, J. R., Auffhammer, M., Moya, P. F., Dobermann, A., and Dawe, D. (2010). Rice yields in tropical/subtropical Asia exhibit large but opposing sensitivities to minimum and maximum temperatures. *Proceedings of the National Academy of Sciences, 107*(33), 14562-14567.

White, P. J., and Karley, A. J. (2010). Potassium *Cell biology of metals and nutrients* (pp. 210): Springer.

Wise, R., Olson, A., Schrader, S., and Sharkey, T. (2004). Electron transport is the functional limitation of photosynthesis in field-grown pima cotton plants at high temperature. *Plant, Cell & Environment, 27*(6), 717-724.

Wollenweber, B., Porter, J., and Schellberg, J. (2003). Lack of Interaction between Extreme High-Temperature Events at Vegetative and Reproductive Growth Stages in Wheat. *Journal of Agronomy and Crop Science, 189*(3), 142-150.

Xia, M., and Qi, H. (2004). Effects of heat injury on grain setting rate for four rice combinations. *Journal of Hebei Agricultural Sciences (2)*, 21-22.

Yin, X., Kropff, M. J., And Goudriaan, J. (1996). Differential effects of day and night temperature on development to flowering in rice. *Annals of Botany, 77*(3), 203-213.

Yoshida, S. (1973). Effects of temperature on growth of the rice plant (*Oryza sativa L.*) in a controlled environment. *Soil Science and Plant Nutrition, 19*(4), 299-310.

Yoshida, S. (1978). Tropical climate and its influence on rice. Internet Print in eprints.icrisat.ac.in. In IRRI res. Paper ser. no.20. IRRI.

Yoshida, S. (1981). *Fundamentals of rice crop science*: page 98-118. Internation Rice Research Institute, Manilla, Philipines.

Young, R. D. (1974). *TVA's development of sulfur-coated urea*: National Fertilizer Development Center, Tennessee Valley Authority.

Yun, W., Jinping, Z., Yong, S., Jauhar, A., Jianlong, X., and Zhikang, L. (2012). Identification of genetic overlaps for salt and drought tolerance using simple sequence repeat markers on an advanced backcross population in rice. *Crop Science, 52*(4), 1583-1592.

Zahid, M. A., Akhter, M., Sabar, M., Manzoor, Z., and Awan, T. (2006). Correlation and path analysis studies of yield and economic traits in Basmati rice (*Oryza sativa L.*). *Asian Journal of Plant Sciences, 5*.

Zain, N. A. M., Ismail, M. R., Mahmood, M., Puteh, A., and Ibrahim, M. H. (2014). Alleviation of water stress effects on MR220 rice by application of periodical water stress and potassium fertilization. *Molecules, 19*(2), 1795-1819.

Zhang, G. L., Chen, L.Y., And Zhang, S.T. (2007). Effects of high temperature stress on rice flower organ and yield components and grain quality *Journal of Hunan Agricultural University (Natural Sciences), 2*, 002.

Zhang, G.L., Chen, L.Y., Zhang, S.T., Zheng, H., And Liu, G.H. (2009). Effects of high temperature stress on microscopic and ultrastructural characteristics of mesophyll cells in flag leaves of rice. *Rice Science*, 16(1), 65-71.

Zhao, M.G., Tian, Q.Y., and Zhang, W.H. (2007). Nitric oxide synthase-dependent nitric oxide production is associated with salt tolerance in Arabidopsis. *Plant Physiology, 144*(1), 206-217.

Ziska, L., and Manalo, P. (1996). Increasing night temperature can reduce seed set and potential yield of tropical rice. *Functional Plant Biology, 23*(6), 791-794.

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LIST OF PUBLICATIONS

Karbalaei Aghamolki, M. T., Yusop, M. K., Oad. F. C., Zakikhani, H., Ze Jaafar, H., Kharidah, H., Kharidah S., Hanafi M. M., (2014). **Response of Yield and Morphological Characteristic of Rice Cultivars to Heat Stress at Different Growth Stages,** World Academy of Science, Engineering and Technology. International Journal of Agricultural, Biosystems Science and Engineering. Vol.8 No.2, 2014

Karbalaei Aghamolki, M. T., Yusop, M. K., Oad. F. C., Zakikhani, H., Ze Jaafar, H., Kharidah, H., Kharidah S., Hanafi M. M., (2014). **Heat stress effects on yield parameters of selected rice cultivars at reproductive growth stages.** JFAE **Vol 12 (2) – 2014.**

Karbalaei Aghamolki, M. T., Yusop, M. K., Oad. F. C., Zakikhani, H., Ze Jaafar, H., Kharidah, H., Kharidah S., Hanafi M. M., (2014). **Effects of Heats Stress on Growth of Rice Cultivars (*Oryza sativa L.*)**, Poster presentation at International Agriculture Congress 2014, Malaysia.

Karbalaei Aghamolki, M. T., Yusop, M. K., Hanafi M. M., Ze Jaafar, H., Khalatbari, A. M., Fallah, A., Kharidah, S., (2015). **Impact of Heat Stress and Fertilizer Management on Yield and Potassium Uptake of Rice.** Poster peresentation at International Conference on Sustainable Development, Strategies and Challenge 2015, Iran.

Karbalaei Aghamolki, M. T., Yusop, M. K., Oad. F. C., Khalatbari. A.M., Ze Jaafar, H., Kharidah, H., Kharidah S., Hanafi M. M., (2014). **IMPACT OF HEAT STRESS ON GROWTH AND YIELD OF RICE CULTIVARS (*Oryza sativa L.*)** JFAE (Submited to Journal).

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