EFFECT OF DIFFERENT RATES OF NPK FERTILIZER APPLICATION ON GROWTH AND YIELD OF SEVERAL SABAH LOCAL TRADITIONAL PADDY VARIETIES

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ABSTRACT

A field experiment was conducted in the net house C of Faculty of Sustainable Agriculture, Universiti Malaysia Sabah, Sandakan from May to November 2016. The experiment was carried out to evaluate the effect of NPK fertilizer application (60:30:30, 90:30:60 and 120:30:90) on the growth and yield of several Sabah local traditional paddy varieties (Tadong, Filipin and Seraudah merah variety) in comparison with the high yielding variety (TR8) and to identify if any of the Sabah local traditional paddy varieties shows a positive response to NPK fertilizer. Treatments were arranged as a 4 x 3 factorial using Completely Randomized Design (CRD) with three replications. The collected data was analyzed using two-way ANOVA at 5% significance level. The results revealed interaction of NPK and the different paddy varieties only significant on length of internodes and dry matter accumulation. Different paddy varieties shows significant difference in most of the parameters, meanwhile, NPK rates only shows significant in culm diameter, internodes length, dry matter, panicle length and 1,000-grains weight. The results showed that for vegetative growth related with lodging incidence characteristics, Tadong (V1) had given the best results of shortest plant height (127.19 cm), culm height (81.66 cm), internode length (8.11 cm) and a larger culm diameter (0.58 cm) compared with the other local traditional variety. In yield component, Filipin (V2) recorded the most panicle numbers (15.66) and percentage of filled grains (80.45%) which in turn having a lower percentage of empty grains (19.54%). Serendah merah (V3) recorded the longest panicle length (24.15 cm) and heaviest weight of 1,000-grains (29.98 g) which in turn produced a higher extrapolated yields (6.00 t ha^{-1}). In terms of NPK rates, 120:30:90 (F3) produced the largest culm diameter (0.51 cm) with shorter internodes length (8.90 cm), longest panicle length (23.15 cm) and heaviest 1,000 grains weight (24.69 g). From the application of different rates of NPK fertilizer, V2F2 recorded the highest pH of 5.34 which had increase to 1.27 from the initial pH value (4.07) of the Silabukan soil. Higher percentage of total nitrogen (2.55%) was observed on V2F3 where an increment of 0.45% was recorded from the initial total nitrogen (2.10%) of Silabukan soil. V2F3 also recorded the highest soil available phosphorus (0.0181 ppm) which had reduced about 0.086 ppm from the initial phosphorus content (0.105 ppm). Among the Sabah local traditional paddy varieties used in this study, variety that can be suggested to farmers is Serendah merah (V3) treated with 60:30:30 kg ha^{-1} (F1) because it may produce a higher yield which was at par with TR8 (HYV). Moreover, the amount of fertilizer used in treatment F1 is the least, thus, it gives an economical advantage as low fertilizer cost is required to achieve high yield and better grain quality. This variety would also be recommended due to their shorter maturity period of 100-110 DAS which may enable farmers to cultivate it twice a year. The second recommendation would be Tadong (V1) treated with 60:30:30 kg ha^{-1} (F1) would be recommended to farmers because it has given the best plant height, culm height, culm diameter and internode length. This variety given the best results in resistance towards lodging incidence compared with the other local traditional varieties.

KESAN PEMBERIAN KADAR BAJA NPK YANG BERBEZA TERHADAP PERTUMBUHAN DAN HASIL BEBERAPA VARIETI PADI TRADISIONAL TEMPATAN SABAH

ABSTRAK

Satu kajian telah dijalankan di Rumah Jaring C Fakulti Pertanian Lestari, Universiti Malaysia Sabah, Sandakan dari Mei sehingga November 2016. Tujuan kajian ini adalah untuk mengkaji kesan pemberian baja NPK (60:30:30, 90:30:60 and 120:30:90) terhadap pertumbuhan dan hasil varieti padi tradisional tempatan Sabah (Tadong, Filipin dan Seraudah merah varieti) yang dibandingkan dengan varieti berhasil tinggi (TR8) dan untuk mengenal pasti varieti padi tradisional tempatan Sabah yang menunjukkan kesan positif terhadap pemberian baja NPK. Rawatan disusun sebagai 4 x 3 Rekabentuk Rawak Lengkap dengan tiga replikasi. Data yang dikumpul telah dianalisa menggunakan Analisa Variasi dua hala (ANAVA) pada aras beerti 5%. Hasil kajian menunjukkan interaksi diantara varieti padi dan baja NPK menunjukkan perbezaan yang signifikan pada panjang ruas dan berat kering pokok. Varieti padi yang berbeza pula menunjukkan perbezaan yang signifikan untuk kesemua parameter manakala, baja NPK hanya mempunyai perbezaan beerti pada diameter batang padi, panjang ruas, berat kering pokok, panjang tangkai padi dan berat 1,000 butiran padi. Hasil kajian menunjukkan, bagi parameter pertumbuhan vegetatif yang berkait rapat dengan insiden pokok rebah, Tadong (V1) mencatatkan ketinggian padi yang terpendek (127.19 sm, ketinggian batang padi (81.66 sm), panjang ruas yang terpendek (8.11 sm) dan diameter ruas yang tebesar (0.58 sm) jika dibandingkan dengan varieti tradisional yang lain. Bagi komponen hasil pula, Filipin (V2) mencatatkan bilangan tankai padi yang terbanyak (15.66) dan peratus padi bernas yang tertinggi (80.45%) dimana turut mempunyai peratusan butiran hampa padi yang terendah (19.54%). Serendah merah mencatatkan panjang tangkai padi yang terpanjang (24.15 sm) dan berat 1,000 butiran padi yang terberat (29.98 g) dimana menyumbang kepada hasil unjuran hasil yang tertinggi (6.00 t ha^{-1}). Bagi kadar baja NPK, 120:30:90 (F3) mencatatkan diameter batang padi yang terbesar (0.51 cm),panjang ruas terpendek (8.90 cm), tangkai padi terpanjang (23.15 cm) dan 1,000 butiran padi yang terberat (24.69 cm). Kesan daripada aplikasi kadar baja NPK yang berbeza, V2F2 mencatatkan nilai pH yang tertinggi iaitu 5.34 yang telah meningkat dari nilai pH tanah Silabukan sebelum rawatan (4.07). Manakala kandungan nitrogen yang tertinggi dalam tanah dikesan pada V2F3 iaitu terdapat peningkatan sebanyak 0.45% dari kandungan nitrogen pada permulaan kajian (2.10%). Tambahan pula, V2F3 mencatatkan kandungan fosforus yang tertinggi (0.0181 ppm) yang menurun sebanyak 0.086 ppm dari kandungan fosforus pada permulaan kajian (0.105 ppm). Antara varieti tradisional tempatan Sabah yang boleh dicadangkan kepada para petani ialah Serendah merah (V3) yang dirawat dengan 60:30:30 kg ha^{-1} dimana ia mampu menghasilkan hasil yang sama dengan TR8 (HYV). Selain itu, kadar baja yang digunakan adalah sedikit, justeru, memberi kebaikan kepada ekonomi dimana kos input yang rendah mampu menghasilkan hasil dan kualiti benih yang berkualiti. Varieti ini juga mempunya tempoh kematangan selama 100-110 HST yang memboleh penanaman padi dilakukan dua kali setahun. Cadangan yang kedua ialah Tadong dengan kadar 60:30:30 dimana ia mempunyai ketinggian padi, batang padi, diameter ruas dan panjang ruas yang terbaik dan kurang berpotensi mengalami padi rebah jika dibandingkan dengan varieti traditional tempatan yang lain.

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ANAVA	*Analisa Variasi*
ANOVA	*Analysis of Variance*
CMS	Chipper Mulcher Shredder
CHN	Carbon, Hydrogen, Nitrogen
CRD	*Completely Randomized Design*
DAS	Days after sowing
FAO	Food and Agriculture Organisation
FSA	Faculty of Sustainable Agriculture
HLT	Hari lepas tanam
HYV	High Yielding Variety
IRRI	International Rice Research Institute
ISTA	International Seed Testing Association
K	Potassium
kg ha^{-1}	Kilogram per hectare
MOP	Muriate of Potash
N	Nitrogen
P	Phosphorus
SAS	Statistical Analysis Software
t ha^{-1}	tonnes ha^{-1}
TR8	Tuaran Rice 8
TSP	Triple Super Phosphate

LIST OF FORMULAE

CHAPTER 1

INTRODUCTION

1.1 Background

Paddy (*Oryza sativa L.*) is an important food crop worldwide and forms the staple diet of Malaysians. The production of paddy has been increasing from year to year in relation to the increasing population in the world. Paddy provides as much as 80% of the dietary calories in some Asian countries including Thailand, Vietnam, Myanmar, Philippines and Malaysia. In Malaysia, about 674,332 ha has been cultivated with paddy, giving 2,615,845 t of annual production with an average yield of 3,879 kg ha^{-1} (Department of Agriculture, 2015). Abdullah *et al.* (2005) stated that paddy crops play an important role in generating income and improving the livelihood for more than 200,000 farmer's families in Malaysia.

Paddy is rich in genetic diversity, with thousands of varieties grown throughout the world and its economic importance is related to agro-ecological adaptation, household food security, ceremonies, nutritional diversification, income generation and employment. With the expansive culture of improved paddy varieties, the number of traditional varieties has reduced. The high yielding variety is more responsive to fertilizer and has greater potential in producing higher yields compare to the traditional varieties. However, there are some of the farmers that are still cultivating traditional paddy varieties. According to Noorzuraini *et al.* (2014), about 32.7% of traditional paddy varieties, from a total of 12, 258 accessions of rice germplasm have been conserved at the Rice Genebank in MARDI Seberang Perai.

Local traditional paddy varieties are still widely cultivated in Sabah especially by smallholders. Souki (2015) stated that there is no accurate record of the number of local paddy varieties cultivated by farmers in Sabah, but according to the Agricultural Department of Sabah, it can reach up to 300 varieties. Some local farmers prefer to plant traditional varieties due to their good grain characteristics and also better tasting. The cultivation of traditional paddy varieties may also be due to its high quality of rice seeds with scented aroma and resistance towards diseases and less susceptible to pests such as fungus, bacterial leaf blight and brown plant hopper. Additionally, most of the farmers produce paddy for their own consumption and sometimes sell their surplus paddy production to increase their home income.

The application of fertilizer provides the soil with all necessary nutrient elements required for crop growth, development and yield production. However, the uptake of nutrients by the plants may vary by paddy varieties, soil conditions and agricultural practices. Among the nutrients, nitrogen plays a major role in rice production as it is essential for vegetative growth. This nutrient is mostly needed during early and mid-tillering, panicle initiation, booting and ripening phases of grain development. Nitrogen is important to increase plant growth and tiller numbers which in turn increases the number of productive tillers. Moreover, nitrogen is required for the production of spikelets during panicle initiation stage and contributes to sink size during the late panicle formation stage which reflects on grain productivity. Swain *et al.* (2010) stated that the accumulation of carbohydrate in the culms and leaf sheaths during the pre-heading stage and in the grains during the ripening stage is largely contributed to by nitrogen.

Phosphorus is an essential element for crop development which is required during the flowering and ripening stages of the rice plant. According to FAO (2006b), phosphorus is required for growth, cell division, root lengthening, seed and fruit development and early ripening. A low phosphorus supply may reduce early nitrogen uptake and prevents the synthesis of protein from nitrogenous fertilizers. Potassium which stands as the third most important macronutrient after nitrogen and phosphorus is needed in growth development of paddy. The absorption of potassium continues from the active growth stage until the dough stage of the rice plant. This element is essential for the osmoregulation process, helps in maintaining the cell turgor pressure, elongation of cell and growth. Ravichandran and Sriramachandrasekharan (2010) stated that potassium is mostly found in the leaves and culm of paddy plants. The accumulation of potassium in the culm is very important as it supports the plant by preventing lodging and helps in reducing the incidence of diseases.

1.2 Justification

This study was conducted with the aim of increasing the yield of several Sabah local traditional paddy varieties through its response to NPK fertilizer application. Local traditional paddy varieties were chosen in this study because nowadays, most farmers depend on the high yielding paddy varieties due to its higher yield production compared to the traditional varieties. The traditional varieties have slowly become extinct in many Sabah communities.

Most of the traditional paddy varieties show less response to increased levels of NPK fertilizer compared with the high yielding varieties. According to Leonard *et al.* (1963), nitrogen elements enhance the vegetative growth of paddy by increasing the plant height, tiller numbers, panicle numbers, grains and straws yield. Therefore, when nitrogenous fertilizer is applied to traditional varieties, they will response to it with an increase in vegetative growth development. However, the tall stature of the traditional varieties may lead to lodging incidence of paddy plants due to the weakening of culm causing yield to decrease. The lodging incidence of paddy plants may disturb the vascular tissues which may reduce the translocation of nutrients necessary for grain filling and other plant needs. Also, the photosynthetic rate of plants will be affected by the lodging incidence which corresponds with the increase in respiration rate. Berry *et al.* (2004) stated that lodging may cause losses of yield by up to 80% and can cause severe knock-on effects, including reduced grain quality and greater drying cost. In addition, traditional varieties have lower number of tillers compared to the high yielding varieties (HYVs). According to Noorzuraini *et al.* (2014), HYVs showed positive response to nitrogen fertilizers by producing more tillers which make them capable of producing higher yield.

However, improvement in the stem strength of rice plants will definitely reduce losses due to lodging. The application of potassium can increase the strength of stems in which higher potassium content in the internodes may prevent the plant from lodging-off. Thus, the yield of traditional paddy varieties can be increased through the application of fertilizers.

1.3 Significance of study

Most of the traditional varieties have valuable advantages such as being very high in nutritional value and medicinal properties and most are resistant to extreme climatic conditions, soil conditions, diseases and pests (Ranawake, *et al.*, 2013). The current practice of applying high rates of nitrogen fertilizer by Malaysian paddy farmers in targeting high grain production with the use of high yielding varieties has prompted a further study on the impact of this practice on local traditional paddy varieties quality and production. Since there is no adequate information on the response of local traditional varieties to fertilizer applications, this study will be carried out to evaluate the response of individual traditional varieties on different levels of NPK fertilizers. Moreover, this study is to find out whether the local traditional varieties will have the same results of vegetative growth and yield production as compared to the high yielding varieties under optimum application rate of NPK fertilizer.

If it is proven that the current nitrogen and potassium fertilizer practices can increase the yield production of local traditional varieties, then it would be worthwhile to use these varieties as planting material. Moreover, it can help those farmers who still rely on this traditional varieties to increase their yield production. Thus, several hundred of traditional varieties of paddy can be collected, conserved and popularized among the farming community before they become extinct.

1.4 Objectives

The objectives of this study are:

1. To evaluate the effect of NPK fertilizer application on the growth and yield of Sabah local traditional paddy varieties and the TR8 paddy variety.

2. To determine if any of the Sabah local traditional paddy varieties used shows a positive response to NPK fertilizer.

1.5 Hypothesis

1. **Ho1**: There is no significant difference on the growth and yield of Sabah local traditional paddy variety with TR8 paddy variety in response to NPK fertilizer application.

   Ha1: There is a significant difference on the growth and yield of Sabah local traditional paddy variety with TR8 paddy variety in response to NPK fertilizer application.

2. **Ho2**: There is no significant difference on the response of any of the Sabah local traditional paddy varieties used to NPK fertilizers.

   Ha2: There is a significant difference on the response of any of the Sabah local traditional paddy varieties used to NPK fertilizers.

CHAPTER 2

LITERATURE REVIEW

2.1 Paddy

Paddy belongs to the Poaceae family and the genus *Oryza*. The genus *Oryza* comprises about 24 species, distributed throughout the tropical and sub-tropical regions of Asia, Africa, central and south America and Australia. There are two cultivated species of paddy which are *Oryza sativa (L.)* and *Oryza glabberima (steud)*. The *Oryza Sativa* is widely cultivated in Asian countries, parts of Europe and America while *Oryza glabberima* is popularly cultivated in Africa. Based on the morphological and physiological characteristics, the *Oryza sativa* species is further divided into three sub-species that are *indica*, *japonica* and *javanica*. The *indica* rice is indigenous to the humid regions of the tropics and sub-tropics of Asia while the japonica rice is limited to temperate zones and sub-tropics. The *javanica* is widely cultivated in parts of Indonesia. The difference between the three- sub-species of *Oryza sativa* is shown in Appendix A.

2.1.1 Morphology of paddy

The shoot unit concept refers to the repetitive and synchronous aspects of vegetative growth (Hoshikawa, 1989). The shooting unit is a basic, repeating unit defined as an internode that produces a leaf at its upper end, a tiller bud on its lower end and a root band on both its upper and lower ends.

Paddy develops a radicle (seminal root), mesocotyl roots, and nodal roots (adventitious roots). The seminal roots or radicles are sparsely branched and persist only for a short time after germination which is until the seventh-leaf stage (Yoshida, 1981). Mesocotyl roots develop only under conditions such as deep seeding or when the seed is treated with a chemical. These roots emerge from the axis between the node of coleoptile and the base of the radicle. The rice root system is basically composed of nodal roots that are produced from the underground nodes of the young culm and are freely branched. Each node usually develops about 5-25 roots. A leaf and thin roots emerge from the upper region of the internode while a tiller and thick roots emerge from the lower region of the internode. Primary roots refer to roots that develop directly from the nodal region of the culm. As growth advances, the primary roots develop branched secondary roots, which in turn develop tertiary roots and so on.

The culm refers to a jointed stem of the rice which is made up of a series of nodes and internodes. The culm remains enclosed in the leaf sheath and does not emerge until a small portion is exserted with the panicle after heading. The main culm is the first plant stem that develops during early vegetative growth and prior to tillering. Tillers arise from the main culm in an alternate pattern. Individual tillers are composed of shoot units each capable of developing roots, leaves, tillers and panicles. Tillers that develop from the main culm are known as the primary tiller and those developing from the primary tiller are called secondary tillers. Culm height is usually measured from the ground to the base of the panicle.

The leaves are borne on the culm in two ranks, one at each node. The leaf consists of the sheath and blade or the lamina. The leaf sheath refers to an elongated leaf rolled into a cylinder that encloses developing new leaves. The leaf blade is long and lanceolate and has a midrib with large and small parallel veins of each side. The last leaf that emerges on the culm is known as the flag leaf. Flag leaves are important in grain filling, as 80% of the total carbohydrate stored in the grains is produced by the top two leaves in rice (Gladun and Karpov, 1993). Yue *et al.* (2006) reported that flag leaves are the major source of phloem-delivered photo-assimilates during the grain-filling stage in rice. The flag leaf area influences the increase in grain yield by increasing the number of spikelets per panicle.

The panicle is borne on the uppermost internode of the culm and composed of a panicle neck node (base), rachis (axis), primary and secondary branches, pedicles, rudimentary glumes, and spikelets. Pedicles are formed from the nodes at the tip of primary branches and from all the nodes of secondary branches. At the tip of the pedicles, the spikelets are formed which is the unit of the inflorescence. The spikelet has two sterile lemmas, the rachilla, and the floret. A floret consists of the lemma, palea, and the enclosed floral organs. The flower consists of six stamens and a pistil.

2.1.2 Vegetative growth of paddy

The growth duration of the paddy plants usually takes about three to six months, depending on the variety and the environment under which it is grown. The growth duration of paddy can be divided into vegetative phase, reproductive phase, and ripening phase.

a) Vegetative phase

The vegetative phase of paddy can be divided into germination, early seedling growth, and tillering stage. This phase is characterized by active tillering, gradual increase in plant height and leaf emergence at regular intervals. The vegetative phase begins with seed germination and continues with a repetitive production of shoots units until the initiation of the panicle.

Rice seeds will germinate into seedling which depend on the food reserved or the endosperm up to the 15th day or until the first two leaves have come out. Germination refers to the resumption of active growth by the embryo culminating in the development of a young plant from the seed. There are five requirements for the seed to germinate which are seed maturity, water, air, temperature and light. Water act as the activating agent that starts the germination process and is essential for enzyme activation breakdown of storage, translocation of food and use of reserve storage material during germination.

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