Effects of Sodium Bicarbonate on Hydroponic Growth, Quality and Nutrient Solution pH

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The purpose of this study was to determine effects of various rates of sodium bicarbonate on hydroponic nutrient solution pH and on growth and nutrient uptake of butterhead lettuce grown for 24 days in a nutrient film technique (NFT) system. This study is necessary for growers using low alkalinity municipal water sources, at high risk for extreme pH fluctuations in hydroponic greenhouses. This challenge is relevant to areas where water is low in water hardness. Keeping pH at a set range for optimum plant growth is crucial for successful hydroponic farming. As population and water scarcity increase, agricultural advances will become increasingly more important. Hydroponic farming will be part of the future of food because of its efficiency in water conservation. Studying hydroponic limitations, such as locations with low water alkalinity, could be crucial in placements and advancements where hydroponic farms will be placed in the future.

In this experiment, *Lactuca sativa* ('Rex' butterhead lettuce) seeds were germinated in rockwool cubes and grown for two weeks prior to transfer into NFT systems. Each NFT systems was 8 ft long and contained 5 lettuce plants (CropKing, Lodi, OH™). Nutrient solutions contained a complete fertilizer including N, P, K, and all essential micronutrients (Jacks's 5-12-26) at a rate of 80 mg/L-1N, calcium nitrate fertilizer containing N and Ca (15.5-0-0) at a rate of 70 mg/L-1N, and magnesium sulfate fertilizer containing Mg and S (10% Mg) at a rate of 40 mg/L-1Mg. A control treatment consisted of municipal water and nutrient solution above (0 mg/L-1HCO_3). The other three consisted of the same nutrient solution and rates of HCO_3 from sodium bicarbonate: 15, 30, and 45 mg/L-1HCO_3. All solutions containing bicarbonate were pH adjusted to 5.8 using a 35% sulfuric acid. Each was evaluated for pH and electrical conductivity (EC) daily for 24 days using a handheld meter (Hanna™). After 24 days, the lettuce plants were measured for leaf greenness (SPAD-502, Konica Minolta). Lettuce plants were removed from NFT, then roots and shoots were weighed separately to determine biomass. Foliar samples were dried in a forced-air drier and later analyzed for nutrient content (Waters Agricultural Lab, Camilla, GA).

Results showed that there were no statistical differences in nutrient solution pH (Table 1). Treatments of sodium bicarbonate did resist a drop in pH. There were no significant differences in foliar nutrient content, plant biomass, leaf greenness, or tipburn, indicating that additions of sodium bicarbonate at rates between 15 and 45 mg/L-1HCO_3 did not inhibit nutrient uptake or reduce plant quality. Growers should be prepared for pH shifts and adjust them when necessary. It is not critical to establish a buffer capacity prior to a pH shift. Sodium bicarbonate is inexpensive and can provide an effective method of pH adjustment when needed. A 50 lb bag of sodium bicarbonate can be bought for approximately $25, and at 15 PPM, it can be used to grow approximately 6,680 heads of lettuce. Sodium bicarbonate is both effective and efficient when used at 15 PPM.

Statement of Research Advisor

Mackenzie conducted research that will be applicable to controlled environment farming, especially in urban areas that rely on municipal water sources. Using sodium bicarbonate (baking soda) to establish a pH buffer in low alkalinity water will reduce costs by allowing for use of a readily available, inexpensive product.
-Daniel Wells, Horticulture

Table 1. Effects of nutrient solution with varying rates of sodium bicarbonate on foliar nutrient concentrations, leaf greenness, biomass, and tipburn rating of 'Rex' butterhead lettuce grown in nutrient film technique for 24 days.

HCO_3 (PPM)	Nutrient Solution[x]		Foliar Nutrient concentrations					Lettuce Growth and Quality			
Treatment[y]	pH	EC	N (%)	P (%)	K (%)	Mg(%)	Ca(%)	SPAD[v]	Shoot biomass (g)	Root biomass (g)	Tip burn
0	5.94	2.58	5.80	0.95	9.61	0.62	0.57	27.56	138	209	0.47
15	6.55	2.74	6.19	1.05	9.71	0.71	0.71	26.99	78	171	0.13
30	6.11	2.55	6.20	0.99	9.62	0.61	0.57	25.1	100	174	0.40
45	6.38	2.65	5.67	0.96	9.23	0.64	0.55	28.35	116	190	0.00
P-Value	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sig.[z]	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[z] Data were subjected to analysis of variance (ANOVA) in SAS using PROC GLIMMIX.

[y] Treatments are mg L^{-1} HCO_3 from $NaHCO_3$.

[x] Nutrient solution contained (Jacks's 5-12-26), Calcium nitrate (15.5-0-0), and Magnesium sulfate (10% Mg). NS=No significant trends are observed.

[v] SPAD Index is a measure of leaf greenness. Tipburn was rated using a subjective rating scale averaged together by each subsample. Root biomass was the weigh in grams of all roots in each replicate. Shoot biomass is the weight in grams of lettuce shoots from each replicate averaged together for the whole treatment.