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Effects of Nitrogen Levels and Nitrate/Ammonium Ratios on Oxalate Concentrations of Different Forms in Edible Parts of Spinach (*Spinach oleracea* L.)

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Abstract

Two hydroponic experiments were carried out to investigate the effects of nitrogen levels and forms on the oxalate concentrations of different form in edible parts of spinach. Nitrogen was supplied at five levels (4, 8, 12, 16, 20 mM) in experiment 1 and five ratios of nitrate (NO_3^-) to ammonium (NH_4^+; 100/0, 75/25, 50/50, 25/75, 0/100) at a total N of 8 mM in experiment 2. Biomass of spinach increased markedly from 4 mM to 8 mM N but a plateau thereafter. The total oxalate and soluble oxalate in leaves and shoots (edible parts) increased significantly with increasing N levels from 4 to 12 mM, while the total oxalate and insoluble oxalate decreased markedly when N level was further increased from 12 to 20 mM. Oxalates of different forms in petioles increased first and then decreased and rose again with increasing nitrogen levels. In the second experiment, decreasing NO_3^-/NH_4^+ ratios markedly increased at first and then significantly decreased the biomass of spinach plants and the maximum biomass was recorded in the treatment of the NO_3^-/NH_4^+ ratio of 50/50. The oxalate concentrations of different form in leaves and shoots were all decreased obviously as the ratio of NO_3^-/NH_4^+ decreased from 100/0 to 0/100. Concentrations of total oxalate and soluble oxalate in petioles could be reduced by increasing the ammonium proportion and were the lowest as the ratio of NO_3^-/NH_4^+ was 50/50 and insoluble oxalate decreased with a decreasing nitrate/ammonium ratio. The concentrations of oxalate forms in leaves were all higher than those in petioles and soluble oxalate was the predominant form of oxalates in both trials. It is evident that high biomass of spinach can be achieved and oxalate concentrations of different forms can be reduced by modulating N levels and NO_3^-/NH_4^+ ratio. This finding is important especially for human nutrition of people with a history of calcium oxalate derived kidney stones.

Keywords: Human health, nitrate to ammonium ratio, nitrogen level, oxalate form, spinach

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