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# Nitrogen Use Efficiency and Performance of Wheat Crop Through Application of Urea Stable and Conventional Urea in Vertisols of Ambo District

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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 nitrogen use efficiency and crop performance of wheat in Vertisols of Ambo District, west Shewa Zone. 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, 46 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). Agronomic use efficiency was significantly varied among applied urea stable and convectional urea during first year. Significantly higher (32.77 and 40.8 kg grain/ kg N applied) agronomic efficiency of wheat from farm one (1) and two (2) were recorded by application of 23 kg N ha$^{-1}$ from urea stable in split form. Mean grain yield, dry biomass, harvest index, plant height and spike length of wheat were significantly affected with application of urea stable and convectional urea. The highest mean spike length (6.6cm), plant height (80cm), harvest index (45%) and thousand seed weight (45g) were recorded from split application of 69 kg N ha$^{-1}$ in the form of urea stable fertilizer. Wheat grain yield of 3623 kg ha$^{-1}$ and dry biomass 8921 kg ha$^{-1}$ were recorded from split application of 69 kg N ha$^{-1}$ from conventional urea fertilizer. Statistically significant difference of yield and yield components of wheat were not observed by applying similar rate of urea stable and convectional urea. Therefore, urea stable and convectional urea could be used as alternatively for wheat production in study area.

**Keywords:** Urea Stable, Wheat, Nitrogen, Nutrient Use Efficiency

## 1. Introduction

Nitrogen is the most limiting nutrient for agricultural production worldwide and application of nitrogen fertilizer is generally required for optimum yield of most crops [1, 2]. It is required by plants comparatively in larger amounts than other essential plant nutrients [3]. Inadequate or absence of nitrogen fertilizer application on soil with insufficient endogenous nitrogen can cause much yield reduction than other plant nutrients [4]. Excess application and misuse of nitrogen fertilizer is result in environment pollution and low

resource use efficiency or low return investment of the farmers [5]. Nitrogen use efficiency can be low due to different factors such as nitrogen sources, climate, soil condition, dose of N applied and time of application [6]. The crops use only 50-60% of applied N and less than half amount of N applied in most case [7, 8]. Therefore, applying optimum rate at the right time from good nitrogen source can increase crop yield, reduce nitrogen lose and improve nitrogen use efficiency [9]. A number of studies were also done to find the optimum rate and time of nitrogen application to improve wheat yield, nutrient use efficiencies

and to reduce environmental pollution [10]. Convectional urea is exposed to urease enzyme activities that found in plants, bacteria, fungi and algae. Urease enzyme is result in low nitrogen use efficiency [1]. Therefore, efforts have made by fertilizer producers to produce urease activity inhibitors that can increase efficiency of applied urea by inhibiting urease enzyme activity in the soil [11].

Ethiopia is the largest wheat producers in sub-Saharan Africa. It is cultivated approximately on 1.7 million hectares of land and ranks fourth next to teff, maize and sorghum both in production and area coverage [12]. However, the yield of this crop is low in Ethiopia due to different factors and the country enforced to import wheat to meet domestic needs [13]. Low soil fertility and insufficient application of fertilizer is mainly responsible for low wheat production in Ethiopia [14, 15]. Wheat grain yield and seed quality can be highly influenced by N fertilization and absence of nitrogen application [16]. Thus, the application of the appropriate rate of N fertilizer at the right time can significantly increase wheat grain yield and improve uptake efficiency as well as protein content of the crop [9, 16]. However, information on effect of different source of nitrogen fertilizer on wheat production and nitrogen use efficiency in Vertisols of west Showa zone is limited. Therefore, the objective was to determine effect urea stable and conventional urea fertilizer rate on nitrogen use efficiency and performance of wheat crop in Vertisols of Ambo district, west Showa zone.

## 2. Materials and Methods

### 2.1. Description of Study Area

The study was conducted for two consecutive years during 2018 and 2019 main cropping seasons on Vertisols of Ambo district. During the two-cropping season the experiment was executed on four farmer's field. Geographically, the district is located between 8°52'30"-9°32'30" N latitude 37°31'50"-38°1'40" N E longitudes. The area receives mean annual rain fall of 1036.24 mm with unimodal distribution. It has a cool humid climate with the mean minimum, mean maximum, and average air temperatures of 10.26, 26.21°C and 18.24, respectively. The dominant soil type of the area is Vertisols which are known for their high-water logging and drainage problems [17].
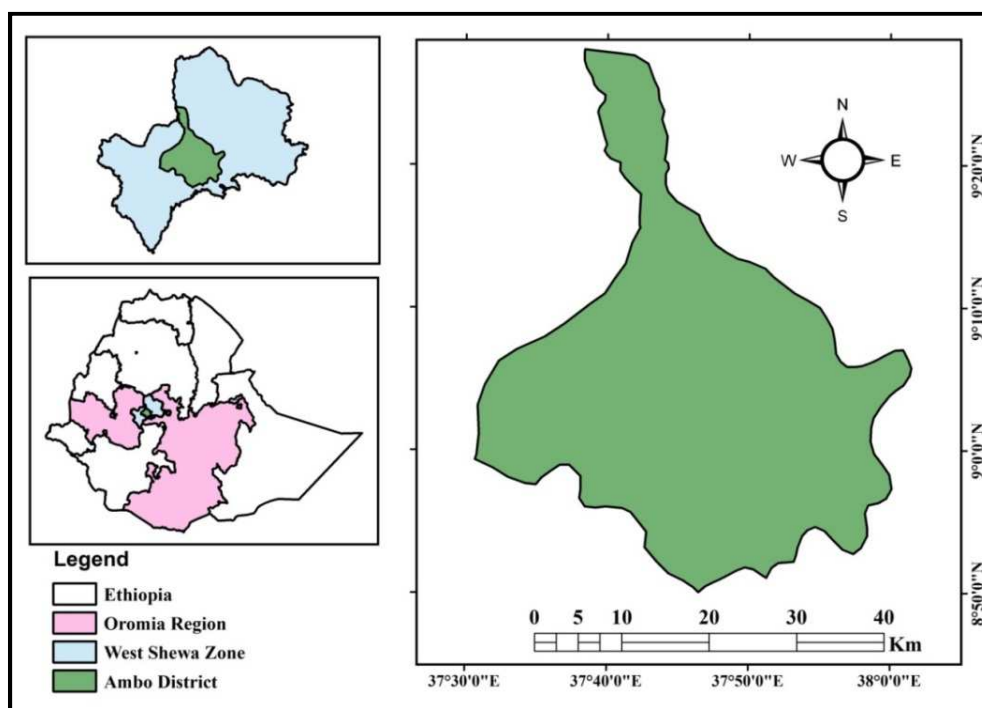


*Figure 1. Map of experimental Site (Ambo District).*

### 2.2. Experimental Design and Treatments

The experiment was laid out in randomized complete block design with three replications. The plot size of 3 m x 3 m was used during both years. The treatments consisted different rate of urea stable and normal urea with different application time. Wane improved wheat variety was planted on first week of July using 20cm recommended row spacing and 150 kg/ha seeding rate. Nitrogen from urea stable and normal urea was applied as per as described in treatment set up. However, recommended rate of phosphorus (26 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.

### 2.3. Soil and Plant Tissue Sampling and Analysis

Prior to planting 10 soil samples were collected to the depth of 0–20 cm across the experimental field. Immediately after sampling the total of 10 samples were thoroughly mixed in the field, about 1 kg composite and homogenized sample was taken and put into the labeled plastic bag. After harvesting, soil

samples were collected from all plots in the experimental field. The samples were taken from central rows of the plots to reduce boarder effect. Then the sample were taken to Ambo Agricultural research Center for sample preparation. Then the soil samples were spread on the sheet and dried with aid of air in the room. The air-dried soil samples were milled using mortar and Pestle, then sieved through a 2 mm diameter sieve for analysis of nitrogen. The tissue of wheat was collected at 50% booming of wheat. Then the wheat straw was chopped and air dried with grain in the room. The grain of wheat was collected after harvesting of the crop. Finally, both soil and plant sample were taken to Kulumsa and Holetta Agricultural Research Center soil and plant laboratory for nitrogen and other soil parameters analysis.

The soil and plant samples were analyzed at Kulumsa and Holetta Agricultural Research Center Soil and Plant Laboratory. Particle size distribution (texture), soil pH, organic carbon (OC), total N, available P, cation exchange capacity (CEC) was analyzed using standard procedures. Determination of soil particle size distribution was carried out using the hydrometer method [18]. The soil pH was measured with digital pH meter potentiometrically in the supernatant suspension of 1:2.5 soils to water ratio. Organic carbon was determined following wet digestion methods as described by Walkley and Black [19], whereas kjeldahl procedure was used for the determination of total nitrogen as described by [20]. Cation exchange capacity of the soil (CEC) was determined by saturating soil with neutral 1M $NH_4OAc$ (ammonium acetate) and the adsorbed $NH4^+$ions were displaced by using 1M KCl and then determined by the Kjeldahl distillation method for estimation of CEC of the soil [21, 22]. The available P was measured by Bray II method [23].

The wheat tissues and grain were subjected to wet digestion using concentrated sulphuric acid and hydrogen per-oxide with selenium as catalyst [24] and the N content of the plant tissue was determined by Kjeldahl methods. Total N uptake was calculated by multiplying N concentration by dry biomass weight (kg ha$^{-1}$) of wheat. Agronomic efficiency was calculated by multiplying the grain yield and applied N [25].

$$AE \text{ (kg grain / kgN)} = \frac{Yn-Yo}{Fn}$$

Whereas AE= Agronomic efficiency Yn and Yo are the grain yield with or without N applied respectively and Fn is the amount of nitrogen fertilizer applied

Apparent fertilizer N use (recovery) efficiency (ANRE) was obtained by dividing the amount of fertilizer N taken up by the plant to the kg of N applied as fertilizer as it was described by (26)

$$ARE(KgN / kgN) = \frac{Un-Uo}{Fn}$$

Where ARE= Apparent recovery efficiency, Un and Uo are nutrient uptake in fertilized and control plot respectively; Fn is the amount of N fertilizer applied.

Plant nitrogen use efficiency/ physiological efficiency was calculated by dividing the total dry matter produced to a unit of N absorbed as indicated below:

$$PE \text{ kg grain /kgN} = \frac{Yn-Yo}{Un-Uo}$$

Where PE= physiological efficiency, Un and Uo are nutrient uptake in fertilized and control plot respectively; Yn and Yo are the grain yield in fertilized and control plot respectively

### 2.4. Agronomic Data Collection

Data on growth parameters yield and yield components of wheat were collected from the central rows of each plot. Agronomic data such as plant height and spike length were measured before harvesting or at grain filling stage. The plant height measured from the base of the plant at ground level to the base of spike for 10 randomly selected plants. At physiological maturity, wheat samples were harvested from central rows and threshed to measure weight of both grain and dry biomass using digital balance. Dry biomass, grain yield and 1000 seed weight were recorded after harvesting and threshing. Harvesting index was calculated from the ratio of grain yield and above ground biomass times 100.

### 2.5. Statistical Analysis

The collected data were analyzed using SAS computer software version 9.13 [27]. Whenever treatment effects were significant, the means was separated using the least significant difference procedures test at 5% level of significance [28].

## 3. Results and Discussion

### 3.1. Some Soil Chemical and Physical Properties of the Study Area

The physicochemical properties of different farmers' field during 2018 cropping season were indicated in Table 1. The soil distribution of both farm fields was clay in textural classes. The soil pH of experimental field at Bayo Kurbi and Amaro kebele were 6.45 and 6.10, respectively and slightly acidic in soil reaction [29]. The organic carbon contents of soil were 1.85 and 2.02% found in high range of organic carbon rate [29]. The nitrogen content of study area soil was 0.13 (low) and 0.09% (medium) at Bayo Kurbi and Amaro kebele farmer's field respectively [29]. Available phosphorus of soil was very low (8.9 ppm) and low (12.42ppm) at Amaro and Bayo Kurbi respectively [30].

*Table 1. Some physical and chemical properties of soil of experimental site before planting in 2018 cropping season.*

| Kebele | Soil texture | | | pH | Available P | Total N (%) | CEC (cmol+/kg) | OC | OM |
|---|---|---|---|---|---|---|---|---|---|
| | Clay | Silt | (pmm) sand | | | | | % | |
| Bayo kurbi | 67.46 | 20.36 | 12.18 | 6.45 | 12.42 | 0.09 | 44.26 | 1.08 | 1.86 |
| Amaro | 66.43 | 21.84 | 10.73 | 6.10 | 8.9 | 0.13 | 46.34 | 2.02 | 3.47 |

### 3.2. Effect of Urea Stable and Conventional Urea on Growth, Yield and Yield Components of Wheat

The combined analysis of variance showed non-significant (p>0.05) effect of cropping year variation on mean plant height, dry biomass, spike length, grain yield and harvest index of wheat. This indicates similar climate condition such as rain fall pattern and distribution during two cropping seasons in the area. Interaction effect of treatment by year (trt *year) was non-significant (p<0.05) for all parameters. Therefore, only treatment effect (nitrogen rate) on growth parameters, yield and yield components of wheat crop was discussed in the manuscript.

#### 3.2.1. Plant Height and Spike Length

Effect of nitrogen rate was significant on mean plant height irrespective of nitrogen source and application time of slow releasing urea stable and conventional urea (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. Wheat plant height was ranged from 60 to 80cm whereas the lower and higher value of the plant height wheat was recorded from control and application of 69 kg N ha$^{-1}$ from urea stable in split (Table 2). The plant height recorded by application of 69 kg N ha$^{-1}$ from urea stable in split was statistically at par with plant height measured from plot treated with the same amount of nitrogen from urea stable applied only at planting and normal urea applied in split. This indicates similar effects of nitrogen from urea stable and normal urea on plant height of wheat. [31] also recorded statistically similar plant height from plot received N from conventional urea and urea with inhibitors. Similarly, [32] also reported significant effects of application time and rate of urea fertilizer in Haramaya and Meta sites. The authors recorded taller plant height of (115cm) wheat from 138 kg N ha$^{-1}$ applied in two splits of 1/2 dose at mid-tillering and ½ at anthesis of wheat.

**Table 2.** Effect of urea stable on mean plant height and spike length of wheat in 2018 and 2019 cropping season and combined over years.

| Treatment (kg N ha$^{-1}$) | Plant height (cm) | | | Spike length (cm) | | |
|---|---|---|---|---|---|---|
| | 2018 | 2018 | Mean | 2018 | 2019 | Mean |
| 0 | 65[e] | 61.8[c] | 64[f] | 4.9[d] | 4.8[d] | 4.8[d] |
| 46 N from NU. in split | 75[abc] | 75.5[ab] | 75[cd] | 5.9[bc] | 5.9[ab] | 5.9[c] |
| 46 N from US. at planting | 69[de] | 70.6[b] | 70[e] | 5.8[c] | 5.2[cd] | 5.6[c] |
| 46 N from US. in split | 73[cd] | 71.4[b] | 72[de] | 5.8[c] | 5.4[bc] | 5.7[c] |
| 23 N from US. at planting | 75[abc] | 76.8[ab] | 75[bcd] | 6.2[abc] | 5.5[bc] | 5.9[bc] |
| 23 N from US. in split | 74[bcd] | 78.2[ab] | 75[cd] | 6.1[abc] | 5.8[abc] | 6[abc] |
| 69 N from US in split | 79[a] | 81.5[a] | 80[a] | 6.9[a] | 6[ab] | 6.6[a] |
| 69 N from NU in split | 78[ab] | 82.3[a] | 79[ab] | 6.3[abc] | 5.9[ab] | 6.1[abc] |
| 69 N from US at planting | 76[abc] | 79.8[a] | 77[abc] | 6.6[ab] | 6.2[a] | 6.5[ab] |
| LSD (5%) | 4.5 | 7.8 | 3.86 | 0.78 | 0.6 | 0.57 |
| CV (%) | 5.2 | 6 | 5.5 | 11 | 6.3 | 10.2 |

US= urea stable, NU= normal urea, NS = nonsignificant difference at 5% probability level; numbers followed by same letter in the same column are not significantly different at 5% probability level.

Mean spike length of wheat was also significantly (P<0.05) affected by different rate of nitrogen fertilizers (Table 2). Mean spike length measured from similar urea stable fertilizer rate applied once at planting and applied in split was statistically similar. There was also no significant difference among mean spike length recorded from application of similar rate of urea stable and conventional urea. Higher spike length was measured from plots received high rates of nitrogen fertilizer. This could be due to the availability of nitrogen in significant quantity to keep the plant healthy which contributed for normal growth and spike length of wheat. Similarly, statistically significant effects of timing of the N fertilizer application and N fertilizer rate on wheat spike length were reported by [32] in eastern Ethiopia.

#### 3.2.2. Dry Biomass and Grain Yield of Wheat

The mean grain yield of wheat was significantly (P< 0.05) affected by nitrogen rate in irrespective to nitrogen source used in the experiment (Table 3). Higher mean grain yield of (3623

kg ha$^{-1}$) was obtained from application of 69 kg N ha$^{-1}$ from urea stable fertilizer applied in split. Statistically similar grain yield of 3622 kg ha$^{-1}$ was obtained from application of 69 kg N ha$^{-1}$ applied in split in the form of conventional urea. However, [33] reported significant effect of nitrogen rate and sources on grain yield of wheat in Tigray region. Statistically significant effect of application time of urea stable at each similar rate was not observed and this this can be due slow releasing of nitrogen from urea stable fertilizer. Similarly, [32] reported highly significant (P<0.01) influence of N fertilizer rate and time of application on grain yield of wheat in Meta district. Also, [34] also reported significant effect nitrogen fertilizer rate on mean grain yield of wheat crop. Application of nitrogen up to 69 kg N ha$^{-1}$ was significantly (P<0.01) improved wheat grain yield while further increasing of nitrogen above 69 kg N ha$^{-1}$ was significantly reduced wheat grain yield in Enderta district of Tigray region [35].

***Table 3.*** *Effect of urea stable and urea on mean grain yield and dry biomass of wheat in 2018, 2019 cropping season and combined over years.*

| Treatments (Kg N ha^{-1}) | Grain yield (kg ha^{-1}) | | | Dry biomass (kg ha^{-1}) | | |
|---|---|---|---|---|---|---|
| | 2018 | 2019 | Mean | 2018 | 2019 | Mean |
| 0 | 1790[e] | 1682[e] | 1754[e] | 4444[e] | 4803[d] | 4564[f] |
| 46 N from NU. in split | 3000[bc] | 3381[abc] | 3127[bc] | 7148[ab] | 8651[ab] | 7649[bc] |
| 46 N from US. at planting | 2753[cd] | 3000[bc] | 2835[bc] | 6488[cd] | 7556[bc] | 6844[bc] |
| 46 N from US. in split | 2802[cd] | 3317[c] | 2974[bc] | 6840[bc] | 8603[ab] | 7427[bc] |
| 23 N from US. at planting | 2389[d] | 2143[ed] | 2307[d] | 5506[de] | 5286[d] | 5433[ef] |
| 23 N from US. in split | 2636[cd] | 2698[dc] | 2657[cd] | 6136[cd] | 6524[cd] | 6265[de] |
| 69 N from US in split | 3679[a] | 3508[ab] | 3622[a] | 7908[ab] | 8841[ab] | 8219[ab] |
| 69 N from NU in split | 3395[ab] | 4079[a] | 3623[a] | 8469[a] | 9825[a] | 8921[a] |
| 69 N from US at planting | 3086[bc] | 3270[bc] | 3147[ab] | 7006[bc] | 8159[abc] | 7390[bc] |
| LSD (5%) | 547 | 1942 | 482 | 1188 | 744.9 | 977 |
| CV (%) | 16.4 | 14.7 | 17.7 | 15.2 | 14.3 | 14.9 |

Means followed by different letter (s) in a column and rows are significant at 5% level of probability.

The combined mean dry biomass was significantly (P<0.05) affected by nitrogen rate applied from urea stable and normal urea (Table 3) and mean dry biomass of wheat was increased with increasing rate of nitrogen fertilizer. Split application of urea stable (69 kg N ha^{-1}) provided 8921 kg ha^{-1} mean dry biomass. This was statistically at par with mean dry biomass of 8190 and 8219 kg ha^{-1} recorded from split application of 69 kg N ha^{-1} from normal urea and 69 kg N ha^{-1} from urea stable applied at planting. Likewise, [34] reported significant effect of nitrogen fertilizer on mean grain yield of wheat varieties in northern Ethiopia. Application of nitrogen rate up to 69 kg N ha^{-1} was significantly improved the dry biomass of bread wheat and decreased with further increase of applied N fertilizer [35]. Application of similar rates of nitrogen from urea stable and urea was provided statistically similar dry biomass yields. Similarly, [32] reported non-significant effect of normal urea and urea stable on straw yield when applied at similar rate. In contrary, [31] reported significant biomass yield increment by application of urea + inhibitor over application of urea without inhibitor.

### 3.2.3. Harvest Index and Thousand Seed Weight

The mean harvest index and thousand seed weight of wheat due to application of urea stable and conventional urea are indicated in Table 4. Both harvest index and thousand seed weight of wheat crop were significantly (P<0.05) affected by application of different nitrogen rate from urea stable and conventional urea on Vertisols of Ambo district (Table 4). Mean harvest index and thousand seed weight were showed increasing trend with increasing rate of nitrogen from 23 to kg N ha^{-1} 69 kg N ha^{-1} when applied both in form of urea stable and conventional urea. However, the effects of application time of urea stable and nitrogen source were insignificant on both parameters. Similarly, [31] also reported statistically similar influence of normal urea and urea with NBPT on 1000 grain weights and harvest indexes of wheat.

The combined mean harvest index of wheat was ranged 38.3 to 44. 70%. These figures were recorded from plot treated with nothing (0 kg N ha^{-1}) and 69 kg N ha^{-1} from urea stable in split application. Similarly, [36] reported statistically higher harvest index (38%) of bread wheat with application of higher nitrogen fertilizer 150 kg ha^{-1} while the lowest harvest index (34%) was recorded from control (0 kg ha^{-1}). The combined mean thousand seed weight of wheat was ranged 37.2 to 45.2g obtained with control and application of 69 kg N ha^{-1} from conventional urea in split application. [36] recorded higher thousand grains weight (44 and 44 g) of by applying higher levels of nitrogen fertilizer (150 and 125 kg ha^{-1}), whereas the lower thousand grains weight (40g) was recorded from the control treatment. Therefore, applications of urea fertilizer from urea stable and conventional urea were significantly increased mean harvest index and thousand weight of wheat as compared to the control treatment.

***Table 4.*** *Effect of urea stable and conventional urea on mean harvest index and thousand seed weight of wheat in 2018, 2019 cropping season and combined over years in Vertisols of Ambo.*

| Treatment (kg N ha^{-1}) | Harvest Index (%) | | | Thousand seed weight (g) | | |
|---|---|---|---|---|---|---|
| | 2018 | 2018 | Mean | 2018 | 2019 | Mean |
| 0 | 40.0 | 35 | 38.3 | 37.8 | 38.2 | 37.2 |
| 46 N from NU. in split | 41.0 | 38.3 | 40.1 | 45.7 | 40.1 | 43.9 |
| 46 N from US. at planting | 43.8 | 41 | 42.9 | 41.9 | 38.9 | 40.9 |
| 46 N from US. in split | 43.0 | 41.7 | 42.6 | 41.1 | 39 | 40.4 |
| 23 N from US. at planting | 42.7 | 39 | 41.4 | 45.7 | 40.6 | 44 |
| 23 N from US. in split | 42.8 | 39.7 | 41.8 | 45.9 | 39.6 | 43.8 |
| 69 N from US in split | 47.0 | 40 | 44.7 | 46.9 | 41 | 44.9 |
| 69 N from NU in split | 41.2 | 41.3 | 41.2 | 46.5 | 42.4 | 45.2 |
| 69 N from US at planting | 44.5 | 40 | 43 | 46.2 | 39.9 | 44.1 |
| LSD (5%) | NS | 4.02 | 6.3 | 2.02 | 2.3 | 1.68 |
| CV (%) | 18.2 | 5.9 | 16 | 3.9 | 3.3 | 4.2 |

US= urea stable, NU= normal urea, NS = non-significant difference at 5% probability level; numbers followed by same letter in the same column are not significantly different at 5% probability level.

### 3.3. Effects of Urea Stable on Nutrient Use Efficiency of Wheat

#### 3.3.1. Agronomic Nitrogen Efficiency

Agronomic nitrogen efficiency of wheat crop was significantly varied among different rates of urea stable and conventional urea (Table 5). This might be due to increasing of grain yield and biomass with increasing of applied nitrogen rate. The highest (32.77 kg grain kg N$^{-1}$) and lowest (18.53 kg grain kg N$^{-1}$) agronomic nitrogen efficiency was recorded from 23 kg N ha$^{-1}$ applied as urea stable in split and 46 kg N ha$^{-1}$ from urea stable applied at planting in farm one. However, in farm 2 significantly higher 40.8 kg grain kg N applied$^{-1}$ and lower 415.4 kg grain kg N applied$^{-1}$ of

agronomic nitrogen efficiency was obtained from plot treated with 23 kg N ha$^{-1}$ (50 kg ha$^{-1}$ urea stable) applied in split and 46 kg N ha$^{-1}$ or (100 kg ha$^{-1}$ urea stable) applied only at planting. Agronomic nitrogen efficiency was higher at lower nitrogen rate and this indicates efficient use of nutrient by plants when applied in low dose. Similarly, the highest agronomic efficiency nitrogen was reported when lowest nitrogen rate (46 kg N ha$^{-1}$) applied in three splits 1/4 at planting, ½ at tillering and ¼ at anthesis [35]. The apparent nitrogen recovery efficiency of wheat during 2018 cropping season was showed significant (P<0.05) difference among applied urea stable and conventional urea fertilizer rates in farm one and farm two (Table 5).

*Table 5. Effect of urea stable and urea on agronomic, physiological and apparent recovery efficiency wheat on Vertisols in 2018 cropping season.*

| Treatment (kg N ha$^{-1}$) | Agronomic Nitrogen efficiency (kg grain kg N$^{-1}$ applied) | | Apparent nitrogen recovery efficiency (%) | | Physiological nitrogen efficiency (kg grain Kg N$^{-1}$ uptake) | |
|---|---|---|---|---|---|---|
| | Farm1 | Farm 2 | Farm1 | Farm 2 | Farm1 | Farm 2 |
| 0 | - | - | - | - | - | - |
| 46 N from NU. in split | 24.13 | 28.5 | 30.4[e] | 38.1[d] | 0.69[abc] | 0.76[b] |
| 46 N from US. at planting | 19.87 | 22 | 48.1[c] | 65.9[a] | 0.71[ab] | 0.46[bc] |
| 46 N from US. in split | 18.53 | 25.5 | 40.0[cde] | 38.8[d] | 0.49[cd] | 0.72[b] |
| 23 N from US. at planting | 30.6 | 21.5 | 77.4[a] | 58.5[b] | 0.48[cd] | 0.70[b] |
| 23 N from US. in split | 32.77 | 40.8 | 66.3[b] | 37.0[d] | 0.86[a] | 1.37[a] |
| 69 N from US in split | 25.27 | 29.5 | 32.3[de] | 41.6[d] | 0.81[ab] | 0.72[b] |
| 69 N from NU in split | 27 | 19.5 | 36.9[de] | 42.8[cd] | 0.62[bcd] | 0.57[bc] |
| 69 N from US at planting | 22.2 | 15.4 | 41.7[cd] | 49.6[c] | 0.45[d] | 0.33[c] |
| LSD (5%) | 12.6 | 22.6 | 9.61 | 7.3 | 0.216 | 0.3463 |
| CV (%) | 13.75 | 17.34 | 11.77 | 8.92 | 19.34 | 28.41 |

Means followed by different letter (s) in a column are not significantly different at 5% probability level.

#### 3.3.2. Apparent Nitrogen Recovery Efficiency

The mean value of wheat apparent nitrogen recovery efficiency was ranged from 30.4-77.4% in farm one with application of 69 kg N ha$^{-1}$ from urea stable applied in split and 23 N from urea stable applied at planting. In farm two, apparent nitrogen recovery efficiency value ranged from 37 to 65.9% was obtained with application of 23 kg N ha$^{-1}$ from urea stable applied in split and 46 kg N ha$^{-1}$ from urea stable applied at planting. Likewise, [35] was also reported the highest apparent nitrogen recovery efficiency of 75% and 81% in 2013 and 2014 cropping seasons when 69 kg N ha$^{-1}$ applied in split. Apparent nitrogen recovery efficiency of 70 to 131% was also reported by [37, 38]. Similarly, [39] was also reported apparent nitrogen recovery efficiency ranging 53% and 86% by application different nitrogen rates. The apparent nitrogen recovery efficiency values for wheat in a well-managed system or low soil N supply was ranged between 50 - 80 kg kg$^{-1}$ [40].

#### 3.3.3. Physiological Nitrogen Efficiency

The physiological nitrogen efficiency of wheat during 2018 cropping season was showed significant (P<0.05) difference with application of urea stable and conventional urea in both farmers field (Table 5). The value of wheat physiological efficiency was ranged from 0.45 to 0.86 and 0.33 to 1.37 kg grain kg$^{-1}$ N uptake at farm one and two

respectively. In both farmers field the highest and lowest values were obtained with application of 69 kg N ha$^{-1}$ from urea stable applied at planting and 23 kg N ha$^{-1}$ from urea stable applied in spilt respectively. Similarly, [35] reported the physiological utilization efficiency of 55 and 78 kg of grain kg$^{-1}$ of N uptake in 2013 and 20014 cropping seasons where 46 kg N ha$^{-1}$ applied in three splits 1/4 at planting, ½ at tillering and ¼ at anthesis. [41] pointed out that there was a significantly N utilization efficiency and N use efficiency for grain yield when N was applied ¼ at planting, 1/2 at mid-tillering, and 1/4 at anthesis. [34] also reported significant effect nitrogen fertilizer on mean nitrogen use efficiency of wheat varieties and NUE. According to the authors NUE of wheat crop was decreased to almost half as the amount of N fertilizer increased from 50 to 100 kg ha$^{-1}$.

## 4. Conclusion

The total nitrogen content of the experimental site was found in low range and indicated the need for application of nitrogen fertilizer from different sources. The applications of urea stable and conventional urea were significantly improved growth yield and yield components of wheat as compared to control. Mean plant height, spike length harvest index and thousand seed weight of wheat was significantly affected by nitrogen rate and increased with increasing of nitrogen rate applied from urea stable and conventional urea.

Higher mean grain yield of 3623 kg ha$^{-1}$ and 3622 kg ha$^{-1}$ were harvested by application of 69 kg N ha$^{-1}$ in the form of urea stable and conventional urea respectively. The combined mean dry biomass of wheat was significantly improved with application of nitrogen rate and increased with increasing rate of nitrogen fertilizer. The highest (8921 kg ha$^{-1}$) and lowest (4564 kg ha$^{-1}$) mean dry biomass were recorded from split application of 69 kg N ha$^{-1}$ in the form of urea stable and control treatment respectively. Thus, the application of equal rate of urea stable in split or at planting was provided statistically the same yield and yield components of wheat crop with split application of conventional urea. In general, significant effect of application time of urea stable at each similar rate was not observed and this can be due to slow releasing of nitrogen from urea stable fertilizer. Therefore, urea stable can be used as alternative in addition to conventional urea if the cost of this fertilizer is the same with convectional urea.

## Acknowledgements

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