Effects of Nitrogen on Yield and Nitrogen Efficiency of Silage Corn Hybrid SC. 604 at Different Plant Density

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ABSTRACT
This research was conducted to study the effects of nitrogen application rates, and plant densities on, nitrogen agronomic efficiency, nitrogen use efficiency and nitrogen recovery fraction of grain corn (hybrid SC.604) in 2007 in experimental field of Agricultural college, of Urmia University, Iran. Three nitrogen rates consisting of 100, 200 and 300 kg N ha⁻¹ were chosen as main plots, and three plant densities consisting of 75, 85 and 95 thousands plant ha⁻¹ as sub plots. The results showed that the effect of plant density and nitrogen on grain, biological and protein yield and harvest index was significant. The increase of nitrogen application rate caused significant increase in grain, biological and protein yield and harvest index. The response of grain and protein yield and harvest index to increase in plant density was negative. The results showed that nitrogen agronomic efficiency was higher in plant density of 95 thousand plants with application of 100 kg N ha⁻¹ and Nitrogen use efficiency and nitrogen recovery fraction was higher in 75 thousand plants ha⁻¹ with application of 100 kg N.

Keywords: Nitrogen, Plant density, Corn, Nitrogen efficiency, Protein yield, Nitrogen recovery

INTRODUCTION
To provide demanding N of plant with the optimal application of N chemical fertilizer and to study the amount of their effectual consumption were so important especially with consider to increase expense costly of production and transportation and environmental pollution, resulting from their incorrect application (Hamidi and Dabagh Mohamadinasab, 1996). While the increase of chemical fertilizers application were very quick in Iran (2500000 ton per year) recently. Also in the 15 last years, in addition to local products, it is get out more than 2 billion dollars to provide chemical fertilizers at country. Unfortunately at this time, not only the increase yield of agricultural products were not proportional with the increase use of chemical fertilizers, but also in relation to some of the crops, for different reasons such as the lack of water, watering method, weakness scientific information of farmers and directions to use fertilizer and etc, yield had no much increasing yet (Malakouti, 2001).

Uhart and Andrade (1995) stated that the lack of N is caused to decrease corn grain yield through decreasing number and weight of grains. To determine the amount of N application is considered as the most effective factors on N use efficiency (Norwood, 2000). Cox et al. (1997)
observed that dry matter of the corn silage is increased by increasing the rate of applied N. Sadeghi and Bahrami (1998) and Gungula et al. (2005) stated that dry weight of corn increased by increasing of N, and the least amount of ear obtained in the least level of N. Reddy and Swamy (1987) and Al-Kaisi et al. (2007) reported that high fertility of soil with N caused to increase biological yield, grain yield, harvest index and 1000-grains weight. This result of harvest index is supported by achievement of Colloud, 1997. Choogan (1996) reported that increase use of N fertilizer in the corn silage caused to increase the forage production quality through increasing of grain yield and protein.

One of the important factors for obtaining maximum yield in the corn is determining of suitable density with consider to environmental condition and variety characteristics. Increase of plant density is caused to increase yield, because the level of photosynthesis becomes higher, and plants are reached to 95% absorption of light. However, with a high plant density, photosynthesis, leaf area and ability of forage production decrease because of mutual shading in the plant (Larson and Hanway, 1977).

Genter and Camper (1973) about effect of plant density (44830, 52150, 58130, 65150 and 72920 plant ha-1) concluded that by increasing of density, grain yield decreased. In cereal, the highest plant density that produces the greatest biomass, it has maximum efficiency in view of consumption of solar energy.

Cuomo et al. (1998) concluded that with increasing of density, the biological yield increased, but the grain yield decreased. Cox and Cherny (2000) stated that forage protein yield decreased by increasing of plant density. Decreasing of corn organs weight with increasing of plant density is reported by Poursuof et al. (1999) too. Increase of plant density because of competition among plants for light and water, more than usual, it caused to produce a little amount of grain in corn (Hashemi-Dezfouli and Herbert, 1996).

Use efficiency of fertilizer is indexed for evaluation the amount of effectual of fertilizers to produce a yield (Malakouti, 2001).

Sisson et al. (1988) during their studies about the effect of the amounts of N use on tobacco observed that N use efficiency of leaf decreased with increasing the used N. Raun and Johnson (1999) observed that N use of wheat grain decreased by increasing the applied N. Ezatamadi et al (1996) reported that N agronomic efficiency in wheat decreased by increasing application of N.

Hamidi and Dabagh Mohamadinasab (1996) concluded that the most amount of N agronomic efficiency obtained in the most density.

This research was carried out to study the effect of different N rates and plant density on corn yield, increasing N use efficiency and using new approaches derived from this study.

**MATERIALS AND METHODS**

This study was carried out during spring and summer, in 2007, at the research farm of Agricultural Faculty, Urmia University (45° 5' N, 37° 32' W). The results of soil analysis are shown in Table 1. The experiment was laid out in Randomized Complete Block Design (RCBD) with a split plot arrangement in four replications. N treatment (100, 200 and 300 kg ha⁻¹) as Urea was in main-plots, while plant densities (75000, 85000 and 95000 plants ha⁻¹) were allocated at random in the sub-plots. Half of N fertilizer added at the time of planting, while remaining half dose of N was applied at side dressing after thinning. There was no need to use Phosphorus and Potassium with consider to results of soil experiment. Each sub-plot consisted of six
rows 7 m long and 0.75 m apart. To prevent water seepage considered 2 m distance between two main- plots. In the each of the block considered one stream for the watering, and one stream for drainage by ditches. Corn grains were sown at a 5 cm depth with 3 seeds per hill on the 19th of May 2007.

Thinning was practiced at 4-6 leaf stage. Hand weeding was practiced to control weeds. Standards cultural practices were carried out until the harvesting time.

The harvest area of each plot was 7 m². Ten plants were chosen randomly from each treatment in the four replicates. Harvesting done when the grain had 40% moisture, and stems and leaves were fresh. Leaf weight, stem and sheath weight, tassel weight and ear weight was determined by drying in the Oven for 72 hr in 70°C temperature according to (Choogan, 1996; Hamidi and Dabagh Mohamadinasab, 1996). Forage samples were collected from plants for each treatment in each plot and then ground in a Willy mill. Sample analyzed for crude protein. Crude protein of forage was calculated by Kejeldal method. To calculated N agronomic efficiency, N use efficiency and N recovery fraction is used from following formulas.

\[
\text{NUE} (\text{kg} \text{kg}^{-1}) = \frac{\text{Yg}}{\text{N}}
\]

\[
\text{NAE} (\text{kg} \text{kg}^{-1}) = \frac{\text{Yg1} - \text{Yg2}}{\text{N}}
\]

\[
\text{NRF} (\text{kg} \text{kg}^{-1}) = \frac{\text{N}}{\text{N1} - \text{N0}}
\]

NUE: N use efficiency; Yg: Yield of grain; N: applied N; NAE N agronomic efficiency; Yg1: Yield of grain with applied N; Yg2: Yield of grain in control treatment with no nitrogen; NRF: N recovery fraction; N1: absorbed N for N treatments; N0: absorbed N for No treatment

The data were analyzed using MSTAT-C software. Regression analysis was used to examine the relationship between various characteristics. The comparison of treatment means was made using the Duncan's test.

RESULTS

Grain yield

Table 2 shows that the effect of N levels, plant density and N levels, plant density interaction on grain yield was significant. The grain yield increased by increasing the applied N rate (Table 3). So that the least amount of grain yield was obtained with control treatment (2.32 ton ha⁻¹) and the most amount of that was obtained with the highest N application (5.522 ton ha⁻¹).

Increasing of plant density caused to decrease grain yield significantly (Table 4). In this research, the single plant grain yield decreased by increasing the plant density. So that increasing of plant density could not be able to compensate this decreasing. The least amount of grain (3.735 ton ha⁻¹) and the most amount of that (4.141 ton ha⁻¹) observed with 95000 and 75000 plants ha⁻¹ respectively.

Related amounts to the interaction showed that the highest grain yield is obtained by the most applied N rate and plant density of 75000 plants ha⁻¹ (Table 5).

Biological yield

Biological yield be affected N levels, plant density and N levels, plant density interaction at 1% probability level (Table 2). Biological yield increased by increasing the applied N rate (Table 3). So that the least amount of biological yield (57.85 ton ha⁻¹) with control treatment, and the most amount of that (94.12 ton ha⁻¹) with 300 kg treatment produced.
Biological yield increased by increasing plant density (Table 4). The least amount of biological yield with 75000 plant ha\(^{-1}\) and the most amounts of that with density of 95000 plants ha\(^{-1}\) was observed with means of 75.41 and 82.39 ton ha\(^{-1}\), respectively.

Comparison of interaction means showed that at a high level of N consumption, with increasing the number of plant, it is compensated the decreasing of single-plant weight and it increased the biological yield (Table 5).

**Harvest index**

The effect of N consumption, plant density and N levels, plant density interaction on harvest index were significant at 1% probability level (Table 2). Harvest index decreased by increasing the applied N rate (Table 3). The least amount of harvest index (16.82) obtained with the least amount of plant density, and the most amount of that (22.77) observed with the highest plant density. In this research, with increasing of N applied, the mean of biological yield and grain yield increased 13 and 63%, respectively. That, this caused to increase harvest index by increasing the applied N rate.

Comparison of harvest index means in the plant densities showed that increasing of plant density cause to decrease harvest index (Table 4). The least amount of harvest index (17.48) obtained with the least amount of plant density, and the most amount of that (21.15) observed with the highest plant density. In this research, grain yield decreased by increasing the plant density to the amount of 10%, while the biological yield increased to the amount of 10%. That, this result caused to decrease harvest index by increasing the plant density.

The statistical analysis of the data showed that there were significant differences in harvest index due to different N levels, plant density interactions (Table 2). The highest harvest index was with the plant density of 75000 and consumption of 300 kg N ha\(^{-1}\) (Table 5).

**Protein yield**

Protein yield be affected by N rates and plant density at 1% probability level significantly (Table 2). Protein yield increased by increasing the applied N rate (Table 3). The most amount of protein yield (2.02 ton ha\(^{-1}\)) obtained with consumption of 300 kg N, whereas the lowest protein yield (0.582 ton ha\(^{-1}\)) observed with the lowest rates of N fertilizer.

Mean of protein yield with increasing of the plant density from 75000 to 85000 plants ha\(^{-1}\) did not decreased significantly. But protein yield decreased significantly by more increasing of plant density to 95000 plants ha\(^{-1}\), so that the lowest amount of protein yield (1.36 ton ha\(^{-1}\)) observed in the highest level of plant density (Table 4).

**N agronomic efficiency and N use efficiency**

N agronomic efficiency is defined as simple index and suitable standard for the purpose of study of N efficiency under the farm condition. N use efficiency was considered as grain yield to the applied N rate ratio too. Also it is considered as the main factor in management of N in crop production (Moll et al., 1982). The effect of N rates on N agronomic efficiency and N use efficiency was significant at 1% probability level (Table 2). The highest and the lowest amount of N agronomic efficiency and N use efficiency obtained with consumption of 100 and 200 kg N ha\(^{-1}\), respectively (Table 3).
Increase of plant density from 75000 to 85000 plants ha\(^{-1}\) caused to increase N agronomic efficiency significantly. While, more increasing of plant density to 95000 plants ha\(^{-1}\) did not show any significant increasing (Table 4). N use efficiency decreased significantly by increasing of plant density. So that the highest amount of N use efficiency observed with plant density of 75000 and the lowest amount of that obtained with 95000 plants ha\(^{-1}\).

N rates, plant density interaction was significant on N agronomic efficiency and N use efficiency (Table 2). The most amount of N agronomic efficiency was determined with consumption of 100 kg N ha\(^{-1}\) and plant density of 95000, and had not any significant difference with 85000 plant ha\(^{-1}\) (Table 5).

The most amount of N use efficiency was observed with application of 100 kg N ha\(^{-1}\) and plant density of 75000 (Table 5). That had not any significant difference with 85000 plant ha\(^{-1}\).

**N recovery efficiency**

N recovery efficiency defines according to the absorbed nutrient rate in lien of per unit of used nutrient rate. In this research, increasing of the applied N rate caused to decrease significant N recovery efficiency (Table 3). Decreasing of N recovery efficiency with increasing the applied N resulted from the fixed absorption capacity of N by plant.

N recovery efficiency decreased significantly by increasing of plant density (Table 4). That, in this research it appears the reason is significant decreasing of grain yield with increasing of plant density.

N rates, plant density interaction on N recovery efficiency became significant at 1% probability level (Table 2). Interaction effect mean showed that the negative effect of increasing of plant density on N recovery efficiency. So that in condition of using the 100 kg N ha\(^{-1}\) is more than application of 200 and 300 kg N ha\(^{-1}\) (Table 5).

**Relationship between all the trait**

The correlation among all pairs of variables is given in Table 6. The simple coefficient calculated from the data indicated that whole of the traits, except the harvest index and N agronomic efficiency had a significant effect on the biological yield. Biological yield had the highest correlation (0.961**) with crude protein yield; also, the grain yield (p=0.01), N use efficiency (p=0.01) and N recovery efficiency (p=0.05) had significant correlation with the biological yield. The grain yield showed a weak negative correlation with N agronomic efficiency (r = - 0.227). The grain yield had the highest correlation (0.950**) with the crude protein yield. The harvest index showed a weak negative correlation with the N agronomic efficiency (r = - 0.465). The harvest index had the highest correlation (0.965**) with the N recovery efficiency.

**DISCUSSION**

N provides needed matter for growth of vegetative organs and ear by increasing of photosynthetic activity (Hamidi and Dabagh Mohamadinasab, 1996). Nitrogen stress delays silking, increases the internal between anthesis and silking and decreases the duration of grain filling by 3-4 days and reduces skin capacity and grain yield of corn (Jahansooz, 1991).

Increased grain yield due to application of high N were reported by other researchers (Griesh and Yakout, 2001). High N rates can promote leaf area development during vegetative development and it can help maintain functional leaf area during the growth period (Cox and Cherny, 1997). They can also increase the rate of dry matter
accumulation during the grain filling period (Tollenaar et al., 1997).

Increasing of plant density cause to decrease available light in the canopy of corn and so it is decrease the photosynthesis and crop growth rate (Malakouti, 2001). In high densities, available light and photosynthetic matter decrease. That this cause to lack of formation and evolution of upper ear grains and it cause to decrease grain yield (Hamidi and Dabagh Mohamadinasab, 1996). Result of this research is similar to the result of Genter and Camper (1973).

High ability of corn is very important in applying more N, and probably this returns to C4 photosynthesis system. Increasing of N cause to increase LAI (leaf area index) and LAD (leaf area duration). This increasing cause to produce more carbohydrates, dry matter and higher yield (Ezatahmadi et al., 1996). Decreasing of biological yield in a little rate of applied N is reported by Girardin et al (1987) too. Maximum biological yield is obtains in density which each of the plants can not reach to their maximum dry weight. It may be due to the lower amounts of metabolites in leaves as a result of high competition for light, water and minerals (Koocheki, 1997). Also, positive effect of increasing of plant density on biological yield reported by Akintoye et al., (1997).

The most important components of corn are the grain for saving N and protein, consequently. In this research, considering to the significant increasing of grain yield with increasing of the applied N rate, the highest protein yield was conform to the most grain yield.

One of the factors of forage quality evaluation is forage protein. The amount of protein in the forage depends on different factors such as the kind of plant, the age of plant, the amount of N fertilizer, etc. In addition to this, environmental conditions and plant density be affected on forage protein too. In the high densities, the applied N was distributing among the more plant number that it caused to decrease protein yield in higher density (Ordas and Stucker, 1977).

Grove et al. (1980) and Berenguer et al. (2009) stated that with increasing of fertilizer consumption, the amount of grain yield had the less increase, following the law of Micherlikh deduction efficiency. That, this condition caused to decrease efficiency of fertilizer consumption. Goodroad and Jellum (1988) defined the reason of this decreasing, excess speed to be lost the mentioned element via sublimation, denitification, leaching, or the lack of effective use of that. Greef (1994) stated that corn is not able to profit by the potential benefits of C4 mechanism and not able to use N, at the time of using the rates that are higher than N optimal.

Table 1. Physical and chemical analysis of the soil in experimental site

<table>
<thead>
<tr>
<th>Sand (%)</th>
<th>Silt (%)</th>
<th>Clay (%)</th>
<th>Soil texture</th>
<th>pH</th>
<th>EC</th>
<th>N (Total) %</th>
<th>P Available (ppm)</th>
<th>K Available (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.9</td>
<td>44.6</td>
<td>42.5</td>
<td>Clay loam</td>
<td>7.5</td>
<td>1.37</td>
<td>0.02</td>
<td>29.88</td>
<td>355.19</td>
</tr>
</tbody>
</table>

www.SID.ir
Table 2. Mean square values in the analysis of variance for different characteristics

<table>
<thead>
<tr>
<th>S.O.V</th>
<th>df</th>
<th>Biological yield</th>
<th>Grain yield</th>
<th>Harvest index</th>
<th>Crude protein yield</th>
<th>N agronomic efficiency</th>
<th>N use efficiency</th>
<th>N recovery efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replication</td>
<td>3</td>
<td>43.184**</td>
<td>0.543**</td>
<td>0.475**</td>
<td>0.088**</td>
<td>19.818**</td>
<td>2.673**</td>
<td>0.096**</td>
</tr>
<tr>
<td>Nitrogen (N)</td>
<td>3</td>
<td>2173.655**</td>
<td>15.428**</td>
<td>57.223**</td>
<td>3.596**</td>
<td>3915.688**</td>
<td>169.489**</td>
<td>24.647**</td>
</tr>
<tr>
<td>Ea</td>
<td>9</td>
<td>0.943</td>
<td>0.008</td>
<td>0.033</td>
<td>0.003</td>
<td>6.176</td>
<td>0.277</td>
<td>0.614</td>
</tr>
<tr>
<td>Plant density (D)</td>
<td>2</td>
<td>147.958**</td>
<td>0.495**</td>
<td>40.629**</td>
<td>0.083**</td>
<td>261.616**</td>
<td>218.8**</td>
<td>1.498**</td>
</tr>
<tr>
<td>N*D</td>
<td>6</td>
<td>8.829**</td>
<td>0.012**</td>
<td>2.596**</td>
<td>0.01 Ns</td>
<td>124.371**</td>
<td>845.4**</td>
<td>0.997Ns</td>
</tr>
<tr>
<td>Eb</td>
<td>24</td>
<td>0.385</td>
<td>0.016</td>
<td>0.359</td>
<td>0.009</td>
<td>6.268</td>
<td>0.213</td>
<td>0.798</td>
</tr>
<tr>
<td>CV %</td>
<td></td>
<td>0.71</td>
<td>3.25</td>
<td>3.12</td>
<td>6.66</td>
<td>2.601</td>
<td>3.548</td>
<td>2.202</td>
</tr>
</tbody>
</table>

ns, *, **: Non-significant, significant at 5% and 1% probability levels, respectively.

Table 3. Yield and nitrogen efficiency of corn silage as affected by N rates

<table>
<thead>
<tr>
<th>N (kg ha⁻¹)</th>
<th>Biological yield (ton ha⁻¹)</th>
<th>Grain yield (ton ha⁻¹)</th>
<th>Harvest index</th>
<th>Crude protein yield (ton ha⁻¹)</th>
<th>N Agronomic efficiency (kg kg⁻¹)</th>
<th>N Use efficiency (kg kg⁻¹)</th>
<th>N Recovery efficiency (kg kg⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>78.59 c</td>
<td>3.882c</td>
<td>18.46c</td>
<td>1.414c</td>
<td>7.187a</td>
<td>38.8a</td>
<td>69.58a</td>
</tr>
<tr>
<td>200</td>
<td>85.96b</td>
<td>4.047b</td>
<td>18.83b</td>
<td>1.796b</td>
<td>3.971c</td>
<td>20.24c</td>
<td>51.65b</td>
</tr>
<tr>
<td>300</td>
<td>94.12a</td>
<td>5.522a</td>
<td>22.77a</td>
<td>2.02a</td>
<td>4.9b</td>
<td>27.24b</td>
<td>41.47c</td>
</tr>
</tbody>
</table>

Means with similar letter in each column are not significantly different at the 0.05 and 0.01 probability level according to Duncan.

Table 4. Yield and nitrogen efficiency of corn silage as affected by plant densities.

<table>
<thead>
<tr>
<th>Density (Plant ha⁻¹)</th>
<th>Biological yield (ton ha⁻¹)</th>
<th>Grain yield (ton ha⁻¹)</th>
<th>Harvest index</th>
<th>Crude protein yield (ton ha⁻¹)</th>
<th>N Agronomic efficiency (kg kg⁻¹)</th>
<th>N Use efficiency (kg kg⁻¹)</th>
<th>N Recovery efficiency (kg kg⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>75000</td>
<td>75.41 c</td>
<td>4.141 a</td>
<td>21.15 a</td>
<td>1.520 a</td>
<td>56.42a</td>
<td>5.02b</td>
<td>29.95a</td>
</tr>
<tr>
<td>85000</td>
<td>79.59 b</td>
<td>3.952 b</td>
<td>19.03 b</td>
<td>1.479 a</td>
<td>55.05b</td>
<td>5.502a</td>
<td>28.67b</td>
</tr>
<tr>
<td>95000</td>
<td>82.39 a</td>
<td>3.735 c</td>
<td>17.48 e</td>
<td>1.360 b</td>
<td>51.22c</td>
<td>5.536a</td>
<td>27.65c</td>
</tr>
</tbody>
</table>

Means with similar letter in each column are not significantly different at the 1% probability level according to Duncan.

Table 5. Yield and nitrogen efficiency of corn silage as affected by N rates and plant densities.

<table>
<thead>
<tr>
<th>N (kg ha⁻¹)</th>
<th>Density (Plant ha⁻¹)</th>
<th>Biological yield (ton ha⁻¹)</th>
<th>Grain yield (ton ha⁻¹)</th>
<th>Harvest index</th>
<th>Crude protein yield (ton ha⁻¹)</th>
<th>N Agronomic efficiency (kg kg⁻¹)</th>
<th>N Use efficiency (kg kg⁻¹)</th>
<th>N Recovery efficiency (kg kg⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>75000</td>
<td>73.42 f</td>
<td>4.01 f</td>
<td>19 cd</td>
<td>0.48a</td>
<td>6.47b</td>
<td>41a</td>
<td>75.2a</td>
</tr>
<tr>
<td>200</td>
<td>85000</td>
<td>81.4 e</td>
<td>3.9 g</td>
<td>18 de</td>
<td>0.47a</td>
<td>7.44a</td>
<td>40a</td>
<td>70.08b</td>
</tr>
<tr>
<td>300</td>
<td>95000</td>
<td>89.3 c</td>
<td>3.8 h</td>
<td>18.06 e</td>
<td>0.44a</td>
<td>4.73c</td>
<td>19d</td>
<td>41.64f</td>
</tr>
</tbody>
</table>

Means with similar letter (s) in each column are not significantly different at the 1% probability level according to Duncan.
Table 6. Correlation coefficients among different characteristics.

<table>
<thead>
<tr>
<th></th>
<th>Nitrogen</th>
<th>Plant density</th>
<th>Biological yield</th>
<th>Grain yield</th>
<th>Harvest index</th>
<th>Crude protein yield</th>
<th>N agronomic efficiency</th>
<th>N use efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biological yield</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grain yield</td>
<td>0.936**</td>
<td>0.898**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Harvest index</td>
<td>0.902**</td>
<td>-0.854**</td>
<td>0.918**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crude protein yield N agronomic efficiency</td>
<td>0.815**</td>
<td>-0.765**</td>
<td>0.560</td>
<td>0.813**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crude protein yield N use efficiency</td>
<td>0.875**</td>
<td>-0.852**</td>
<td>0.961**</td>
<td>0.950**</td>
<td>0.703*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N recovery efficiency</td>
<td>-0.617</td>
<td>-0.998**</td>
<td>-0.492</td>
<td>-0.227</td>
<td>-0.465</td>
<td>-0.752*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.691</td>
<td>0.894**</td>
<td>-0.821**</td>
<td>-0.609</td>
<td>-0.587</td>
<td>-0.866**</td>
<td>0.886**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.988**</td>
<td>-0.932**</td>
<td>-0.754*</td>
<td>-0.660</td>
<td>-0.965**</td>
<td>-0.870**</td>
<td>0.705*</td>
<td>0.949**</td>
</tr>
</tbody>
</table>

ns, *, **: Non- significant, significant at 5% and 1% probability levels, respectively.

**CONCLUSION**

The results indicated that in the high amount of N application, increasing of plant density could not cause to increase N efficiency. Because high N applied caused to increase growth and so the less N be consumed to produce the grain. In other words, the application of equilibrant N rates was effective more than plant density. Considering to the result, it can state that due to the important effect of plant density and the applied N rate on N use efficiency, for preventing from leaching, denitrification, sublimation and environmental problems must consider determining suitable density and applied N rate.

**REFERENCES**


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