EFFECT OF HIGH NPK FERTILIZER RATE, OPTIMUM RATE OF CHICKEN MANURE AND FOLIAR FERTILIZERS ON GROWTH AND YIELD OF TR-9 PADDY VARIETY PLANTED ON BRIS SOIL

SIM HOONG HOOI

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SAYA: LIM HOONG HOOI SESI PENGAJIAN: 2012 - 2016

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

SIM HOONG HOOI
BR12110121
11th JANUARY 2016

VERIFIED BY

1. Associate Prof. Datuk Haji Mohd. Dandan @ Ame Bin Haji Alidin
SUPERVISOR

PROF. MADYA HJ. MOHD. DANDAN @
AME HJ. ALIDIN
FELO KANAN
FAKULTI PERTANIAN LESTARI
UMS KAMPUS SANDAKAN

2. Associate Prof. Dr. Mohamadu Boyie Jalloh
CO-SUPERVISOR

MOHAMADU BOYIE JALLOH, PhD
Profesor Madya
FAKULTI PERTANIAN LESTARI
UMS CAWANGAN SANDAKAN

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ABSTRACT

This study was carried out at the net house of Faculty of Sustainable Agriculture, Universiti Malaysia Sabah, Sandakan from April 2015 to November 2015 to study the effect of high rate NPK fertilizer, optimum rate of chicken manure and foliar fertilizers towards growth and yield of TR-9 paddy variety planted 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. In the result, there was no interaction effect between chicken manure and foliar fertilizers, however different rate of chicken manure showed significant effects on some parameter. Foliar fertilizers did not showed significant effects on any of the parameter, but there is a comparatively difference between different types of foliar fertilizer. Chicken manure had showed a significant effects on plant height and plant tiller numbers but not foliar. Treatment T4F3 (60 t ha^{-1} of chicken manure with F3 foliar fertilizer) produced the highest plant height and number of tillers at 112.58 cm and 41.67 tiller respectively. Chicken manure also showed significant effects on culm height where treatment T4 and F2 foliar fertilizer produced the highest culm height (T4 = 74.08 cm, F2 = 70.88 cm). Both chicken manure and foliar fertilizer did not affect percentage of productive tiller significantly, but treatment T3 (40 t ha^{-1} of chicken manure) and F3 foliar fertilizer could produce the highest percentage of productive tillers at 78.19 % and 77.48 % respectively. For yield components, chicken manure also showed significant effect on number of panicles and panicles length as treatment T4 and F3 produced the highest number of panicles (T4= 35.22, F3=28.88) while treatment T3 and F1 (control) produced the longest panicles length (T3=26.04 cm, F1= 25.18 cm). Besides, T3 and F1 also produced the highest number of grains per panicle (T3 = 155.98, F1 = 143.2). Both chicken manure and foliar fertilizer did not showed any significant effects on filled grains percentage but treatment T3 and F2 still able to produce the highest mean percentage of filled grains (T3=85.88%, F2= 85.37%). Chicken manure significantly affected the total amount of grains produced and extrapolated yield where treatment T4 and F3 foliar fertilizer produced the highest number of total grains (T4= 5051.17, F3=3964) while treatment T4 and F1 (control) produced the highest extrapolated yield (T4=11.47 tons ha^{-1}, F1= 9.26 tons ha^{-1}). The result also showed significant difference where treatment T2 (20 t ha^{-1} of chicken manure) and F1 produced the most heavy thousand grains weight (T2 = 25.76 g, F1 = 25.18 g). Treatment T4 and T3 produced the highest dry weight (T4 = 177.74 g, F3 = 132.14 g) and it was significantly affected by different rate of chicken manure. For BRIS soil properties, chicken manure only showed significant effects on soil pH and soil cation exchangeable cation capacity. Treatment T4 and F2 produced the highest pH value (T4 = 5.81, F2 = 5.22) and the highest percentage of soil organic matter in the soil (T4=6.93%, F2=6.95%). For soil total nitrogen, treatment T4 and F1 produced highest percentage of soil total nitrogen (T4 = 0.2%, F1 = 0.19%) and highest cation exchange capacity (T4 = 18.39 $cmol_c\ kg^{-1}$, F1 = 16.35 $cmol_c\ kg^{-1}$) whereas treatment T4 and F3 produced the highest soil available phosphorus (T4 = 5.866 ppm, F3 = 4.036 ppm). Thus, treatment T4 is recommended to farmers because it produced the highest tiller number, the highest culm height, the highest number of panicles, the highest number of grains and the highest extrapolated yield. While in BRIS soil properties, treatment T4 could improve the soil nutrient content by produced the highest percentage of soil total nitrogen and the highest soil available phosphorus. Besides, treatment T4 also produced the highest cation exchange capacity and increased the soil pH and soil organic matter content as well.

KESAN BAJA NPK YANG BERKADAR TINGGI, TAHI AYAM YANG OPTIMUM DAN BAJA FOLIAR ATAS PERTUMBUHAN DAN HASIL PADI VARIETI TR-9 YANG DITANAM PADA TANAH BRIS

ABSTRAK

Kajian ini telah dijalankan di Rumah Lindungan Hujan Fakulti Pertanian Lestari, Universiti Malaysia Sabah, Sandakan dari April 2015 hingga November 2015 untuk mengkaji kesan tahi ayam, baja foliar dengan penggunaan baja NPK yang berkadar tinggi terhadap pertumbuhan dan hasil padi varieti TR-9 yang ditanam di atas tanah BRIS. Rawatan disusun berdasarkan faktorial menggunakan reka bentuk rawak lengkap (Complete Randomized Design, CRD) dengan tiga replikasi untuk setiap rawatan. Data yang diperolehi dianalisis dengan menggunakan ANAVA dua hala pada 5% aras keertian. Hasil kajian menunjukkan tiada interaksi di antara tahi ayam dan baja foliar, tetapi perbezaan kadar tahi ayam yang digunakan menunjukkan kesan perbezaan bererti. Baja foliar tidak menunjukkan kesan perbezaan bererti tetapi ia menunjukkan perbezaan antara baja foliar yang berbeza. Rawatan T4F3 menunjukan kesan perbezaan yang bererti pada ketinggian pokok and bilangan anak padi. Rawatan T4F3 (60 t ha^{-1} tahi ayam dan baja foliar Calmag Amino dengan TE) menghasilkan pokok padi dan bilangan anak padi yang tertinggi masing-masing pada 112.58 sm dan 41.67 anak padi. Rawatan T4 dan baja foliar F2 menghasilkan batang padi yang tertinggi (T4=74.08 sm, F2=70.88 sm). Kedua-dua tahi ayam dan baja foliar tidak menunjukkan kesan perbezaan bererti pada peratusan anak padi berproduktif tetapi rawatan T3 (40 t ha^{-1} tahi ayam) dan baja foliar menghasilkan peratusan anak padi berproduktif yang tertinggi masing-masing pada 78.19% dan 77.48%. Bagi komponen segi hasil, tahi ayam menunjukkan kesan perbezaan yang bererti pada bilangan tangkai dan kepanjangan tangkai, rawatan T4 dan F3 menghasilkan bilangan tangkai yang paling banyak (T4=35.22, F3=28.88) manakala rawatan T3 dan F1 (baja NPK dengan 40 t ha^{-1} tahi ayam) menghasilkan tangkai yang paling panjang (T3=26.04 sm, F1=25.18 sm). Rawatan T3 (40 t ha^{-1} tahi ayam) dan baja foliar F1 (Rawatan Kawalan) menghasilkan bilangan butiran padi pada setiap tangkai yang tertinggi (T3 = 155.98, F1 = 143.2). Kedua-dua tahi ayam dan baja foliar tidak menunjukkan kesan perbezaan bererti pada peratusan butiran padi penuh tetapi rawatan T3 dan F2 telah menghasilkan min peratusan butiran padi penuh yang tertinggi (T3=85.88%, F2=85.37%). Tahi ayam menunjukkan kesan perbezaan bererti pada jumlah butiran padi dan hasil unjuran. Rawatan T4 dan baja foliar F3 menghasilkan jumlah butiran padi yang tertinggi (T4=5051.17, F3=3964). Manakala, rawatan T4 dan F1 (baja NPK dengan 60 t ha^{-1} tahi ayam) yang menghasilkan hasil unjuran yang tertinggi (T4=11.47 tan ha^{-1}, F1=9.26 tan ha^{-1}). Hasil kajian juga menunjukkan kesan perbezaan bererti dengan rawatan T2 dan F1 (baja NPK dengan 20 t ha^{-1} tahi ayam) dengan penghasilkan berat ribu butiran padi yang paling berat (T2=25.76 g, F1=25.18 g). Rawatan T4 dan T3 menghasilkan berat kering yang tertinggi (T4=177.74 g, F3=132.14 g) dan ia mempunyai kesan perbezaan bererti pada kadar tahi ayam yang berbeza. Bagi sifat tanah BRIS, tahi ayam hanya menunjukkan kesan perbezaan bererti pada pH tanah dan kapasiti pertukaran kation tanah. Rawatan T4 dan F2 menghasilkan nilai pH yang tertinggi (T4=5.81, F2=5.22) dan peratusan bahan organik tanah yang tertinggi (T4= 6.93%, F2= 6.95%). Untuk jumlah kandungan nitrogen tanah, rawatan T4 dan F1 menghasilkan peratusan jumlah kandungan nitrogen tanah yang tertinggi (T4=0.2%, F1=0.19%) dan kapasiti pertukaran kation yang tertinggi (T4=18.39 cmolc kg^{-1}, F1=16.35 cmolc kg^{-1}) manakala rawatan T4 dan F3 menghasilkan kandungan fosforus tanah yang tertinggi (T4=5.866 ppm, F3=4.036 ppm). Oleh itu, rawatan T4 adalah kadar yang disyorkan kepada petani kerana ia menghasilkan bilangan anak padi,

batang padi, bilangan tangkai, jumlah butiran padi dan hasil unjuran yang tertinggi. Manakala bagi sifat tanah BRIS, rawatan T4 dapat meningkatkan kesuburan tanah dengan menghasilkan jumlah kandungan nitrogen tanah dan kandungan fosforus tanah yang tertinggi. Selain itu, rawatan T4 juga menghasilkan kapasiti pertukaran kation tanah yang tertinggi dan juga dapat meningkatkan pH tanah dan kandungan bahan organik tanah.

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LIST OF SYMBOLS, UNITS AND ABBREVIATIONS

°C	Degree Celcius
%	Percentage
=	Equal
ANOVA	Analysis of variance
BRIS	Beach Ridges Interspersed with Swales
CD	Convex Depth
CEC	Cation Exchange Capacity
cm	Centimeter
CM	Chicken manure
CRD	Completely Randomized Design
DOA	Department of Agriculture
ECe	Electronic conductivity
ha^{-1}	Per hectare
IRRI	International Rice Research Institute
K	Potassium
kg	Kilogram
MOP	Muriate of Potash
N	Nitrogen
O.C	Organic Carbon
P	Phosphorus
SOM	Soil Organic Matter
SSL	Self Sufficient Level
TSP	Triple Super Phosphate

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Formulae **Page**

3.1 Percentage of Productive Tillers (%) 28

$$(\%) = \frac{\text{Number of panicles}}{\text{Highest number of tillers}} \times 100$$

3.2 Percentage of Filled Grain (%) 28

$$(\%) = \frac{\text{Number of filled spikelet panicle}^{-1}}{\text{Number of total spikelets panicle}^{-1}} \times 100$$

3.3 Percentage of Empty Grain (%) 28

$$(\%) = \frac{\text{Number of empty spikelet panicle}^{-1}}{\text{Number of total spikelets panicle}^{-1}} \times 100$$

3.4 Grain Number Panicle^{-1} (a) 28

$$a = \frac{\text{Filled Grain Panicle}^{-1}}{\text{Percentage of Filled Grain}} \times 100$$

CHAPTER 1

INTRODUCTION

1.1 Introduction

Rice is one of the world's staple foods. Most Malaysian consumes rice for getting energy and the demand for rice as a staple food is increased along with the increasing of human population. Malaysia is a tropical country where temperatures range between 25ºC and 35ºC during the year. Besides, Malaysia also has a high rainfall, hence it is suitable for rice cultivation. However, the rice production is not yet enough for Malaysian consumption. Malaysia is still importing 1,583.8 thousand metric tonnes of rice to fulfil the requirement of its population in 2013 (Department of Agriculture Peninsular Malaysia, 2014). The National Food Security Policy aims to increase National Self Sufficiency Level (SSL) of domestic rice from 70% in 2010 to 85% by 2015 and reduce the importation of rice from 30% to 15% by 2015 (Mohd Rashid and Mohd Dainuri, 2013). Besides, there is also increase in amount of abandoned paddy land (Indrani, 2001) and some are converted for other land use.

Paddy soils are mostly alluvial soils and low humic gley soils (or Entisols and Inceptisols). Grumusols (or Vertisols), reddish-brown earths (or Alfisols), red-yellow podzolic soils (or Ultisols) and latosols (or Oxisols) are also utilized, but to a limited extent (Kawaguchi and Kvuma, 1974). However, BRIS (Beach Ridges Interspersed with Swales) soil is a problematic soil in Malaysia (Mohd Ekhwan *et al.*, 2009) and unsuitable for rice cultivation. BRIS where the swales are found in between the ridges, sitting in the depression areas; therefore inundated by water due to eustatic changes in the sea level (Nossin, 1964; Hutchison, 2009). The total area of BRIS soils spread along the east coast of the Peninsular and the coastal area of Sabah is about 200,000 hectare in total with 155,400 ha in Peninsular Malaysia and 40,400 ha in Sabah respectively (Hazandy *et al.*, 2009). In Sabah, BRIS soil can be found around the coastal area like Tuaran, Papar, Beufort, Kimanis and Kota Belud. According to Ku (2013), the Sabah Shoreline Management Plan stated that there are excessive river sand mining in the rivers of the Tuaran District namely Sg.Tuaran (Appendix C).

The BRIS soils in Malaysia are not well utilized for crop production due to their inherent fertility. Besides, BRIS soil is unsuitable to produce rice due to its poor physical and chemical properties (Mohd Khairi *et al.*, 2011). BRIS soil structure contains mostly of sand particles with having low water-holding capacity (Jensen, 1989) and poor in nutrient. Since these soils (BRIS) in the coastal region of Peninsula Malaysia are known to be successful in growing Tobacco with the combination of waste products like chicken manures and palm oil extracts etc. can improve on the development of the soil quality, hence, to replace Tobacco with economical crops like paddy will be important to the Malaysian people (Usman *et al.*, 2013).

Soil amendments can be added to increase the ability of the sandy soil to retain water and increase the nutrients in the soil as well. NPK fertilizer consists of high nutrient content, especially for nitrogen (N), phosphorus (P), and potassium (K) can be added to improve the soil fertility. Nitrogen promotes rapid plant growth and improves grain yield and grain quality through higher tillering, leaf area development, grain formation, grain filling, and protein synthesis (IRRI, 2014). Phosphorus promotes root development, tillering, early flowering, and ripening while potassium improves root growth and plant vigour (IRRI, 2014).

Besides, chicken manure can also be used and it is the most preferred compared to other animal wastes because of its high concentration of macro-nutrients (Warman, 1986; Duncan, 2005). Manures decompose (mineralize) in the soil releasing nutrients for crop uptake. Mineralization rates of manure materials in warm, moist, sandy soils are rapid, thus it may be applied in BRIS soil. Besides, application of chicken manure in the soil enhances concentration of water soluble salts in soil. Besides of supplying nutrients, poultry manure or litter also serves as a soil amendment and increase the soil organic matter content. The added organic matter increases the moisture holding capacity of the soil, lowers soil bulk density, and improves overall soil structure and water infiltration.

Moreover, foliar fertilizer spraying will have a quicker plant response and able to respond immediately to plant conditions (Oosterhuis, 2009). It is recognized as a supplement that applied during crop growth to improve the mineral status of plants and increase the crop yield (Kolota and Osinska 2001).

1.2 Justification

Nowadays, the rice production is not yet enough for Malaysian consumption. Malaysia is still importing 1,583.8 thousand metric tonnes of rice to fulfil the requirement of its population in 2013 (Department of Agriculture Peninsular Malaysia, 2014). In Sabah, the paddy planted area is decreasing and thus causing the decreases of paddy yield and rice production (Appendix B). This may due to the conversion of arable paddy land to other land use purposes. For example, many sand mining activities is done at the Sg.Tuaran for industry, housing and road construction purposes (Ku, 2013). Besides, most of the arable land has been converted for oil palm cultivation also leads to less fertile soils such as BRIS soil for rice planting. According to Olaniyi *et al.* (2012), amount of agricultural land use for rubber, cocoa, paddy and coconut were decreased while the corresponding land use for oil palm, vegetables and fruits were increased (Appendix B).

BRIS soil is a problematic soil in Malaysia and most of it is abandoned and not used for cultivation of paddy by the farmers. Only tobacco and coconut is planted on BRIS soil. Currently, many farmers in Kelantan and Terengganu are planting kenaf on BRIS soil (Malisa *et al.*, 2011). Besides, chili, yam, bean, sweet potato and some other vegetative crops have been grown successfully on BRIS soil with a good management practices (Roslan *et al.*, 2011). Moreover, paddy is a water-standing plant which needs a constant water level; however BRIS soil has low water retention capacity. Thus, it is less suitable to produce rice unless the soil structure is improved by adding of soil amendment. Sandy soil on beach ridges has a nature characteristic of extreme leaching, low cation exchange capacity and low exchangeable bases leads to their low productivity. Sandy soil has dominated with larger pores which allow water flow rapidly result in leaching.

Organic fertilizers such as chicken manure can improve the soil structure and increase its ability to hold water and nutrients. Since it is a slow-release fertilizer, it is very difficult to over fertilize and harmless to the plants. Organic fertilizers are renewable, biodegradable, sustainable, and environmentally friendly. It increases the number and diversity of soil microorganisms, particularly in sandy conditions (Mohamed Amanullah *et al.*, 2010). Besides, recycling of organic manure or waste is an important global issue to improve soil productivity for sustaining agricultural production as well as to preserve the environment (Khalil *et al.*, 2005). Since BRIS soil is very infertile, NPK fertilizer is applied to provide the essential nutrient for paddy plants. It has a quick-release action of nutrients and available to the plant immediately. Foliar application can be used to provide nutrients to the foliage and it generally more rapidly absorbed. Besides, the danger of fixation is also reduced when nutrients are applied to the foliage of the plant (McCall, 1980).

The major constraint in food crop production is the limited availability of agricultural land and there are about 2 million people in Malaysia depending on poor (BRIS) soils for economic survival (Malisa *et al.*, 2011). Thus, BRIS soil must be amended and manage wisely to enhance rice production in order to overcome the food security issue in Malaysia.

1.3 Significant of Study

This study may help the farmers to improve the BRIS soil health. BRIS soil is infertile due to the low nutrient retention capacity. However, adding of soil amendment such as chicken manures which consists of high organic matter can improve the soil aggregation and thus, leaching or losing of nutrient can be reduced. Besides, adding of NPK fertilizer provides essential nutrients for the paddy plant growth and addition of foliar application can improve paddy cultivation. Thus, land with BRIS soil need not to be abandoned by the farmers.

According to the farmer, some BRIS soil land owners do plan to sell the sandy soil for contractors to build building as they may not know how to benefit the sandy soil by planting crops such as paddy. Besides, many farmers at Tuaran prefer to plant watermelon, petola, bird's eye chili and banana in smaller scale rather than paddy as they meet difficulties in planting paddy on BRIS soil. Thus, the farmers will have a chance to expose to a better way of paddy cultivation on BRIS soil with the aid of soil amendment and fertilizer in this study. Therefore, it can also become a source of income for the farmers too. Besides, the optimum rate of chicken manure and the most suitable types of foliar fertilizers found through the study can be recommended to the famers to avoid too higher rate of fertilizer application as it will cause nutrient toxicity and hence reduce yield production. Besides, the study can also be used as a guideline for the farmers to improve the BRIS soil fertility and productivity and provide a solution to increase the rice production; improving the food security and Self Sufficiency Level (SSL) of domestic rice in Sabah.

1.4 Research Objectives

The objectives of this study are:

I. To determine the effect of chicken manure and foliar fertilizer with application of high rate NPK fertilizer towards the growth and yield of TR-9 paddy variety planted on BRIS soil.

II. To determine the BRIS soil's fertility before and after the study.

1.5 Hypotheses

H_0: There is no significant difference in the effect of chicken manure and foliar fertilizer with application of NPK fertilizer towards the growth and yield of TR-9 paddy variety planted on BRIS soil.

H_A: There is a significant difference in the effect of chicken manure and foliar fertilizer with application of NPK fertilizer towards the growth and yield of TR-9 paddy variety planted on BRIS soil.

H_0: There is no increase of fertility of BRIS soil after the study compared to the BRIS soil taken before the study.

H_A: There is an increase of fertility of BRIS soil after the study compared to the BRIS soil taken before the study.

CHAPTER 2

LITERATURE REVIEW

2.1 Paddy Plant (*Oryza sativa*)

The cultivated rice plant (*Oryza sativa*) belongs to the tribe Oryzeae under grass family Gramineae (Poaceae) which are cultivated and considered as a staple food in most parts of the world. The rice plant may be characterized as an annual, monocarpic cereal with C_3 type photosynthesis pathway (Fageria, 2013). Besides, it has a round, hollow, jointed culms, rather flat leaves and a terminal panicle (Panda, 2010). The rice plants take three to six months to complete its life cycle from germination to maturity, depending on the variety and environmental conditions (Mae, 1997). *Oryza sativa* is grown worldwide and was believed to have been domesticated in the northeast and southeast regions of the continent (Asia) around 5000 years ago (Huong, 2010).

2.1.1 Paddy's Morphology

Paddy plant can grow up to 1 to 2 m in height. The vegetative organs consist of roots, culms, and leaves. The roots are fibrous, possessing rootlets and root hairs. The culm, or jointed stem of the rice, is made up of a series of nodes and internodes (IRRI, 2009). The node (nodal region) bears a leaf and a bud which may give rise to a tiller. Adventitious roots appear in the axis at the base of the internode. The septum inside the node separates two adjoining internodes (Chang *et al.*, 1965). Young internodes are smooth and solid (IRRI, 2009). Mature internodes are hollow and finely grooved with a smooth outer surface (IRRI, 2009). Tillers arise from the main culm in an alternate pattern while the primary tillers are produced from the basal node on the main culm and give rise to secondary tillers followed by tertiary tillers (Panda, 2010). The leaves consist of the sheath and blade and are borne on the culm in opposite direction, one at each node. Auricles are small, paired, ear-like appendages borne on either side of the base of the blade (Chang *et al.*, 1965).

The reproductive organs consist of panicle, spikelet and grains. The panicle grows on the uppermost internode of the culm (IRRI, 2009). The panicle axis (rachis) is the main axis of the inflorescence, extending from the panicle base to the apex (Chang *et al.*, 1965). The panicle has a racemose mode of branching in which each node on the main axis gives rise to the primary branches and each of which in turn bears the secondary branches which bear the pediceled spikelets (Chang *et al.*, 1965). A spikelet consists of a minute axis (rachilla) which bears the single floret. The floret contains a flower which consists of a pistil (female organ) and six stamens (male organs) (IRRI, 2009). The rice grain is known as caryopsis which is a dry one-seeded fruits, with its pericarp fused with the seed coat (Panda, 2010). The seeds consist of a husk or pericarp, endosperm and an embryo.

2.1.2 Growth Stages and Development

A rice plant has two distinct sequential growth stages: vegetative and reproductive (Table 2.1). Vegetative stage refers to a period from germination to the initiation of panicle primordia while the reproductive stage refers to period from panicle primordia initiation to heading, and the ripening period from heading to maturity. It spends about 60 days in vegetative stages, 30 days in reproductive stages and another 30 days in ripening period (Panda, 2010).

The vegetative phase of the rice plant begins with grain germination becoming a seedling. During the seedling stage, seminal and lateral roots and the first few leaves develop while the leaves develop at the rate of 1 every 3-4 days (Bhan, 2011). Besides, secondary adventitious roots form the permanent fibrous root system to replace the seminal roots. The tillering stage begins when the first tiller emerges from the axillary bud in one of the lowermost nodes (Bhan, 2011). The first primary tiller usually emerges from the sheath of the first complete leaf before the fifth leaf (Dunand and Saichuk, 2009). After emerging, the primary tillers give rise to secondary tillers, followed by tertiary tillers and reaches the maximum tiller number which is known as maximum tiller number stage. During tillering, crown develops at the base of the main shoot and the crown is the region of a plant where shoots and secondary roots join

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