



RESEARCH PAPER

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Sustainable production of new released wheat cultivars by using urea plus nitragin as a biofertilizer

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Abstract

In order to improvement of nitrogen use efficiency in two winter wheat (*Triticum aestivum* L.) cultivars using chemical nitrogen and biofertilizer an experiment was conducted with nitrogen rate (0, 33, 67, 100 kg ha⁻¹ urea), seed biofertilization with nitragin and wheat cultivars (Kascogen and Augusta). Results showed that with increasing of urea application number of fertile tillers per plant improved. In biofertilized seeds thousand seed weight of wheat cultivars was reduced up to 3.8 g. Kascogen produced 19.5% higher yield than Augusta. Seed biofertilization increased grain yield of wheat up to 14% and 6% in Kascogen and Augusta, respectively, compared with control. In those treatments that seeds were sown after biofertilization, yield improved at lower urea rates. Increasing of urea application from 67% to 100% of recommended dose was caused a reduction of 91 and 70 kg ha⁻¹ in yield of studied cultivars, while, in non-biofertilized seeds application of full dose of urea improved yield up to 125 and 99 kg ha⁻¹, respectively in cultivars. Biofertilization could increase harvest index of wheat from 37% to 39.8%. In experiment environmental condition using seed biofertilization before sowing wheat farmers can improve yield of wheat, reduce urea application up to 33% of recommended dose and improve nitrogen use efficiency.

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Introduction

One of the major essential elements for growth of plants is nitrogen. Nitrogen is required in large quantities for plants to grow, since it is the basic constituent of proteins and nucleic acids. Nitrogen is provided in the form of synthetic chemical fertilizers. Such products pose a health hazard and microbial population problem in soil besides making the cost of production high. Wheat farmers in Iran usually apply higher dose of nitrogen fertilizer ($>100 \text{ kg ha}^{-1}$). In such a situation the biofertilizers play a major role (Karimi, 2007).

Biofertilizers are the formulation of living microorganisms, which are able to fix atmospheric nitrogen in the available form for plants (Subba Rao, 1993; Chen, 2006). Biological activities are markedly enhanced by microbial interactions in the rhizosphere of plants (Tilak & Reddy, 2006). There are number of microbial inoculants like *Azospirillum* and *Azotobacter* used as nitrogen-fixing organisms (diazotrophs), capable of forming an associative relationship with the roots of several economically important cereals under field inoculation (Vande Broek & Vanderleyden, 1995), which have been given much attention as they are responsible to plant growth and yield of cereal crops (Karimi, 2007).

Using biofertilizers has led to a decrease in the use of chemical fertilizers and has provided high quality products free of harmful agrochemicals. Use of biofertilizers on soils decreases the pH, which leads to increased availability of microelements that enhance plant growth (Mahfouz and Sharaf-Eldin, 2007). *Azospirillum* promotes plant growth (Cohen *et al.*, 2007), but the exact mechanism of plant promotion has not been fully characterized (Dommelen *et al.*, 1998).

Beneficial effects of organic fertilizers application on growth and yield of millet was shown by El-Kholy and Gomaa (2000). Beneficial effect of *Azotobacter* on wheat yield has been reported 7-39% (Ram *et al.*, 1999). Seed biofertilization with *Azospirillum* causes a significant increase in yield and nitrogen use

efficiency of rice (Malik *et al.*, 2002). Rai and Gaur (1998) resulted that grain yield of wheat in control, seed treatment with *Azospirillum*, *Azotobacter* and both of them were 17.7, 17.8, 25.7 and 25.8 g pot⁻¹. Kandeel *et al.* (2002) found that dual inoculation with symbiotic N₂ fixers (*Azotobacter* and *Azospirillum*) increased plant height, number of branches per plant and dry weight of *Ocimum basilicum*. In another experiment using phosphorous solubilizing microorganisms was concluded that when seeds were sown after biofertilization with *Pseudomonas fluorescens* and *Bacillus megaterium*, soluble phosphorous in soil improved and wheat yield increased 6.5% (El-Komy, 2005).

Wheat nutrition management in Iran heavily relies on application of chemical fertilizers. The main objective of this research was improvement of nitrogen use efficiency in two winter wheat cultivars using chemical nitrogen and biofertilizer as a biological nitrogen management strategy.

Materials and methods

Field experiment was carried out during 2008 at Tabriz (Lat. 38°, 5'; Long. 46°, 17' and elevation 1360 m) on wheat (*Triticum aestivum* L.). Tabriz is located in the north-west of Iran and the climate is semiarid and cold; in spite of dispersed precipitation in summer, it's arid and average annual precipitation is 270 mm. Average annual temperature; average maximum and minimum annual temperatures have been reported 10, 16 and 2.2 °C, respectively. The soil was a sandy-loam with EC of 0.68 ds m⁻¹ and pH of 7.7. The research field was ploughed in early autumn, manured with 10 t ha⁻¹, and then disked. Application dose of fertilizers was based on soil analysis.

A factorial experiment was established in a randomized complete block design with three replications and three factors including nitrogen rate (0, 33, 67, 100 kg ha⁻¹ urea), seed biofertilization with nitragin and wheat cultivars (kascogen and agusta). Nitragin as a biofertilizer contains nitrogen-fixing microorganisms such as *Azospirillum* and

Azotobacter, that has been isolated from regional soils.

Plots were 3 by 3-m and each plot consisted of 20 wheat rows spaced 15-cm apart. The seeds were pre-inoculated with biofertilizer and hand sown on early-October. Throughout the growing season, all plots were hand weeded to remove narrow and broad leaf

species. Also, the plots were top-biofertilized with nitragin simultaneously to irrigation. Studied variables in the experiment were number of tillers and fertile tillers per plant, thousand seed weight, grain yield, biomass, harvest index and agronomic nitrogen use efficiency (ANUE) based on equation 1 (El-Komy, 2005).

Seed yield in N₂ - Seed yield in N₁ equation (1)
 ANUE = $\frac{\text{Seed yield in N}_2 - \text{Seed yield in N}_1}{\text{Seed treatment with nitragin of tillers only in Kascogen by 31\%, when compared with control (Fig. 1). Response of wheat cultivars to seed treatment with microorganisms is different (Singh et al., 2004). With increasing of urea dose up to 67 kg ha}^{-1}$ number of tillers per plant improved, significantly (Fig. 2).

Results and discussion

Number of tillers per plant

Interaction of cultivar×biofertilizer on number of tillers per plant of wheat was significant (Table 1).

Table 1. Variance analysis of effects of chemical nitrogen and biofertilizer on studied variables in wheat cultivars.

| SV | Df | Number of tillers per plant | Number of fertile tillers per plant | Thousand seed weight | Grain yield | Biomass | Harvest index |
|--------|----|-----------------------------|-------------------------------------|----------------------|-----------------------|-----------------------|---------------------|
| R | 2 | 32.13* | 29.00** | 48.11** | 526.35 ^{ns} | 1800.48 ^{ns} | 80.00** |
| V | 1 | 30.00* | 45.96** | 4.58 ^{ns} | 3600.05** | 1998.41 ^{ns} | 80.88** |
| B | 1 | 25.89* | 29.00* | 46.36** | 2002.41* | 2805.01 ^{ns} | 142.00** |
| V×B | 1 | 60.30** | 34.85** | 16.25 ^{ns} | 529.11 ^{ns} | 2924.24 ^{ns} | 58.34 ^{ns} |
| F | 3 | 40.34** | 72.04** | 8.22 ^{ns} | 900.19 ^{ns} | 5908.14** | 80.58** |
| V×F | 3 | 20.20 ^{ns} | 9.05 ^{ns} | 10.10 ^{ns} | 1700.00 ^{ns} | 2025.24 ^{ns} | 40.00 ^{ns} |
| B×F | 3 | 11.84 ^{ns} | 18.99 ^{ns} | 5.24 ^{ns} | 3311.91** | 2485.00 ^{ns} | 45.88 ^{ns} |
| V×B×F | 3 | 17.25 ^{ns} | 118.24 ^{ns} | 12.15 ^{ns} | 2133.12* | 984.44 ^{ns} | 13.29 ^{ns} |
| E | 30 | 8.34 | 9.34 | 8.18 | 618.54 | 1000.14 | 19.58 |
| CV (%) | - | 18.89 | 20.48 | 8.99 | 20.25 | 26.01 | 14.44 |

*, **, ns significant at 5%, 1% and non-significant, respectively.

V, B, F indicate cultivar, biofertilizer and fertilizer, respectively.

Kascogen had higher fertile tillers than Agusta. In biofertilized seeds fertile tillers per plant with 17% increasing value reached from 2.3 in control to 2.7. With increasing of urea dose fertile tillers per plant improved, significantly, but there was no significant difference between 67 and 100 kg ha⁻¹ urea levels (Fig. 3). Son *et al.* (2005) has emphasized on negative effect of higher nitrogen rate on fertile tillers. It seems that with increasing of urea rate vegetative growth improves and tillering in wheat influence by

reduction of light transmission in lower parts of canopy especially on crown.

Thousand seed weight

When wheat seeds were sown after biofertilization, thousand seed weight tolerated a reduction of 4 g and reduced from 54 to 50 g that was not unexpected with attention to increasing of tillers and seeds per plant with biofertilization. This is in agreement with Okon and Labandera-Gonzalez (1994) studies.

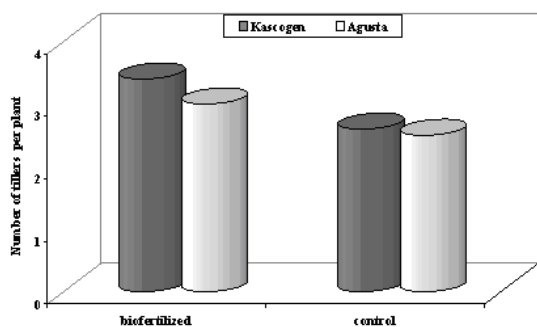


Fig. 1. Effect of seed biofertilization on number of tillers per plant.

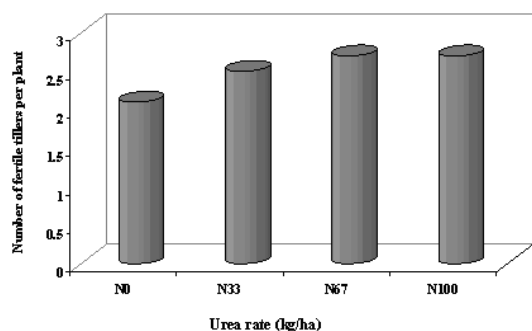


Fig. 2. Effect of urea rate on number of fertile tillers per plant.

Grain yield

Kascogen produced 19.5% higher yield than Agusta. Nitragin treatment increased yield in Kascogen and Agusta cultivars up to 14% and 6%, respectively (Fig. 4 and 5). Azospirillum promote plant growth and improve crop yield resulting from higher water and nutrient absorption (Tilak *et al.*, 2005). In the study of Dobbelaere *et al.* (2002) seed inoculation with *A. irakense* and *A. brasilense* increased root improvement and grain yield of spring wheat and corn. Afzal *et al.* (2005) have reported same results on *P. fluorescens* and *B. megaterium* inoculation in wheat.

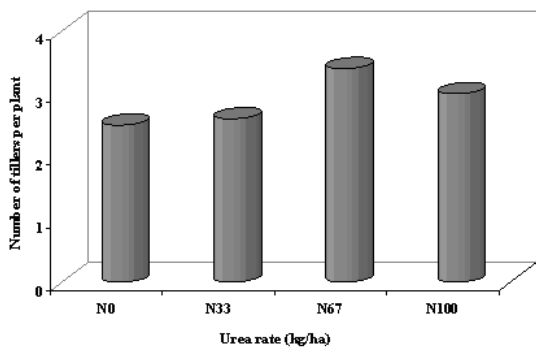


Fig. 3. Effect of urea rate on number of tillers per plant.

Interaction of biofertilizer×urea rate on yield was significant (Table 1). In biofertilized treatments with increasing of urea dose grain yield increased 9.5% and 18.5% in 33 and 67 kg ha⁻¹ urea, respectively in Kascogen, and 10% and 23% in same levels of urea, respectively in Agusta, when compared with control. While, when urea rate increased from 67 to 100 kg ha⁻¹, was caused a reduction of 91 and 70 kg ha⁻¹ in grain yield, respectively in wheat cultivars. On the contrary in non- biofertilized treatments application of 100 kg ha⁻¹ increased 125 and 99 kg ha⁻¹ in grain yield, respectively in cultivars (Fig. 4 and 5).

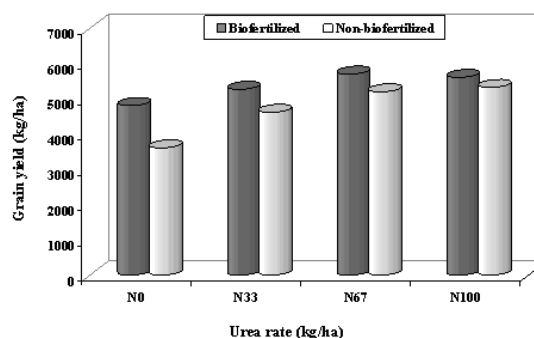


Fig. 4. Interaction of seed biofertilization and urea rate on grain yield.

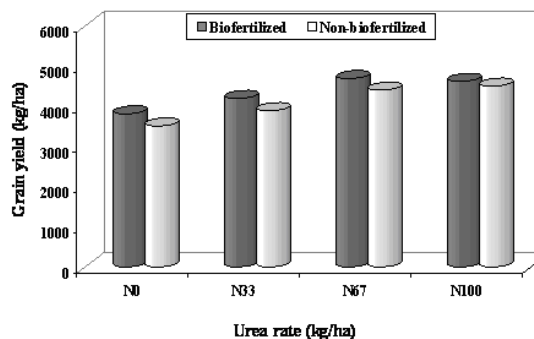


Fig. 5. Interaction of seed biofertilization and urea rate on grain yield.

Biomass

In the experiment wheat biomass affected only by urea application rate (Table 1). So that crop biomass experienced an increasing trend from 9 t ha⁻¹ in control to 11.3 t ha⁻¹ in full dose application of urea (Fig. 6), that was expected because of the effect of nitrogen on vegetative growth in plants.

Harvest index

Kascogen had higher harvest index (40.8%) than Agusta (36%). Also, seed biofertilization could improve its value from 37% to 39.8%. Harvest index experienced 2.8% increase, when urea rate increased from 33 to 67 kg ha⁻¹. While, in full dose application of urea increasing value in harvest index was lower and non-significant (Fig. 7).

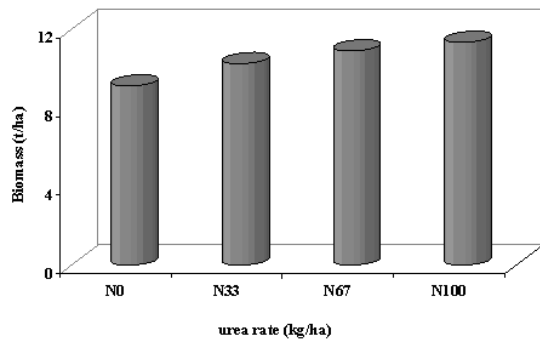


Fig. 6. Effect of urea rate on biomass.

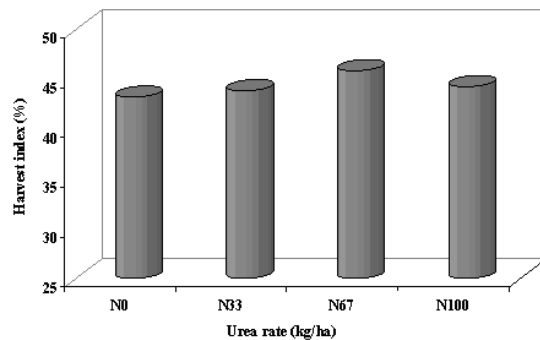


Fig. 7. Effect of urea rate on harvest index.

ANUE in wheat cultivars

In non-biofertilized treatments in stead of one kg ha⁻¹ urea application grain yield increased 31, 24 and 17 kg ha⁻¹ in Kascogen and 12, 13 and 10 kg ha⁻¹ in Agusta at 33, 67 and 100 kg ha⁻¹ urea rates, respectively (Fig. 8). Also, when urea dose increased from 33 to 67 kg ha⁻¹, 33 to 100 kg ha⁻¹ and 67 to 100 kg ha⁻¹ yield increasing value were 17, 10.5 and 4 kg ha⁻¹ in Kascogen and 15, 9 and 3 kg ha⁻¹ in Agusta per unit urea (Fig. 10).

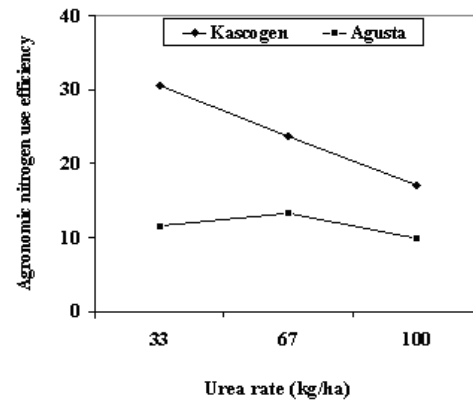


Fig. 8. Agronomic nitrogen use efficiency in non-biofertilized treatments compared to control in wheat cultivars.

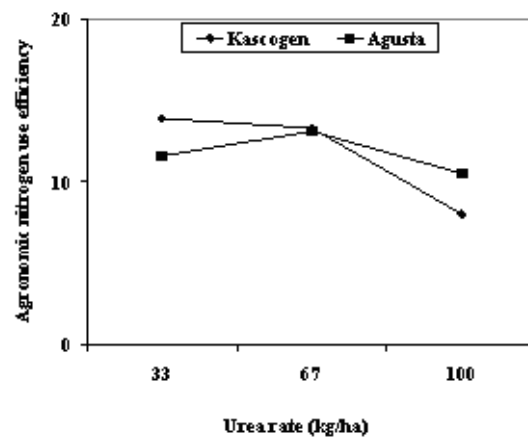


Fig. 9. Agronomic nitrogen use efficiency in biofertilized treatments compared to control in wheat cultivars.

Similarly in biofertilized treatments in stead of one kg ha⁻¹ urea application grain yield increased 17.5, 14 and 8 kg ha⁻¹ in Kascogen and 12, 13 and 10.5 kg ha⁻¹ in Agusta at 33, 67 and 100 kg ha⁻¹ urea rates, respectively (Fig. 9). Also, when urea dose increased from 33 to 67 kg ha⁻¹ and 33 to 100 kg ha⁻¹, increasing value in yield were 13 and 5 kg ha⁻¹ in Kascogen and 8 and 6 kg ha⁻¹ in Agusta per unit urea. While when urea application improved from 67 to 100 kg ha⁻¹, yield reduced 3 and 2 kg ha⁻¹ per unit urea, respectively in Kascogen and Agusta (Fig. 11).

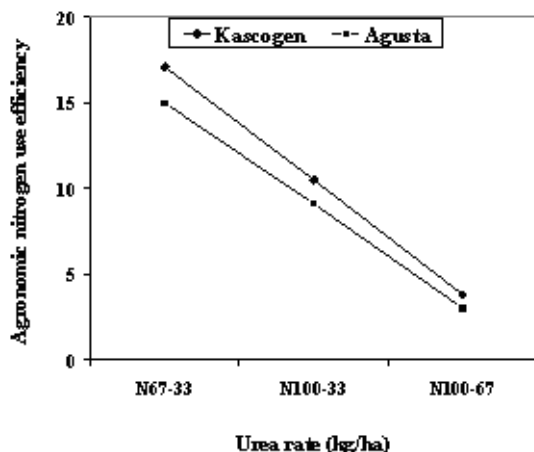


Fig. 10. Agronomic nitrogen use efficiency in non-biofertilized treatments compared to previous level in wheat cultivars.

These results are in agreement with those reported by Afifi *et al.* (2003) on corn, Cassman *et al.* (1998) and Malik *et al.* (2002) on rice. It is concluded that in the research environmental conditions wheat farmers using seed inoculation with the biofertilizer can economically use urea up to 33% of its recommended dose. Obviously, these kinds of programs could be effective for elimination of nitrogen fertilizers application and approaching to sustainable agriculture objectives.

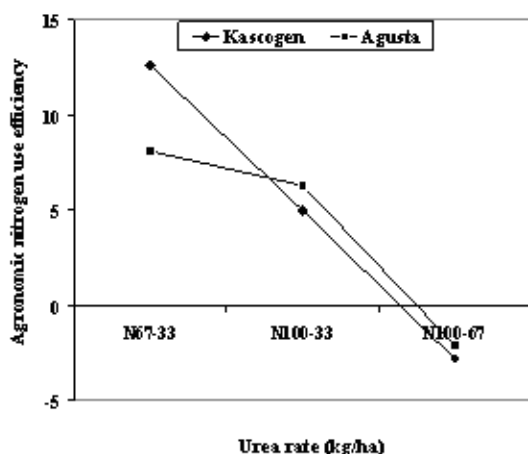


Fig. 11. Agronomic nitrogen use efficiency in biofertilized treatments compared to previous level in wheat cultivars.

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