Vol. 16(2), pp. 22-28, February 2022
DOI: 10.5897/AJPS2021.2200
Article Number: 9C27E9C68749
ISSN 1996-0824

http://www.academicjournals.org/AJPS

ACADEMIC JOURNALS
expand your knowledge

African Journal of Plant Science

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 (NH3) volatilization and denitrification that reduce NUE and yield. The study was conducted to determine the effects of UREA^{Stabil} on enhancement of nitrogen utilization efficiencies of rice crop and to evaluate the influence of UREA^{Stabil} 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^{Stabil} fertilizer applied once as basal, recommended N from UREA^{Stabil} (split as basal and tillering), half below the recommended N from UREA^{Stabil} as basal, half more than the recommended N from UREA^{Stabil} (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^{Stabil} 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-1) was recorded on 136.5 kg N ha^{-1} in split application 45.5 kg N ha^{-1} as basal and 91 kg N ha^{-1} tillering stage from UREA^{Stabil} source. Conventional urea source of N, application of 136.5 kg N ha^{-1} in split application (45.5 kg ha^{-1} as basal and 91 kg ha^{-1} 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^{-1} from UREA^{Stabil} in split application of 45.5 kg N ha^{-1} as basal and 91 kg N ha^{-1} tillering stage provided highest net benefit of Birr 47,356 ha-1 was the most profitable treatment for lowland rice production. Application of 136.5 kg N ha^{-1} rate from the source of UREA^{Stabil} in split application of 45.5 kgha^{-1} as basal and 91 kg N ha^{-1} 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^{Stabil}, 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.

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, Minestry of Agriculture (MoA), Central Statistics Agenecy (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^{-1} (CSA, 2018), which is lower compared to the world average productivity of 4.6 t ha^{-1} (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^{stabil} 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$^{\mathbf{Stabil}}$ 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_4^+ 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$^{\mathbf{Stabil}}$ on the enhancement of nitrogen utilization efficiencies of the rice crop. To evaluate the influence of UREA$^{\mathbf{Stabil}}$ on the growth and yield of rice under waterlogged conditions.

MATERIALS AND METHODS

Description of the study area

An experiment on UREA$^{\mathbf{Stabil}}$ 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 adapatability 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. Inaddtion 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_2O) of the soil was 5.89 and soil organic carbon was 1.2%.

Experimetal design and treatments

The treatments were comprised UREA^{Stabil} and conventional urea at recommended rates of nitrogen sources. Therefore, a total of eight rates were used to evaluate the efficiencies of UREA^{Stabil} 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 kgha^{-1} (30 kgha^{-1} at planting and 61 kgha^{-1} tillering stage), recommended N from UREA^{Stabil} (91 kgha^{-1}), half of the recommended N from UREA^{Stabil} (45.5 kgha^{-1}), recommended N from UREA^{Stabil} (45.5 kgha^{-1} at planting and 45.5 kgha^{-1} tillering), half more than the recommended N from UREA^{Stabil} (136.5 kgha^{-1}, 45.5 kgha^{-1} at planting and 91 kgha^{-1} tillering), half more than the recommended N from conventional urea (136.5 and 45.5 kgha^{-1} at planting and 91 kgha^{-1} tillering), half more than the recommended N from UREA^{Stabil} 136.5 kgha^{-1}) 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 $^{-1}$ 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^2, number of fertile panicles per m^2, 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 incorporaites 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^{Stabil} and Conventional urea. The highest plant height (83.6 cm) was recorded from the split application of 136.5 kg N ha^{-1} from UREA^{Stabil} splited at planting (45.5 kg N ha^{-1}) and tillering stage (91 kg N ha^{-1}) 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^{-1} and splited at planting (45.5 kg N ha^{-1}) and 91 kg N ha^{-1} tillering stage.

Panicle length was not significantly affected by conventional urea and UREA^{Stabil} 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^2) was found from the application of UREA^{Stabil} (136.5 kgha^{-1}) at planting and tillering stage where as the lowest number of tiller (154.7 m-^{2}) 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 kgha^{-1} at planting (45.5 and 91 kgha^{-1} at tillering stage) had resulted 245.7 tiller number per m^2.

The analysis of variance for the number of fertile grains showed that significantly (P<0.05) affected by UREA^{Stabil} and conventional urea fertilizer. The highest number of fertile grains (248.0 per m^2) was found from 136.5 kg N ha^{-1} of UREA^{Stabil} in split application 45.5 kgha^{-1} at planting and 91 kg N ha^{-1} 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^{-1} planting and 91 kg N ha^{-1} at tillering stage 226.0 fertile grains per m^2 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^{Sabil} and conventional urea fertilizer N source applications. However, Concerning UREA^{Stabil} fertilizer application the highest grain yield

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

PH= Plant height (cm), TC=Tiller count per m^2, PL=Panicle length (cm), NFP= Number of fertile panicles per m^2, DB=Dry bio-mass (tha^{-1}), Gy= Grain yield (tha^{-1}), Sy= Straw yield (tha^{-1}), 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 (kgha^{-1})	Grain yield (kgha^{-1})	Agronomic efficiency (AE)
0	1020.00	
91 Conventiomnal urea (30/61)	3260.01	24.62
91 UREA^{Stabil}	3020.11	21.98
91 UREA^{Stabil} (45.5/45.5)	3380.21	25.93
45.5 UREA^{Stabil}	2410.00	30.55
136.5 UREA^{Stabil} (45.5/91)	3550.01	18.53
136.5 Conventional urea (45.5/91)	3140.10	15.53
136.5 UREA^{Stabil}	3160.00	15.68

(3.55 t ha^{-1}) was found from the application of 136.5 kg N ha^{-1} from the split application while from the conventional urea fertilizer application 3.14 t ha^{-1} grain yield was produced at 136.5 kg N ha^{-1} split application at planting (45.5 kgha^{-1}) and tillering stage (91kgha^{-1}). 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^{Stabil} 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^{-1}) was recorded from 136.5 kg N ha^{-1} from UREA^{Stabil} and from the conventional urea fertilizer 5.67 t ha^{-1} was recorded as split application of 136.3 kg N ha^{-1} (45.5 kgha^{-1} planting and 91 kg N ha^{-1} at tillering stage) of rice (Table 1). Thousand of seed weight was not significantly (P<0.05) affected by UREA^{Stabil} 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^{Stabil}. The highest HI (44.6) was shown from 136.5 kg N ha^{-1} from UREA^{Stabil} source of nitrogen applied once at planting and the lowest (26.0) from 45.5 N as the source of UREA^{Stabil} followed by 91 kg N ha^{-1} (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^{-1} from UREA^{Stabil} source of nitrogen split application (45.5 kgha^{-1} basal and 91 kgha^{-1} tillering stage), then the AE reduce to 15.53 at 136.5 kg N ha^{-1} from conventional urea N source split application (45.5 kgha^{-1} at planting and 91 kgha^{-1} at tillering satge) and 15.68 AE at 136.5 kg N ha^{-1} from UREA^{Stabil} source onec application. The AE becomes high 30.55, 25.93, 24.62 at 45.5 kg N ha^{-1} from UREA^{Stabil}, 91 kg N ha^{-1} from UREA^{Stabil} (45.5/45.5), 91 kg N ha^{-1} 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^{-1}	TVC (Birrha^{-1})	GY (tha^{-1})	SY (tha^{-1})	AGY (tha^{-1})	ASY (tha^{-1})	GB (Birrha^{-1})	NB (Birrha^{-1})
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^{stabil})	3120	3.02	3.6	2.72	3.24	41256	38136
91N (UREA^{stabil} 45.5/45.5)	3210	3.38	3.64	3.04	3.28	45240	42030
45.5 N (UREA^{stabil})	1560	2.41	2.92	2.17	2.63	33036	31476
136.5N (UREA^{stabil} 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^{stabil})	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 (kgha^{-1})	TVC (Birrha^{-1})	NB (Birrha^{-1})	Dominace
0 N	0	17040	
45.5 N (UREA^{Stabil})	1560	31476	
91 N (UREA^{Stabil})	3120	38136	
91N (Conventional urea 30/61)	3180	41052	
91N (UREA^{Stabil} 45.5/45.5)	3210	42030	
136.5N (UREA^{Stabil})	4600	36344	D
136.5N(Conventional urea 45.5/91)	4700	42820	D
136.5N (UREA^{Stabil} 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 relase 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 contempleted 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^{-1}) with acceptable level of MRR (478.3%) was observed at 136.5 kg N ha^{-1} split application of UREA^{Stabil} (45.5/91) (Table 5). Split application of 136.5 kg N ha^{-1} from UREA^{Stabil} source 45.5 kg N ha^{-1} as basal and 91 kg N ha^{-1} 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^{Stabil} and conventional urea fertilizer strongly affected the grain yield of rice. Parallel to the grain yield, the straw yield is highly necessary for cattel feed in Fogera area. Slow release UREA^{Stabil} nitrogen fertilizer sturdily influenced the straw yield. In waterlogged areas, the application of highly mobile nitrogen fertilizer beyond the optimum increase the lose and decrease the final out put yield. From the study split application of 136.5 kgha^{-1} conventional nitrogen (as basal 45.5 and 91 kgha^{-1} tillering stage) reduce net benefit by increasing the total variable cost. The split application method even for slow release N fertilizer is highly essentional for water logged areas like Fogera because that from the current

Table 5. Results of mariginal rate of return (MRR) analysis.

Nitrogen levels (kgha^{-1})	TVC (Birrha^{-1})	NB (Birrha^{-1})	MRR (%)
0 N	0	17040	
91N (Conventional urea 30/61)	3180	41052	718.1
91 N (UREA^{Stabil})	3120	38136	4860.0
91N (UREA^{Stabil} 45.5/45.5)	3210	42030	4326.7
45.5 N (UREA^{Stabil})	1560	31476	639.6
136.5N (UREA^{Stabil} 45.5/91)	4880	47356	478.3
136.5N(Conventional urea 45.5/91)	4700	42820	2520.0
136.5N (UREA^{Stabil})	4600	38744	4076.0

experiment the AE is higher at split application of slow relase 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^{Stabil} 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^{Stabil} 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^{-1} applied in the form of UREA^{Stabil} in split application 45.5 kg N ha^{-1} as basal and 91 kg N ha^{-1} tillering stage for water logged areas of Fogera and similar agro-ecologies in Ethiopia. Further research work for the improvent of nitrogen use efficeny of rice on slow release UREA^{Stabil} nitrogen sources of fertilizer incombination 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 Environment189(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 Recommendatlions: 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 4th 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, Taddesse 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 en-hanced efficiency fertilizers on nitrous oxide emissions and crop yields: A meta-analysis. Soil Science Society of America Journal 80(5):11211134.
TilahunT, Zelalem T, Habtamu A, Christian T (2020). Optimum Nitrogen and Phosphors 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, Tovohery 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.