International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024

Optimization Nitrogen Fertilizer Application for a New Mutant Rice Variety var. Sin Shwe Se by Using Isotopic ^{15}N Tracer

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***Abstract*— *Major challenge in rice production is to achieve the goal of enhancing both yield and fertilizer use efficiency. A new mutant rice variety var. Sin Shwe Se was used in the present study to monitor the efficiency and effectiveness of the N-fertilization technique under irrigation and different nitrogen fertilization rates, 60kg N/ha, 80kh N/ha and 100kg N/ha with split application (at 10 days after transplanting, active tillering stage and panicle initiation stage). An experiment was conducted as split plot based on randomized complete block design with three replications at the Research Farm of Biotechnology Research Department (BRD, Kyauk-Se) during 2015 summer and rainy cropping season. ^{15}N labeled urea fertilizer with 5.21%a.e was applied to micro-plot (1 m^2) and ^{14}N urea to sampling plot. According to the experimental result,80 kgN/ha lead the highest grain yield (%), nitrogen harvest index NHI(%), physiological N-used efficiency PNUE, fertilizer N-uptake and fertilizer N used efficiency FNUE in 2015 summer cultivated season and dry matter yield (t/ha), grain yield (t/ha), plant N-uptake (kg/ha), Nitrogen derive from fertilizer NDFF (kg/ha), N recovery (%) in 2015 rainy cultivated season.*

***Keywords*— *Isotopic ^{15}N technique,^{15}N-labelled fertilizer, Nutrient management, Rice.*

I. INTRODUCTION

Myanmar has a long history of rice production. Traditionally, rice production occurred only as a monsoon crop in the rainy season (from the end of May through November). This changed during the late 1970s and early 80s with the government-sponsored Whole Township Paddy Production Program that introduced modern high yielding varieties (HYVs) of rice and thereby enhanced production possibilities.

Since that time, over 60 HYVs, usually of the semi-dwarf type, have been introduced, and comprise 70% of the total land rice area. Overall, this adaptation of HYVs and the improvement of irrigation systems in some area of the country has allowed for the cultivation of rice in the dry summer season and for double cropping. Since that time, many farmers have grown rice after rice every year on the same site, and this has resulted in a greater dependence on fertilizer. Since that time, many farmers have grown rice after rice every year on the same site, and this has resulted in a greater dependence on fertilizer. Typical crop is paddy rice whose area covers about 62 percent of the net grown area. Increased uses of fertilizer, plus increased cost per unit of fertilizer, results in N fertilization being the one of major cost in rice production.(T.T.A. Naing,2008) Improving fertilizer N use efficiency is therefore more important than ever.

Water and nutrient supply are the main factors controlling productivity of irrigated agriculture. Improving the use of efficiency these factors is the target of good management and becomes crucial in arid and semiarid regions where water resources are limited. In addition, in dry land irrigated agriculture, nitrogen (N) becomes the most limiting factor for crop productivity. Under these conditions, the use of efficiency of both irrigation water (IW) and N is often low and depends largely on the method of application. (N.Lamaddalena, 2007)

In most cases, the availability of N was examined indirectly through crop yield or based on the total N content of succeeding crops. For example, by a crop is measured in the presence and absence of added residues, and the differences is attributed to mineralization of N present in the applied residues. N release in practical situations is often rather small compared with total crop N uptake, so measurement precision is poor. Techniques such as isotope labeling are often used to distinguish the origins of N removed and to calculate the balance sheet of different N sources. Indeed, direct management of the recovery of fertilizer in the soil and the subsequence calculation of N that is lost from the crop soil system can only be conducted using ^{15}N-labelled fertilizer.

Nitrogen is essential for rice, and usually it is the most yield-limiting nutrient in irrigated rice production around the world. Although rice yield usually depends on both soil nitrogen and added fertilizer nitrogen, little information is available on the relative contribution of each source of nitrogen to yield. The use of ^{15}N labeled fertilizer and neutron probe provides accurate tools to evaluate the N and water utilization efficiency. (Pamela Artacho,2009).

Nitrogen use efficiency has been defined in several ways. Yield increase that results from N application in comparison with noNapplication is defined as agronomic NUE (Peng et al., 2006). Other indices include NUE for grain yield (Koutroubas and Ntanos, 2003; Zhao et al., 2007), also called internal NUE (Peng et al., 2006), which express grain yield in relation to total N uptake; NUE for biomass accumulation (Koutroubas and Ntanos, 2003), also called physiological NUE (Zhao et al., 2007), that corresponds to aboveground plant biomass produced in relation to total N uptake; and,

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grain yield per unit of N accumulated in grain (Koutroubas and Ntanos, 2003).

In this study, the normal urea from the market and ^{15}N labeled urea were used for the following:

(i) To study the response of new rice variety to N fertilizer
(ii)To develop the most efficient fertilizer strategy for crop
(iii) To adopt nuclear and isotopic techniques for better soil, water and nutrient management practices in Myanmar.

II. Materials and Methods

In order to investigate nitrogen indices at different nitrogen fertilization management, this study was conducted at the experimental field of Biotechnology Research Department (Kyauk-Se).

A. Rice variety Sin shwe Se

Sin Shwe Se is a new mutant rice variety released by Biotechnology Research Department (BRD) in 2015. It is developed from IR53936 by Gamma ray as an early maturity mutant with 120 DAS. An optimized fertilizer application for a newly released variety is a challenge for both breeders and farmers to achieve a goal of production.

B. Isotopic ^{15}N labelled urea

In the indirect method the nutrient uptake by the crop in a control plot (without fertilizer application) is subtracted from that of the fertilized treatments. It is assumed that the nutrient uptake of the control plot measures the amount of nutrient available from the soil, whereas that of the fertilized treatments, the amount of nutrients available from soil and fertilizer. The only direct means of measuring nutrient uptake from the applied fertiliser is through the use of isotopes. The principal tracer isotopes used in the present study is ^{15}N tracer.

Nitrogen and its isotopes are of great importance in the study of biological systems and participate in the majority of biogeochemical reactions (Fritz, 1989). In various fields of science, mainly in agricultural sciences (the fertility and chemical composition of the soil and plant nutrition) and in animal nutrition (IAEA, 1974), the isotopic technique employing ^{15}Nlabeled urea has proven to be an important tool. In this experiment, *^{15}N labeled urea fertilizer with 5.26%a.e* is used and it is supported by International Atomic Energy Agency (IAEA) under the regional project IAEA/ RAS/5/0/65.

C. Micro plot and sampling plot preparation

The following treatments were investigated in a randomized complete block design (RCBD) with three replications of each treatment: zero N application (N0); 60N kg/ha (N60); 80N kg/ha (N80) and 100Nkg/ha (N100). Recommended doses of phosphorous (80kg/ha) and potassium (40kg/ha) were applied as basal to every plot. The plastic sheet with 5m in length and 1m in width was used to make micro-plots and sampling plots. The plastic was inserted to a depth of 30cm. The sampling plot and the micro-plot size were $15m^2$ and $1m^2$ respectively. In this experiment, nitrogen as normal 14N urea and the ^{15}N labeled urea fertilizer (^{15}Na.e 5.26) were used. Normal urea was applied to the sampling plots and ^{15}N labeled fertilizer was applied to the micro-plots. The treatments were applied in each plot except for the zero treatment, 20% at seedling stage, 30% at tillering stage, and 50% during vegetative stage.

D. Weather Condition

There are three seasons in Myanmar, the hot and dry season lasting from mid -February to mid - May, the rainy season from mid - May to mid - October and the winter season from mid – October to mid - February. The mean maximum and mean minimum temperatures and precipitation during the growing season for 2015 summer and rainy were presented in Table I.

E. Soil sampling and analysis

Soil samples were collected before and after cultivation. Before cultivation, five subsamples of top soils of cultivated area were collected, mixed them together and air dried. After cultivation, soil samples were collected at 10cm intervals to a depth of 30cm by using 5cm diameter steel pipe from all of the sampling plots and micro-plots. Soils were air dried, mixed the same layer of soil to obtain the final sample and then grounded with blender (Panasonic, Mxac 400). The resultingsoil samples were analyzed by NOI7 at Agrotechnology and Biosciences Division, Malaysian Nuclear Agency.

F. Plant sampling and analysis

At physiology maturity, the whole plants in the central area of the micro-plots and sampling plots were uprooted. The plants were separated into plant parts and fresh weight of grain, straw and root were recorded. The sub-samples from both plots were oven dried at 70˚C for three days and then weighed to obtain dry weight. Oven dried straw and root were cut into 1-3cm pieces with scissors. The chopped sub-samples were mixed thoroughly and grinded by blender.Samples with lower % 15N a.e. are chopped first to minimize contamination from one sample to another.The plant samples (grain and straw) were analyzed by NOI7 at Agrotechnology and Biosciences Division, Malaysian Nuclear Agency for analysis.

The grain yield, % of nitrogen harvest index, physiological N-used efficiency and % of harvest index, fertilizer nitrogen uptake in plant parts in 2015 summer and Nitrogen derived from fertilizer (%Ndff) and soil %Ndfs, N yield (kg/h) and nitrogen use efficiency (NUE) in 2015 rainy were calculated by following the equations from “Use of Nuclear Techniques in Studies of Soil-Plant Relationships”, IAEA, Vienna, 1990. Total N concentration (% total N in dry matter) of the plant parts, grain and straw, were done through Kjeldhal method.

III. Results and Discussion

A. Metrological Condition

The weather data, the daily mean air temperature and precipitation are recorded from local weather station during growing seasons in 2015. The air temperature often exceeded 35° C during this year. Well-distributed rainfall was received during September and October. In particular, the rainfall was relatively high around October. (Table I)

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TABLE I. Weather Condition of experimental location

Year	Month	Mini-Temp(˚C)	Max- Temp (˚C)	Rainfalls (mm)
2015	January	15.5	30.4	0.26
	February	13.7	33.9	0
	March	24	38	0.1
	April	22.5	37.7	0.95
	May	24.8	36	1.61
	June	24	37	0.05
	July	23.1	37.9	85.6
	August	24.7	35.2	23.8
	September	23.3	37.8	128.8
	October	19.8	35.3	307.8

B. Nitrogen Isotope Discrimination

The experiments were carried out in two rice cropping seasons of year 2015. Nitrogen level and N application had significant effects on yield, agronomic characteristics, harvest index, fertilizer nitrogen uptake, physiological N used efficiency and nitrogen used efficiency of rice.

During the summer season experiment, 80kgN/ha treatment give better yield and higher plant nitrogen uptake in grain. The higher efficiency was found in both yield and plant biomass. (Table II).

TABLE II. Effect of N addition on dry matter production and N uptake in rainy season

	Dry Matter Yeild (Kg/ha)(x1000)			
Treatment	0	60	80	100
Samples				
Grain	1.4	1.8	2.6	1.6
Straw	2.8	3.2	3.3	2.6
	Plant N Uptake (Kg/ha)			
Grain	15.82	21.55	28.4	26.9
Straw	15.08	25.5	26.6	25.5

The highest amount of nitrogen derived from fertilizer (NDFF) was occurred in the treatment receiving 100kgN/ha (78.67kh/ha) as compared with the treatment receiving 60kgN/ha (60.32kh/ha) and 80khN/ha (67.05kh/ha). There is a similar amount of nitrogen derived from soil among all treatment. Although the highest NDFF was found in the use of 100kgN/ha aplication, the higher yield and nitrogen recovery were found in the treatment 80kgN/ha. (Table III).

TABLE III. Effect of time of application of fertilizer on nitrogen assimilation by rice

Treatment	Total N Uptake (Kg/ha)	N Derived From Soil (kg/ha)	N Derived from Fertilizer (kg/ha)	Grain Yield (t/ha)	N Recovery (%)
0	30.912	-	-		
60	46.71	13.295	60.32	5	11.56
80	54.99	12.133	67.05	7	13.11
100	52.39	13.968	78.67	6.6	12.78

During the rainy experiment, 80kgN/ha treatment also leads in yield and physiological nitrogen use efficiency of rice variety. Although the harvest index is not very much differed among treatments, the percentage of nitrogen harvest index and grain yield are higher in 80kgN/ha treatment. (Fig. 1). It was found in this experiment that the nitrogen harvest indices was effected by the amount of fertilizer application.

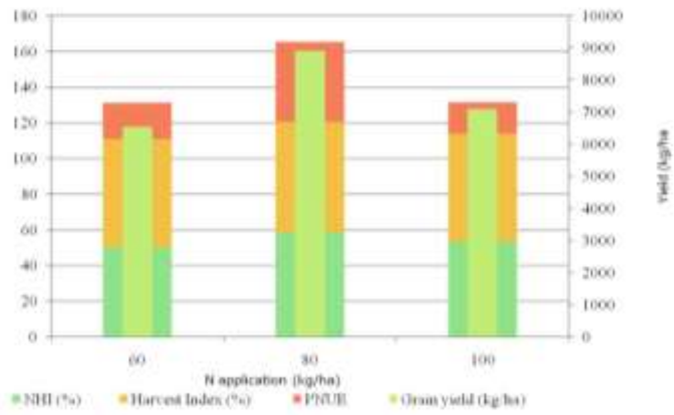

Fig. 1. Grain yield, % Nitrogen harvest index, physiological N-used efficiency and % harvest index at different 15N urea fertilizer application

In case of fertilizer nitrogen uptake of the plant parts, there was higher fertilizer nitrogen use efficiency in the grain of treatment 80kgN. The similar rate of fertilizer nitrogen uptake was found in the straw of rice in each treatment. (Fig. 2).

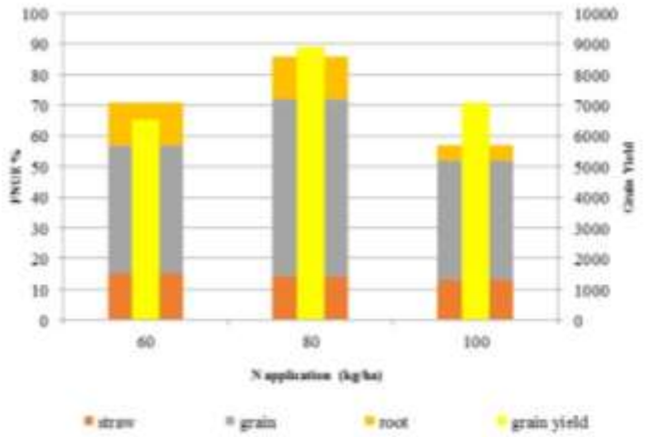

Fig. 2. Grain yield and fertilizer nitrogen uses efficiency in plant parts at different ^{15}N urea fertilizer applications

IV. Conclusion and Recommendations

Urea fertilization by nature is volatile or easily leached by water/ heat so that split application and proper time of urea fertilizer application for early maturing local and improved rice varieties were a vital role in rice growing areas. The mutant variety IR53936 with early maturity trait showed the highest yields when 80kgN/ha was applied in three split applications. The resulting data revealed that nitrogen levels and their interaction of the N application x nitrogen rates are not significant differed. Similar results have been reported by Roy and Biswas (1992). The result of this study clearly shows the benefits of split applications of N and also results in an increase in N uptake efficiency. The present Urea fertilizer application could be used for parent IR53936 and a mutant variety (Sin Shwe Se) with early maturity trait growing areas. As a future research gap it is better to verify this research finding at the other major local growing areas of the regions and other local cultivars so as to derive a dependable Urea fertilizer application.

ACKNOWLEDGMENT

This research received full financial and logistical support of Biotechnology Research Department (BRD) and International Atomic Energy Agency (IAEA). We sincerely appreciate Dr. AziAziShyful from Malaysia Nuclear Agency for his kind help to measure the ^{15}N abundance. The author would like to thank her colleagues who worked together throughout the research actively and helpfully.

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