

**EFFECT OF SILICON AND HIGH NITROGEN
FERTILIZER APPLICATION ON GROWTH
AND YIELD OF RICE (VAR.SERENDAH
MERAH)**

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**PERPUSTAKAAN
UNIVERSITI MALAYSIA SABAH**

**CROP PRODUCTION PROGRAMME
FACULTY OF SUSTAINABLE AGRICULTURE
UNIVERSITI MALAYSIA SABAH
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APPLICATION ON GROWTH AND YIELD OF
RICE (VAR.SERENDAH MERAH)**

NG HOOI CHIN

**PERPUSTAKAAN
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FACULTY OF SUSTAINABLE AGRICULTURE
UNIVERSITI MALAYSIA SABAH**

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DECLARATION

I hereby declare that this dissertation is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that no part of this dissertation has been previously or concurrently submitted for a degree at this or any other university.



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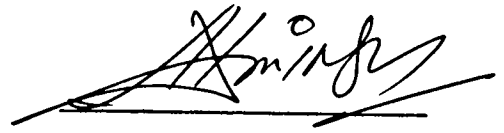
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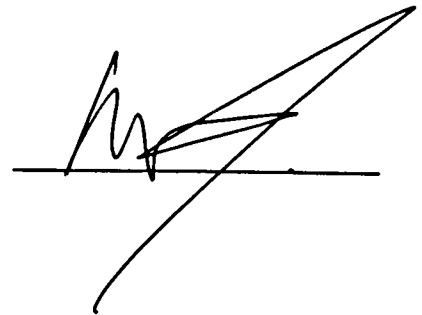


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ABSTRACT

Lodging of rice plants in paddy fields can reduce yield and cause economic loss to the farmers. A field experiment was conducted at the Faculty of Sustainable Agriculture (FSA) located at University Malaysia Sabah, Sandakan, Sabah to study the effect of silicon and high nitrogen fertilizer on the growth and yield of Serendah Merah rice variety and to study the effect of silicon in reducing the lodging effect on Serendah Merah rice variety. The experimental design used was Factorial Completely Randomized Design (CRD) by using 60kg/ha, 120kg/ha and 180kg/ha of Nitrogen fertilizer and 0kg/ha⁻¹, 200kg/ha⁻¹ and 400kg/ha⁻¹ of the silicon fertilizer. This experiment had three replications in each treatment. Data were analyzed with two-way analysis of variance (ANOVA) by using Minitab 16 Statistical Analysis Software. The means were compared at $P < 0.05$ by using Tukey's test. The results revealed that application of 180kg/ha N contributed to the maximum culm diameter (10.11mm), panicle length (24.2cm), number of grains per panicle (113), number of filled grains per panicle which were 77 (68.14%), number of empty grains per panicle which were 37 (32.74%), leaves dry weight (14.06g) and stem dry weight (10.16g). However, application of nitrogen at the rate of 120kg/ha produced the highest 1,000 grains weight (27.09g), highest root dry weight (33.51g) and also highest extrapolated yield (5.42 tons/ha) but showed no significant effect between nitrogen rates. In the case of silicon, the largest culm diameter (10.29mm) was from 400kg/ha Si. Although there were no significant differences for the interaction between N and Si on all yield parameters, the highest Si rates, 400kg/ha, showed a significant effect on culm diameter in order to reduce lodging incidence. In order to strengthen the culm of the rice plant, application of silicon fertilizer is recommended. Additionally, more studies on growth and yield of Sabah traditional rice varieties need to be carried out to contribute the knowledge about the effect of nitrogen and silicon fertilizer to increase yield and income to the farmers.



**KESAN APLIKASI BAJA SILIKON DAN NITROGEN KADAR TINGGI
THERHADAP PERTUMBUHAN DAN HASIL PADI
(VAR. SERENDAH MERAH)**

ABSTRAK

Padi rebah di sawah padi boleh menjejaskan hasil dan mengurangkan pulangan kepada para petani. Kajian telah dijalankan di Fakulti Pertanian Lestari (FPL), Universiti Malaysia Sabah, Sandakan, Sabah untuk mengkaji kesan silikon dan baja nitrogen yang tinggi terhadap pertumbuhan dan hasil variti padi Serendah Merah dan juga mengkaji kesan silikon dalam mengurangkan kesan rebah pada variti padi Serendah Merah. Reka bentuk kajian adalah dengan menggunakan Factorial Complete Randomized Design (CRD) dengan mengaplikasikan baja Nitrogen pada kadar 60kgN, 120kgN dan 180 kgN dan 0kg/ha, 200kg/ha dan 400kg/ha bagi baja silikon. Eksperimen ini mempunyai tiga ulangan pada setiap rawatan. Data telah dianalisis dengan dua cara analisis varians (ANOVA) dengan menggunakan perisian Minitab 16 Statistical Analysis. Nilai purata telah dibandingkan pada $P < 0.05$ dengan menggunakan ujian Tukey. Hasil kajian menunjukkan bahawa penggunaan 180kg/ha N menyumbang kepada maksimum garis pusat batang (10.11mm), maksimum panjang tangkai (24.2cm), maksimum jumlah butir setiap tangkai (113), maksimum bilangan butir penuh setiap tangkai (77), maksimum bilangan butir kosong setiap tangkai (37), maksimum berat kering daun (14.06g) dan maksimum berat kering batang (10.16g). Walau bagaimanapun, penggunaan nitrogen pada kadar 120kg/ha menghasilkan berat padi bagi 1,000-butir yang tertinggi (27.09g), berat kering akar yang tertinggi (33.51g) dan anggaran hasil yang tertinggi (5.42 tan/ha) tetapi tidak menunjukkan kesan yang ketara antara kadar nitrogen. Dalam kes silikon, kadar 400kg/ha Si menghasilkan garis pusat batang yang tertinggi (10.29mm). Walaupun tidak terdapat perbezaan yang ketara bagi interaksi antara N dan Si pada semua parameter komponen hasil, kadar Si yang tertinggi, 400kg/ha, menunjukkan kesan yang penting terhadap garis pusat batang untuk mengurangkan masalah rebah. Bagi menguatkan batang padi, penggunaan baja silikon adalah disyorkan. Di samping itu, lebih banyak kajian tentang pertumbuhan dan hasil bagi padi variti tradisional Sabah perlu dijalankan untuk menyumbang ilmu pengetahuan tentang kesan baja nitrogen dan silikon bagi meningkatkan hasil and pendapatan kepada petani.

TABLE OF CONTENT

CONTENT	PAGES
DECLARATION	ii
VERIFIED BY	iii
ACKNOWLEDGEMENT	iv
ABSTRACT	v
<i>ABSTRAK</i>	vi
LIST OF FIGURES	xi
LIST OF TABLES	xv
LIST OF SYMBOLS, UNITS AND ABBREVIATIONS	xvi
LIST OF FORMULAE	xvii
CHAPTER 1 INTRODUCTION	
1.1 Introduction	1
1.2 Justification	3
1.3 Significance of study	4
1.4 Objectives	5
1.5 Hypothesis	6
CHAPTER 2 LITERATURE REVIEW	
2.1 Rice	7
2.2 Irrigated rice	7
2.3 Traditional rice	8
2.4 Rice morphology	8
2.4.1 Leaves	9
2.4.2 Culm	9
2.4.3 Tillers	9
2.4.4 Panicle	10
2.5 Growth and developmental stages of rice	10
2.5.1 Vegetative stage	10
2.5.2 Reproductive stage	11
2.5.3 Ripening stage	11
2.6 Water requirement of rice	12



2.7	Physics, chemistry and biology of paddy soils	12
2.7.1	Physical processes in paddy soils	13
2.7.2	Chemical processes in paddy soils	13
2.7.3	Organic matter in paddy soils	14
2.7.4	Major environment of paddy field ecosystem	14
2.8	Nitrogen	15
2.8.1	Functions of Nitrogen	15
2.8.2	Deficiency symptoms	16
2.8.3	Nitrogen uptake in plant	16
2.8.4	Nitrogen use efficiency	16
2.8.5	Sources and Nitrogen content of fertilizer	17
2.8.6	Adequate rate of Nitrogen in rice	17
2.8.7	Application timing during growth cycle	18
2.8.8	Effect of excessive nitrogen application on plant	19
2.9	Lodging in rice	19
2.9.1	The relations between leaf sheath and lodging resistance in rice crop	21
2.9.2	Lodging mechanism	22
2.10	Silicon	23
2.10.1	Behavior of silicon in paddy soil	23
2.10.2	Silicon cycle in soil throughout the plant	23
2.10.3	Function of Silicon	24
2.10.4	Silicon deficiency symptoms	26
2.10.5	Silicon uptake in plant tissue	26
2.10.6	Silicon management practice	27
2.10.7	Silicon application ratio	27

CHAPTER 3 METHODOLOGY

3.1	Site of study	28
3.2	Period of study	28
3.3	Materials	28
3.4	Collection of Sabah traditional rice variety	29
3.5	Seed germination test	29
3.6	Experimental setup	29
3.6.1	Cleaning of net house	30

3.6.2	Soil preparation	30
3.6.3	Pots preparation	30
3.6.4	Preparation of the rice seed	31
3.6.5	Planting of rice seedlings into planting pots	31
3.6.6	Fertilizer application	32
3.7	Parameters	32
3.7.1	Vegetative growth	32
3.7.2	Yield components	34
3.7.3	Soil analysis	35
3.8	Experimental design and treatments	35
3.9	Statistical Analysis	37

CHAPTER 4 RESULTS

4.1	Vegetative Growth	39
4.1.1	Plant height	39
4.1.2	Number of tillers per hill	41
4.1.3	Culm diameter	44
4.1.4	Percentage of productive tillers	46
4.1.5	Panicle length	48
4.1.6	Internode length	50
4.2	Yield components	51
4.2.1	Number of grains per panicle	51
4.2.2	Number of filled grains per panicle	53
4.2.3	Number of empty grains per panicle	54
4.2.4	1,000 grains weight	56
4.2.5	Leaf dry weight	57
4.2.6	Stem dry weight	59
4.2.7	Root dry weight	60
4.2.8	Percentage of filled grains	62
4.2.9	Extrapolated yield	63

CHAPTER 5 DISCUSSION

5.1	Vegetative growth	65
5.1.1	Plant height	65

5.1.2	Number of tillers per hill	66
5.1.3	Culm diameter	67
5.1.4	Percentage of productive tillers	68
5.1.5	Panicle length	69
5.1.6	Internode length	70
5.2	Yield components	71
5.2.1	Number of grains per panicle	71
5.2.2	Number of filled grains per panicle	72
5.2.3	Number of empty grains per panicle	73
5.2.4	1,000 grains weight	74
5.2.5	Leaf dry weight	75
5.2.6	Stem dry weight	76
5.2.7	Root dry weight	76
5.2.8	Percentage of filled grains	77
5.2.9	Extrapolated yield	78

CHAPTER 6 CONCLUSION

6.1	Conclusion	80
6.2	Recommedations	81

REFERENCES	82
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APPENDICES	87
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LIST OF FIGURES

FIGURE	Page
2.1 Leaf sheath of rice crop to reduce lodging effect	21
2.2 Three types of lodging in rice namely culm bending, culm breaking and root lodging	22
2.3 Mechanism for the increased lodging resistance of dwarf rice	22
4.1a Effect of nitrogen fertilizer on plant height at 21 days after transplanting (DAT)	40
4.1b Effect of silicon fertilizer on plant height at 28, 35 and 42 days after transplanting (DAT)	40
4.1c Effect of nitrogen and silicon fertilizers on plant height throughout the planting period	41
4.2a Effect of nitrogen fertilizer on number of tillers per hill at 70 days after transplanting (DAT)	42
4.2b Effect of silicon fertilizer on number of tillers per hill at 70 days after transplanting (DAT)	43
4.2c Effect of nitrogen and silicon fertilizers on number of tillers per hill at 21 days after transplanting (DAT)	43
4.3a Effect of nitrogen fertilizer on culm diameter	44
4.3b Effect of silicon fertilizer on culm diameter	45
4.3c Effect of nitrogen and silicon fertilizers on culm diameter	45
4.4a Effect of nitrogen fertilizer on percentage of productive tillers	46
4.4b Effect of silicon fertilizer on percentage of productive tillers	47
4.4c Effect of nitrogen and silicon fertilizers on percentage of productive tillers	47
4.5a Effect of nitrogen fertilizer on panicle length	48
4.5b Effect of silicon fertilizer on panicle length	49
4.5c Effect of nitrogen and silicon fertilizers on panicle length	49
4.6a Effect of nitrogen fertilizer on internodes length	50
4.6b Effect of silicon fertilizer on internodes length	51
4.7a Effect of nitrogen fertilizer on number of grains per panicle	52

LIST OF FIGURES

FIGURE	Page
4.7b Effect of silicon fertilizer on number of grains per panicle	52
4.8a Effect of nitrogen fertilizer on number of filled grains per panicle	53
4.8b Effect of silicon fertilizer on number of filled grains per panicle	54
4.9a Effect of nitrogen fertilizer on number of empty grains per panicle	55
4.9b Effect of silicon fertilizer on number of empty grains per panicle	55
4.10a Effect of nitrogen fertilizer on 1,000 grains weight	56
4.10b Effect of silicon fertilizer on 1,000 grains weight	57
4.11a Effect of nitrogen fertilizer on leaf dry weight	58
4.11b Effect of silicon fertilizer on leaf dry weight	58
4.12a Effect of nitrogen fertilizer on stem dry weight	59
4.12b Effect of silicon fertilizer on stem dry weight	60
4.13a Effect of nitrogen fertilizer on root dry weight	61
4.13b Effect of silicon fertilizer on root dry weight	61
4.14a Effect of nitrogen fertilizer on percentage of filled grains	62
4.14b Effect of silicon fertilizer on percentage of filled grains	63
4.15a Effect of nitrogen fertilizer on extrapolated yield	64
4.15b Effect of silicon on extrapolated yield	64
8.1 The visited site for background study is located at Tuaran, Sabah, which was 36 miles from Kota Marudu and 96 miles from Kudat	87
8.2 Drainage system called "palung" with the function as a small drainage system in paddy field and works as walking path in paddy field	87
8.3 The site for collecting the paddy soil is located at Kampung Indai in Tuaran, Sabah, Malaysia	88
8.4 Soil profile of paddy soil taken in Kampung Indai, Tuaran, Sabah, Malaysia with the depth of 15cm from the soil surface	88
8.5a Taking samples of paddy soil	89
8.5b Paddy soil being transferred into sack with approximately 10kg of paddy soil per sack	89

LIST OF FIGURES

FIGURE	Page
8.5c Tightening of the sack by using raffia string once the sack is filled with paddy soil	89
8.6a Drying of paddy soil	90
8.6b Sealing of the hole of the pot with tape as a protective layer	90
8.6c Putting of three layers of plastic bags as second protective layer inside the pots	90
8.6d Sieving of soil through 2mm sieve to get the fine and homogeneous soil	90
8.7 Seed Counter Machine used for counting 100-seeds for pre-germination test for each replication	91
8.8 Pre-germination test on Serendah Merah rice variety	91
8.9 Pot and media preparation for nursery pots	92
8.10 Forty pre-germinated seeds planted on each nursesey pot	92
8.11 Pots were filled with soil leaving 5 cm space from the brim	93
8.12 Distance where the rice seedlings were planted in the pot	93
8.13 Three layers will form on paddy soil after puddling process	93
8.14 The media used for nursery pots are 3:2:1 soil mixture which consists of paddy soil: topsoil: sand	94
8.15 Metal sheets were used to fence the surrounding of the net house to prevent the infestation by rodents like mice	94
8.16a Puddling of soil	95
8.16b Labelling preparation	95
8.16c Labelling of the pots arranged according to the experimental layout	95
8.16d Fertilizers application	95
8.17 Maximum tillering stage (53 DAT)	96
8.18 Grain formation stage (73 DAT)	96
8.19 Bulging stage (DAT 56)	97
8.20 Heading stage (DAT 57)	97

LIST OF FIGURES

FIGURE	Page
8.21 Panicle initiation (DAT 58)	97
8.22 Flowering stage (DAT 60)	97
8.23 Milking stage (DAT 70)	97
8.24 Dough stage (DAT 72)	97
8.25a Comparison of plant height between T1 (Control) and T9	98
8.25b Measuring of internodes length	98
8.25c Side view of experimental site	98
8.25d Front view of the experiment site	98
8.26 Measuring soil pH	106
8.27 CHN machine	107

LIST OF TABLES

TABLE	Page
3.1 Arrangement of the experimental units in Completely Randomized Design (CRD)	36
4.1 Seed germination rate on Serendah Merah rice variety	91
5.1 Soil pH	106
6.1 Carbon, Hydrogen and Nitrogen (CHN) content in soil	107
8.1.1 ANOVA analysis on Serendah Merah plant height at 21 DAT	108
8.1.2 ANOVA analysis on Serendah Merah plant height at 28 DAT	108
8.1.3 ANOVA analysis on Serendah Merah plant height at 35 DAT	108
8.1.4 ANOVA analysis on Serendah Merah plant height at 42 DAT	108
8.2.1 ANOVA analysis on number of tillers per hill at 21 DAT	108
8.2.2 ANOVA analysis on number of tillers per hill at 70 DAT	108
8.3 ANOVA analysis of culm diameter of Serendah Merah rice variety	109
8.4 ANOVA analysis on percentage of productive tillers	109
8.5 ANOVA analysis of panicle length of Serendah Merah rice variety	109
8.6 ANOVA analysis of internode length of Serendah Merah rice variety	109
8.7 ANOVA analysis number of grains per panicle of Serendah Merah rice	109
8.8 ANOVA analysis number of filled grains per panicle	109
8.9 ANOVA analysis number of empty grains per panicle	110
8.10 ANOVA analysis of 1,000 grains weight of Serendah Merah rice variety	110
8.11 ANOVA analysis of leaf dry weight of Serendah Merah rice variety	110
8.12 ANOVA analysis of stem dry weight of Serendah Merah rice variety	110
8.13 ANOVA analysis of root dry weight of Serendah Merah rice variety	110
8.14 ANOVA analysis of percentage of filled grains	110
8.15 ANOVA analysis of extrapolated yield	111
8.16 Mean square value obtained from ANOVA table for vegetative growth parameters	112
8.17 Mean square value obtained from ANOVA table for yield component parameters	113

LIST OF SYMBOLS, UNITS AND ABBREVIATIONS

Al	aluminium
CRD	Completely Randomized Design
cm	centimeter
DAT	Days After Transplanting
DAS	Days After Sowing
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
Fe	iron
H ₄ SiO ₄	monosilicic
ha	Hectares
IRRI	International Rice Research Institute
MARDI	Malaysian Agricultural Research and Development Institute
Mn	manganese
mm	millimeter
N	nitrogen
NO ₃ ⁻	nitrate
NH ₄ ⁺	ammonium
ppm	parts per million
RM	Ringgit Malaysia
Si	silicon

LIST OF FORMULAE

Formula	Page
3.1 Germination rate $= \frac{\text{number of germinated seeds}}{\text{total number of seeds}}$	29
3.2 Percentage of the productive tiller $= \frac{\text{number of panicles produced}}{\text{total number of tiller produced per hill}} \times 100\%$	33
3.3 Percentage of filled grains per panicle (%) $= \frac{\text{number of filled grains per panicle}}{\text{total number of grains per panicle}} \times 100\%$	34

CHAPTER 1

INTRODUCTION

1.1 Introduction

Rice is the most common grain in Malaysia, not only in production but also in consumption. There were 674,332 hectares planted with rice including those planted twice a year. Rice becomes the third most widely planted crop in Malaysia after oil palm and rubber (Heatwave may see, 2016). The area of rice harvested in Malaysia was 689,732 ha and the production was 2,645,119 tons (Food and Agriculture Organization Corporate Statistical Database, FAOSTAT, 2014). There are two farming seasons done in a year for rice crop which is from March to August and September to February. More than 65% of domestic rice demand has been produced by our country meanwhile Kedah contributing more than 50% of this (Heatwave may see, 2016). The rice production in Sabah is considered low which was only 2.8 tons/ ha compared to the national average production of five tons (The Star Online, 2016).

The genus of rice is *Oryza* and belongs to the family of Poaceae or Gramineae. Meanwhile, the diploid chromosome number for rice crop is 24. There are 23 species of genus *Oryza* and it involves 21 wild species and two cultivated species namely *Oryza sativa* from Asian and *Oryza glaberrima* from African (Siddiq, Saxena, Malik, 2006; Panda, 2010; Mackill, Coffman, Garrity, 1996).

Traditional rice variety can tolerate drought. Meanwhile, it requires less water while planting. This characteristic is important to conserve water in agriculture as water consumption in rice crop is large. Unlike the hybrid rice which the



seed cannot be saved since it is sterile and not respond well in organic compost. In addition, traditional rice variety has the characteristic of resistance to pest and disease as their immunity is preserved and it is claimed that traditional rice is healthier and hardier than hybrid rice (Ramoo, 2012). Furthermore, traditional rice present in unique colours, shapes, sizes and distinct flavours based on each variety.

Fertilizers that are supplied to plant are divided into two kinds which are macronutrients and the micronutrients. A macronutrient is a nutrient that the plant needs to complete the life cycle of the plant while the micronutrient is the beneficial nutrients that plant need as an enhancer for the plant in small quantities. Nitrogen, N fertilizer is the example of macronutrient while silicon, Si, is the example of the micronutrient for the growth and development of the plant.

Nitrogen fertilizer has the function to improve root growth and thus enhance the nutrient uptake by the plant. Next, the functions of nitrogen towards rice plant are to increase plant height, tillering, panicles and yield. However, too much of nitrogen application will cause the plant to lodge easily and make the plant susceptible to pest and disease.

Factors like excessive nitrogen application, storm damage, strong wind, soil density, disease, sowing date, overpopulation and seed type contribute to the lodging effect of most of the cereal crops especially in rice crop. This lodging effect will bring down the rice yield, deterioration of rice quality and also increase cost of production as it makes the harvesting process more difficult (Liu *et al.*, 2011; Grant, 2016).

According to Nagata *et al.*, 2002, Zhang *et al.*, 2010 and Takahashi *et al.*, 2005, silicon content in rice plant is one of the factors that influence the rice sheath on yield and lodging resistance (Cited in Liu *et al.*, 2011). Besides that, Liu *et al.* (2011) stated that leaf sheaths can control the lodging effect of the rice plant. Rice crop with thin leaf sheath is easy to lodge compared to thick leaf sheath (Wang *et al.*, 1991, Cited in Liu *et al.*, 2011). According to Wang *et al.*, 1998 and Rao *et al.*, 2009, when there is more stem tightly wrapped with leaf sheaths, the more resistance is the rice crop towards lodging (Cited in Liu *et al.*, 2011). So, silicon plays an important role to increase the lodging resistance as silicon strengthening the stalk strength and improve

the wrapping ability of the leaf sheath towards stems and thus reduce lodging effect of rice crop (Liu *et al.*, 2011, and Jones, 2012).

Rice is the crop that will uptake large amount of silica for their growth and development (Srivastava and Mahapatra, 2012). Korea and Japan are the two greatest countries that used silica fertilizer in rice planting as they realized the benefit of the silica fertilizer towards rice plant (Srivastava and Mahapatra, 2012). Research done by Brown, Welsh and Cary (1987) showed that silicon has the function of strengthening the stalk strength of rice crop, providing cellular protection and limit the pest attack on rice plant (cited in Jones, 2012). Rice plants are easy to lodge when there is lack of silicon supply due to the weak stalk strength (Srivastava and Mahapatra, 2012). According to Datta (1970), rice needs the supply of silica to continue its growth (Srivastava and Mahapatra, 2012). Yoshida (1981) also reported that there is an increase of one-tenth of the rice yield in Japan when there is an application of silicon fertilizer on rice crop. This author also mentioned that there is an increase of one-third of rice production in Japan when rice crop was infested with blast disease (cited in Fageria, 2014). This finding is important in term of rice yield when Si is applied while planting rice.

1.2 Justification

Farmers do not pay enough attention to silicon as the effect of the silicon deficiency is not so obvious and its universal existence. But research showed that in the group of cereal crops, Si uptake in rice is the highest which is 80mg g^{-1} root dry weight whereas Si uptake in other cereals crops like wheat, sorghum, maize, rye and barley are lesser than 15mg g^{-1} root dry weight (Ma and Takahashi, 2002). This study is to be conducted with the purpose of sharing the information of the appropriate use of the silicon and the nitrogen application rate on the traditional rice variety with the local farmers to increase their rice production.

Traditional rice varieties are tall and their adoption is low as they are susceptible to lodge that reduces the yield. According to Abdullah *et al.* (1991), traditional variety is often low in yield as they are less responsive to nitrogen fertilizer application (Cited in Sinong, 2016). Due to this problem, farmers tend to increase the rate of nitrogen application to get high yield. However, this practice normally makes

the physiological structure of rice crop becomes weak and thus easy lodged. Lodging in paddy field will reduce the production and yield of rice crop (Kashiwagi *et al.*, 2008, Cited in Liu *et al.*, 2011).

The presence of silicon in rice will increase culm wall thickness, size of vascular bundle and thus increase the breaking strength when a high rate of nitrogen is used (Takahashi, 1995, cited in Fageria, 2014). Therefore, silicon is capable to alleviate the problem of lodging. By applying the proper amount of fertilizer, it will help to minimize the problem of lodging in paddy field and thus increased the rice yield.

In short, silicon fertilizer will be used to reduce this problem especially in traditional rice variety which is tall, having longer internodes and droopy leaves. Silicon fertilizer can improve rice growth by maintaining more erect leaves and improve the culm strength to support the grain weight (Panda, 2010, Fageria, 2014).

1.3 Significance of study

According to Ranawake *et al.* (2013), most traditional rice varieties have advantages like high in nutritional value, excellent eating quality, having medicinal properties and can resist extreme climate as well as resistant to pest and disease (Cited in Sinong, 2016).

Most researchers showed that appropriate use of fertilizer could improve the yield of rice, so it is good news for farmers to plant traditional rice varieties continuously as the traditional varieties have the good taste and aroma. Furthermore, planting of traditional rice is encouraged as it improves the diversity of rice in planting (Sinong, 2016).

The current problem in Malaysia is that farmers are applying excessive N fertilizer on rice crop hoping to increase the yield of rice. But this practice promotes the problem of lodging to occur. Lodging is a big problem that farmers faced at this moment and limits further increase of rice production. Since there is limited information on the response of traditional rice towards fertilizer application, this study wants to figure out whether the application of the high rate of nitrogen and silicon can improve the yield of traditional rice variety by reducing the effect of lodging.

According to the data obtained from World Bank (2017), the price of rice per metric ton is RM 1632.78. Lodging will contribute to a loss of 11 to 52% reduction in grains weight and thus reduce the yield and income of farmers (Panda, 2010). So, the average in grain reduction due to lodging is 31.5%. Average rice production in Sabah is 2.8 tons per hectare, but when lodging happen, farmers can only get the yield of 1.9 tons per hectare (The Star Online, 2016, World Bank, 2017). This will bring the loss of income of RM 1469.50 per hectare to the farmers.

Meanwhile, a supplier of silicon fertilizer said that price of silicon is RM 1.30/kg. It is worth to apply silicon fertilizer when the rice production can increase up to one ton as the cost of silicon fertilizer is RM 520.00/ha when the application rate of silicon is 400kg/ha. The cost of silicon can be covered by the rice production that will be produced.

This study aims that farmers can benefit from this project in term of rice production and farmer's income. Appropriate use of nitrogen fertilizer and with the help of silicon fertilizer in rice planting, farmers may save the cost of nitrogen fertilizer as well as reduce the lodging problem. This action will lead to increase in the income of farmers and thus improve the quality of life of farmers when lodging incidence reduces and rice production increases.

1.4 Objectives

The objectives of this study are:

1. To study the effect of silicon and high nitrogen fertilizer on growth and yield of Serendah Merah rice variety.
2. To study the effect of silicon in reducing the lodging effect on Serendah Merah rice variety.

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