Higher nitrate: ammonium ratio increased Calcium and Magnesium in tomato leaves in Mexico

Nitrogen is the only plant nutrient that can be absorbed by the plant in three forms: as anion (NO_3^-), as cation (NH_4^+), or as amino acids, in molecular form ($CO(NH_2)_2$). When plants are provided with both nitrate and ammonium simultaneously, the activity of the enzyme phosphoenolpyruvate carboxylase (PEPC) in the roots is increased. It is suspected that this enzyme plays a role in the process of assimilation of the ammonium cation in the roots by aiding the production of carboxylate skeletons that are used to store metabolic intermediates during the synthesis of amino acids.

Most of the carbon needed for these skeletons is derived from assimilation in the leaves of atmospheric CO_2, but the roots can take up inorganic carbon from the carbon supply in the soil as well. In hydroponics, bicarbonate ions could be a carbon source for the production of organic acids. The objective of this study was to study the combined effect of three nitrate:ammonium ratios and three bicarbonate dosages, to see if addition of bicarbonate to high dose of ammonium would prevent damage that can be observed in tomato plants when fertigated with an excess of ammonium.

Seeds of tomato cultivar “Slolly F-1” were sown in 1:1 peat:vermiculite and transplanted on day 46 after sowing to a hydroponic system in volcanic rock (tezlonte). In a Mexican greenhouse, the plants received the various nutrient solutions during propagation and cultivation, and were cultured to production. Seedling growth and harvest parameters were assessed. Nutrient content of leaves, fruits and stems was measured. The osmotic value of the nutrient solution was adjusted to be the same for all HCO_3^- doses (0,72 atm.). Total N concentration was kept at 11-12 mol_c m^{-3}

and pH for the hydroponic solution was adjusted to 5,5.

No consistent interactions were found between bicarbonate and the nitrate/ammonium ratio. In the seedlings, a lower root volume and magnesium content in the leaves was found in the treatment with 70/30 nitrate/ammonium, and a lower content of calcium was found in all treatments where ammonium was added compared to 100% nitrate. At 5 $mol_c\ m^{-3}$ of bicarbonate in the medium, the root volume of seedlings decreased and calcium content of the leaves was lower when no bicarbonate was added.

The lowered uptake of Ca^{2+} to the leaves found in the seedlings fed with 70/30 nitrate/ammonium, was also found in the leaves of the mature plants under this treatment. This can be explained by the plant's effort to maintain electrostatic balance and taking up the positively charged NH_4^+ at the expense of the doubly positively charged Ca^{2+}. A deficit of calcium in tomato plants can lead to loss of fruits due to blossom end rot, even though this physiological disorder was not manifested in this trial.

Similarly, the negative charge of the nitrate (NO_3^-) or the bicarbonate (HCO_3^-) molecule can result in a synergistic uptake of the positive Ca^{2+} ion, as is seen in the increased calcium content in both seedling and adult leaves grown on 100% nitrate or on the highest dose of bicarbonate. Addition of the positively charged ammonium ion increases uptake of anions, such as phosphate, manifested in an increase of P content in the stems of seedlings and fruiting plants in the treatment with 70/30 nitrate/ammonium.

Yield was lower at the lowest nitrate/ammonium ratio, though the difference was not statistically significant. Therefore, no conclusions on a possible mitigating effect of HCO_3^- on damage due to a low nitrate/ammonium ratio in the nutrient solution could be drawn. Due to the characteristics of the medium used for the hydroponic culture, i.e. tezlonte, the authors suggest that the ammonium in the nutrition was nitrified quickly, avoiding the negative effects on yield after lowering nitrate/ammonium ratios which have previously been found in literature. The authors conclude that for tomato grown on tezlonte, it is safe to replace a part of the nitrogen in the fertigation by ammonium up to a maximum of 30%.