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Yield, water and nitrogen-use response of rice to zeolite and nitrogen fertilization in a semi-arid environment

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ABSTRACT

Water scarcity and soil nitrogen (N) loss are important limitations for agricultural production in semi-arid region especially for rice production. Zeolite (Z) as a soil conditioner can be used to retrain water and nitrogen in near-surface soil layer in lowland rice production system. The objectives of this study were to investigate the effects of different application rates of natural zeolite (clinoptilolite) and nitrogen on rice yield, yield components, soil nitrogen, water use, water productivity in a silty clay soil in 2004 and 2005. Zeolite was only applied in the first year. In order to study the long-term and continuous effect of zeolite on the objectives of the study, no zeolite was applied in the second year and the study was conducted on the same land as the first year. Zeolite and N were applied at rates of 0, 2, 4, and 8 t ha^{-1} and 0, 20, 40, and 80 kg ha^{-1}, respectively in 2004. In 2005, each plot received the same amount of N as received in 2004. It is concluded that by decreasing N application rates, higher Z application rate is needed to improve grain yield. Highest grain yield was obtained at N application rate of 80 kg ha^{-1} and Z application rate of 4 t ha^{-1}. Higher grain yield was mostly attributed to lower unfilled grain percentage and higher 1000-grain weight that were a result of higher N application rate and N retention in soil due to Z application. Nitrogen and Z applications resulted in higher grain protein contents and nitrogen recovery efficiency (NRE). Based on these results and due to higher N retention in soil under Z application, improved grain yield quality, nitrogen-use efficiency (NUE), and nitrogen recovery efficiency (NRE) could be obtained at Z application rate of 8 t ha^{-1} and N application rate of 80 kg ha^{-1} or more. However, this was not satisfied for NUE. Moreover, it is found that at higher N application rates lower Z application rates are needed to effectively retain soil residual mineral nitrogen. Furthermore, at N application rates of 80 kg ha^{-1} or more, Z application increased soil water retention and resulted in lower seasonal water use and higher water productivity. In general, it was concluded that the effect of Z application in retaining soil N was also effective in the second year.

1. Introduction

Rice (*Oryza sativa* L.) is the most important food crop in the world next to wheat. It is a major food grain for more than half of the world population. Rice is a grain that provides more than 80% of the daily calories for the consumers (Gallagher, 1984). According to FAO statistics, paddy production in Islamic Republic of Iran is about 2.3 million tons produced from 578,000 ha. It is mostly produced in Mazandaran, Guilan, Fars, Khuzestan and Isfahan provinces (Anonymous, 2006).

The world population is continuously increasing, while the world renewable water resources are limited. Increasing world population requires more water for domestic, industrial, environmental, recreational and agricultural needs. While water is very abundant in global scale, but 97% is saline, 2.25% is glacier and just 0.75% is available as freshwater in watersheds, rivers and lakes (FAO, 2003). Because of restricted water resources their effective use is more emphasized.

Nitrogen (N) is currently the most widely used fertilizer nutrient and the demand for it is likely to grow in future (Godwin and Jones, 1991). Nitrogen is a component of protein and nucleic acid and when N amount in soil is not optimal, growth is reduced (Weinhold et al., 1995). Nitrate-N is highly soluble in water and hence susceptible to leaching, potentially contributing to environmental contamination. Also, fertilizer N can be lost via denitrification, especially from moist soils. Denitrification losses reduce the N fertilizer use efficiency and are environmental concern for the potential role of N_2O that it may play in stratospheric ozone depletion (Qian et al., 1997).

Nitrogen plays an important role in plant growth (Weinhold et al., 1995). Uhart and Andrade (1995) indicated that the grain yield

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