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Effect of nitrogen fertilizer on nitrogen uptake, nitrogen use efficiency of rice

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Abstract. Nitrogen is one of the most yield–limiting nutrients in lowland rice in Iran. Three rice cultivars (Hashemi, Kazemi, Khazar) in a completely randomized block design with 3 replications were used to study the effects of nitrogen fertilizer on nitrogen use efficiency, yield and characteristics of nitrogen uptake during two years (2008-2009) in paddy soil in Guilan province, Iran. In this experiment, four treatments including: N1-control (no N fertilizer); N2- 30 kg ha^{-1} N (at transplanting time); N3- 60 kg ha^{-1} N (at transplanting, and tillering times); N4- 90 kg ha^{-1} N were compared. Results showed that total N uptake, physiological Nitrogen use efficiency (PNUE), apparent nitrogen recovery efficiency (ANRE) and agronomic nitrogen use efficiency (ANUE) was varied in different cultivars significantly and Khazar variety had the highest contents. Total N uptake, physiological N use efficiency (PNUE), agronomic nitrogen use efficiency (ANUE) was varied significantly with the increasement of the amount of nitrogen applied. As total N uptake increased with increasing in N fertilizing contents but physiological N use efficiency (PNUE), Agronomic Nitrogen use efficiency (ANUE) decreased. There were significant differences in the effects of applying nitrogen fertilizer on nitrogen use efficiency and characteristics of nitrogen uptake.

Keywords: Rice, Nitrogen, fertilizer, Nitrogen use efficiency.

1. Introduction

Rice is a major food crop in South America, Asia, and Africa (Fageria et al, 2009). Modern production agriculture requires efficient, sustainable, and environmentally sound management practices. Nitrogen is normally a key factor in achieving optimum lowland rice grain yields (fageria et al, 1997). Nitrogen (N) is essential for rice, and usually it is the most yield-limiting nutrient in irrigated rice production around the world (Samonte et al., 2006).

Nitrogen use efficiency by flooded rice is less than 50% (Fageria et al, 2001, 2005). The low N use efficiency of lowland rice is associated with its loss by several mechanisms in the soil-plant systems. The main N loss mechanisms are volatilization of ammonia (NH_3), leaching loss of nitrate (NO_3), loss through denitrification and soil erosion. Nitrogen use efficiency of crops can be improved by adopting adequate management practices. Use of N fertilizers in adequate amount, form and methods of application are important management strategies of this element. Nitrogen use efficiency has been defined in various ways, but these definitions generally take into account quantity of N accumulated in the plant, known as uptake efficiency and quantity of N utilized in grain production known as utilization efficiency.

The objectives of this study were: study commercial varieties of rice response to N fertilization, and estimate N uptake and N use efficiency at two years and four N rates (Moll et al, 1982).

2. Materials and Methods

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2.1. Field experiment site.

The field experiment was conducted at Rice Research Institute, Rasht, Guilan, Iran, during the growing season 2007 and 2008.

2.2. Fertilizer treatments.

The experiment was laid out factorial in randomized complete block design (RCBD) with three replications of four nitrogen fertilizers levels (N1-control (no N fertilizer); N2- 30 kg ha^{-1} N; N3- 60 kg ha^{-1} N; N4- 90 kg ha^{-1} N.

2.3. Rice cultivar.

Three different varieties were examined (Hashemi: V1, Alikazemi: V2 and khazar: V3).

Table 1: Definitions and methods of calculating nutrient use efficienc

Nutrient efficiency	Definitions and formulas for calculation
Nitrogen harvest index (NHI)	Grain N uptake / total plant N uptake.
Apparent N recovery efficiency (ANRE)	(total plant N uptake with N application-total plant N uptake without N application) / N application ×100.
Agronomic N use efficiency (ANUE)	(grain yield with N application-grain yield without N application) / N application.
Physiological N-use efficiency (PNUE)	(grain yield with N application-grain yield without N application) / N application.

2.4. Analysis.

Definitions and N equations for calculating N use efficiencies are given in Table 1. (Quanbao et al, 2007). Grain nitrogen concentration was determined by the methods of micro-Kjeldal digestion, distillation, and titration (Fageria et al, 2009).

2.5. Statistical method.

Factorial analysis of variance were conducted using General Linear Model procedure in the SAS package (SAS, 1990) to determine the significance of the effects of N fertilization, cropping varieties, year and their interactions on N uptake, and NUE indices.

3. Results and Discussion

3.1. Effect of N application on grain N-uptake, straw N-uptake and total N-uptake

Nitrogen uptake in grain and total nitrogen uptake had a significant response to N fertilization and different varieties (Table 2).Grain N-uptake increased significantly with N .In the other hand, the highest grain N-uptake was due to Khazar variety. Khazar variety accumulated maximum N (52.41 $kgha^{-1}$) in the grain and straw totally. This may be associated with maximum yield. Fageria et al, (2003) and Shinano et al, (1995) reported that in cereals including rice, N accumulation is associated with dry matter production and yield of shoot and grain. Nitrogen uptake in the straw differs significantly between 0 and 90(kg N ha^{-1}), and straw N-uptake increased significantly with N. As N4 (90kg N ha^{-1}) caused the highest content of N uptake (57.16 kg ha^{-1}). Fageria et al (2009) believed that this may be associated with maximum yield of shoot yield. But there was no interaction effect among varieties and straw N-uptake.

3.2. Effect of N application on N use efficiency under different N treatments

N harvest index was defined as the percent of grain N uptake to total plant N uptake. The proportion of total plant N partitioned to the grain is called the N harvest index (NHI) (Fageria et al, 2003). Effect of N was not significant, but NHI of rice was decreased with increasing N application (Table 3). It indicated that the N ratio in straw enhanced with increasing N application and it led to rice plant uptake N excessively.

Table 2: Significance of the F values from the analysis of variance for rice cultivar 'Diamante' parameters

Parameters	Nitrogen (N)	Variety (V)
grain N-uptake	**	**
straw N-uptake	*	Ns
total N-uptake	**	*

NHI	Ns	Ns
ANUE	Ns	**
PNUE	*	*
ANRE	**	*

*, ** = significant at the 0.05 and 0.01 probability levels,

Respectively; ns = not significant.

This result was similar to that of Quanbao et al (2007). Results showed that NHI of rice genotypes for experiment was decreased significantly with increasing N application. Artacho et al (2009) in his research showed that N harvest index was not affected significantly with N fertilization.

Table 3: N use efficiency indices for rice varieties for the different treatments

N rate (kg ha-1)_	NHI		ANRE		ANUE		PNUE	
	2007	2008	2007	2008	2007	2008	2007	2008
0	69	76						
30	67	77	0.47	0.51	20.01	19.96	58.53	48.47
60	71	77	0.33	0.47	18.47	20.28	55.57	49.16
90	69	75	0.35	0.4	14.25	18.36	36.73	45.76

Apparent n recovery efficiency (ANRE) was defined as the ratio that total plant N uptake with N application minus total plant N uptake without N application, then divided by N application. It was the primary index to describe the characteristics of N uptake and utilization in rice. Most researchers considered that this description accorded with the fact of rice production. Data indicated that ANRE of rice was decreased with increasing N application (table3). Quanbao et al (2007), showed that ANRE was increased with increasing of N application in sandy soil while it was increased firstly and reach to the maximum under 225 kg ha^{-1} N application, then declined significantly under 300 kg ha^{-1} N application in clay soil. It indicated that it was not useful for improvement of ANRE with more or less N application.

Agronomic n use efficiency (ANUE) was defined as the ratio of grain yield with N application minus grain yield without N application to N application and was used to describe the capability of yield increase per kilogram pure N. Results showed that with increasing of N application, ANUE decreased (table3). It indicated that the capability of yield increase per kilogram pure N declined remarkably with increasing N application. In another research Zhang et al (2007) reported the same results. As agronomic N use efficiency of different genotypes was different. ANUE of all genotypes was decreased significantly. Also the same results was showed in Artacho's research (2009).

Physiological N use efficiency (PNUE) was defined as the ratio of yield increased with N application to total plant N uptake increased with N application and it reflected the use efficiency of N absorbed by rice plant. Analysis of data indicated that, PNUE of all varieties was decreased with increasing N application (table 3). It showed that yield increased per kilogram N accumulated in rice plant was decreased with increasing N application. Quanbao et al, (2007) in the same research showed that under two soil conditions, PNUE of all genotypes was decreased significantly with increasing N application. Compared to PNUE under two soil conditions, it was higher in sandy soil than that in clay soil.

4. References

[1] Artacho, P., Bonomelli, C., Meza, F., 2009, Nitrogen Application in irrigated rice grown in mediterranean conditions: Effects on grain yield, dry matter production, nitrogen uptake, and nitrogen use efficiency, Journal of Plant Nutrition. 32: 1574-1593.

[2] Fageria, N.K and V.C. Baligar. 2001. Lowland rice response to nitrogen fertilization Communications in Soil Science and Plant Analysis 32: 1405–1429.

[3] Fageria, N. K. 2003. Plant tissue test for determination of optimum concentration and uptake of nitrogen at different growth stages in lowland rice. Communications in Soil Science and Plant Analysis 34: 259–270.

[4] Fageria, N.K., Baligar, V.C., Jones, C.A., 1997 Growth and Mineral Nutrition of Field Crops; 2nd Ed; Marcel Dekker: New York.

[5] Fageria, N. K., Dos Santos, A. B., Cutrim, V. dos A. 2009. Nitrogen uptake and its association with grain yield in lowland Rice genotypes. Journal of Plant Nutrition, 32: 11, 1965 — 1974

[6] Mae, T. 1997. Physiological nitrogen efficiency in rice: Nitrogen utilization, photosynthesis, and yield potential. Plant and Soil 196: 201–210.

[7] Moll, R. H.; Kamprath, E. J.;Jackson, W.A.;(1982), Analysis and interpretation of factors which contribute to efficiency of nitrogen utilization, Agron. J. , 47, 562-564(2 pages).

[8] Quanbao, Y., Hongcheng, Z., Haiyan, W., Ying, Z., Benfo, W., Ke, X., Zhongyang, H., Qigen, D.,Ke, X., 2007, Effects of nitrogen fertilizer on nitrogen use efficiency and yield of rice under different soil conditions. Agric. China 1(1): 30-36.

[9] Samonte, S. O. P. B., L. T. Wilson, J. C. Medley, S. R. M. Pinson, A. M. Mc- Clung, and J. S. Lales. 2006. Nitrogen utilization efficiency: relationships with grain yield, grain protein, and yield-related traits in rice. Agronomy Journal 98: 168–176.

[10] Shinano, T., M. Osaki, and T. Tadano. 1995. Comparison of growth efficiency between rice and soybean at the vegetative growth stage. Soil Science Plant Nutrition 41: 471– 480.

[11] Traore, A., and J. W. Maranville. 1999. Nitrate reductase activity and diverse grain sorghum genotypes and its relationship to nitrogen use efficiency. Agronomy Journal 91: 863–869.

[12] Yoshida, S. 1981. Fundamentals of Rice Crop Science. LosBa˜nos, Philippines: International Rice Research Institute.

[13] Zhao, B.H., Zhang, W.J., Chang, E.H., Wang, Z.Q., Yang, J.C. 2004, Changes in activities of the key enzymes related to starch synthesis in rice grains during grain filling and their relationships with the filling rate and cooking quality. Sc.Agri.Sin. 37(8), pp:1123-1129. (In Chinese with English abstract).