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EFFECTS OF AGE OF SEEDLING TRANSPLANTS AND NITROGEN FERTILIZER IN LOWLAND RICE PRODUCTION

BY

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BY

BRIDGET AIDOO NKRUMAH

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DECLARATION

I hereby declare that this submission is my own work towards the Master of Science degree and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the university, except where due acknowledgement has been made in the text.

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ABSTRACT

Two field experiments were conducted at the C.S.I.R Crops Research Institute Rice Research field at Nobewam during the 2014 and 2015 growing seasons. The 2014 experiment was conducted in the minor season to evaluate the effect of age of seedling transplants on the growth and yield of lowland rice. The 2015 experiment was also conducted in the major season to evaluate the best top dressing time for urea application in lowland rice.

Both experiments were laid out in the Randomized Complete Block Design with three replications each. Seedlings were transplanted in the 2014 experiment at 14, 21, 28, 35 and 42 days after nursery. In the 2015 experiments all plots received NPK fertilizer at the rate of 40kg ha^{-1} at 2 weeks after planting. Urea fertilizer was top dressed at 90kg/ha at various split times and concentrations. All cultural practices were carried out at the right times. Data collected included plant height, number of tillers, number of leaves, number of spikelets per particle, mean seed weight and grain yield. The results showed that the best transplanting time was 14 days, and that beyond 21 days growth, tiller production, grain weight and grain yield decreased. The 2015 experiment showed that although split urea application showed greater growth in rice, mean grain weight and total grain yield were greater when urea was top-dressed in a single dose of 90kg N/ha at 2weeks after transplanting.

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DEDICATION

This thesis is dedicated to my mother Mrs. Felicia Aidoo Nkrumah

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CHAPTER ONE

1.1 INTRODUCTION

Rice (*Oryza sativa)* is predominately a self-pollinated annual crop belonging to the family *Poaceae*. The crop is believed to have originated from South East Asia and introduced into Africa by Portuguese traders (OGTR, 2005). Rice is the most important food crop in the world and the staple food of more than 3 billion people or more than half of the world's population. Rice is grown in more than a hundred countries with a total harvested area of about 160 million hectares, producing more than 700 million tons every year (IRRI, 2010).

Despite efforts at encouraging increases in production, rice yields per unit area are still very low in Ghana (Hiroyuki *et al*., 2012). Among the identified causes for low yields are declining soil fertility and inability of farmers to use the required quantities of mineral fertilizers (Buri *et al*.,2008). According to Sanchez (2001), too much emphasis has been placed on the development of high yielding crop varieties with little attention on efficient nutrient utilization in rice production. He further noted that crop yields in Africa can be tripled through proper management of the soil environment and nutrients utilization. Over application or under supply of plant nutrients can have excessive consequences resulting in the desired yields not being obtained (Buri *et al.*, 2008). The principle of balanced nutrients employment requires that, the demanding effect of fertilization can be eliminated through judicious use of minerals in order to sustain an economically viable and environmentally friendly agriculture (Ernest and Mutert, 1995).

Effective nutrient management (mainly nitrogen fertilization) is, therefore a prerequisite to obtaining optimal yields in rice. Irrigated rice occupies 50% of total rice area and produces

75% of total rice output, further intensification of irrigated rice ecosystem is necessary to feed the growing population and maintain food security in coming years (Nchimuthu *et al.,* 2007*).*

Nitrogen is an essential nutrient for rice production as it plays an important role in sustaining high yields (Guindo *et al.*, 1994; Peng *et al.*, 2002; Liu *et al.*, 2007; Yang *et al.*, 2010). Declining soil nitrogen supply is one of the main limiting factors for achieving high rice yields (Yu *et a.,l* 2013). Nitrogen is a major essential plant nutrient and key input for increasing yield in rice growing countries. Yield increases of about 70-80 % in rice fields could be obtained by the application of nitrogen fertilizer (Yaug *et al.,* 2010). Though nitrogen fertilization increases crop yield, application of nitrogen fertilizer does not necessarily mean its availability in soils and hence its uptake as applied nitrogen is subjected to losses through leaching, volatilization and denitrification. Nitrogen fertilizer application rate is very high in rice production globally, but its use efficiency is very low owing to these losses (Liu *et al.*, 2007; Ye *et al*., 2011). Ammonia volatilization from rice farmland is an inevitable source of nitrogen loss and it is closely related to the nitrogen application rate (Song *et al*., 2004; Ye *et al*., 2011). The timing of nitrogen fertilizer applications can also remarkably affect nitrogen use efficiency and the potential of nitrogen losses. Supplying the needed nitrogen prior to the crops greatest demand maximizes the efficiency of nitrogen applications.

Nutrient uptake characteristics differ with rice cultivar, fertilizer type, fertilization technology, soil type, growth stage and environmental factors (Zhang *et al*., 2006; Huang *et al*., 2008). Nutrient absorption is usually low at the seedling stage and peaks before the heading stage, and then decreases as root activity declines (Guindo *et al*., 1994; Liu *et al*., 2007). According to (Yu *et al.,* 2013), nitrogen uptake in some rice varieties is highest at the maximum tillering stage, followed by the young panicle developmental stage. The question of how to reduce the nitrogen application rate and improve nitrogen use efficiency, while maintaining high yield, has therefore become an important research focus (Vlek and Byrnes, 2000; Zhu *et al*., 2005). Research on the effects of nitrogen application rate on rice growth has been well elucidated by several researchers, but available information on the relationship between increasing nitrogen application rate and nutrient uptake especially in relation to nitrogen management practices is very scanty.

The objectives were to;

- ❖ Determine the effects of age of seedlings transplant on the growth and yield of rice.
- ❖ Determine the best timing of top dressing of Nitrogen fertilizer in lowland rice production system.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Origin and Production of rice

Rice is the seed of the monocot plants *Oryza sativa* or *Oryza glaberrima*. As a cereal grain, it is the most widely consumed staple food for a large world's human population. It is the agricultural commodity with the highest worldwide production (www.plantsciences.ucdavis.edu). The crop is believed to have originated from South East Asia and introduced into Africa by Portuguese traders (OGTR, 2005). Rice is the most important food crop in the world and the staple food of more than 3 billion people or more than half of the world's population. Rice is grown in more than a hundred countries with a total harvested area of about 160 million hectares, producing more than 700 million tons every year (IRRI, 2010).

It is normally grown as an annual plant, although in tropical areas it can survive as a perennial crop. Rice was introduced to Europe through the western Asia, and to the Americas through European colonization. It can grow to 1-1.8m tall, occasionally more depending on the variety and soil fertility. Rice has become the second most important food staple after maize in Ghana and its consumption keeps increasing as a result of population growth, urbanization and change in consumer habits. Between 1996 and 2005, paddy production was in the range of 200,000 and 280,000 tons (130,000 to 182,000 tons of milled rice) with large annual fluctuations. The annual production fluctuations are largely due to the area put under rice cultivation, rather than yield variations (www.tnau.ac.in)

Rice is cultivated in Ghana both as a food crop and a cash crop. The total rice consumption in 2005 amounted to about 500,000 tons (JICA, 2007), which is equivalent to per capita consumption of 22 kg per annum. Ghana depends largely on imported rice to make up the deficit in rice supply. On the average, annual rice import is 400,000 tons. The selfsufficiency ratio of rice in Ghana has declined from 38 % in 1999 to 24 % in 2006 (CIRAD, 2007). It is important for stakeholders in the food and agriculture sector to ensure increased and sustained domestic production of good quality rice for food security, import substitution and savings in foreign exchange. Global rice imports have increased by 80% - from 2.5 billion tons (grain) in the early 1990s to 4.5 billion tons in 2004. During the same period,

African countries increased rice imports by 140% - from 5 million tons in the early 1990s to 12 million tons in 2004. This is equivalent to about a quarter of the world import, with an import value estimated at US$2.5 billion. West African countries showed the same increasing trend of rice import, increasing from 4 million tons (US$ 0.8 billion) in early 1990s to 8 million tons (US$1.6 billion) in 2004-2005, accounting for two-thirds of Africa's rice import. Annual import value exceeded US$200 million (JICA, 2007). Rice imports are projected to be between 6.5 and 10.1 million tons by 2020 (Lançon and Erenstein, 2002). In recent years, rice production in Africa has been expanding at a rate of 60% per annum, with 70% of the production increase due mainly to land expansion and only 3% being attributed to an increase in productivity. Much of the expansion has been in the rain fed systems, particularly in two ecosystems, (upland and rain fed lowland) that make up 78% of rice land in West and Central Africa. Africa cultivated about 9 million hectares of rice in 2006 and production, which is expected to increase by 7% per year, surpassed 20 million tons. Rice cultivation is well suited to countries and regions with low labour costs and high rainfall, as it is labour intensive to cultivate and requires ample water. The varieties of rice are typically classified as long, medium and short-grained.

2.1.1 Ecology

Rice can be grown in different environments, depending upon water availability. Generally, rice does not thrive in waterlogged area, yet it can survive and grow herein and it can also survive flooding. Because cultivation is so widespread, development of four distinct types of ecosystems has occurred, such as irrigated rice eco system rain fed, upland rice eco system rain fed, lowland rice eco system, and flood prone rice eco system.

Irrigated Rice Eco System: Irrigated ecosystems are the primary type found in East Asia. Irrigated ecosystems provide 75per cent of global rice production. In India, the total area under irrigated rice is about 22.00 million hectares, which accounts about 49.5per cent of the total area under rice crop in the country. Rice is grown under irrigated conditions in the states of Punjab, Haryana, Uttar Pradesh, Jammu & Kashmir, Andhra Pradesh, Tamil Nadu, Sikkim, Karnataka, Himachal Pradesh and Gujarat. Irrigated rice is grown in bunded (embanked), paddy fields (*www.philrice.gov.ph*).

Rain- fed Upland Rice Eco System: Upland zones are found in Asia, Africa, and Latin America. In India, the total area under upland rain- fed rice in the country is about 6.00 million hectares, which accounts for13.5per cent of the total area under rice crop in the country. Upland rice areas lies in eastern zone comprising of Assam, Bihar, Eastern M.P., Orissa, Eastern U.P., West Bengal and North-Eastern Hill region. Upland rice fields are generally dry, unbunded, and directly seeded. Land utilized in upland rice production can be low lying, drought-prone, rolling, or steep sloping.

Rain fed Lowland Rice Eco System: Rain fed low-land rice is grown in such areas as East India, Bangladesh, Indonesia, Philippines, and Thailand, and is 25per cent of total rice area used worldwide. In India, low land rice area is about 14.4 million hectares, which accounts for 32.4 per cent of the total area under rice crop in the country. Production is variable because of the lack of technology used in rice production. Rain fed lowland farmers are typically challenged by poor soil quality, drought/flood conditions, and erratic yields

Flood Prone Rice Eco System: Flood-prone ecosystems are prevalent in South and Southeast Asia, and are characterized by periods of extreme flooding and drought. Yields are low and variable. Flooding occurs during the wet season from June to November, and rice varieties are chosen for their level of tolerance to submersion *(www.irri.org*)

Rice cultivation on wetland rice fields is thought to be responsible for 1.5% of the anthropogenic methane emissions. Rice needs slightly more water to produce than other grains. Rice production uses almost a third of Earth’s fresh water. Long-term flooding of rice fields cuts the soil off from atmospheric oxygen and causes anaerobic fermentation of organic matter in the soil (www.brri.gov.bd).

Other factors, like increased rates of fertilizer nitrogen, may increase the yield but reduce the quality of the grain. An adequate supply of nitrogen to the crop plants during their early growth period is very important for the initiation of leaves and florets primordial (www.philrice.gov.ph)

The type of nitrogenous fertilizer may also affect the yield and quality of the grain. Some of these fertilizers, like urea, are substantially cheaper than others, and their use may be justified on economic grounds provided they do not adversely affect the yield or quality of the grain (*www.tnau.ac.in*).

Aside from moisture needs to ensure a stand, most crops have critical periods during the growing season when good soil moisture levels must be maintained to obtain high quality and quantity yields. The critical period for most crops occurs during the part of the growing season of pod, fruit, tuber, or ear formation and development. If sufficient growing season exists for the desired development of the crop, short periods of low moisture during the early part of the growing season may not be harmful except for leaf or forage crops. However, over stimulation of vegetative growth from a combination of high soil fertility and available soil moisture can also be objectionable. This may delay time of harvest enough to miss the period of highest fresh market demand, affect the grade for processing, or cause losses in late maturing crops from frost damage. If irrigation water supplies are limited, the best use of the irrigation water supply would be during the critical growth period of the crop.

2.1.2 Uses and Nutritional value of rice

There is a wide variation in rice consumer preference in Ghana on the basis of grain characteristics. However, most consumers prefer long grain perfumed rice of good taste, good appearance, and with whole grains, although broken grains have their place in specific local dishes. Health-conscious consumers patronize local brown rice while parboiled rice is preferred in the Northern regions of Ghana (FAO, 2005). Annual per capita rice consumption during 1999-2001 was 17.5 kg on average. This increased to 22.6 kg during 2002-2004. In the same period, per capita rice consumption increased to around 8.9% per annum, higher than the population growth of 2.5% per annum. Assuming the same trend continues, per capita rice consumption will increase to 41.1 kg in 2010 and 63.0 kg in 2015. Based on population growth rate alone the current demand of about 500,000 tons per year will increase to about

600,000 tons per year in 2015. However, taking both population growth and increase in per capita consumption together, rice demand will increase to 1,680,000 tons per year. Furthermore, rice cultivation plays a very important role in providing employment to about 10% of farming households. With a total rice cropping area of 118,000 hectares in 2008, an estimated average household holding of 0.4 hectares indicates an approximate total of 295,000 households' involvement in rice cultivation (Africarice, 2015).

Rice is a nutritional staple food which provides instant energy as its most important component is carbohydrate (starch). On the other hand, rice is poor in nitrogenous substances with average composition of these substances being only 8% and fat content or lipids only negligible, i.e., 1%.

Rice flour is rich in starch and is used for making various food materials. It is also used in some instances by brewers to make alcoholic malt. Likewise, rice straw mixed with other materials is used to produce porcelain, glass and pottery. Rice is also used in manufacturing of paper pulp and livestock bedding (Plantsciences, 2010).

The variability of composition and characteristics of rice is really broad and depends on variety and environmental conditions under which the crop is grown. In husked rice, protein content ranges in between 7per cent to 12per cent. The use of nitrogen fertilizers increases the percentage content of some amino acids.

The comparative nutritional value of cereals differs in nutritional content of rice bran and raw rice. The brown rice is rich in some vitamins, especially B1 or thiamine (0.34 mg), B2 or riboflavin (0.05 mg), niacin or nicotinic acid (4.7 mg). In contrast, the white rice is poor in vitamins (0.09 mg of vitamin B1, vitamin B2 0.03 mg and 1.4 mg of niacin) and minerals as they are found mostly in the outer layers of the grain, which are removed by polishing process, or "bleaching" whereas parboiled rice is rich in these vitamins as a result of their particular process. (WARDA, 2003).

The immense diversity of rice germplasm is a rich source for many rice based products and is also used for treating many health related maladies such as indigestion, diabetes, arthritis, paralysis, epilepsy and give strength to pregnant and lactating mothers. Ancient Ayurvedic literature testify the medicinal and curative properties of different types of rice grown in India. Medicinal rice varieties like Kanthi Banko (Chhattisgarh), Meher, Saraiphul & Danwar (Orissa), Atikaya & Kari Bhatta (Karnataka), are very common in India. Few varieties cultivated in restricted pockets of Kerala for their medical properties e.g.

Chennellu, Kunjinellu, Erumakkari & Karuthachembavu etc. *(*www.brri.gov.bd *)*.

2.2 Importance of Nitrogen to crop production

Nitrogen losses are particularly high at low plant demand during the early growth stages when urea, the major N fertilizer used by farmers, is broadcast onto the floodwater surface (Schnier, 1995).

The high N losses from applied N fertilizers and the low efficiency of N utilization by rice cause substantial economic losses to farmers and contribute highly to a number of environmental problems such as water eutrophication and greenhouse warming. In the past, management strategies such as gypsum coating of urea and the use of urease inhibitors to delay urea hydrolysis *(*Chaiwanakupt *et al.*, 1996) had been devised to address the high N losses and poor N use efficiency problems.

These management techniques, however, had met limited success in the field. Most of them are expensive (Damodar Reddy and Sharma, 2000) and entail more costs to farmers than what they can save. It is a challenge, therefore, to develop a technology, which can curtail not only the high N losses and improve the poor N use efficiency by rice, but at the same time, a technology which is also environmental-friendly, simple, and inexpensive and on the whole, beneficial to rice farmers. Soil nitrogen deficiency has been cited as a major constraint to rice production. Nitrogen deficiency is mostly acute in the highly weathered upland areas where an average yield of only one ton per hectare, which is about 25 percent of yield potential, has been recorded. Also, nitrogen is difficult to retain when applied in lowland areas due to floods and flowing water that characterize such areas.

Nitrogen is a constituent of compounds such as amino acids, proteins, RNA, DNA, and several phytohormones and is thereby an essential macro element for plants (Wang and Schjoerring, 2012). It is not only the constituent of key cell molecules such as amino acids, nucleic acid, chlorophyll, ATP and several plant hormones, but also the pivotal regulator involved in many biological processes including carbon metabolism, amino acid metabolism, nucleic acid metabolism and protein synthesis (Cai *et al.,* 2012). Nitrogen is essential for all living organisms, the synthesis of cellular proteins, amino acids, nucleic acids, purine and primidine nucleotide are dependent upon N. It is the most abundant mineral element in plant tissues which is derived from the soil. However, excess N may cause significant biochemical changes in plants and may lead to nutritional imbalances (Salim, 2002).

Among different nutrients, Nitrogen is one of the essential macronutrient required for proper plant growth (Gholizaleh *et al.*, 2011). An experiment conducted on rice by (Bridget, 2005) showed that number of stems and panicles per square meter and the total spikelets increased with Nitrogen fertilization which reflected on grain productivity.

Nitrogen management is important for rice under aerobic culture. Application of nitrogen at the right time is perhaps the simplest agronomic solution for improving the use efficiency of nitrogen (Ganga Devi *et al.,* 2012*).* Approximately 65% of the applied mineral N is lost from the plant soil system through gaseous emissions, runoff, erosion and leaching. Environmental effects of this loss ranges from greenhouse effect, diminishing stratospheric ozone and acid rain to changes in the global N cycle and nitrate pollution of surface (Saikia *et al.,* 2012). Nitrogen is normally a key factor in achieving optimum lowland rice grain yields, it is, however, one of the most expensive inputs and in different ecosystems, many of the world's rice is grown under irrigated or rain-fed lowland conditions. Soils under these conditions are saturated and increasing rice yield per unit area through use of appropriate N management practices has become an essential component of modern rice production technology *(*Metwally *et al.,* 2011). Moreover, the production of inorganic N by the Haber - Bosch process generates huge amount of carbon dioxide, between 0.7-1.0 tons per tons of ammonia. At the same time due to unavailability of fossil fuels, the price of chemical fertilizers is also increasing rapidly since inorganic fertilizers are derived from fossil fuels particularly natural gas

There are also problem of losses of fertilizer after application through leaching, volatilization and through denitrification. The overall effects of these problems requires more concentration on greater access to inexpensive bio- fertilizer technologies, as they are ecologically sound and their application could help to minimize the global warming as well as to reduce the fertilizer input in farming practices (Saikia *et al.,* 2012). The efficient N use is critical to produce enough food for feeding the growing population and avoid large scale; degradation caused by excess N (Nchimuthu *et al.*, 2007). Application of nitrogen fertilizers are responsible for emissions of greenhouse gases like nitrous oxide and ammonia. Excessive nitrogen fertilizer application can lead to pest problems by increasing the birth rate, longevity and overall fitness of creating pests (Siavoshi *et al.*, 2011). Excessive application of chemical nitrogen fertilizer can result in a high soil nitrate concentration after crop harvest.This situation can lead to increase in the level of nitrate contamination of potable water, because nitrate remaining in the soil profile may leach to ground water (Azarpour *et al.*, *2*011). The most sustainable cropping systems will maximize uptake and cycling of N and water without loss of nutrients from the system or creation of deficits that reduce economic yield. Nitrogen fertilizer is a key factor to the enhancement and sustainability of rice production. It is, however, highly susceptible to losses after their application, contributing highly to the inefficiency of N use. The average loss from applied N fertilizers can be as high as 60 percent, whereas the average N fertilizer recovery efficiency can be as low as 30 percent (Dobermann and Witt, 2000). Nitrogen losses are particularly high at low plant demand during the early growth stages when urea, the major N fertilizer used by farmers, is broadcast onto the floodwater surface (Schnier, 1995). The high N losses from applied N fertilizers and the low efficiency of N utilization by rice cause substantial economic losses to farmers and contribute highly to a number of environmental problems such as water eutrophication and greenhouse warming. In the past, management strategies such as gypsum coating of urea and the use of urease inhibitors to delay urea hydrolysis (Siavioshi *et a*l., 2011).

Nitrogen requires careful management, as it is very susceptible to being lost from soils. Nitrogen can be lost from the soil through leaching, denitrification, erosion and surface volatilization. Nitrogen is more readily leached in sandy soils than in fine texture soils. If not properly applied, nitrogen loss can account for up to 50-60% of the applied amount. For example, if nitrogen is applied too early, before the plant really needs it, a significant portion of the nitrogen may be lost before the crop takes it up. Therefore, the unit of N added to soil before the plant takes greater quantities should be minimized. Splitting nitrogen application is one way to do that. Splitting the nitrogen application reduces the risk of nitrogen loss and improves the efficiency of the application. Split fertilizer application has over the years shown to be very helpful in optimizing nutrient management (IRRI, 2010). Split nitrogen (N) fertilizer applications can play an important role in a nutrient management strategy that is productive, profitable and environmentally responsible. Dividing total nitrogen application into two or more treatments can help growers enhance nutrient efficiency, promote optimum yields and mitigate the loss of nutrients. By more specifically

synchronizing nitrogen supply with a plant's ability to utilize nutrients, split application can be an important component of 4R Nutrient Stewardship — right source, right rate, right time and right place (WARDA, 2003).

2.3 Age of Transplants effects on growth and development in rice and other crops

Nutrient absorption characteristics differ with rice cultivar, fertilizer type, fertilization technology, soil type and environmental factors (Zhang *et al*, 2006; Huang *et al*, 2008). The nutrient absorption amount varies with rice growth stage.

Absorption is low at the seedling stage and peaks before the heading stage, then decreases as root activity declines (Guindo *et al*, 1994; Liu *et al*, 2007). Increasing the nitrogen application level could significantly increase rice production within limits. High nitrogen uptake is observed at the tillering stage, followed by the young panicle developmental stage. Nitrogen taken up during early growth stages accumulated in the vegetative parts of the plant and is utilized for grain formation, a large portion of the nitrogen is absorbed during differentiation. The leaves and stems contain a large portion of the nitrogen taken up by the plant (Abou-khailfa, 2012).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study location

The study was carried out at the Crops Research Institute Rice Research fields at Nobewam, on (Lat. 6˚43'N and 1˚36'W) located within the Forest agro ecological zone of Ghana. The location experiences two rainy seasons, the major season from (April to July) and the minor season from (August to November). The soils at Nobewam are classified as Ferric aerosols and belong to the Asuansi series with about 5 cm thick top layer of dark gritty clay loam (by USDA classification).

3.2 Experiment 1: Effects of Age of Transplanting seedlings on rice growth and yield

3.2.1 Land preparation

The field was cleared, ploughed and flooded prior to puddling so as to soften the soil. Ploughing was done twice. The first ploughing was done 3 weeks before transplanting whiles the second ploughing was done 8 days after the first ploughing. The first ploughing gave organic matter sufficient time to decompose, and toxic substances released during organic matter decomposition was dissipated before the seedlings were planted. The second ploughing was to break soil lumps. Puddling was done 10 days after the second ploughing and a day before transplanting to help maintain balance and to break up remaining soil clumps. It further facilitated leveling, and break down of soil structure into a soupy mud suitable for transplanting.

3.2.2 Source of planting materials and establishment of seedlings

The lowland rice variety Jasmine rice was selected for the study based on yield and its related attributes (i.e. high yield, minimal perfumed smell, short growth period). This variety was obtained from CSIR- Crops Research Institute at Fumesua. Seeds from this variety was nursed on seedbeds, by broadcasting pre-germinated seeds on a prepared wet bed nursery. Younger seedlings at different physiological ages was selected for transplanting. Prior to uprooting seedlings, the beds was flooded with water to minimize damage to the seedlings.

3.2.3 Transplanting of seedling

Seedlings were transplanted onto the pudded field after 14, 21, 28, 35 and 42 days of nursing. Two seedlings/ hill were planted at a spacing of 20 x 20 cm between hills. The different transplanting ages served as the treatments.

3.2.4 Experimental design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The different seedling ages served as treatments.

3.2.5 Cultural /Agronomic practices

The following agronomic practices were carried out following transplanting of seedlings.

3.2.5.1 Fertilizer application

NPK 15-15-15 fertilizer was applied by broadcasting on all plots at the rate of 200kg/ha.

The fertilizer was broadcasted uniformly on each plot one week after transplanting (i.e. 28th July, 4th August, 11th August, 18th August and 25th August 2014 respectively). Plots were top-dressed with urea at a rate of 90kg/ha.

3.2.5.2 Weed control

At the early stages of growth, emerging weeds were carefully handpicked. Subsequent weeds were controlled using the selective herbicide pronil plus on the first of September 2014. 50 ml of the weedicide was mixed with 16 litres of water and sprayed using a knapsack sprayer. Later weeds were controlled by total submersion under irrigated water.

3.2.5.3 Pest and Disease control

Few insects that emerged were sprayed with sunpyrifos (48%EC). 50ml of the insecticide was mixed with 16 litres of water and sprayed using a knapsack sprayer. This was done twice. Birds' damage was restrained by covering the whole plot with a net during grain filling.

3.2.5.4 Irrigation

Plots were pre flooded before transplanting, and subsequent irrigation was done when needed. Water for irrigation was obtained from the dam at the site.

3.2.5.5 Data Collection

The following data were collected are; Plant height, number of leaves, number of tillers, number of spikelet per panicle, mean grain weight and grain yield.

3.2.5.5.1 Plant Height

A measuring tape was used to measure height of five consecutive plants in the second row of every plot. The average height for each plot was calculated. Measurements were done at 21, 42 and 63 days after planting (DAP).

3.2.5.5.2 Number of Leaves

Total number of leaves on the five consecutive plants in the second row of every plot were counted, for each plot and the mean calculated at 21, 42 and 63 days after planting (DAP).

3.2.5.5.3 Number of Tillers

The number of tillers of per plant were counted from each of the selected plants at the times stated and the means calculated for each plot.

3.2.5.5.4 Number of spikelet per panicle

This was determined by counting the total number of grains on a panicle from 5 selected plants from each plot.

3.2.5.5..5 Mean grain weight

This was determined by counting one thousand seeds from every plot, oven drying for 48 hrs at 80 ^{0}C to a moisture content of 14%. These were weighed and recorded.

3.2.5.5.6 Grain yield

This was determined by harvesting all plants from a $4m^2$ area from the central rows. The grains were, threshed, sun dried to a moisture content of 14% and weighed.

3.3 Experiment 2: Effects of Time of Urea Fertilizer Application on Growth and Yield of Rice

3.3.1 Management practices

3.3.1.1 Land Preparation

The field was cleared, ploughed and puddled. The cleared field was flooded prior to puddling so as to soften the soil. Ploughing was done twice. The first ploughing was done 3 weeks before transplanting whiles the second ploughing was done 8 days after first ploughing. Puddling was done 10 days after the second ploughing and one day before transplanting to help maintain balance and to break up remaining soil clumps.

3.3.1.2 Transplanting of Seedlings

Seedlings at the fourth leaf stage were hand transplanted onto the pudded field after 3 weeks of nursing. One seedling per hill was planted at a spacing of 20×20 cm.

3.3.1.3 Fertilizer application

NPK 15-15-15 fertilizer was applied at 40 kg for all plots. The fertilizer was broadcasted uniformly on each plot on one week after transplanting. Plots were top-dressed with urea.

3.3.1.4 Weed control

At the early stages of growth, emerging weeds were carefully handpicked. Subsequent weeds were controlled using the selective herbicide pronil plus. 50 ml of the weedicide was mixed with 16 litres of water and sprayed using a knapsack sprayer. Later weeds were controlled by total submersion under irrigated water.

3.3. 1.5 Pest and Disease control: Few insects that emerged were sprayed with sunpyrifos (48% EC). 50ml of the insecticide was mixed with 16 litres of water and sprayed using a knapsack sprayer. This was done twice. Birds' damage was restrained by covering the whole plot with a net during grain filling

3.3.1.6 Irrigation

Plots were pre flooded before transplanting, and subsequent irrigation was done when needed. Water for irrigation was obtained from the dam at the site.

3.3.1.7 Experimental design and Treatments

The design used was a Randomized Complete Block Design with three replications. Every plot received a basal application of NPK-15-15-15 fertilizer at 200kg/ha.

The following urea rates and timings were applied as treatments:

T1= 90 kg N/ha at 2 WAT (farmers' practice)

T2= 45 kg N/ha at 3 WAT + 45 kg N/ha at 4 WAT

T3= 45 kg N/ha at 3 WAT + 45 kg N/ha at 5 WAT

T4= 60 kg N/ha at 3 WAT + 30 kg N/ha at 5 WAT
T5= 30 kg N/ha at 3 WAT + 60 kg N/ha at 6 WAT

T6= 75 kg N/ha at 4 WAT+ 15 kg N/ha at 6 WAT

T7= 15 kg N/ha at 4 WAT + 75 kg N/ha at 6 WAT T8=

60 kg N/ha at 4 WAT + 30 kg N/ha at 6 WAT

T9= 90 kg N/ha at 4 WAT

3.3.1.8 Data Collection

The following data were collected: Plant height, number of leaves, number of tillers, number of spikelet per panicle, mean grain weight and grain yield.

3.3.1.8.1 Plant Height

A measuring tape was used to measure height of five consecutive plants in the second row of every plot. The average height for each plot was calculated. Measurements were done at 21, 42 and 63 days after planting (DAP).

3.3.1.8.2 Number of Leaves

Total number of leaves on the selected plants were counted and the mean calculated for each plot.

3.3.1.8.3 Number of tillers

The number of tillers of per plant were counted from each of the selected plants at the times stated and the means calculated for each plot.

3.3.1.8.4 Number of spikelet per panicle

This was determined by counting the total number of grains on a panicle from 5 selected plants from each plot.

3.3.1.8.5 Mean grain weight

This was determined by counting one thousand seeds from every plot, oven drying for 48hrs at 80^0c. These were weighed and recorded.

3.3.1.8.6 Grain yield

This was determined by harvesting all plants from a $4m^2$ area from the central rows. The grains were, threshed, sun dried to a moisture content of 14% and weighed.

3.3.1.9 Statistical Analysis

Data was analysed using the Analysis of Variance (ANOVA) using Genstat statistical package (Discovery Edition 12).The Least Significant Difference (LSD) at 5% was used to determine significant differences among treatment means.

CHAPTER FOUR

4.0 RESULTS

4.1 Experiment One

4.1.1 Plant height

Rice plant height results are presented in Table 4.1. During sampling at 21 DAT, there was no significant difference (P>0.05) among the various transplanting ages.

At 42 DAT, height of the seedlings transplanted at 42 in DAP was the tallest, but this was significantly higher than those transplanted at 28 DAP only. All other treatment differences were not significant (P>0.05). (Table 4.1)

Sampling at 63 DAT showed that height of plants transplanted at 21 DAP were the tallest, which was significantly higher than that of 35 days after nursery treatment only. Plant height of seedlings transplanted at 14 days after nursery was significantly taller than those transplanted at 35 DAP. All other treatment effects were similar. (Table 4.1)

Table 4. 1 Effect of seedling transplanting age on plant height of rice at three sampling periods

Transplanting age (DAP)	Plant height		
	21 DAT	42 DAT	63 DAT
14	37.7	64.6	86.7
21	51.5	63.7	91.9
28	34.5	59.6	81.5
35	39.4	67.5	72.7
42	49.8	71.4	80.8
LSD (5%)	NS	7.8	12.2
CV (%)	34.6	6.3	7.9

4.1.2 Number of tillers

Number of tillers per plant produced from various treatments are presented in Table 4. 2. Results showed that there were no significant (P>0.05) treatment differences at 21 and 63 DAT. However, at 42 DAT plants nursed at 14 days produced the greater number of tillers, and this was significantly higher (P<0.05) than those that were nursed for 28 and 42 days. All other treatment differences were not significant (Table 4.2)

Table 4.2 Effect of seedling transplanting age on number of tillers per plant of rice at three sampling periods.

Transplanting age (DAP)	Number of tillers		
	21 DAT	**42 DAT**	**63 DAT**
14	3.07	10.20	13.27
21	6.20	7.87	12.33
28	2.33	7.07	11.40
35	3.00	8.67	10.27
42	3.80	7.60	11.60
LSD (5%)	NS	2.53	NS
CV (%)	30.4	16.20	17.60

4.1.3 Number of leaves

Results of number of leaves produced from the various treatments are presented in Table 4.3. There were no significant differences in all treatment effects at 21 and 63 DAT. At 42 DAT, plants transplanted at 14 days produced the greatest number of leaves per plant, and this was significantly higher than number of leaves at those from the 42 days after planting only. All other treatment effects were not significantly different from one another at 5% level of probability.

Table 4.3 Effect of seedling transplanting age on number of leaves per plant of rice at three sampling periods

Transplanting age (DAP)	Number of leaves		
	21 DAT	42 DAT	63 DAT
14	8.6	28.8	38.7
21	16.8	23.7	39.1
28	7.5	22.0	34.5
35	7.4	21.5	31.5
42	10.7	14.9	36.3
LSD (5%)	NS	9.48	NS
CV (%)	25.7	2.7	15.9

4.1.4 Panicle length, panicle weight and dry matter weight

Results of the three parameters (dry matter weight, panicle length and panicle weight) are presented in Table 4.4 Treatment differences for all parameters were not significant (P>0.05).

Table 4.4 Effect of seedling transplanting age on panicle length, panicle weight and dry matter weight of rice (21, 42 and 63 DAP)

Transplanting age (DAP)	Panicle length (cm)	Panicle weight (g)	Dry matter weight (g)
14	24.35	2.81	40.4
21	24.22	2.73	33.8
28	24.75	2.60	40.3
35	24.57	2.86	30.5
42	23.95	3.04	33.7
LSD (5%)	NS	NS	NS
CV (%)	3.4	19.1	17.5

4.1.5 Number of panicle per plant, number of spikelets, 1000 grain weight and grain yield

The results on grain yield of seedling transplanted after 14, 21 and 28 days in nursing produced similar grain yield. On average these produced grain yields that were 32-39% and 42-49% more than the grain yields produced by transplants that were 35 and 42 days in nursery respectively.

Generally, as seedlings stayed longer in the nursery, their grain yield decreased in the field. Treatment differences number of panicle per plant, number of spikelets per panicle and 1000 grain weight were not significant (P>0.05)(Table 4.5).

Table 4. 5 Effect of seedling transplanting age on number of panicle per plant, number of spikelets, 1000 grain weight and grain yield

Transplanting age (DAP)	Number of panicle per plant	Number of spikelets per panicle	1000 grain yield(g)	Grain yield (kg/ha)
14	25.3	154.1	25.00	609
21	29.0	165.1	24.63	597
28	34.0	155.2	24.49	581
35	27.0	156.2	24.53	439
42	29.0	160.4	24.72	408
LSD (5%)	NS	NS	NS	134
CV (%)	19.0	6.9	1.2	17.5

4.2 Experiment Two

4.2.1 Plant height

Plant height results are presented in Table 4.6. Treatment differences were significant at all sampling days. At 21 DAT, the 60kg N/ha at 3 WAT+ 30kg N/ha at 5 WAT treatment effect was the greatest, but this was significantly higher than that of 15kg at 4 WAT plus 75kg N/ha at 6 WAT treatment only. All other treatment differences were not significant (P>0.05).

Results at 42 DAT showed the 45kg N/ha at 3 WAT plus 45kg N/ha at 4 WAT had the greatest effect on plant height, which was significantly higher than that of 90kg N/ha at 2WAT. All other treatment differences were not significant.

At 63 DAT, the treatment effect of 45kg at WAT and 45kg at 5 WAT supported the greatest effect, and this was significantly higher than that of 15kg at 4 WAT plus 75kg at 6 WAT treatment only. All other treatment means were similar

Table 4.6 Effects of timing of urea fertilizer application on plant height (cm) of rice at three sampling periods

Treatment	Plant height (cm)		
	21 DAT	**63 DAT**	**42 DAT**
90 kg N/ha 2WAT	33.80	54.1	71.2
45 kg 3WAT+ 45 kg N/ha 4WAT	31.73	74.2	68.2
45 kg 3WAT + 45 kg N/ha 5WAT	35.80	69.0	80.8
60 kg 3WAT + 30 kg N/ha 5WAT	36.73	61.8	79.9
30 kg 3WAT + 60kg N/ha 6WAT	29.47	58.7	72.1
75kg 4WAT + 15 kg N/ha 6WAT	32.27	56.7	74.6
15 kg 4WAT + 75 kg N/ha 6WAT	27.87	66.9	59.7
60 kg 4WAT + 30 kg N/ha 6WAT	35.73	69.5	74.6
90 kg N/ha 4WAT	35.67	66.8	80.1
LSD (5%)	8.53	18.5	20.6
CV (%)	14.8	16.7	16.2

4.2.2 Number of leaves per plant

Results of leaf production from the various treatment are presented in Table 7. Treatment differences at 21 DAT was not significant (P>0.05). At 42 DAT, treatment effect of 90kg N at 4 WAT was the greatest, and this was significantly higher than all other treatment effects except those of 45kg N/ha at 3 WAT plus 45kg N/ha at 4 WAT, 45kg N/ha at 3 WAT plus 45kg N/ha at 5 WAT, and 60kg at 4 WAT plus 30kg at 6 WAT treatment only. The treatment effect of 75kg at 4 WAT plus 15kg at 6 WAT was also significantly lower than that of 45kg at 3 WAT plus 45kg at 5 WAT treatments. All other treatment differences were not significant. (Table 4.7)

At 63 DAT, the 45kg at 3 WAT and 45kg at 5 WAT treatment effect was the greatest, and this was significantly higher than other treatment effects, except those of the control,60kg at 3 WAT plus 30kg at 5 WAT,60kg at 4WAT plus 30kg at 6 WAT, and 90kg at 4 WAT treatments. The control treatment effect was also significantly higher than those of 30kg at 3WAT + 60kg at 6 WAT, 75kg at 4 WAT plus 15kg at 6 WAT, and 15kg at 4 WAT plus 75kg at 6 WAT treatments.

Table 4.7 Effects of timing of urea fertilizer application on the number of leaves of rice at three sampling periods.

Treatment	Number of Leaves		
	21DAT	**42DAT**	**63DAT**
90 kg N/ha 2WAT	11.87	29.70	56.20
45 kg 3WAT + 45 kg N/ha 4WAT	9.07	53.10	39.40
45 kg 3WAT + 45 kg N/ha 5WAT	9.33	46.60	57.10
60 kg 3WAT + 30 kg N/ha 5WAT	9.93	31.00	54.50
30 kg 3WAT + 60kg N/ha 6WAT	7.00	29.00	37.90
75kg 4WAT + 15 kg N/ha 6WAT	7.73	26.70	34.90
15 kg 4WAT + 75 kg N/ha 6WAT	7.40	33.20	33.30
60 kg 4WAT + 30 kg N/ha 6WAT	9.00	37.80	45.40
90 kg N/ha 4WAT	9.87	54.50	44.90
LSD (5%)	NS	18.41	17.69

CV (%)	33.8	28.0	22.8

4.2.3 Number of tillers

Tiller production was significantly affected by treatments on all sampling occasions (Table 4.8). At 21 DAT, treatment effect of 90 kg N/ha at 4 WAT was the greatest, and this was significantly higher than that of 30kg N/ha at 3 WAT and 60 kg N/ha at 6 WAT treatments only. All other treatment effects were similar.

At 42 DAT, treatment effect of 90kg N/ha at 4 WAT was the greatest, but this was significantly higher than those of the control, 60 kg at 3 WAT + 30 kg at 5 WAT, 30 kg at 3WAT + 60 kg at 6 WAT, and 75 kg at 4 WAT + 15 kg at 6WAT treatment only.(Table 4. 8).

At 63 DAT, the 45 kg at 3 WAT+ 45 kg at 5 WAT produced the greatest number of tillers, and this was significantly ($P<0.05$) higher than those of 30 kg at 3 WAT + 60 kg at 6 WAT, 75 kg at 4 WAT + 15 kg at 6 WAT, and 15 kg at 4 WAT + 75 kg at 6 WAT treatments only.

Table 4.8 Effects of timing of urea fertilizer application on the number of tillers of rice at three sampling periods

Treatment	Number of Tillers/ plant		
	21 DAT	42 DAT	63 DAT
90 kg N/ha 2WAT	2.20	10.47	18.73
45 kg 3WAT + 45 kg N/ha [1]WAT	2.40	16.47	13.33

[1] .2.4 Number of Panicles per plant, Panicle length and Panicle weight

Number of panicles was significantly affected ($P<0.05$) by the treatments (Table 4. 9). The 45 kg N/ha at 3 WAT +45 kg at 5 WAT treatment effect was the greatest, and this was

45 kg 3WAT + 45 kg N/ha 5WAT	2.53	15.53	18.80
60 kg 3WAT + 30 kg N/ha 5WAT	2.60	10.67	18.13
30 kg 3WAT + 60kg N/ha 6WAT	1.93	9.27	12.47
75kg 4WAT + 15 kg N/ha 6WAT	2.33	8.93	11.53
15 kg 4WAT + 75 kg N/ha 6WAT	2.20	10.93	11.60
60 kg 4WAT + 30 kg N/ha 6WAT	2.47	13.67	15.00
90 kg N/ha 4WAT	2.80	17.47	14.80
LSD (5%)	0.77	6.59	5.93
CV (%)	18.7	30.2	22.9

significant (Table 4.9). Treatment differences for panicle weight were not significant (P>0.05) from one another (Table 4.9).

Table 4.9 Effects of timing of urea fertilizer application on number of panicles, panicle length and panicle weight of rice at Nobewam, 2015

Treatment	Number of panicles per plant	Panicle length (cm)	Panicle weight (g)
90 kg N/ha 2WAT	28.00	23.70	2.80
45 kg 3WAT + 45 kg N/ha 4WAT	26.00	23.79	2.56
45 kg 3WAT + 45 kg N/ha 5WAT	34.00	24.60	2.88
60 kg 3WAT+ 30 kg N/ha 5WAT	27.67	24.73	2.79
30 kg 3WAT + 60kg N/ha 6WAT	27.67	23.64	2.68
75kg 4WAT + 15 kg N/ha 6WAT	28.00	23.99	2.90
15 kg 4WAT + 75 kg N/ha 6WAT	25.67	23.68	2.69
60 kg 4WAT + 30 kg N/ha 6WAT	20.67	23.68	2.97

significantly higher (P<0.05) than those of 60 kg at 4 WAT + 30 kg at 6 WAT and the 90 kg at 4 WAT treatments only. All other treatments effects were similar.

Panicle length was greatest in 90 kg at 4 WAT treatment, which was significantly higher than all other treatment effects, except those of 45 kg at 3 WAT + 45 kg at 5 WAT as well as 60 kg at 3 WAT + 30 kg at 5 WAT treatments. All other treatment differences were not

90 kg N/ha 4WAT	25.33	25.86	2.81
LSD (5%)	8.47	1.98	NS
CV (%)	18.1	4.7	20.3

4.2.5 Number of spikelets per panicle, mean seed weight and grain yield.

The results of the number of spikelets per plot are presented in Table 4.10. The greatest number of spikelets were produced in the 60 kg N/ha at 3 WAT + 30 kg N/ha at 5 WAT treatment, but this was significantly higher ($P<0.05$) than that of the 60 kg N/ha at 4 WAT treatment only. All other treatment effects were similar. One thousand seed weight among the treatments did not vary significantly from one another (Table 4.10).

Grain yield was greatest in the 90 kg at 2 WAT, and this was significantly higher than the effects of the 45 kg N/ha at 3 WAT + 45 kg at 5 WAT, 60kg N/ha at 4WAT + 3O kg N/ha at 6 WAT+ 90 kg at 4 WAT treatments only. The least grain yield of 400 kg/ha was measured in the 75 kg at 4 WAT + 15 kg at 6 WAT, and this was also lower than all other treatments effects, except those of 45 kg at 3 WAT + 45 kg at 4 WAT, 60 kg at 4 WAT + 30 kg at 6 WAT, and 90 kg at 4 WAT treatments.

Table 4.10. Effects of timing of urea fertilizer application on number of spikelets per panicle and 1000 grain weight and grain yield of rice.

Treatment	Number of spikelets per panicle	Mean seed weight (g)	Grain yield(kg/ha)
90 kg N/ha 2WAT	156.6	3.39	631
45 kg 3WAT + 45 kg N/ha 4WAT	152.8	3.30	581
45 kg 3WAT + 45 kg N/ha 5WAT	164.9	3.01	410
60 kg 3WAT + 30 kg N/ha 5WAT	171.2	3.36	620

30 kg 3WAT + 60kg N/ha 6WAT	162.5	3.32	600
75kg 4WAT + 15 kg N/ha 6WAT	156.8	2.87	400
15 kg 4WAT + 75 kg N/ha 6WAT	151.1	3.23	592
60 kg 4WAT + 30 kg N/ha 6WAT	148.8	3.11	421
90 kg N/ha 4WAT	151.9	3.20	439
LSD (5%)	16.88	0.85	154
CV (%)	6.2	15.4	19.7

CHAPTER FIVE

5.0 DISCUSSION

5.1 Experiment 1

5.1.1 Seedling Age

The results reported indicated that the growth and yield parameters of rice were significantly influenced by the time of transplanting. Similar observation was made by (Uphoff, 2002) who reported that age of seedlings at transplanting is important in influencing grain yield in water scarce rice production systems, primarily by laying the foundation for determining the number of panicles at harvest. Seedling age at transplanting is an important factor for uniform stand of rice and regulating its growth and yield.

The age of seedling has much effect on rice yield. According to (Migo and Datta,1982), very younger seedlings produced greater grain yield and yield attributing characters such as productive tillers than the older seedlings, but Ladha *et al*.(1990) stated that they required ample attention for establishment. Barison (2002) observed that appearance of more nodal roots for every newly formed tiller led to a more developed root system which was the joint effect of better soil aeration by different water management practices and by transplanting of young seedling. A significant decline in productive tillers per hill was observed with delayed transplanting resulting in reduced grain yield (Sahoo *et al.*, 2000; Saikia *et al*., 2003), the number of tillers in the present study produced was significantly higher in the rice transplanted after 14 days of nursing.

5.1.2 Effect of age of seedlings on plant height

The study showed that age of seedlings had effect on plant height (Table 1). Koshta *et al.* (1987) observed that plant height was maximum when young seedlings were used for transplanting as compared to old seedlings. Singh and Singh (1999) reported that transplanting 30 to 45 days old seedlings produced taller plants than transplanting 60 days old seedlings. The reason was that 60 days old seedling remained in the nursery for longer period till it attained maximum tillering stage and transplanting at this stage did not provide sufficient nutrients for vegetative growth, which led to reduction in plant height. Increase in plant height by transplanting 14 days old seedlings has been observed by Gokila (2005) and Sivakumar (2006).

5.1.3 Effect of age of seedlings on tillering

The study also indicated that, the age of seedlings has effect on tillering, as seedlings transplanted at 14 and 21 days of nursing produced greater number of tillers than those of 28, 35 and 42 days of nursing. Venkateswarlu and Madhulety (1980) reported that aged seedling which started with higher dry matter content and greater assimilatory system exhibited greater tiller production rate, but the efficiency in tiller production was greater in early duration types than in medium and late duration varieties. Das *et al.* (1988) observed that planting with two weeks old seedlings had maximum number of tillers followed by three, four and five week old seedlings in a short duration variety. Devi and Singh (2000) observed that more number of tillers was recorded when 20 days old seedlings were transplanted, and the lowest number of tillers was found in 41 and 48 days old seedlings in

India. Transplanting very young seedlings usually 8-10 days old, not more than 15 days old, had better tillering and rooting, which were reduced if the transplanting was done after the 4th phyllochron, usually about 15 days after emergence (Uphoff, 2002). Transplanting young seedlings preserved the potential for tillering and root growth (Balasubramanian *et al.,* 2005). Transplanting very young seedlings (14 days old) raised from modified mat nursery recorded more tillers per hill (Veeramani, 2007).

5.1.4 Effect of seedling on dry matter production

The study showed that 14 days recorded the highest dry matter production, although treatment differences were not significant in the present study. Mandel *et al*. (1984) stated that greater dry matter was recorded by transplanting young seedlings (25 days old) followed by 35, 45, 55 and 75 days old seedlings of early maturing variety. Gill and Shahi (1987) reported that planting of older seedlings (60 days) was found to increase the dry matter accumulation over 30 and 45 days old seedlings whiles Rao and Raju (1987) reported that by planting 25 days old seedlings increased the dry matter production as compared to 35 and 45 days old seedlings. Planting of four weeks old seedlings recorded greater shoot dry matter than that of five and six week old seedlings during kharif season (Sahoo and Rout, 2004).

5.1.5 Effects of age of seedlings on yield and yield attributes

The study shown that younger seedlings recorded higher yields than older seedlings. Transplanting of young seedling from modified mat nursery recorded higher percentage of productive tillers and was between 43% and 67% for Youming-86 variety and 44% and 74% for Xieyou-9308 variety with an increase in the maximum tiller number (Zhu *et al.*, 2002).

Sahoo and Rout (2004) reported that planting of four weeks old seedlings recorded higher number of ripened grains /m^2 than five and six week old seedlings during kharif. Venugopal and Singh. (1985) stated that the age of seedlings (40, 50 and 60 days) of DR-92 rice during kharif did not show any significant influence on panicle length. Gill and Shahi, (1987) reported that planting of older seedlings recorded higher spikelet fertility, panicle weight and test weight. Datt and Gautam (1988) found that filled grain percentage and 1000 grain weight were significantly higher with 14 and 21 days old seedlings than that of with 42 days old ones. Reddy and Reddy (1992) reported lower sterility percentage in the crop planted with 30 days old seedlings than 40 and 50days old seedlings in Surekha rice variety at Warangal during wet season in clay loam soil. Murty and Sahu (1979) found that the test weight was not affected by seedling age, whereas grains panicle- increased with aged seedling (60days old) during rainy season at CRRI, Cuttack. According to Thanunathan and Siva Subramanian (2002) age of seedling had significant influence on grain weight.

5.2 Experiment 2

5.2.1 Effects of Time of N top-dressing on Rice

The 2015 experiment indicated that the timing of urea fertilizer application had great effect on rice growth. The time of nitrogen fertilizer applications can also remarkably affect nitrogen use efficiency and the potential of nitrogen losses (Bundy, 1998). The appropriate timing for fertilizer application is therefore determined by the nutrient uptake of the crop. In rice, as in other cereals and legumes, most of the absorbed nitrogen is stored in the leaves and may be transported to the grains during grain filling (Jiang *et al.*, 2004; Duan *et al.*, 2005). Cao *et al.* (1992) reported that the largest amount of nitrogen absorption occurs at the tillering and booting stages. Split application offers efficacy benefits on a wide range of crops and forages but its management must be considered on a crop-by-crop basis. The most sustainable cropping systems will maximize uptake and cycling of N and water without loss of nutrients from the system or creation of deficits that reduce economic yield. Nitrogen fertilizer is a key factor to the enhancement and sustainability of rice production. It is, however, highly susceptible to losses after their application, contributing highly to the inefficiency of N use. The average loss from applied N fertilizers can be as high as 60 percent, whereas the average N fertilizer recovery efficiency can be as low as 30 percent (Dobermann and Witt, 2000). Nitrogen losses are particularly high at low plant demand during the early growth stages when urea, the major N fertilizer used by farmers, is broadcast onto the floodwater surface (Schnier, 1995). The high N losses from applied N fertilizers and the low efficiency of N utilization by rice cause substantial economic losses to farmers and contribute highly to a number of environmental problems such as water eutrophication and greenhouse warming.

Nitrogen is the most essential element in determining the yield potential of rice and nitrogenous fertilizer is one of the major inputs to rice production Mae (1997).Thus farmers endeavour to apply costly N fertilizer sometimes in excess to get a desirable yield (Saleque *et al.*, 2004), but imbalance use of N fertilizer can cause harm to the crop and decrease grain yield. Given the importance of nitrogen fertilization on the yield in grain from the rice plant, it is necessary to know what the best dose is for each variety as well as its influence on components of yield and other agronomic parameters such as the cycle, plant height, lodging and moisture content of the grain, in order to obtain better knowledge of said productive response. Greater fertilizer N efficiency may be achieved through improved timing and application methods, and particularly through better incorporation of basal fertilizer N without standing water. Timing of fertilizer application has a significant effect on crop yields. Proper timing of the fertilizer application increases yields, reduces nutrient losses, increases nutrient use efficiency and prevents damage to the environment. In the present study, although split application of urea enhanced some growth and yield parameters, grain yield was greatest in the single dose treatment of 90 kg at 2 WAT.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

The present study showed that plant height, number of tillers, number of leaves and yield decreased with the age of seedling beyond 14 days of nursery. The greatest grain yield was obtained in seedlings transplanted at 14 days of nursing.

Split application of urea as top dressing fertilizer improved some growth and yield parameters. However, grain yield was greatest in the single dose treatment of 90 kg at 2 weeks after transplanting.

6.2 RECOMMENDATIONS

The results showed that transplanting rice seedlings at 14 days of nursing gave the greatest yield. However, the results should be verified in other rice growing areas using other varieties before extending technology to famers.

Split application improved some yield parameters, but could not support the greatest grain yield.

It is recommended that future studies should monitor nitrogen losses so that the environmental aspect of single dose application can be estimated. Further studies using other varieties especially upland types in also recommended.

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