TIME-SPECIFIC MULTI-COMPONENT FOLIAR FERTILIZATION OF RICE FOR YIELD INCREASE AND BLAST CONTROL

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By

WAN SUHANA BINTI WAN TALIB

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DEDICATION

This thesis is dedicated to the late Mohd Ali Mohd Rashid and Prof Dr Wan Mohamed Wan Othman, my greatest supporters from the very beginning of this journey and who did not live to celebrate this victory.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science

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Chairman : Professor Mohd Razi Ismail, PhD
Institute : Tropical Agriculture and Food Security

Balanced nutrition imposed at specific times of a plant's critical growth stages is a key factor in achieving high yield and disease control. Efficient and rapid uptake of nutrients critically needed at a specific time can be deployed through foliar fertilization. The objective of this study is to investigate the effect of multi-component foliar fertilizer application at different growth stages on rice yield and blast control. A glasshouse experiment was conducted in University Agriculture Park, Universiti Putra Malaysia in Serdang, Selangor. Field experiment on yield was performed in two different locations representing our major granary areas. The first area is classified as medium productivity district, namely, Muda Agriculture Development Authority (MADA) in Tunjang, Kedah whereas the second area is classified as low productivity district that is Integrated Agriculture Development Area (IADA) in Semerak Kemasin. Multi-component foliar fertilizer was applied at three different critical growth stages with different frequency of application for rice cv. MR 219. The different frequencies were deployed as: (T1) Two sprays at seedling stage (emergence of 2nd and 5th leaf); (T2) Three sprays at the seedling stage (two sprays: 2nd and 5th leaf) and tillering stage (single spray: active tillering day 35 DAS); (T3) Five sprays at the seedling (two sprays), tillering (single spray), and panicle stages (two sprays at panicle initiation: 45 DAS and panicle differentiation stages: 60 DAS). Results in glasshouse experiment showed increased growth, yield and yield component of rice. Significant increase was recorded in plant height (2.9%), leaf area index (114%), photosynthesis rate (23%), biomass (134%), 1000-grain weight (9.8%), number of tillers (71.8%), productive tillers (64%) and grain yield (59%). It is concluded that five foliar applications of multi-component foliar fertilizer at seedling stage (two sprays), tillering (single spray) and panicle (two sprays at panicle initiation and panicle differentiation) stages facilitate in enhancing yield and yield components of rice in the glasshouse experiment. Rice leaf blast was also reduced through five-time application of multi component foliar fertilizer by

87.36%. Results in field experiment in MADA area, in the district of Tunjang, Kedah showed increased growth, yield component and yield of rice. Significant increase was recorded in tiller number (47.5%), panicle length (11.42%), grain number (30.64%), grain filling (11.03%), grain weight (18.68%), biomass (22.80%) and yield (25.87%). Similarly, results in IADA area, Semerak Kemasin district showed increased growth and yield component. Significant increase was recorded in chlorophyll content SPAD value (7.83%), panicle length (15.17%), grain number (43.13%), grain filling (14.99%), grain weight (3.2%) and biomass (69.86%). It is concluded that the treatment 3 with five foliar applications of multi-component foliar fertilizer at seedling (two sprays), tillering (single spray) and panicle (two sprays at panicle initiation and panicle differentiation) stages facilitate in enhancing yield and yield components of rice in the field experiment. Rice leaf blast was reduced by five-time application of multi-component foliar fertilizer. Based on these findings, farmers should be advised and guided according to critical growth stages in foliar fertilizer application. Timely application of foliar fertilizer is important to ensure sufficient supply of macro- and micronutrients to supplement nutrients from soil applications for better plant growth and rice production. Concomitantly, foliar fertilization can be a useful pest management strategy among paddy farmers to prevent or lessen disease severity.

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

PEMBAJAAN DAUN PELBAGAI KOMPONEN SECARA BERKALA KE ATAS BERAS UNTUK MENINGKATKAN HASIL DAN MENGAWAL PENYAKIT KARAH

Oleh

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Penggunaan nutrisi yang seimbang ketika peringkat tumbesaran kritikal tumbuhan adalah faktor utama dalam mempastikan hasil yang tinggi dan kawalan ke atas penyakit. Penyerapan nutrisi yang diperlukan pada masa yang spesifik secara efisyen dan cepat boleh dilakukan melalui pembajaan daun. Tujuan kajian ini adalah untuk menyelidik kesan pembajaan daun pelbagai komponen nutrisi pada peringkat pertumbuhan yang spesifik ke atas hasil tanaman padi dan kawalan penyakit. Eksperimen rumah kaca telah dilaksanakan di Taman Pertanian Universiti, Universiti Putra Malaysia. Eksperimen lapangan ke atas hasil dilaksanakan di dua lokasi yang mewakili jelapang utama. Kawasan pertama dikategorikan sebagai daerah produktiviti sederhana iaitu Lembaga Kemajuan Pertanian Muda (MADA) di Tunjang, Kedah, manakala kawasan yang kedua dikategorikan sebagai daerah produktiviti rendah, iaitu Kawasan Pembangunan Pertanian Bersepadu (IADA) di Semerak Kemasin. Baja foliar pelbagai komponen telah diaplikasi ke atas padi jenis cv. MR 219 pada tiga peringkat pertumbuhan kritikal yang berlainan dengan frekuensi yang berbeza. Perbezaan frekuensi dilaksanakan sebagai: (T1) dua semburan pada peringkat anak benih (kemunculan daun ke-2 dan ke-5); (T2) tiga semburan pada peringkat anak benih (dua semburan: daun ke-2 dan ke-5) dan peringkat anak padi (satu semburan: pucuk aktif hari 35 DAS); (T3) Lima semburan pada peringkat anak benih (dua semburan), anak padi (satu semburan), panikel (dua semburan pada permulaan panikel: 45 DAS dan perbezaan panikel: 60 DAS). Hasil eksperimen rumah kaca menunjukkan peningkatan tumbesaran, hasil tanaman dan komponen hasil padi. Peningkatan signifikan direkodkan pada ketinggian tumbuhan (2.9%), indeks keluasan daun (114%), kadar fotosintesis (23%), biojisim (134%), berat 1000 butir (9.8%), bilangan anak padi (71.8%), anak padi produktif (64%) dan hasil bijirin (59%). Adalah disimpulkan bahawa aplikasi baja daun sebanyak lima kali

menggunakan baja daun pelbagai komponen pada peringkat anak benih (dua semburan), anak padi (satu semburan) dan panikel (dua semburan pada permulaan panikel dan perbezaan panikel) membantu meningkatkan hasil tanaman dan komponen hasil padi dalam eksperimen rumah kaca. Penyakit karah daun padi juga telah dikurangkan (87.36%) dengan lima kali aplikasi baja daun pelbagai komponen. Hasil eksperimen lapangan di kawasan MADA, daerah Tunjang, Kedah menunjukkan peningkatan tumbesaran, komponen hasil dan hasil tanaman padi. Peningkatan signifikan telah direkodkan dalam bilangan anak padi (47.5%), panjang panikel (11.42%), bilangan bijirin (30.64%), isian bijirin (11.03%), berat bijirin (18.68%), biojisim (22.80%) dan hasil tanaman (25.87%). Begitu juga dengan hasil kajian di kawasan IADA, daerah Semerak Kemasin yang menunjukkan peningkatan tumbesaran dan komponen hasil. Peningkatan signifikan telah direkodkan pada kandungan klorofil nilai SPAD (7.83%), panjang panikel (15.17%), bilangan bijirin (43.13%), isian bijirin (14.99%), berat bijirin (3.2%) dan biojisim (69.86%). Adalah disimpulkan bahawa aplikasi baja daun pelbagai komponen pada peringkat anak benih (dua semburan), anak padi (satu semburan) dan panikel (dua semburan pada permulaan panikel dan perbezaan panikel) membantu dalam meningkatkan hasil tanaman dan komponen hasil padi dalam eksperimen lapangan. Penyakit karah daun padi juga telah dikurangkan dengan aplikasi lima kali baja daun pelbagai komponen. Berdasarkan kajian ini, adalah dicadangkan bahawa para petani diberi bimbingan dan nasihat berkenaan pembajaan foliar pada masa yang sesuai di peringkat pertumbuhan kritikal bagi memastikan nutrien tambahan adalah mencukupi sebagai tambahan kepada nutrient yang dibekal oleh tanah. Pada masa yang sama, pembajaan foliar adalah berguna sebagai strategi pengurusan penyakit dan perosak dalam kalangan penanam padi bagi mencegah atau mengurangkan keterukan penyakit.

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

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LIST OF ABBREVIATIONS

ADP	Adenosine diphosphate
ATP	Adenosine triphosphate
B	Boron
Ca	Calcium
Cu	Copper
DAS	Days after sowing
DAT	Days after transplanting
DOA	Department of Agriculture
DPA	Days after post anthesis
FAO	Food Agriculture Organization
Fe	Iron
IADA BLS	Integrated Agriculture Development Area Barat Laut Selangor
IRRI	International Rice Research Institute
K	Potassium
LPCB	Lactophenol Cotton Blue
KADA	Kemubu Agricultural Development Authority
MADA	Muda Agricultural Development Authority
Mg	Magnesium
Mn	Manganese
Mo	Molybdenum
MOA	Ministry of Agriculture
N	Nitrogen
P	Phosphorous

Si	Silicon
SSL	Self-sufficiency level
Zn	Zinc

CHAPTER 1

INTRODUCTION

Rice (*Oryza sativa L.*) is the staple food for more than a billion people or one fifth of the world's population. Hundreds of millions of rural poor in Asian region are involved in rice farming, making it their main source income. About 90% of rice is grown in Asia covering about 200 million rice farms, mostly being less than one hectare. Inconsistency in rice availability will affect the price and had caused social unrest in several countries (Mengel and Kirkby, 2001; Xiao et al., 2009). The global food crisis involving rice that took place in 2007 is a classic case of supply surpassing the demand, leading to a drastic increase in the price of the prized staple (Gnanamanickam, 2009). To maintain global food security, IRRI estimated that an additional 8 to10 million tons of rice need to be produced every year (Buck et al., 2008; IRRI, 2015).

Malaysia is largely dependent on rice imports to meet the domestic demand. In 2018, rice imports are forecast at 950000 tonnes as local production only meets 50% of the national rice demand (FAO, 2016). The Ministry of Agriculture and Agro-based Industries in Malaysia aims to increase average yields from 4.5t/ha to 10t/ha to achieve 100% self-sufficiency level (SSL) by 2020 (Ministry of Agriculture and Agro-based Industries, Malaysia, 2013). However, coupled with pests and diseases, competition for land use for urban sectors and rapid annual population growth in Malaysia estimated with 32,042,458 million of population with the density of 98 p/km^2 (Briones and Felipe, 2016) would made it more difficult to achieve this goal. In 2018 rice production in Malaysia has hit 72% SSL, compared with the target of 80% (Malaysia Insight, 2018).

Disease management is a critical challenge in rice production. Rice blast causes 11-30% reduction in total world rice production or 10 million tonnes annually (Xiao et al., 2009). In Malaysia, at least 85% cases of pests and diseases were reported by rice farmers (Amir et al., 2012). Fungicide is widely used to control blast by the farmers but unfortunately, it is expensive and, therefore, impractical and not environmentally friendly.

To achieve 100% SSL, it is important to source for more effective ways of increasing production whilst overcoming potential threats such as disease. Furthermore, due to the increasing cost of fossil fuel to manufacture fertilizer, foliar fertilization is one of many fertilization techniques that provides a promising outcome (Kannan, 2010).

Foliar fertilization is the application of foliar sprays of one or more mineral nutrients to supplement traditional soil applications of fertilizer. Emphasis is on supplementing the available nutrients and not serve as a sole source of nutrition (Oosterhuis and Weir, 2010). In Malaysia, a study conducted by Liew et al. (2012) showed that a supplementation of foliar copper and boron in combination increased yield of MR219 and decreased blast incidence by 5%. Efficiency and rapidity of utilization of the nutrients critically needed at a specific time is at the utmost through foliar fertilization (Oosterhuis and Weir, 2010) as it is fast and target-oriented compared to soil fertilization since nutrients can be directly delivered to plant tissues during critical stages of plant growth (Fernández and Brown, 2013; Mengel and Kirkby, 2001). The application of foliar sprays of nutrients after 45 days from transplanting had proven in maximizing grain yield and quality of rice cultivar *Sakha 104* (Sharief et al., 2006). More significant result obtained by application of foliar fertilizer at a different critical growth stages seedling, tillering and flowering with different concentrations of multi-component of nutrients for rice cultivar metica (Shaygany et al., 2012).

Several studies have reported the role of foliar fertilization and disease interaction. (Buck et al., 2008) reported that foliar fertilization of potassium silicate (K_2SiO_3) at 4g Si L^{-1} reduced rice blast incidence. A study conducted by Shaygany et al. (2012) also concluded that foliar fertilization of sodium silicate (Na_2SiO_3) at 0.004 g Si L^{-1} with five different time of foliar fertilizer application reduced the effect of blast in rice. Two foliar sprays of micronutrients such as borax, zinc sulfate, copper sulfate and ferrous sulfate at 0.05% have been reported to reduce the disease incidences of sheath blight and increased grain yield (Sehgal et al., 2001). A mixture of boron, copper, manganese and zinc as foliar fertilizer is proven to support the management of air borne infection of brown spot disease (Sehgal et al., 2001). However, these studies were only limited to certain combinations of nutrients and growth stages and lacking information on the effects on yield and disease affected by foliar fertilization at seedling, tillering and flowering.

1.1 Problem Statement

Balanced nutrition imposed at specific intervals during the plant's critical growth points is fundamental in nutrient management, yield improvement, and disease control (Ciampitti and Vyn, 2014; Dordas, 2009; Fageria, 2016; Fageria et al., 2010; Gupta et al., 2017). Modifying nutrients concentration as well as nutrients uptake have demonstrated effectiveness towards disease control and plant nutrition (Amtmann et al., 2008; Fageria et al., 2010; Huber and Graham, 1999; Wang et al., 2013). The supply of nutrients affects disease resistance in plants either physiologically or by affecting pathogens or both. The plant growth will be highly affected by the level of nutrients and affect the microclimate, therefore affecting infection and sporulation of the pathogen (Marschner, 1995). Fertilization has been the most common way to affect nutrient availability. Foliar fertilization is most affective in the control of micronutrients deficiencies

(Kannan, 2010), improving rice growth and main yield component (Zayed et al., 2011) and reduced blast incidence (Buck et al., 2008).Therefore, it is crucial to obtain basic information on the effectiveness of foliar fertilization at different critical growth stages that is highly correlated with the effectiveness of the degree of disease control.

1.2 Objectives

The major objective of this study was to determine the best times of foliar application at critical growth stages at seedling, tillering and flowering, to increase yield and control blast disease. The specific objectives were to:

i) Determine the yield response of MR219 to foliar fertilizer applications at different critical growth stages in glass house and field experiments.
ii) Determine the effects of foliar fertilization on MR219 on blast incidence in glass house and field experiments.
iii) Evaluate the effects of multi component foliar fertilizer at low and medium productivity areas on yield and blast disease in field experiment.

1.3 Hypotheses

H_{a1}: Foliar fertilization at different critical stages will increase yield

H_{a2}: Foliar fertilization at different critical stages will suppress rice blast.

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