

OPEN ACCESS



# African Journal of **Plant Science**

February 2022  
ISSN 1996-0824  
DOI: 10.5897/AJPS  
[www.academicjournals.org](http://www.academicjournals.org)

 **ACADEMIC  
JOURNALS**  
expand your knowledge

# About AJPS

The African Journal of Plant Science (AJPS) is a peer reviewed open access journal. The journal commenced publication in September 2007. The African Journal of Plant Science covers all areas of plant science such as phytopathology, plant morphology, sustainable plant production, plant pathology and plant microbe biology.

## Indexing

[AgBiotechNet](#), [Agricultural Economics Database](#), [Agroforestry Abstracts](#), [Animal Breeding Abstracts](#), [Animal Production Database](#), [Animal Science](#), [Biofuels Abstracts](#), [Botanical Pesticides](#), [CAB Abstracts](#), [CABI's Global Health Database](#), [Chemical Abstracts \(CAS Source Index - CASSI\)](#), [CNKI Scholar](#), [Crop Physiology Abstracts](#), [Crop Science Database](#), [Environmental Impact](#), [Environmental Science Database](#), [Field Crop Abstracts](#), [Forest Science Google Scholar](#), [Grasslands and Forage Abstracts](#), [Helminthological Abstracts](#), [Horticultural Science](#), [Horticultural Science Abstracts](#), [Irrigation and Drainage Abstracts](#), [Maize Abstracts](#), [Microsoft Academic](#), [Nematological Abstracts](#), [Nutrition Abstracts and Reviews Series A: Human and Experimental](#), [Nutrition Abstracts and Reviews Series B: Livestock Feeds and Feeding](#), [Nutrition and Food Sciences](#), [Ornamental Horticulture](#), [Parasitology Database](#), [Plant Breeding Abstracts](#), [Plant Genetic Resources Abstracts](#), [Plant Genetics and Breeding Database](#), [Plant Growth Regulator Abstracts](#), [Plant Protection Database](#), [Potato Abstracts](#), [Poultry Abstracts](#), [Protozoological Abstracts](#), [Rice Abstracts](#), [Rural Development Abstracts](#), [Seed Abstracts](#), [Soil Science Database](#), [Soils and Fertilizers Abstracts](#), [Soybean Abstracts](#), [Sugar Industry Abstracts](#), [The Essential Electronic Agricultural Library \(TEEAL\)](#), [Veterinary Science Database](#), [VetMed Resource](#), [Weed Abstracts](#), [Wheat, Barley and Triticale Abstracts](#), [World Agricultural Economics and Rural Sociology Abstracts](#)

## Open Access Policy

Open Access is a publication model that enables the dissemination of research articles to the global community without restriction through the internet. All articles published under open access can be accessed by anyone with internet connection.

The African Journal of Plant Science is an Open Access journal. Abstracts and full texts of all articles published in this journal are freely accessible to everyone immediately after publication without any form of restriction.

## Article License

All articles published by African Journal of Plant Science are licensed under the [Creative Commons Attribution 4.0 International License](#). This permits anyone to copy, redistribute, remix, transmit and adapt the work provided the original work and source is appropriately cited. Citation should include the article DOI. The article license is displayed on the abstract page the following statement:

This article is published under the terms of the [Creative Commons Attribution License 4.0](#)

Please refer to <https://creativecommons.org/licenses/by/4.0/legalcode> for details about [Creative Commons Attribution License 4.0](#)

### **Article Copyright**

When an article is published by in the African Journal of Plant Science, the author(s) of the article retain the copyright of article. Author(s) may republish the article as part of a book or other materials. When reusing a published article, author(s) should; Cite the original source of the publication when reusing the article. i.e. cite that the article was originally published in the African Journal of Plant Science. Include the article DOI Accept that the article remains published by the African Journal of Biotechnology (except in occasion of a retraction of the article). The article is licensed under the Creative Commons Attribution 4.0 International License.

A copyright statement is stated in the abstract page of each article. The following statement is an example of a copyright statement on an abstract page.

Copyright ©2016 Author(s) retains the copyright of this article.

### **Self-Archiving Policy**

The African Journal of Plant Science is a RoMEO green journal. This permits authors to archive any version of their article they find most suitable, including the published version on their institutional repository and any other suitable website.

Please see <http://www.sherpa.ac.uk/romeo/search.php?issn=1684-5315>

### **Digital Archiving Policy**

The African Journal of Plant Science is committed to the long-term preservation of its content. All articles published by the journal are preserved by [Portico](#). In addition, the journal encourages authors to archive the published version of their articles on their institutional repositories and as well as other appropriate websites.

<https://www.portico.org/publishers/ajournals/>

### **Metadata Harvesting**

The African Journal of Plant Science encourages metadata harvesting of all its content. The journal fully supports and implement the OAI version 2.0, which comes in a standard XML format. [See Harvesting Parameter](#)

## Memberships and Standards



Academic Journals strongly supports the Open Access initiative. Abstracts and full texts of all articles published by Academic Journals are freely accessible to everyone immediately after publication.



All articles published by Academic Journals are licensed under the [Creative Commons Attribution 4.0 International License \(CC BY 4.0\)](#). This permits anyone to copy, redistribute, remix, transmit and adapt the work provided the original work and source is appropriately cited.



[Crossref](#) is an association of scholarly publishers that developed Digital Object Identification (DOI) system for the unique identification published materials. Academic Journals is a member of Crossref and uses the DOI system. All articles published by Academic Journals are issued DOI.

[Similarity Check](#) powered by iThenticate is an initiative started by CrossRef to help its members actively engage in efforts to prevent scholarly and professional plagiarism. Academic Journals is a member of Similarity Check.

[CrossRef Cited-by](#) Linking (formerly Forward Linking) is a service that allows you to discover how your publications are being cited and to incorporate that information into your online publication platform. Academic Journals is a member of [CrossRef Cited-by](#).



Academic Journals is a member of the [International Digital Publishing Forum \(IDPF\)](#). The IDPF is the global trade and standards organization dedicated to the development and promotion of electronic publishing and content consumption.

## Contact

Editorial Office: [ajps@academicjournals.org](mailto:ajps@academicjournals.org)

Help Desk: [helpdesk@academicjournals.org](mailto:helpdesk@academicjournals.org)

Website: <http://www.academicjournals.org/journal/AJPS>

Submit manuscript online <http://ms.academicjournals.org>

Academic Journals  
73023 Victoria Island, Lagos, Nigeria  
ICEA Building, 17th Floor,  
Kenyatta Avenue, Nairobi, Kenya.

## **Editors**

### **Prof. Amarendra Narayan Misra**

Center for Life Sciences  
School of Natural Sciences  
Central University of Jharkhand  
Jharkhand,  
India.

### **Prof. H. Özkan Sivritepe**

Faculty of Agriculture and Natural Sciences,  
Konya Food and Agriculture University,  
Dede Korkut Mah. Beyşehir Cad. No.9  
Meram, Konya,  
42080 Turkey.

## **Editorial Board Members**

### **Dr. Feng Lin**

Department of Plant, Soil and Microbial Sciences  
Michigan State University  
USA.

### **Prof. Roger O. Anderson**

Biology Department  
Columbia University  
Lamont-Doherty Earth Observatory  
USA.

### **Dr. Alexandre Bosco de Oliveira**

Plant Science,  
Federal University of Ceará,  
Brazi.

### **Dr. Mohamed Mousa**

Biology,  
UAE University,  
UAE.

### **Dr. Aysegul Koroglu**

Pharmaceutical Botany,  
Ankara University,  
Ankara.

# Table of Content

**Nitrogen use efficiency and performance of rice to the application of slow release nitrogen fertilizer under waterlogged conditions in North Western Ethiopia**  
Christian Tafere

22

*Full Length Research Paper*

# **Nitrogen use efficiency and performance of rice to the application of slow release nitrogen fertilizer under waterlogged conditions in North Western Ethiopia**

**Christian Tafere**

Fogera National Rice Research and Training Center, Woreta, Ethiopia.

Received 22 October, 2021; Accepted 5 January, 2022

Highly soluble N fertilizers like urea may be lost from the soil plant system through leaching, ammonia (NH<sub>3</sub>) volatilization and denitrification that reduce NUE and yield. The study was conducted to determine the effects of UREA<sup>Stabil</sup> on enhancement of nitrogen utilization efficiencies of rice crop and to evaluate the influence of UREA<sup>Stabil</sup> on growth and yield of rice under waterlogged conditions of Fogera area. Treatments were comprised, control, recommended N from conventional urea (as basal and tillering), recommended N from UREA<sup>Stabil</sup> fertilizer applied once as basal, recommended N from UREA<sup>Stabil</sup> (split as basal and tillering), half below the recommended N from UREA<sup>Stabil</sup> as basal, half more than the recommended N from UREA<sup>Stabil</sup> (split as basal and tillering), half more than the recommended N from conventional urea (split as basal and tillering), half more than the recommended N from UREA<sup>Stabil</sup> as basal. Data were collected plant height, total tiller number, panicle length, number of fertile grains, thousand seed weight, grain yield, straw yield and harvest Index. Highly significantly ( $P < 0.01$ ) affected grain yield (3.55 t ha<sup>-1</sup>) was recorded on 136.5 kg N ha<sup>-1</sup> in split application 45.5 kg N ha<sup>-1</sup> as basal and 91 kg N ha<sup>-1</sup> tillering stage from UREA<sup>Stabil</sup> source. Conventional urea source of N, application of 136.5 kg N ha<sup>-1</sup> in split application (45.5 kg ha<sup>-1</sup> as basal and 91 kg ha<sup>-1</sup> tillering stage was provided higher yield (3.14) which is statistically non-significant compared to slow-release fertilizer. The economic analysis has further revealed that application of 136.5 kg N ha<sup>-1</sup> from UREA<sup>Stabil</sup> in split application of 45.5 kg N ha<sup>-1</sup> as basal and 91 kg N ha<sup>-1</sup> tillering stage provided highest net benefit of Birr 47,356 ha<sup>-1</sup> was the most profitable treatment for lowland rice production. Application of 136.5 kg N ha<sup>-1</sup> rate from the source of UREA<sup>Stabil</sup> in split application of 45.5 kg ha<sup>-1</sup> as basal and 91 kg N ha<sup>-1</sup> tillering stage is the best to be recommended for lowland rice production of Fogera and similar agro-ecologies in Ethiopia.

**Key words:** Nitrogen use efficiency (NUE), UREA<sup>Stabil</sup>, profitability, yield.

## **INTRODUCTION**

Nitrogen is the most limiting plant nutrients in general and in the tropics particular where the fluctuation of

\*Corresponding author. E-mail: [christaintafere03@gmail.com](mailto:christaintafere03@gmail.com).

Author(s) agree that this article remain permanently open access under the terms of the [Creative Commons Attribution License 4.0 International License](https://creativecommons.org/licenses/by/4.0/)

temperature and precipitation scorches the organic matter, which is a large reserve of organically bounded nitrogen which later converted into inorganic forms and utilized by plants with the deed of soil biota. Hence, high rate of organic matter decomposition severely depletes soil nutrients especially soil nitrogen and usually manifested in the poor performance of test crops in Ethiopia without any supply of inputs ((Banerjee and Pathak, 2002; Gete et al., 2010).

Different studies released recommendations since ninten seventy especially on nitrogen and phosphorus although it is blanket recommendation. Since then, the associated yield obtained from a given pieces of land decreases without the application of chemical fertilizers witnessing that there is a need for applying sufficient amount of nitrogen in the cropping systems in Ethiopia (Mulugeta et al., 2014). Therefore, the fertilizer import has been progressively increased for the last decade (Agricultural Input and Marketing Directorate, Ministry of Agriculture (MoA), Central Statistics Agency (CSA), 2010, 2011, African Fertilizer, FAO). Parallel to this, the national fertilizer consumption started at ninten seventy and gradually increased through ninten eighty, ninten ninty five and two thousand four and two thousand five which stood at 950, 43 200, 250 000, and 323 000 tons respectively. Based on the International Fertilizer Association's (IFA) suggestion fertilizer application rate, nutrient uptake close to 4.3 million tons of nitrogen, phosphate, and potash is required to produce this much maize, wheat, barley, and sorghum(Si, 2018). However, CSA's farm management practice data from two thousand three/ two thousand four to two thousand ten / two thousand eleven shows that the actual amount of fertilizer applied was 1.6 million tons, and when considering that a limited amount of nutrients from the fertilizer is actually taken up by the crops, more than 2.7 million tons of nutrients from the soil. A large portion of the uptake of nitrogen, which is the most important micronutrient for crop growth, is coming from the soil, given the fact that insufficient amounts applied (Khan et al., 2013).

Sieling et al. (1998) reported that the mineral fertilizer NUE for winter wheat decreases with increasing N levels. Hatfield and Prueger (2004) also confirmed that the efficiency of N use by a crop depends upon the response of water and N availability during the growing season.

Accordingly, in Ethiopia urea as a source of nitrogen and DAP as a source of nitrogen and phosphorus applied as a high-grade fertilizer in order to obtain optimum harvest. One of the major challenging issues especially in high rainfall and waterlogged area in connection with these are the loss of nitrogen through ammonium volatilization or fixation by clay minerals. On the other hand, in low moisture area, its low solubility and toxic effect burns the root so as to reduce its growth and the performance of the crops grown under this condition also challenges the use of these fertilizers. The national

average yield of rice is about 2.8t ha<sup>-1</sup> (CSA, 2018), which is lower compared to the world average productivity of 4.6 t ha<sup>-1</sup> (FAOSTAT, 2018).

Nitrogen is the major yield-limiting plant nutrient in the rice production system of northwestern Ethiopia as stated by Amare et al.(2018). UREA<sup>stabil</sup> is one of the slow-releasing nitrogen fertilizers and hydrolysis of urea is reduced by the presence of N-(nbutyl) thio-phosphoric-triamide (nBTPT) that slows down urease activity of urea hydrolysis thereby improve recovery of nitrogen applied (Abalos et al., 2014). This fertilizer application belived to increase crop productivity (Abalos et al., 2014; Qiao et al., 2015). However, the soil, crop management practice, availability of water and climate condition affects urease inhibitor (nBTPT) (Thapa et al., 2016).

UREA<sup>Stabil</sup> is a concentrated nitrogen fertilizer that can be applied as a granular for field crops as well as liquid fertilizer through irrigation water for the orchard (Wang, 2019). Besides, it supposed to have basic advantage of having a combination of rapidly soluble, well absorbable nitrogen with urease inhibitor that helps to improve nitrogen penetration to plant roots by restraining the sorption and fixation of NH<sub>4</sub><sup>+</sup> in the surface soil layer, which slows the effect of this nitrogen form down (Mohammad and Jamie, 2010). In another way it helps to reduce its losses due to ammonia volatilization into the atmosphere during surface application. However, this product has never been tested in our context. Therefore, this research is proposed: To determine the effects of UREA<sup>Stabil</sup> on the enhancement of nitrogen utilization efficiencies of the rice crop. To evaluate the influence of UREA<sup>Stabil</sup> on the growth and yield of rice under waterlogged conditions.

## MATERIALS AND METHODS

### Description of the study area

An experiment on UREA<sup>Stabil</sup> and conventional urea nutrients were conducted on rainfed lowland rice in Fogera district. The study at Fogera area is situated at 11°54.4'46.3"N to 11°57'03.0"N latitude and 37°41'23.9"E to 37°42'32.2" E longitude at elevation range of 1787-1812 m above sea level (Tilahun et al., 2020). The study site received mean annual rainfall of 1219 mm with annual average minimum and maximum temperature of 12.75 and 27.37°C, respectively.

### Plant material

The rice variety X-jigna has rainfed lowland ecosystem adaptability and good characteristics of cold tolerance. The morphology of the variety is unerect leaf angle and unerect flage leaf angle. The genotype has intermediate type of panicle and purple color of the apex. The biomass response is promising and highly preferred by the producers with the right agronomic management practice. Inaddition to the high biomas and yield performance white color grain of X-jigna variety chosen by the rice producing farmers (Mulugeta et al., 2021).

### Soil characteristics

The soil in Fogera immeasurably require nitrogen fertilizer and with out N fertilizer yield is not expected but other macro nutrients like P & K deficiency not highly observed. The experimental soil type was found to be vertisols and the textural class was clay loam. The pH (H<sub>2</sub>O) of the soil was 5.89 and soil organic carbon was 1.2%.

### Experimetal design and treatments

The treatments were comprised UREA<sup>Stabil</sup> and conventional urea at recommended rates of nitrogen sources. Therefore, a total of eight rates were used to evaluate the efficiencies of UREA<sup>Stabil</sup> under waterlogged and high rainfall conditions. The treatments set-up was (without any external application of N (control=0N), recommended N from conventional urea 91 kg ha<sup>-1</sup> (30 kg ha<sup>-1</sup> at planting and 61 kg ha<sup>-1</sup> tillering stage), recommended N from UREA<sup>Stabil</sup> (91 kg ha<sup>-1</sup>), half of the recommended N from UREA<sup>Stabil</sup> (45.5 kg ha<sup>-1</sup>), recommended N from UREA<sup>Stabil</sup> (45.5 kg ha<sup>-1</sup> at planting and 45.5 kg ha<sup>-1</sup> tillering), half more than the recommended N from UREA<sup>Stabil</sup> (136.5 kg ha<sup>-1</sup>, 45.5 kg ha<sup>-1</sup> at planting and 91 kg ha<sup>-1</sup> tillering), half more than the recommended N from conventional urea (136.5 and 45.5 kg ha<sup>-1</sup> at planting and 91 kg ha<sup>-1</sup> tillering), half more than the recommended N from UREA<sup>Stabil</sup> 136.5 kg ha<sup>-1</sup> once at planting. The treatments were laid out in Randomized Complete Block Design (RCBD) and replicated three times. The gross size of the experimental plots was 3 m × 4 m consisting of 15 rows planted at a spacing of 20 cm apart with the seeding rate of 100 kg ha<sup>-1</sup> X-jigna rice variety. The net plot area was made by excluding the left and right outer rows and a plot length of 0.5 m from the top and bottom sides of the plot. The final net plot size was thus 2.6 m × 3 m.

### Data collected

Data on plant height, panicle length, number of total tillers per m<sup>2</sup>, number of fertile panicles per m<sup>2</sup>, thousand seeds weight, grain yield, straw yield and harvest index were collected timely from the net plot areas following their respective standard measuring methods and procedures. The rice grain yield and thousand seeds weight were adjusted at 14% standard moisture content.

### Data analysis

All collected data were subjected to analysis of variance (ANOVA) using SAS software version 9.0 (SAS-Institute, 2003). Mean separation was done by using Least significance difference (LSD) method at probability levels of P≤0.01 and P≤ 0.05 depending on the ANOVA results. Statistical analysis of the grain yield and NUE data were also accomplished by standard analysis of variance (ANOVA).

### Partial budget analysis

A method of organizing experimental data and information about the costs and benefits of various alternative treatments. A partial budget analysis methodology is a way of computing the total costs that vary and the net benefits of each treatment in an on-farm experiment. Includes the average yields for each treatment, adjusted yields and gross benefit (based on the field price of the crop). It also incorporates all the costs that vary for each treatment (CIMYYT (1988). The N use efficiency of mineral N fertilization was calculated according to Craswell and Godwin (1984); Fageria and

Baligar (2001) and Sofoniyas et al. (2018) by equation:

$$\text{Agronomic N use efficiency (NUE)} = \frac{(\text{Grain Yield F} - \text{Grain yield C})}{\text{Fertilizer N applied kg per kg N}}$$

Where F and C represent Fertilized and Control plots respectively. NUE can be calculated as the ratio between the amount of fertilizer N removed with the crop and the amount of fertilizer N applied. It can be expressed in %.

## RESULTS AND DISCUSSION

The analysis of variance indicated that plant height was significantly (P<0.05) affected by UREA<sup>Stabil</sup> and Conventional urea. The highest plant height (83.6 cm) was recorded from the split application of 136.5 kg N ha<sup>-1</sup> from UREA<sup>Stabil</sup> splited at planting (45.5 kg N ha<sup>-1</sup>) and tillering stage (91 kg N ha<sup>-1</sup>) while the lowest plant height (70.7 cm) was recorded from the control without the application of nitrogen fertilizer (Table 1). However, from the conventional urea fertilizer the plant height was recorded 80.8 cm from the application of 136.5 kg N ha<sup>-1</sup> and splited at planting (45.5 kg N ha<sup>-1</sup>) and 91 kg N ha<sup>-1</sup> tillering stage.

Panicle length was not significantly affected by conventional urea and UREA<sup>Stabil</sup> fertilizer application where as the number of total tillers were highly significantly (P<0.01) affected. The highest number of tiller (260.7 per m<sup>2</sup>) was found from the application of UREA<sup>Stabil</sup> (136.5 kg ha<sup>-1</sup>) at planting and tillering stage where as the lowest number of tiller (154.7 m<sup>-2</sup>) was found from the control without application of nitrogen fertilizer (Table 1). Similar results reported as rice is a unique crop with an indeterminate tillering potential, and the actual tillering number is easily influenced by nutrients availability, planting density and variety (Guangli et al., 2017). Split application of conventional urea fertilizer (136.5 kg ha<sup>-1</sup> at planting (45.5 and 91 kg ha<sup>-1</sup> at tillering stage) had resulted 245.7 tiller number per m<sup>2</sup>.

The analysis of variance for the number of fertile grains showed that significantly (P<0.05) affected by UREA<sup>Stabil</sup> and conventional urea fertilizer. The highest number of fertile grains (248.0 per m<sup>2</sup>) was found from 136.5 kg N ha<sup>-1</sup> of UREA<sup>Stabil</sup> in split application 45.5 kg ha<sup>-1</sup> at planting and 91 kg N ha<sup>-1</sup> at tillering stage where as the lowest number of fertile grain (147.3) was attained from the control without the application of nitrogen fertilizer. However, from conventional urea through the application of 136.5 and 45.5 kg N ha<sup>-1</sup> planting and 91 kg N ha<sup>-1</sup> at tillering stage 226.0 fertile grains per m<sup>2</sup> were produced (Table 1). The disadvantage of urea fertilizer is that considerable amounts of N can be lost from through volatilization which may result in very low N fertilizer use efficiency (Chen et al., 2008).

The grain yield was highly significantly (P<0.01) affected by both UREA<sup>Stabil</sup> and conventional urea fertilizer N source applications. However, Concerning UREA<sup>Stabil</sup> fertilizer application the highest grain yield

**Table 1.** Combined mean effects of UREA<sup>Stabil</sup> and conventional urea fertilizer sources and rates on growth and yield of rice for two consecutive years (2015-2016) in Fogera districts, northwest Ethiopia.

| Nitrogen levels kg ha <sup>-1</sup>     | PH                 | TC                   | PL                | Nfg                  | GY                 | Tsw                | Sy                | HI%                  |
|-----------------------------------------|--------------------|----------------------|-------------------|----------------------|--------------------|--------------------|-------------------|----------------------|
| 0 N                                     | 70.7 <sup>c</sup>  | 154.7 <sup>c</sup>   | 16.3 <sup>a</sup> | 147.3 <sup>c</sup>   | 1.0 <sup>c</sup>   | 26.0 <sup>a</sup>  | 2.51 <sup>b</sup> | 28.9 <sup>de</sup>   |
| 91N (Conventional urea 30/61)           | 75.7 <sup>bc</sup> | 223.3 <sup>abc</sup> | 16.3 <sup>a</sup> | 213.3 <sup>abc</sup> | 3.26 <sup>ab</sup> | 20.0 <sup>b</sup>  | 3.76 <sup>b</sup> | 41.3 <sup>abc</sup>  |
| 91 N (UREA <sup>Stabil</sup> )          | 75.0 <sup>bc</sup> | 213.3 <sup>abc</sup> | 16.9 <sup>a</sup> | 206.7 <sup>abc</sup> | 3.02 <sup>ab</sup> | 25.0 <sup>a</sup>  | 3.60 <sup>b</sup> | 36.6 <sup>bcd</sup>  |
| 91N (UREA <sup>Stabil</sup> 45.5/45.5)  | 75.4 <sup>bc</sup> | 228.7 <sup>ab</sup>  | 16.3 <sup>a</sup> | 213.3 <sup>ab</sup>  | 3.38 <sup>ab</sup> | 23.7 <sup>ab</sup> | 3.64 <sup>b</sup> | 39.4 <sup>abcd</sup> |
| 45.5 N (UREA <sup>Stabil</sup> )        | 71.5 <sup>c</sup>  | 177.3 <sup>bc</sup>  | 16.3 <sup>a</sup> | 165.3 <sup>bc</sup>  | 2.41 <sup>b</sup>  | 22.3 <sup>ab</sup> | 2.92 <sup>b</sup> | 26.0 <sup>e</sup>    |
| 136.5N (UREA <sup>Stabil</sup> 45.5/91) | 83.6 <sup>a</sup>  | 260.7 <sup>a</sup>   | 17.0 <sup>a</sup> | 248.0 <sup>a</sup>   | 3.55 <sup>a</sup>  | 23.7 <sup>ab</sup> | 5.79 <sup>a</sup> | 31.0 <sup>cde</sup>  |
| 136.5N(Conventional urea 45.5/91)       | 80.8 <sup>ab</sup> | 245.7 <sup>ab</sup>  | 17.0 <sup>a</sup> | 226.0 <sup>ab</sup>  | 3.14 <sup>ab</sup> | 24.7 <sup>a</sup>  | 5.67 <sup>a</sup> | 27.8 <sup>e</sup>    |
| 136.5N (UREA <sup>Stabil</sup> )        | 75.4 <sup>bc</sup> | 218.7 <sup>abc</sup> | 16.6 <sup>a</sup> | 230.7 <sup>a</sup>   | 3.16 <sup>ab</sup> | 21.7 <sup>a</sup>  | 3.84 <sup>b</sup> | 44.6 <sup>ab</sup>   |
| <b>P-value</b>                          | *                  | *                    | Ns                | *                    | **                 | ns                 | **                | **                   |
| <b>CV (%)</b>                           | 5.71               | 18.86                | 6.6               | 19                   | 12.29              | 11.09              | 27.8              | 16.48                |

PH= Plant height (cm), TC=Tiller count per m<sup>2</sup>, PL=Panicle length (cm), NFP= Number of fertile panicles per m<sup>2</sup>, DB=Dry bio-mass (tha<sup>-1</sup>), Gy= Grain yield (tha<sup>-1</sup>), Sy= Straw yield (tha<sup>-1</sup>), HI%=harvest index. \*\*= highly significant at P≤ 0.01, \*= significant at P≤ 0.05, ns= non-significant at P>0.05.

**Table 2.** Agronomic efficiency (AE) of nitrogen.

| N (kg ha <sup>-1</sup> )               | Grain yield (kg ha <sup>-1</sup> ) | Agronomic efficiency (AE) |
|----------------------------------------|------------------------------------|---------------------------|
| 0                                      | 1020.00                            |                           |
| 91 Conventiomnal urea (30/61)          | 3260.01                            | 24.62                     |
| 91 UREA <sup>Stabil</sup>              | 3020.11                            | 21.98                     |
| 91 UREA <sup>Stabil</sup> (45.5/45.5)  | 3380.21                            | 25.93                     |
| 45.5 UREA <sup>Stabil</sup>            | 2410.00                            | 30.55                     |
| 136.5 UREA <sup>Stabil</sup> (45.5/91) | 3550.01                            | 18.53                     |
| 136.5 Conventional urea (45.5/91)      | 3140.10                            | 15.53                     |
| 136.5 UREA <sup>Stabil</sup>           | 3160.00                            | 15.68                     |

(3.55 t ha<sup>-1</sup>) was found from the application of 136.5 kg N ha<sup>-1</sup> from the split application while from the conventional urea fertilizer application 3.14 t ha<sup>-1</sup> grain yield was produced at 136.5 kg N ha<sup>-1</sup> split application at planting (45.5 kg ha<sup>-1</sup>) and tillering stage (91kg ha<sup>-1</sup>). Improved grain and straw yields at the higher rates of N nutrient may be attributed to the fact that application of fertilizer for crop uptake and translocation to sink thereby expressing superior crop growth and development (Riste et al., 2017; Tilahun et al., 2020).

Straw yield was highly significantly (P<0.01) affected by UREA<sup>Stabil</sup> and conventional urea N sources. The straw yield was affected both by sources and rates of N fertilizer (Sofoniyas et al., 2018). However, the highest straw yield (5.79 t ha<sup>-1</sup>) was recorded from 136.5 kg N ha<sup>-1</sup> from UREA<sup>Stabil</sup> and from the conventional urea fertilizer 5.67 t ha<sup>-1</sup> was recorded as split application of 136.3 kg N ha<sup>-1</sup> (45.5 kg ha<sup>-1</sup> planting and 91 kg N ha<sup>-1</sup> at tillering stage) of rice (Table 1). Thousand of seed weight was not significantly (P<0.05) affected by UREA<sup>Stabil</sup> and conventional urea treatments even if the grain yield is significantly different between treatments.

The rice harvest index was highly significantly (P<0.001) affected by the UREA<sup>Stabil</sup>. The highest HI

(44.6) was shown from 136.5 kg N ha<sup>-1</sup> from UREA<sup>Stabil</sup> source of nitrogen applied once at planting and the lowest (26.0) from 45.5 N as the source of UREA<sup>Stabil</sup> followed by 91 kg N ha<sup>-1</sup> (41.7 HI) from conventional urea split application among nitrogen source of fertilizers. Similar results observed at the highest harvest index from the report of Worou et al. (2017). Higher grain yields in the fertilizer treatments were associated with higher harvest index.

The analysis of Agronomic Efficiency (AE) for the nitrogen sources and rates indicates that the maximum AE 30.55 was exhibited at 136.5 kg N ha<sup>-1</sup> from UREA<sup>Stabil</sup> source of nitrogen split application (45.5 kg ha<sup>-1</sup> basal and 91 kg ha<sup>-1</sup> tillering stage), then the AE reduce to 15.53 at 136.5 kg N ha<sup>-1</sup> from conventional urea N source split application (45.5 kg ha<sup>-1</sup> at planting and 91 kg ha<sup>-1</sup> at tillering satge) and 15.68 AE at 136.5 kg N ha<sup>-1</sup> from UREA<sup>Stabil</sup> source onec application. The AE becomes high 30.55, 25.93, 24.62 at 45.5 kg N ha<sup>-1</sup> from UREA<sup>Stabil</sup>, 91 kg N ha<sup>-1</sup> from UREA<sup>Stabil</sup> (45.5/45.5), 91 kg N ha<sup>-1</sup> from conventional urea (30/90) respectively (Table 2).

The lower agronomic efficiency at the highest N rates in the current experiment indicate that emphasis should be

**Table 3.** Results of grain yield and straw yield adjustments, total variable cost , gross and net benefits analysis.

| Nitrogen levels kg ha <sup>-1</sup>     | TVC<br>(Birrha <sup>-1</sup> ) | GY<br>(tha <sup>-1</sup> ) | SY<br>(tha <sup>-1</sup> ) | AGY<br>(tha <sup>-1</sup> ) | ASY<br>(tha <sup>-1</sup> ) | GB<br>(Birrha <sup>-1</sup> ) | NB<br>(Birrha <sup>-1</sup> ) |
|-----------------------------------------|--------------------------------|----------------------------|----------------------------|-----------------------------|-----------------------------|-------------------------------|-------------------------------|
| 0 N                                     | 0                              | 1                          | 2.51                       | 0.92                        | 2.26                        | 17040                         | 17040                         |
| 91N (Conventional urea 30/61)           | 3180                           | 3.26                       | 3.76                       | 2.93                        | 3.38                        | 44232                         | 41052                         |
| 91 N (UREA <sup>stabil</sup> )          | 3120                           | 3.02                       | 3.6                        | 2.72                        | 3.24                        | 41256                         | 38136                         |
| 91N (UREA <sup>stabil</sup> 45.5/45.5)  | 3210                           | 3.38                       | 3.64                       | 3.04                        | 3.28                        | 45240                         | 42030                         |
| 45.5 N (UREA <sup>stabil</sup> )        | 1560                           | 2.41                       | 2.92                       | 2.17                        | 2.63                        | 33036                         | 31476                         |
| 136.5N (UREA <sup>stabil</sup> 45.5/91) | 4880                           | 3.55                       | 5.79                       | 3.20                        | 5.21                        | 52236                         | 47356                         |
| 136.5N(Conventional urea 45.5/91)       | 4700                           | 3.14                       | 5.67                       | 2.83                        | 5.10                        | 47520                         | 42820                         |
| 136.5N (UREA <sup>stabil</sup> )        | 4600                           | 3.16                       | 3.84                       | 2.84                        | 3.46                        | 43344                         | 38744                         |

TVC= Total Variable Cost, GY=Grain Yield, SY= Straw Yield, AGY= Adjusted Grain Yield, ASY= Adjusted Straw Yield, GB= Gross Benefit, NB= Net Benefit.

**Table 4.** Results of dominance analysis.

| Nitrogen levels (kg ha <sup>-1</sup> )  | TVC (Birrha <sup>-1</sup> ) | NB (Birrha <sup>-1</sup> ) | Dominance |
|-----------------------------------------|-----------------------------|----------------------------|-----------|
| 0 N                                     | 0                           | 17040                      |           |
| 45.5 N (UREA <sup>Stabil</sup> )        | 1560                        | 31476                      |           |
| 91 N (UREA <sup>Stabil</sup> )          | 3120                        | 38136                      |           |
| 91N (Conventional urea 30/61)           | 3180                        | 41052                      |           |
| 91N (UREA <sup>Stabil</sup> 45.5/45.5)  | 3210                        | 42030                      |           |
| 136.5N (UREA <sup>Stabil</sup> )        | 4600                        | 36344                      | D         |
| 136.5N(Conventional urea 45.5/91)       | 4700                        | 42820                      | D         |
| 136.5N (UREA <sup>Stabil</sup> 45.5/91) | 4880                        | 47356                      |           |

D= Dominated.

given to efficient nitrogen application methods. The split application method even for slow release N fertilizer is highly essential for water logged areas like Fogera because that from the current experiment the AE is higher at split application of slow release N source than from conventional urea N sources and real time of N management to reduce denitrification and loss of nitrogen fertilizer to efficiently use by the plant. AE N is usually higher at low N rate than at high N rate (Gewaily et al., 2018; Yasuhiro et al., 2019; Tilahun et al., 2020).

Following the CIMYYT (1988) partial budget analysis method, grain and straw yield adjustments, computations of total variable costs (TVC), gross benefits (GB) and net benefits (NB) were accomplished (Table 3). Dominance analysis was conducted after arranging the treatments in their order of TVC. A treatment will be contemplated as dominated if it has higher TVC but lower NB than a previous treatment with lower TVC and higher NB (Table 4). Non-dominated treatments were taken out and marginal rate of return (MRR) was computed (Table 5). According to the CIMYYT (1988) partial budget analysis, treatments revealing the minimum or more MRR (>100%) will be considered for the comparison of their NB. Highest NB (Birr 47,356 ha<sup>-1</sup>) with acceptable level of MRR

(478.3%) was observed at 136.5 kg N ha<sup>-1</sup> split application of UREA<sup>Stabil</sup> (45.5/91) (Table 5). Split application of 136.5 kg N ha<sup>-1</sup> from UREA<sup>Stabil</sup> source 45.5 kg N ha<sup>-1</sup> as basal and 91 kg N ha<sup>-1</sup> tillering stage is the most profitable rate and source to be recommended for low land rice production of Fogera area.

## Conclusion

Application of different rates of slow release UREA<sup>Stabil</sup> and conventional urea fertilizer strongly affected the grain yield of rice. Parallel to the grain yield, the straw yield is highly necessary for cattle feed in Fogera area. Slow release UREA<sup>Stabil</sup> nitrogen fertilizer sturdily influenced the straw yield. In waterlogged areas, the application of highly mobile nitrogen fertilizer beyond the optimum increase the loss and decrease the final output yield. From the study split application of 136.5 kg ha<sup>-1</sup> conventional nitrogen (as basal 45.5 and 91 kg ha<sup>-1</sup> tillering stage) reduce net benefit by increasing the total variable cost. The split application method even for slow release N fertilizer is highly essential for water logged areas like Fogera because that from the current

**Table 5.** Results of marginal rate of return (MRR) analysis.

| Nitrogen levels (kg ha <sup>-1</sup> )  | TVC (Birr ha <sup>-1</sup> ) | NB (Birr ha <sup>-1</sup> ) | MRR (%) |
|-----------------------------------------|------------------------------|-----------------------------|---------|
| 0 N                                     | 0                            | 17040                       |         |
| 91N (Conventional urea 30/61)           | 3180                         | 41052                       | 718.1   |
| 91 N (UREA <sup>Stabil</sup> )          | 3120                         | 38136                       | 4860.0  |
| 91N (UREA <sup>Stabil</sup> 45.5/45.5)  | 3210                         | 42030                       | 4326.7  |
| 45.5 N (UREA <sup>Stabil</sup> )        | 1560                         | 31476                       | 639.6   |
| 136.5N (UREA <sup>Stabil</sup> 45.5/91) | 4880                         | 47356                       | 478.3   |
| 136.5N(Conventional urea 45.5/91)       | 4700                         | 42820                       | 2520.0  |
| 136.5N (UREA <sup>Stabil</sup> )        | 4600                         | 38744                       | 4076.0  |

experiment the AE is higher at split application of slow release N source than from conventional urea N sources and real time of N management and to efficiently use by the plant. This further revealed slow release UREA<sup>Stabil</sup> nitrogen fertilizer enables to enhance the nitrogen utilization efficiency by reducing denitrification, leaching and ammonia volatilization. In waterlogged conditions of rice production, slow release UREA<sup>Stabil</sup> nitrogen source of fertilizer has strong and promising effect on the growth and yield and yield components rice.

Based on the results of the present study both biological and partial budget analysis revealed that the highest grain yield and economic profitability was exhibited from 136.5 kg N ha<sup>-1</sup> applied in the form of UREA<sup>Stabil</sup> in split application 45.5 kg N ha<sup>-1</sup> as basal and 91 kg N ha<sup>-1</sup> tillering stage for water logged areas of Fogera and similar agro-ecologies in Ethiopia. Further research work for the improvement of nitrogen use efficiency of rice on slow release UREA<sup>Stabil</sup> nitrogen sources of fertilizer in combination with micro nutrients also recommended.

## CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

## REFERENCES

- Abalos D, Jeffrey S, Sanz-Cobena A, Guardia G, Vallejo A (2014). Meta-analysis of the effect of urease and nitrification inhibitors on crop productivity and nitrogen use efficiency. *Agriculture Ecosystems and Environment* 189(1May):13615.
- Amare T, Bazie Z, Alemu E, Wubet A, Agumas B, Muche M, Feyisa T, Fentie D (2018). Crop responses to balanced nutrients in Northwestern Ethiopia. *Blue Nile Journal of Agricultural Research* 1(1):1-14.
- Banerjee BH, Pathak PA (2002). Effects of dicyandiamide, farmyard manure and irrigation on crop yields and ammonia volatilization from an alluvial soil under a rice (*Oryza sativa* L.) - wheat (*Triticumaestivum* L.) cropping system. *Biology and Fertility of Soils* 36:207-214.
- Chen D, Suter H, Islam A, Edis R, Freney JR, Walker CN (2008). Prospects of improving efficiency of fertilizer nitrogen in Australian agriculture: a review of enhanced efficiency fertilizers. *Australia Journal of Soil Research* 46:289-301.
- CIMMYT (1988). From Agronomic Data to Farmer Recommendations: An Economics Training Manual. Completely revised edition. Mexico. D.F. ISBN 968-6127-18-6.
- Craswell ET, Godwin DC (1984). The efficiency of nitrogen fertilizers applied to cereals in different climates. No. REP-3326. CIMMYT.
- CSA (Central Statistics Agency) (2010). Agricultural Sample survey and Agricultural farm management Input practices 2003/04-2010/11.
- Fageria NK, Baligar VC (2001). Lowland rice response to nitrogen fertilization. *Communication Soil Science and Plant Analysis* 32:1405-1429.
- FAOSTAT (2018). (Statistics Division Food and Agriculture Organization of the United Nations. <https://www.fao.org/statistics/en/>
- Gete Z, Getachew A, Dejene A, Shahidur R (2010). Fertilizer and soil fertility potential in Ethiopia. Constraints and opportunities for enhancing the system, International Food Policy Research Institute.
- Gewaily EE, Ghoneim AM, Osman MMA (2018). Effects of nitrogen levels on growth, yield and nitrogen use efficiency of some newly released Egyptian rice genotypes. *Open Agriculture* 3(1):310-318.
- Guangli T, Limin G, Yali K, Xiangyu H, Kailiu X, Ruiqing Z, Ning L, Qirong S, Shiwei G (2017). Improving rice population productivity by reducing nitrogen rate and increasing plant density. *PLoS ONE* 12(8):e0182310. <https://doi.org/10.1371/journal.pone.0182310>
- Hatfield JL, Prueger JH (2004). Nitrogen Over-use, Under-use, and Efficiency. Proceedings of the 4<sup>th</sup> International Crop Science Congress.
- Khan MA, Shah Z, Rab A, Arif M, Shah T (2013). Effect of urease and nitrification inhibitors on wheat yield. *Sarhad Journal of Agriculture* 29(3):371-378.
- Mohammad Z, Jamie B (2010). Can urease inhibitor N-(n-butyl) thiophosphoric triamide (nBPT) improve urea efficiency: effect of different application rate, timing and irrigation systems. 19th World Congress of Soil Science, Soil Solutions for a Changing World.
- Mulugeta A, Abebaw D, Fisseha W, Zelalem Z, Assaye B, Tadesse L (2021). Why Has a Single Rice Cultivar Dominated the Lowland Rice Production Portfolio of Ethiopia for so Long? *Ethiopian Journal of Agricultural Sciences* 31(2):1-11.
- Mulugeta S, Heluf GK (2014). Inherent properties and fertilizer effects of flooded rice soil. *Journal Agronomy* 13(2):72-78.
- Qiao C, Liu L, Hu S, Compton JE, Greaver TL, Li Q (2015). How inhibiting nitrification affects nitrogen cycle and reduces environmental impacts of anthropogenic nitrogen input. *Global Change Biology* 21(3):12491257.
- Riste D, da Silva MP, Ryan CA, Cross AW, Córcoles AD, Smolin JA, Gambetta JM, Chow JM, Johnson BR (2017). Demonstration of quantum advantage in machine learning. *NPJ Quantum Information* 3(1):1-5.
- Si G (2018). Effects of an integrated rice-crayfish farming system on soil organic carbon, enzyme activity, and microbial diversity in waterlogged paddy soil. *Acta Ecologica Sinica* 38:29-35.
- Sieling K, Schroder H, Finck M, Hanus H (1998). Yield, N uptake, and apparent N-use efficiency of winter wheat and winter barley grown in different cropping systems. *Journal of Agricultural Science Cambridge* 131:375-387.
- Sofoniyas D, Lemma W, Selamyihun K (2018). Response of Bread

- Wheat (*Triticum aestivum* L.) to Application of Slow Releasing Nitrogen Fertilizer in Tigray. Ethiopian Journal of Agricultural Sciences 28(1):111-126.
- Thapa R, Chatterjee A, Awale R, McGranahan DA, Daigh A (2016). Effect of enhanced efficiency fertilizers on nitrous oxide emissions and crop yields: A meta-analysis. Soil Science Society of America Journal 80(5):1121-1134.
- Tilahun T, Zelalem T, Habtamu A, Christian T (2020). Optimum Nitrogen and Phosphorus Fertilizer Rates for Upland Rice Production in North Western Ethiopia. Journal of Agriculture and Environmental Sciences 5(1).
- Wang D (2019). Effects of nitrogen fertilizer and water management practices on nitrogen leaching from a typical open field used for vegetable planting in northern China. Agricultural Water Management 213:913-921.
- Yasuhiro T, Tovoheri R, Astuko T, Kazuki S (2019). Challenges and opportunities for improving N use efficiency for rice production in Sub-Saharan Africa. Plant Production Science 22:4.

**Related Journals:**

