Effects of Nitrogen on Soil Microbial Abundance, Enzyme Activity, and Nitrogen Use Efficiency in Greenhouse Celery under Aerated Irrigation

The effect of N on soil enzyme activity and microbial abundance under aerated irrigation conditions was explored. The experiment included four N levels under aerated irrigation (N0, 0 kg N ha$^{-1}$; N150, 150 kg N ha$^{-1}$; N200, 200 kg N ha$^{-1}$; N250, 250 kg N ha$^{-1}$) and a control treatment (CK, conventional irrigation with 250 kg N ha$^{-1}$). Soil bacteria, fungi, and actinomycete abundance as well as catalase and phosphatase activity increased with increasing N application, with maximum values in the N200 treatment. Soil nitrifier and denitrifier microbial abundance as well as urease activity increased with increasing N levels and maximized in the N250 treatment. Compared with the CK treatment, the N200 treatment enhanced soil microbial abundance by approximately 1.62- to 13.69-fold and increased soil enzyme activity by 16.67 to 22.92%. Nitrogen application significantly promoted plant N uptake, and the N250 treatment offered the highest uptake levels. Compared with CK, celery (Apium graveolens L.) N uptake in the N200 and N250 treatments were significantly enhanced ($P < 0.05$). The celery yield, N agronomic efficiency, N physiological efficiency and N recovery efficiency in the N250 treatment were 6.50, 46.94, 26.59, and 16.07% higher compared with the N200 treatment, respectively. Partial-factor productivity in the N150 treatment was 10.35% higher than in the N200 treatment yet yields decreased by 20.82%. The N200 treatment offered maximum yield value, net income and ratio of output to input. Therefore, a 200 kg N ha$^{-1}$ application with aerated irrigation effectively improves soil biological environments, increases the N utilization rate and transfers more N to dry matter.

Abbreviations: AE, agronomic efficiency; CK, conventional irrigation with 250 kg N ha$^{-1}$; DAT, days after transplant; N0, aerated irrigation with 0 kg N ha$^{-1}$; N150, aerated irrigation with 150 kg N ha$^{-1}$; N200, aerated irrigation with 200 kg N ha$^{-1}$; N250, aerated irrigation with 250 kg N ha$^{-1}$; PE, physiological efficiency; PFP, partial-factor productivity of applied N; RE, recovery efficiency.

Increasing N application is one of the main agricultural strategies to improve crop yield and dry matter accumulation (Guo et al., 2010). The application of synthetic N to agricultural crops via the Haber-Bosch process has aided in providing foods to an estimated half of the world's population since the Green Revolution (Erisman et al., 2008). Currently, the overconsumption of these synthetic nitrogen fertilizers and their associated environmental impacts have become a growing concern. Therefore, the development of new tactics and strategies for optimizing N use is necessary.