

**EFFECT OF ADDING APPROPRIATE MIXTURE OF NPK AND CHICKEN  
MANURE ON GROWTH AND YIELD OF TR-9 PADDY VARIETY ON  
BRIS SOIL**

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UNIVERSITI MALAYSIA SABAH**

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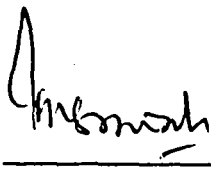
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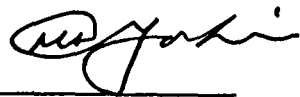
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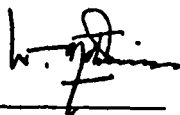
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## ABSTRACT

This study was carried out at the Faculty of Sustainable Agriculture, Universiti Malaysia Sabah (UMS) Sandakan Campus from April 2014 to October 2014 to investigate the effects of high application rate of NPK fertilizer (60:30:30, 100:60:60, and 150:90:90 kg ha<sup>-1</sup>) incorporated with high application rate of chicken manure (20, 40, and 60 t ha<sup>-1</sup>) on the growth and yield of TR-9 paddy variety grown on Beach Ridges Interspersed with Swales (BRIS) soil. Treatments were arranged as a factorial using complete randomized design (CRD) with three replications. Data collected was analyzed using two-way ANOVA at 5% significance level. The results showed that for vegetative growth of paddy plants, treatment T2 and S1 (100:60:60 kg ha<sup>-1</sup> NPK incorporated with 20 t ha<sup>-1</sup> chicken manure) produced the highest plant height which was 120.44 cm and 127.75 cm respectively. Treatment T2 and S2 (100:60:60 kg ha<sup>-1</sup> NPK incorporated with 40 t ha<sup>-1</sup> chicken manure) produced the highest tillers number of 42 and 45 tillers respectively. Treatment T2 and S1 (100:60:60 kg ha<sup>-1</sup> NPK incorporated with 20 t ha<sup>-1</sup> chicken manure) produced the highest number of culm height, which was 82.37 cm and 85.58 cm respectively. Treatment T1 and S2 (60:30:30 kg ha<sup>-1</sup> NPK incorporated with 40 t ha<sup>-1</sup> chicken manure) produced the highest percentage of productive tillers of 71.62 % and 79.37 % respectively. For yield components of paddy plants, treatment T2 and S2 (100:60:60 kg ha<sup>-1</sup> NPK incorporated with 40 t ha<sup>-1</sup> chicken manure) produced the highest number of panicles, which was 32 and 39 panicles respectively. Treatment T3 and S3 (150:90:90 kg ha<sup>-1</sup> NPK incorporated with 60 t ha<sup>-1</sup> chicken manure) produced the highest length of panicles, which was 24.57 cm and 25.95 cm respectively. Treatment T2 and S1 produced the highest percentage of filled grains (T2 = 74.60 %, S1 = 83.73 %) and extrapolated yield (T2 = 9.16 tons ha<sup>-1</sup>, S1 = 11.26 tons ha<sup>-1</sup>). Both treatment T2 and S1 also produced the least percentage of empty grains of 25.40 % and 16.27% respectively. Treatment T1 and S1 (60:30:30 kg ha<sup>-1</sup> NPK incorporated with 20 t ha<sup>-1</sup> chicken manure) produced the highest number in weight of 1000 grains which was 24.73 g and 25.81 g respectively. While for dry weight, treatment T2 and S1 (100:60:60 kg ha<sup>-1</sup> NPK incorporated with 20 t ha<sup>-1</sup> chicken manure) produced the highest number of 418.63 g and 464.44 g respectively. For BRIS soil's chemical properties, treatment T3 and S1 (150:90:90 kg ha<sup>-1</sup> NPK incorporated with 20 t ha<sup>-1</sup> chicken manure) produced the highest soil pH of 5.36 and 5.91 respectively. Treatment T3 and S3 (150:90:90 kg ha<sup>-1</sup> NPK incorporated with 60 t ha<sup>-1</sup> chicken manure) produced the highest soil organic matter of 3.38 % and 3.57 % respectively. Treatment T3 and S3 also produced the highest number of soil total nitrogen (0.22 %, 0.25 %) and soil available phosphorus (1756.66 ppm, 2253.10 ppm). For soil exchangeable potassium, treatment T2 and S3 (100:60:60 kg ha<sup>-1</sup> NPK incorporated with 60 t ha<sup>-1</sup> chicken manure) produced the highest number which was 41.68 ppm and 59.01 ppm respectively. Treatment T1 and S3 (60:30:30 kg ha<sup>-1</sup> NPK incorporated with 60 t ha<sup>-1</sup> chicken manure) produced the highest number of cation exchange capacity of 180.44 cmol<sub>c</sub> kg<sup>-1</sup> and 190.00 cmol<sub>c</sub> kg<sup>-1</sup> respectively. Thus, it can be recommended that the treatment T2 and S1 is the best rate to be recommended to farmers because they produced the highest extrapolated yield. The second recommendation is treatment T1 and S2 because it showed the second best results as compared to treatment T2 and S1.

# **KESAN PENAMBAHAN CAMPURAN SESUAI BAGI BAJA NPK DAN NAJIS AYAM KE ATAS PERTUMBUHAN DAN HASIL PADI VARIETI TR-9 YANG DITANAM PADA TANAH BRIS**

## **ABSTRAK**

Kajian ini dijalankan di Fakulti Pertanian Lestari, Universiti Malaysia Sabah Kampus Sandakan (UMSKS) dari April 2014 hingga Oktober 2014 untuk mengkaji kesan campuran pemberian kadar tinggi baja NPK (60:30:30, 100:60:60, dan 150:90:90 kg ha<sup>-1</sup>) disebatikan dengan kadar tinggi baja organik najis ayam (20, 40, and 60 t ha<sup>-1</sup>) ke atas pertumbuhan dan hasil padi varieti TR-9 yang ditanam pada tanah Beach Ridges Interspersed with Swales (BRIS). Rawatan-rawatan tersebut diatur sebagai reka bentuk rawak secara keseluruhan (CRD) dengan tiga replikasi. Data yang diperolehi dianalisis dengan menggunakan ANOVA dua-hala atas keertian 5%. Keputusan bagi pertumbuhan vegetatif padi menunjukkan rawatan T2 dan S1 (100:60:60 kg ha<sup>-1</sup> NPK disebatikan dengan 20 t ha<sup>-1</sup> najis ayam) mempunyai ketinggian pokok padi tertinggi iaitu masing-masing 120.44 sm dan 127.75 sm. Rawatan T2 dan S2 (100:60:60 kg ha<sup>-1</sup> NPK disebatikan dengan 40 t ha<sup>-1</sup> najis ayam) mempunyai bilangan anak padi tertinggi iaitu masing-masing 42 dan 45 anak padi. Rawatan T2 dan S1 (100:60:60 kg ha<sup>-1</sup> NPK disebatikan dengan 20 t ha<sup>-1</sup> najis ayam) mempunyai ketinggian batang padi tertinggi iaitu masing-masing sebanyak 82.37 sm dan 85.58 sm. Rawatan T1 dan S2 (60:30:30 kg ha<sup>-1</sup> NPK disebatikan dengan 40 t ha<sup>-1</sup> najis ayam) mempunyai peratusan anakan padi yang produktif tertinggi iaitu masing-masing sebanyak 71.62 % dan 79.37 %. Bagi komponen hasil pokok padi pula, rawatan T2 dan S2 (100:60:60 kg ha<sup>-1</sup> NPK disebatikan dengan 40 t ha<sup>-1</sup> najis ayam) menunjukkan bilangan tangkai tertinggi iaitu masing-masing 64 dan 78 tangkai. Rawatan T3 dan S3 (150:90:90 kg ha<sup>-1</sup> NPK disebatikan dengan 60 t ha<sup>-1</sup> najis ayam) menunjukkan panjang tangkai padi tertinggi iaitu masing-masing 24.57 sm dan 25.95 sm. Rawatan T2 dan S1 (100:60:60 kg ha<sup>-1</sup> NPK disebatikan dengan 20 t ha<sup>-1</sup> najis ayam) menunjukkan peratusan bilangan butiran padi penuh tertinggi (T2 = 74.60 %, S1 = 83.73 %) dan hasil ekstrapolasi tertinggi (T2 = 17.24 t ha<sup>-1</sup>, S1 = 21.19 t ha<sup>-1</sup>). Kedua-dua rawatan T2 dan S1 (100:60:60 kg ha<sup>-1</sup> NPK disebatikan dengan 20 t ha<sup>-1</sup> najis ayam) juga menunjukkan peratusan bilangan butiran padi kosong terendah iaitu masing-masing 25.40 % dan 16.27 %. Rawatan T1 dan S1 (60:30:30 kg ha<sup>-1</sup> NPK disebatikan dengan 20 t ha<sup>-1</sup> najis ayam) menunjukkan berat 1000 butiran padi tertinggi iaitu masing-masing 24.73 g dan 25.81 g. Bagi sifat kimia tanah BRIS, rawatan T3 dan S1 (150:90:90 kg ha<sup>-1</sup> NPK disebatikan dengan 20 t ha<sup>-1</sup> najis ayam) menunjukkan pH tanah tertinggi iaitu masing-masing 5.36 dan 5.91. Rawatan T3 dan S3 (150:90:90 kg ha<sup>-1</sup> NPK disebatikan dengan 60 t ha<sup>-1</sup> najis ayam) menunjukkan bahan organik tanah tertinggi iaitu masing-masing 3.38 % dan 3.57 %. Rawatan T3 dan S3 juga menunjukkan jumlah kandungan nitrogen tanah (T3 = 0.22 %, S3 = 0.25 %) dan kandungan fosforus tanah tertinggi (T3 = 1756.66 ppm, S3 = 2253.10 ppm). Bagi kandungan kalium tanah pula, rawatan T2 dan S3 (100:60:60 kg ha<sup>-1</sup> NPK disebatikan dengan 60 t ha<sup>-1</sup> najis ayam) adalah terbaik iaitu masing-masing menunjukkan bilangan sebanyak 41.68 ppm dan 59.01 ppm. Rawatan T1 dan S3 (60:30:30 kg ha<sup>-1</sup> NPK disebatikan dengan 60 t ha<sup>-1</sup> najis ayam) menunjukkan bilangan kapasiti tukar kation tertinggi iaitu masing-masing 180.44 smol kg<sup>-1</sup> dan 190.00 smol kg<sup>-1</sup>. Oleh itu, kadar terbaik yang dicadangkan kepada petani ialah rawatan T2 dan S1 kerana rawatan tersebut mempunyai hasil ekstrapolasi tertinggi. Cadangan kedua ialah rawatan T1 dan S2 kerana rawatan tersebut menunjukkan keputusan kedua terbaik jika berbanding dengan rawatan T1 dan S1.

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## LIST OF SYMBOLS, UNITS AND ABBREVIATIONS

%	Percentage
ANOVA	Analysis of Variance
cm	Centimeters
cmol kg <sup>-1</sup>	Centimole per kilogram
CRD	Completely Randomized Design
FAO	Food and Agricultural Organization
g	Gram
ha	Hectare
IPI	International Potash Institute
IRRI	International Rice Research Institute
K	Potassium
K <sub>2</sub> O	Potassium Oxide
kg	Kilogram
lbs	Pounds
MOP	Muriate of Potash
mm	Millimeters
N	Nitrogen
P	Phosphorus
ppm	Part Per Million
P <sub>2</sub> O <sub>5</sub>	Phosphorus Pentoxide
r	Radius
SPSS	Statistical Package for Social Science
t	Tonne
TR-9	Tuaran Rice-9
TSP	Triple Super Phosphate
USDA	United States Department of Agriculture

# CHAPTER 1

## INTRODUCTION

### 1.1 Introduction

Rice is cultivated in over 100 countries around the world. It accounts for over 22% of global energy intake (Kainuma, 2004). While the production and consumption of rice is concentrated in Asia, which accounts for about 92% of the world's total production. Besides, rice is also an important crop in specific regions of North and South America, Africa and Europe (Kainuma, 2004).

In Malaysia, rice is the main staple food and is a strategically important commodity for food security in the country. In 2010, Malaysia used 677,884 hectares of area for planting paddy and had 2,464,830 metric tonnes of paddy production (Jabatan Pertanian, 2012). It is believed that the paddy growing area is going to decline with time as a result of conversion of paddy land for other land use including urbanization mainly for housing, business, and industrial purposes.

Furthermore, due to growing population in Malaysia, land resources become scarce hence production growth entirely depends on the growth of agricultural productivity. Malaysia is an inefficient producer of rice. This was systematically recorded as early as 1988 in a World Bank study, illustrating that most rice produced in the country is for self-sufficient. In addition, most of the arable land that has been converted for other land use also leads to less fertile soils for rice planting.

Many kinds of problem soils exist in the world, each of them hampering agriculture in one way or another (Dudal, 1976). Red tropical soils, sandy soils and



shallow soils pose problems of soil fertility and soil conservation. Sandy soils contain a high proportion of sand particles, with little silt or clay to modify the grainy nature of the soil. Sandy soils occur in patches in many districts, and can be very coarse, like builders' sand, or very fine and powdery. One of the examples of sandy soils is BRIS soil. The acronym BRIS stands for Beach Ridges Interspersed with Swales. It can be found in between 0.2 to 0.8 km from sea beach which covers about 155,400 ha in peninsular Malaysia and about 40,000 hectares in state of Sabah (Mohd Ekhwan *et al.*, 2009). In Sabah, Bris soil can be found around the coastal area like Tuaran, Papar, Beaufort, Kimanis and Kota Belud. BRIS soils in Malaysia are classified based on the occurrence of the spodic horizon at various depths known as spodosols while without spodic horizon known as entisols (United States Department of Agriculture, 2010). BRIS soil contains more than 90% sand, low in water holding capacity, low in nutrients and organic water content (Zaki and Mustafa, 2005). Thus, it is not well utilized for crop production due to its inherent poor fertility.

However, there is a potential to produce rice if paddy are planted on BRIS soil. BRIS soil can be improved by adding soil amendment such as chemical fertilizer and organic fertilizer. Soil amendment is added to a soil to improve its physical properties, such as water retention, permeability, water infiltration, drainage, aeration and structure. The ultimate goal is to provide a better environment for roots. Most of the farmers prefer applying chemical fertilizer in paddy plantation as it is rich equally in three essential nutrients that are needed for crops and always ready for immediate supply of nutrients to plants if situation demands. Nevertheless, there are still farmers incorporating chemical fertilizer with organic manure to grow paddy as organic fertilizers improve and sustain the soil.

Nguyen (2005) and Hoa (2008) consistently suggested that highest and sustainable crop production were achieved from mixtures of chemical fertilizers and animal manure. Developing integrated nutrient management practices are needed to improve soil physical, chemical and biological fertilities of sandy soils and also address environmental considerations by matching nutrient applications to crop needs and soil conditions to minimise nutrient losses to water.



## 1.2 Justification

This study was conducted with the aims to study BRIS soil and also to improve its fertility to grow paddy by using soil amendments. TR-9 paddy variety is used in this study because it has been produced numerously in Sabah lately, has wide adaptability and carrying well disease resistance capability, and thus able to provide good grain yield. However, there is little available research and information related to TR-9 paddy variety. Therefore, one of the objectives of this research was to provide information to farmers about the effect of combination of inorganic and organic fertilizers on the growth and yield of TR-9 paddy variety. BRIS soil has poor physical and chemical properties and is less suitable to be used for producing rice because it has low yield capacity. In addition, BRIS soil is used as the medium in this study to plant paddy because there is limited land suitable for paddy cultivation and there is a need to explore potential of less preferable type of soil to expand rice cultivation. Hoa (2010) stated that sandy soils have a wide range of limiting factors for agricultural production, including nutrient deficiencies, acidity, low water holding capacity and wind erosion risk (on coastal dunal sands).

BRIS soil is less suitable to produce rice due to its poor physical and chemical properties unless BRIS soil fertility is improved. The addition of soil amendment which is the incorporation of chemical fertilizers (NPK) with organic fertilizer (chicken manure) to the BRIS soil to improve BRIS soil fertility is an issue to increase rice production in Malaysia. Both organic and inorganic fertilizers are effective in restoring the productivity of degraded soils with poor characteristics. NPK fertilizer alone did not improve soil physical properties, thus incorporation of NPK fertilizer with organic fertilizer, chicken manure significantly increased soil nutrients content and organic carbon content which in turn can promote better growth and yield. Chicken manure is preferred than other animal manures to be used as organic fertilizer because it is cheap, readily available, easy source of organic matter, and has a higher nutrient composition. Thus, high application rate of both NPK fertilizer and chicken manure is needed to investigate the BRIS soil nutrient content and the optimum rate can be used to determine the potential yield and growth of paddy planted on BRIS soil.

Sandy soil has limitation because it has low capacity to hold water and nutrients. Frequent applications of both fertilizer and water may be needed. Adding organic

matter to sandy soils will improve nutrient and water holding capacity. Sandy soils are easy to work, fast drying and low in nutrients due to leaching of soluble plant nutrients. For better performance, sandy soils need continual addition of large amounts of organic matter to hold water and nutrients within the range of plant roots. By using soil amendments, almost every type of soil can be made fertile (West Coast Seeds, 2011). Soil amendment includes all inorganic and organic substances mixed into the soil for achieving a better soil constitution regarding plant productivity. Organic amendments increase soil organic matter content and offer many benefits. Over time, organic matter improves soil aeration, water infiltration, and both water and nutrient holding capacity.

The major constraint in food crop productivity is the limited availability of agricultural land and thus much of the agriculture in developing countries is nevertheless practised on less preferable soils which are unsuitable or only marginally suitable such as BRIS soil. In Malaysia, there are about 2 million people depending on this poor (BRIS) soils for economic survival and their need for their improvement is important to address (Melisa *et al.*, 2011). In this case, BRIS soil has been utilized to plant food crop such as paddy in order to overcome food security issue. However, there is likely to be pressure to develop agriculture on sandy soil. Therefore, it is important to improve BRIS soil fertility by incorporating both chemical and organic fertilizers to ensure better growth of paddy.

### **1.3 Significance of the Study**

This study is significant because it could expose the development of agriculture, particularly paddy cultivation on poor BRIS soil to agriculturists and farmers as most of the paddy fields had been used for development purposes, restricting continuation of paddy farming. By incorporating chemical and organic fertilizers, BRIS soil fertility can be improved and converted into paddy field. With these areas of BRIS soil that available, acreage under paddy cultivation can be increased and food security issue can be overcome because food crop productivity is no longer restricted by limited availability of agricultural land.

## 1.4 Objectives

The objectives of this study were:

- i. To determine the optimum rate of NPK and chicken manure for growth and yield of TR-9 paddy variety planted on BRIS soil.
- ii. To determine the nutrient content of the BRIS soil series after the experiment.

## 1.5 Hypothesis

$H_0$ : The high application rates of NPK and chicken manure do not affect the growth and yield of TR-9 paddy varieties and soil nutrient status.

$H_1$ : The high application rates of NPK and chicken dung do affect the growth and yield of TR-9 paddy varieties and soil nutrient status.

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Rice cultivation in Malaysia

Rice belongs to the genus *Oryza* and the tribe Oryzeae of the family Gramineae (Poaceae). The genus *Oryza* contains 25 recognized species, of which 23 are wild species and two; *O. sativa* and *O. glaberrima* are cultivated (Morishima, 1984; Vaughan, 1994; Brar and Khush, 2003). *Oryza sativa* is grown worldwide including in Asian, North and South American, European Union, Middle Eastern, and African countries, whereas *Oryza glaberrima* is grown solely in West African countries. Rice varieties are often classified as indica rice, japonica rice and javanica rice. Each of these varietal groups has differences and is shown in Table 2.1.

Table 2.1 Characteristics of *Oryza sativa* varietal groups

Characteristics	Subspecies		
	Indica	Japonica	Javanica
Tillering	High	Low	Low
Height	Tall	Medium	Tall
Lodging	Easily	Not easily	Not easily
Photoperiod	Sensitive	Non-sensitive	Non-sensitive
Cool temperature	Sensitive	Tolerant	Tolerant
Grain shattering	Easily	Not easily	Not easily
Grain type	Long to medium	Short and round	Large and bold
Grain texture	Non-sticky	Sticky	Intermediate

Rice crop can be grown in different locations and under variety of climate and soil moisture conditions. The variation in soil moisture can cause numerous physiological and biochemical changes in various plant parts to sense soil water status. The soil moisture variation will influence rice yield by directly affecting the physiological process involved in vegetative growth and grain production. Intermittent flooding and



drying of the soils depresses availability of several nutrients for rice uptake, and low nutrient supply will limit the yield potential (Bell *et al.*, 2001). In Malaysia, the traditional cultivation of rice is performed by the planting of rice crops on small hills as the land suitable for growing wet rice is often scarce. Rice in Malaysia is often grown in a paddy field to prevent the growth and spread of weeds. However, land sources in Malaysia have becoming scare and are limited for rice cultivation. Consequently, this problem leads to insufficient rice production. Since rice is a strategic crop in Malaysia, it is essential to maintain a domestic production level for food security purposes and the target of self-sufficiency must be in tandem with the growing population. Therefore, the limitations on agricultural land resources and high rice demand giving rise to the need of practising paddy cultivation on BRIS soil.

## **2.2 Paddy seed**

Paddy seed comprises four major parts which are hull, bran, endosperm and germ. There are 20 % of hulls and 80 % of grain in the paddy (Panda, 2010) which contains high amount of nutrition value needed by human body. The hull is the fibrous indigestible shell of the rice kernel. It comprises of numerous lignified, brittle and highly silica concentration cells are functioned to protect the caryopsis. Bran is the outer layer of the de-hulled rice kernel. Rice bran ranges in color (due to the presence of naturally antioxidant-rich pigments) from pale tan to brown and from red to purple-black. The endosperm is the large interior of the rice kernel, which includes most of the protein, starch, vitamins and minerals. Germ is the embryo of the rice kernel, which would sprout into a new plant if allowed to germinate. The germ contains most of the oil in the rice kernel.

Quality seed is concerned with the behavior of seed as end product of plant growth, as a biological entity in itself and as determinant of future plant growth. It is therefore important to plant quality paddy seed to ensure proper germination and good establishment of seedling growth which in turns enabling higher yield. To obtain quality paddy seeds, they must be stored under optimum temperature and proper condition to keep them viable.

### 2.3 Paddy growth and development

The growth of rice plant is divided into three phases: vegetative, reproductive and ripening phase. The stages of development in each phase are further divided according to numerical scales (from 0 to 9) to identify the growth stage of a rice plant. Specific growth stage is corresponded to each number in the scale (Table 2.2).

Table 2.2 The stages of development of rice plant according to 0-9 numerical scale

	Growth phase	Stage
I.	Vegetative phase (germination to panicle initiation)	0 – From germination to emergence
		1 – Seedling
		2 – Tillering
		3 – Stem elongation
II.	Reproductive phase (panicle initiation to flowering)	4 – Panicle initiation to booting
		5 – Heading or panicle exertion
		6 – Flowering
III.	Ripening phase (flowering to mature grain)	7 – Milk grain stage
		8 – Dough grain stage
		9 – Mature grain stage

The growth duration of the rice plant is three to six months, depending on the variety and the environment under which it is grown. During this time, rice completes two distinct growth phases: vegetative and reproductive. The vegetative phase is subdivided into germination, early seedling growth, and tillering. The reproductive phase is characterized by culm elongation, decline in tiller number, and emergence of the flag leaf, booting, heading, and flowering of the spikelets. Panicle initiation is the stage about 25 days before heading when the panicle has grown to about 1 mm long. Spikelet anthesis begins with panicle exertion, or on the following day. It takes 10 to 14 days for a rice plant to complete heading. Within the same panicle, it takes seven to ten days for all the spikelets to complete anthesis. Ripening phase is subdivided into milky, dough, yellow-ripe, and maturity stages according to the texture and colour of the growing grains. The length of ripening varies among varieties from about 15 to 40 days.

## 2.4 TR-9 paddy seed variety

*Oryza sativa* is the most common paddy cultivar in Malaysia and serves as the important food crop among Asian people. Paddy seeds variety TR-9 has been produced numerously in Sabah lately through three ways of cross breeding among *BG 90-21*, *IR 19661-131-1-2* and *IR 4215-301-2-2-6* in International Rice Research Institute (IRRI), Philippine. TR-9 paddy seed variety with the common name Seri Sabah is widely produced today as the grains have performed high eating quality. While from the agronomic point of view, this paddy variety is resistant to disease such as bacterial blight. In addition, it has good performance in terms of yield. The average yield of TR-9 paddy seeds variety is around 5.0 to 7.2 t ha<sup>-1</sup> and the weight of 1000 grains is ranged from 23.5 to 25.5 g. Therefore, TR-9 paddy seed variety will be used in this study as it has good agronomic traits.

## 2.5 Nutrients requirement for paddy growth

Paddy requires essential macro and micronutrients for its normal development and further growth. The nutrients required are carbon, nitrogen, calcium, hydrogen, phosphorus, magnesium, oxygen, potassium, sulphur, iron, zinc, chlorine, manganese, boron, copper and molybdenum. The amount of plant nutrients uptake by rice crop, based on the yield, is presented in Table 2.3. More plant nutrients uptake can be expected at higher yields.

Table 2.3 Nutrients uptake

Yield (kg/ha)	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	S	Mg
7,847	126	67	188	13	16

Source: IPI, 2006

The total plant nutrients removed from the field by grain rice is different from the amount plant uptakes during the growth period of straw and grain together, is presented in Table 2.4.

Table 2.4 Harvested plant nutrients

Yield (kg/ha)	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
7,847	78	49	31

Source: IPI, 2006

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