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Evaluate Performance of Rice Crop through Application of Urea Stable and Conventional Urea in Pawe District, North Western Ethiopia

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Abstract

Nitrogen is the most yield liming nutrient that can be highly soluble and lost through leaching, volatilization and denitrification. In this view an experiment was conducted to determine the effects of urea stable and convectional urea on crop performance of rice in Pawe district, north western Ethiopia. The experiment was laid out in randomized complete block design with three replications. The treatments were different rate of urea stable and convectional urea applied at planting and in split: (Control, 23 kg N ha^{-1} from urea stable applied once at planting,23 kg N ha^{-1} from urea stable in split application, 23 kg N ha^{-1} from urea stable in split application, 46 kg N ha^{-1} from urea stable applied once at planting, 46 kg N ha^{-1} from urea in split application, 69 kg N ha^{-1} from urea stable in split application, 69 kg N ha^{-1} from urea in split application, 69 kg N ha^{-1} from urea stable applied once at planting).The applications of urea stable and conventional urea were significantly improved growth yield and yield components of rice as compared to control. Mean grain yield and biomass yield of rice was significantly affected by nitrogen rate and increased with increasing of nitrogen rate applied from urea stable and conventional urea. Moreover, the mean of over years and over locations result show that the highest biomass yield (11319 kg ha^{-1}) was obtained from 69kg N ha^{-1} urea stable applied once at planting, whereas the lowest biomass yield (7630 kg ha^{-1}) was recorded in negative control treatment Applications of 69 kg N ha^{-1} from urea stable fertilizer applied at planting, 69 kg N ha^{-1} from conventional urea fertilizer applied in split and 69 kg N ha^{-1} from urea stable fertilizer applied in split in increased the grain yield by 49.3, 49 and 45 % over the negative control, respectively but statistically similar from application of 46 kg N ha^{-1} applied in split in the form of conventional urea (+ve control) and 46 kg N ha^{-1} from urea stable fertilizer applied at planting. Therefore, there was no evidence in our research that supports the advantage of urea stable over the conventional urea. Hence it is concluded that the application N fertilizers sources from both of urea and urea-stable are equal result obtained in improving of rice productivity.

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Keywords

Urea Stable, Rice, Nitrogen, NH3 volatilization, NO3− leaching and N2O emission.

Introduction

Nitrogen is the most yield-limiting nutrient under all soils, landscapes, agro-ecologies, and regions of the region (Amare *et al.*, 2018). It is also a universal yield-limiting nutrient (Hirel *et al.*, 2007). Synthetic nitrogen fertilizer accounted for about 50% of food increased in the world (Yang *et al.*, 2016). The primary sources for synthetic nitrogen fertilizers in Ethiopia is urea as it has high contents of nitrogen (46%), its low cost, ease of handling, storage, and transport makes urea to be used worldwide for the agricultural production that accounts about 56% (Mira *et al.*, 2017). However, the recovery of nitrogen from urea is only about 30–40% (Zhou *et al.*, 2003), 30–50% (Abalos *et al.*, 2014), 50% (Janssen *et al.*, 1990), 30–65% (Herrera *et al.*, 2016). According to Zaman *et al.*, (2013) the key nitrogen loses could be summarized as NH_3 volatilization, NO_3^- leaching and N_2O emission.

Integrated soil fertility management, selection of fertilizer sources, identifying and applying at a critical time, improving the reaction of urea fertilizer through various modifications increase the nitrogen fertilizer recovery and efficiency as well as reduces environmental impacts (). Among the measures, a split application of urea is reducing the nitrogen losses (Hinton *et al.*, 2015). New technologies that reduce the loss of nitrogen by modifying the conventional urea are getting the attention of researchers and development practitioners. These technologies release nitrogen more slowly than the conventional urea and hence improve the recovery of fertilizers (Feng *et al.*, 2016; Trenkel, 2010). 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; Krajewska, 2009; Watson *et al.*, 2008). This fertilizer technology increased crop productivity (Abalos*et al.*, 2014; Qiao *et al.*, 2015). However, the effect of urease inhibitor (nBTPT) depends on the climate, soil, crop and management (Thapa *et al.*, 2016). Therefore, the objectives of this research was to evaluate the advantages of urea stable compared to the conventional urea in increasing the rice crop productivity and to determine optimum urea stable nitrogen fertilizer rate under balanced fertilizer.

Materials and Methods

Description of the Study Area

The study was conducted for three consecutive years during 2017 to 2019 main cropping seasons in Pawe district. During the three-cropping season the experiment was executed on five farmer's field. Pawe District is located in Metekel Zone of the Benishangul-Gumuz Regional State, Ethiopia. It is located at about 570 kilometers distance from Addis Ababa in Northwestern direction. The altitude of the study area ranges between 1000 - 1200 meters above sea level. According to the meteorological data gathered by the Pawe Meteorological Station on Pawe Agricultural Research Center from 2017 to 2019, the mean annual minimum and maximum temperatures of the District are 17.5 and 32.8 ^{0}C, respectively, and the mean annual rainfall is 1717.4 mm. The area has a uni-modal rainfall pattern with high rainfall that extends from May to October (Figure 1). The mean annual potential evapotranspiration is about 1300 mm. The climate of the area characterized as hot humid. The dominant soil types in district are broadly categorized as Vertisols (40 – 45% of the area), Nitisols (25 – 30%), and intermediate soils of a blackish brown color (25 – 30%) (Viezzoli, 1992).

Experimental Design and Procedures

The experiment was laid out in randomized complete block design with three replications. The plot size of 3 m x 4 m was used during both years. The treatments consisted different rate of urea stable and normal urea with different application time. Nerica 4 improved rice variety was planted on first week of July using 70cm between row and 30 between plant spacing. Nitrogen from urea stable and normal urea was applied as per as described in treatment set up. However, recommended rate of phosphorus (20 kg P ha^{-1}) from TSP was uniformly applied during planting. Recommended agronomic practices like ploughing and hand weeding were uniformly adapted to all plots.

Experimental set-up

The experiment was conducted for three consecutive rainy seasons with the treatment setups shown in (Table 1). This on-farm research was conducted on multi-locations of district.

Results and Discussion

Soil chemical properties before establishment of the experiment

The soil chemical properties of different farmers' field during 2018 cropping season were indicated in Table 1. The soil pH of experimental field at farm 1 and farm 2 were very strongly acidic (pH = 5.12) and slightly acidic (pH = 6.42), respectively and in soil reaction (Tekalign, 1991).

The organic carbon contents of soil were 1.19 and 2.57% found in medium range of organic carbon rate farm 2 and farm 1 farmer's field, respectively (Tekalign, 1991). The nitrogen content of study area soil was 0.112 and 0.105% medium at farm 1 and farm 2 farmer's field, respectively

(Tekalign, 1991). Available phosphorus of soil was very low (8.9 ppm) and low (12.42ppm) at farm 1 and farm 2 farmer's field, respectively (Jones, 2003).

Plant height

The analysis of variance showed that plant height was affected significantly ($p < 0.001$) by the main effects of urea stable and urea fertilizer rates (Table 2). The mean plant height of wheat was showed increasing trend with increasing rate of nitrogen applied. This indicated the positive effect of N on vigorous vegetative growth and inter-nodal extension due to more availability of N throughout the growing period. Rice plant height was ranged from 78.5 to 88.6 cm whereas the lower and higher value of the plant height rice was recorded from control and application of 69 kg N ha^{-1} from urea stable applied at planting. The plant height recorded by application of 69 kg N ha^{-1} from urea stable applied at planting was statistically at par with plant height measured from plot treated with the same amount of nitrogen from urea stable and normal urea applied in split. This indicates similar effects of nitrogen from urea stable and normal urea on plant height of rice. In line with this, Tolcha *et al.*, (2020) reported that the mean plant height was showed increasing trend with increasing rate of nitrogen applied. Marcelo *et al.*, (2013) also recorded statistically similar plant height from plot received N from conventional urea and urea with inhibitors.

Biomass Yield

The result of combined analysis of biomass yield was significantly ($P<0.0001$) affected by nitrogen rate applied from urea stable and conventional urea (Table 3). Hence, mean biomass yield of rice was increased with increasing rate of nitrogen fertilizer. Moreover, the mean of over years and over locations result show that the highest biomass yield (11319 kg ha^{-1}) was obtained from 69kg N ha^{-1} urea stable applied once at planting, whereas the lowest biomass yield (7630 kg ha^{-1}) was recorded in negative control treatment (Table 3). Application of 69 kg N ha^{-1}from urea stable applied at planting increased the biomass yield by 50 % over the negative control. Application of similar rates of nitrogen from urea stable and urea was provided statistically similar biomass yields. In a similar study with wheat as a test crop, Tolcha *et al.*, (2020) reported that application of similar rates of nitrogen from urea stable and urea was provided statistically similar dry biomass yields. In line with this, Marcelo *et al.*, (2013) who also reported non-significant effect of normal urea and urea stable on straw yield when applied at similar rate.

Grain Yield

The result combined analysis of over three years and over five locations of rice grain yield was significantly ($P< 0.001$) affected by nitrogen rate in irrespective to nitrogen source used in the experiment (Table 4). Higher mean grain yield of (3848, 3841 and 3736kg ha^{-1}) were obtained from applications of 69 kg N ha^{-1} from urea stable fertilizer applied at planting, 69 kg N ha^{-1} from conventional urea fertilizer applied in split and 69 kg N ha^{-1} from urea stable fertilizer applied in split in, respectively whereas the lowest gain yield (2578kg ha^{-1}) was in negative control treatment.

Applications of 69 kg N ha^{-1} from urea stable fertilizer applied at planting, 69 kg N ha^{-1} from conventional urea fertilizer applied in split and 69 kg N ha^{-1} from urea stable fertilizer applied in split in increased the grain yield by 49.3, 49 and 45 % over the negative control, respectively but statistically similar from application of 46 kg N ha^{-1} applied in split in the form of conventional urea (+ve control) and 46 kg N ha^{-1} from urea stable fertilizer applied at planting. Similar, Serret *et al.*, (2008) also reported significant effect nitrogen fertilizer rate on mean grain yield of wheat crop. There was also no significant difference among mean grain yield recorded from application of similar rate and application time of urea stable and conventional urea. The current result is in agreement with that of Tolcha *et al.*, (2020) who reported that statistically there is no significant effect of application time of urea stable at each similar rate.

Relationships between Rice Grain Yield and yield components

The correlation between grain yield and yield components are presented in Table 5. Grain yield was positively correlated with biomass yield, plant height, panicle length, thousand seed weight and harvesting index and the correlation was significant at ($p< 0.05$). Moreover, grain yield was most strongly correlated with biomass yield (r =0.977) and plant height (r = 0.976). Similarly, biomass yield had positive and significant correlation ($p< 0.01$) with plant height, panicle length and thousand seed weight. Similar results obtained by numerous authors (Ortiz *et al.*, 2002; Abeledo *et al.*, 2003; Temesgen *et al.*, 2016a) indicated that significant associations of barley grain yield with its yield components.

Table.1 Treatment set-up and level of N (kg/ha)

No	Treatments	N (kg ha^{-1})
1	No external application of N (negative control)	0
2	100% of the recommended N from normal urea applied in split (positive control)	46(15/31)
3	100% of the recommended N from UREA stable applied at planting	46
4	100% of the recommended N from UREA stable applied in split	46(15/31)
5	50% of the recommended N from UREA stable applied once at planting	23
6	50% of the recommended N from UREA stable applied in split	23(11/12)
7	150% of the recommended N from UREA stable applied in split	69(34/35)
8	150% of the recommended N from normal UREA applied in split	69(34/35)
9	150% of the recommended N from UREA stable applied once at planting	69

Table.2 Selected soil chemical properties before cropping of rice in 2018 cropping season

Soil Chemical properties	Farm 1	Farm 2
	Value	
pH 1:2.5 (H_2O)	5.12	6.42
Available P mg kg^{-1}	5.32	21.90
Organic carbon %	2.57	1.19
Organic matter %	4.44	2.05
Total N %	0.112	0.105
Exchangeable acid cmol(+)kg^{-1}	0.321	0.06
Exchangeable Al cmol(+) kg^{-1}	0.241	0.04

Table.3 Effect of urea stable and normal urea on plant height of rice in 2017, 2018 and 2019 cropping season and combined over years

Treatment	Plant height (cm) Years and Locations					Combined Analysis
	2017	2018		2019		
	Station	Station	Village17	Station	Village17	
0 N (-ve control)	92.60	79.87abc	76.33c	67.40	76.20d	78.5e
46 N from Normal Urea (+ve control)	92.60	85.53ab	82.67bc	73.40	83.00bac	83.4bcd
46 N from Urea Stable at planting	92.47	88.13ab	86.70abc	72.67	80.00dc	84.0bcd
46 N from Urea Stable in split	92.80	71.33c	80.00bc	74.80	83.20bac	80.4de
23 N from Urea Stable at planting	92.60	77.47bc	87.60ab	71.20	80.80c	81.9cde
23 N from Urea Stable in split	92.93	78.93abc	82.47bc	76.40	81.47bc	82.4cde
69 N from Urea Stable in split	93.93	83.93abc	89.53ab	75.67	85.40ba	85.7abc
69 N from Normal Urea in split	99.47	84.53abc	87.00ab	79.27	87.40a	87.5ab
69 N from Urea Stable at planting	98.73	92.6a	93.87a	79.00	78.80dc	88.6a
LSD (0.05)	10.438	13.995	10.645	ns	4.489	4.3891
CV (%)	6.4	9.8	7.2	8.4	3.2	7.3
Significance	ns	*	*	ns	**	***

Table.4 Effect of urea stable and normal urea biomass yield of rice in 2017, 2018 and 2019 cropping seasons and combined over years

Treatment	Biomass yield (kg ha^{-1}) Years and Locations					Combined Analysis
	2017	2018		2019		
	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5	
0 N (-ve control)	8592.6	6667c	10000c	5925.9d	6962.7	7630d
46 N from normal Urea (+ve control)	9481.5	8667abc	10815bc	9629.6ab	8518.5	9422bc
46 N from Urea stable at planting	8518.5	11852ab	15185a	7407.4bcd	7555.6	10104abc
46 N from Urea stable in split	8296.3	7259bc	10000c	8666.7abcd	8740.7	8593cd
23 N from Urea stable at planting	9925.9	7630bc	11481bc	6666.7cd	6666.7	8474cd
23 N from Urea stable in split	11037.0	7111bc	10963bc	8666.7abcd	7851.8	9126bcd
69 N from Urea stable in split	11185.2	10370abc	12963ab	9407.4abc	9037.0	10593ab
69 N from Normal Urea in split	11037.0	8815abc	12000bc	11185.2a	8740.7	10356ab
69 N from Urea stable at planting	11333.3	13185a	15185a	7629.6bcd	9259.3	11319a
LSD (0.05)	2986.9	5086.5	2596	2959.6	ns	1508.4
CV (%)	17.4	32.4	12.4	20.5	20.0	21.9
Significance	ns	ns	**	*	ns	***

Table.5 Effect of urea stable and Normal urea on grain yield of rice in 2017, 2018 and 2019 cropping season and combined over years

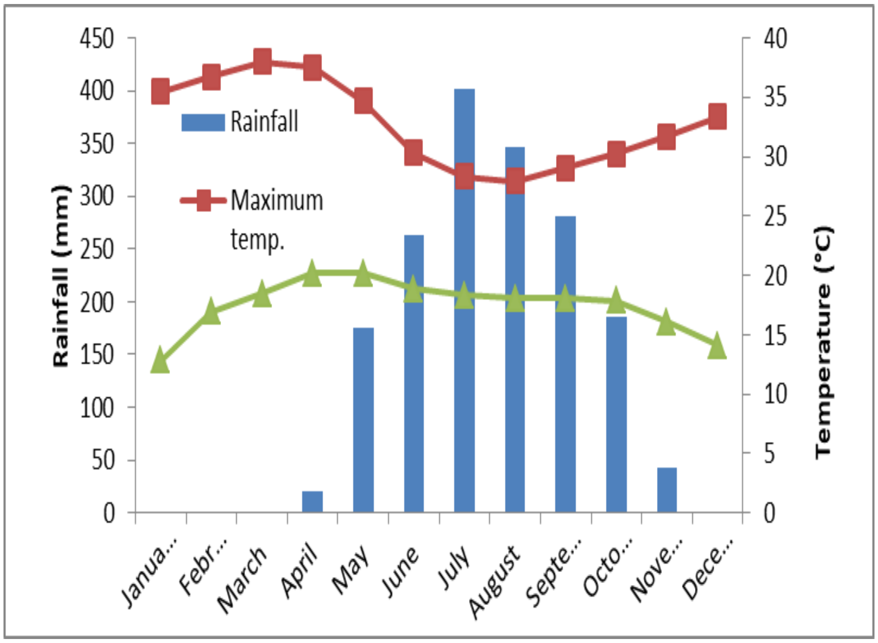
Treatment	Grain yield (kg ha^{-1}) Years and Locations					Combined Analysis
	2017	2018		2019		
	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5	
0 N (-ve control)	3004.9	2336.3ab	3278.4f	2139.85c	2132.66b	2578d
46 N from normal Urea (+ve control)	3672.1	2902.8ab	3919.3de	3334.35ab	2798.56ab	3325abc
46 N from Urea stable at planting	3140.8	3310.0ab	5505.9a	2911.69abc	2646.81ab	3503ab
46 N from Urea stable in split	3153.0	1839.9b	3383.6ef	3264.74ab	2956.74ab	2920cd
23 N from Urea stable at planting	3783.2	2179.0ab	4105.3d	2528.93bc	2208.88b	2961cd
23 N from Urea stable in split	3640.0	2127.4ab	3986.3d	3351.10ab	2743.44ab	3170bc
69 N from Urea stable in split	4277.4	3211.1ab	4720.4c	3485.81ab	2986.96ab	3736a
69 N from Normal Urea in split	4386.6	2999.3ab	4887.0bc	3816.51a	3113.51a	3841a
69 N from Urea stable at planting	4157.8	3615.3a	5390.9ab	3261.54ab	2813.95ab	3848a
LSD (0.05)	1601.1	1759.1	596.83	1051.7	873.71	522.3
CV (%)	25.1	37.3	7.9	19.5	18.6	21.7
Significance	ns	ns	***	*	*	***

Table.6 Correlation among rice grain yield and yield components of urea stable and urea

Parameters	GY	BMY	PH	SL	TSW	HI
GY	1	0.977**	0.976***	0.799**	0.643*	0.693*
BMY		1	0.961***	0.804**	0.672*	0.550ns
PH			1	0.854**	0.773**	0.688*
SL				1	0.785**	0.524ns
TSW					1	0.489ns
HI						1

Note: PH= plant height, SL= spike length, BMY= biomass yield, GY= grain yield and TSW= thousand seed weight, HI=harvesting index, * Significant at *P* < 0.001, ** significant at *P* < 0.01, *significant at *P* < 0.05, ns – no significant difference. Means along the column with the same letter are not significantly different.**

Fig.1 Mean monthly rainfall and mean monthly maximum and minimum temperatures of the study area.



The applications of urea stable and conventional urea were significantly improved growth yield and yield components of rice as compared to control. Mean grain yield and biomass yield of rice was significantly affected by nitrogen rate and increased with increasing of nitrogen rate applied from urea stable and conventional urea.

Moreover, the mean of over years and over locations result show that the highest biomass yield (11319 kg ha^{-1}) was obtained from 69kg N ha^{-1} urea stable applied once at planting, whereas the lowest biomass yield (7630 kg ha^{-1}) was recorded in negative control treatment Higher mean grain yield of (3848, 3841 and 3736kg ha^{-1}) were obtained from applications of 69 kg N ha^{-1} from urea stable fertilizer applied at planting, 69 kg N ha^{-1} from conventional urea fertilizer applied in split and 69 kg N ha^{-1} from urea stable fertilizer applied in split in, respectively whereas the lowest gain yield (2578 kg ha^{-1}) was in negative control treatment.

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