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Irrigation Water Considerations

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I. Introduction:

Commercial greenhouse operations use water from wells, surface water, drainage ponds, rain, and/or municipal water sources. The 'quality' of different water sources varies considerably. Differences in rain water, well water and municipal water can result in differences in crop growth and your fertilizer regime for a optimal crop growth. The importance of water quality greatly increases as growers shift from media that contain soil to soilless media. Soil based media are often highly buffered, i.e. pH changes occur slowly or not at all during production of crops with a short growing season. In contrast, soilless media nutrition/pH often readily change. Because of this, the ability of your irrigation water to affect your growing media greatly increases when you grow in soilless media.

Many growers outside of municipalities use water from ground wells. The water quality of ground wells in Minnesota varies considerably. In most cases, growers need to/should chemically treat their irrigation water to avoid problems associated with irrigation water effects on crops grown in soilless media. This article outlines standards for water quality, when modification of irrigation water may be necessary, ways water can treated, and gives examples of how to modify water from different sources in the upper Midwest.

II. Municipal Versus Well Water:

Municipal water in Minnesota is treated to 1) add fluoride/chlorine for dental hygiene, 2) reduce alkalinity, and/or 3) increase pH to decrease pipe corrosion. Fluoride, in general, does not affect growth of most greenhouse crops. However, fluoride is known to cause 'tip burn' of some crops with longer leaves and parallel leaf veination. Most notable, Easter lily (*Lilium longiflorum* Thunb.), 'spikes' (*Drancena* spp.), and spider plants (*Chlorophytum* spp.) are sensitive to supplemental fluoride in irrigation water (Biernbaum, 1994). Fluoride problems can be reduced by elevating media pH to approx. 6.5-6.8 and/or by increasing calcium levels to precipitate fluoride out of solution to make it unavailable for plant uptake.

> "The most common problems with Minnesota irrigation water are low/high alkalinity, high sodium/chloride, and low/high boron."

Water is 'softened' to reduce hardness or alkalinity. 'Softening' of water often results in an increase in sodium (Na+) in water. Therefore, 'hardness' associated with carbonates in water is reduced after softening but sodium chloride level is increased.

Increased pH in municipal water sources resulting from treatment can result in an increased need for acidification by the grower compared to using well water. Although increasing pH in municipal water treatment plants is not common, more and more municipalities are considering this option.

Well water in Minnesota ranges in quality from very clean to very poor. Common problems with Minnesota well water are 1) high or low alkalinity (lime), 2) high sodium (Na+), and/or 3) high boron (B). Alkalinity levels in well water in different parts of Minnesota are shown in Figure 1.

High Alkalinity:

High alkalinity is, by far, the most common problem with Minnesota greenhouse irrigation water originating from private wells. In particular, high alkalinity is a problem with well water in central and western Minnesota (3/4 of Minnesota). High alkalinity is also common throughout North and South Dakota, Iowa, and southern Wisconsin.

The most common problems associated with growing crops using high alkalinity water in soilless media are 1) rapid media pH rise, and 2) magnesium deficiency induced by

Table 1. Milliliters of acid required per gallon of water to neutralize 1 milliequivalent of bicarbonate. Divide by 27 to get the number of ounces needed.

Acid Type	Constant
Nitric (61%)	0.0062
Phosphoric (75%)	0.0041
Phosphoric (85%)	0.0037
Sulfuric (93%)	0.0019

excessive calcium in the media. High pH problems are usually first identified by observing iron deficiency, i.e. interveinal chlorosis of upper leaves with many crops (especially petunias). Rapid pH rise is controlled or eliminated by adding acid to your irrigation water. The correct amounts of acid to add for different acid types to neutralize a milliequivalent of bicarbonate (CO3-) is shown in Table 1.

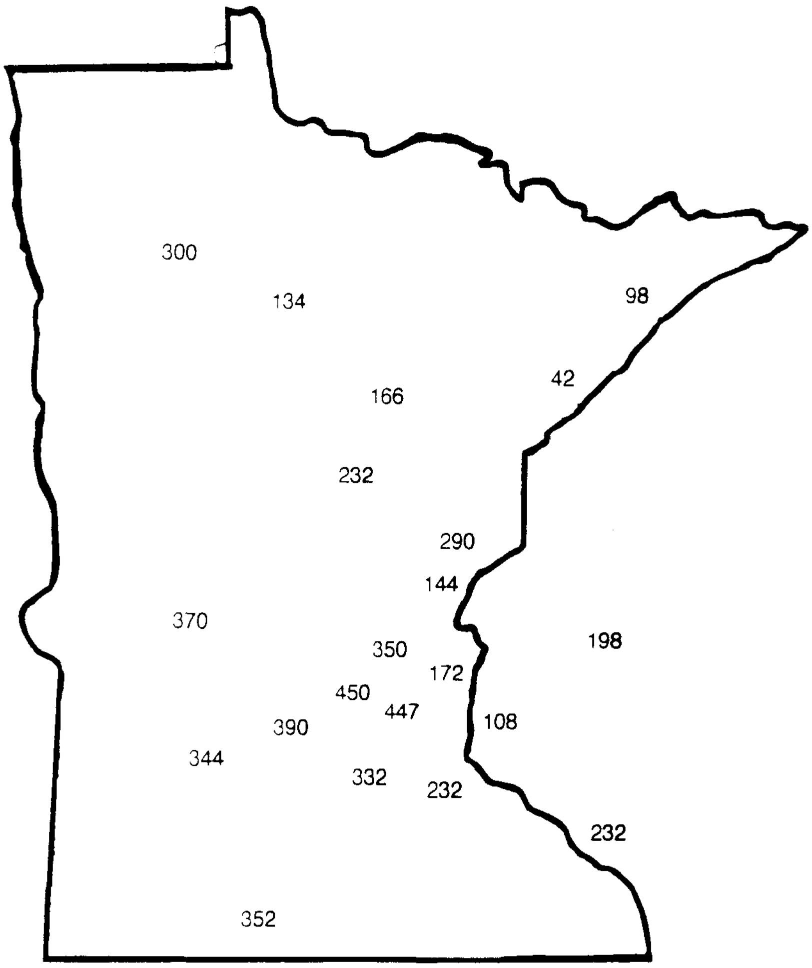

Figure 1. Alkalinity (milliequivalents $CaCO_3$/liter) levels in different regions of Minnesota.

Selection of the correct acid is very important to successfully grow a crop with amended water. Initially people used phosphoric acid to adjust irrigation water pH because it was readily available and was the least caustic. However, problems arose when phosphorus levels in the media (phosphorus is often retained in the media and does not readily leach) would become excessive. In particular, excessive phosphorus levels can induce micronutrient deficiencies. Most growers have switched to using sulfuric acid. Sulfuric acid costs almost half the price of phosphoric acid but is much more caustic. Therefore, take great care when handling this material. There is some discussion about using nitric acid. We do not recommend nitric acid since is very caustic (dangerous), is more expensive than sulfuric acid, and more nitric acid is required compared to sulfuric acid to acidify your water.

As mentioned above, the other common problem when growing a crop using high alkalinity water is magnesium deficiency. Magnesium deficiency is primarily expressed through interveinal chlorosis of the lower leaves and reduced growth (Bottrill et al., 1970; Terry and Ulric, 1974). Most notably, leaf expansion is

Table 2. Acidity, basicity and calcium levels in different of different common fertilizers.

Fertilizer Formulation	Acidity	Basicity	Calcium (ppm)
14-5-38 K-Cel		307	0
15-0-0 Cal-Lite		394	120
15-5-15 Cal-Mag		141	33
20-5-19 Poinsettia	350		0
21-5-20 All Purpose	389		0
4-25-35 Conifer Finisher	248		0
5-11-26 Hydro-Sol		216	0
5-50-17 Varieg. Violet Spec.	649		0
9-45-15 Plant Strater	977		0
10-30-20 Blossom Booster	358		0
12-0-43 Cut Mum Special		510	0
12-36-14 Afr. Violet Spec.	676		0
13-0-44 Potassium Nitrate		520	0
15-0-15 Dark Weather Feed		296	73
15-2-20 Pansy, Salvia Form.		241	25
15-5-25 Poinsettia Peat-Lite	37		0
15-10-30 Pot Mum Special	44		0
15-11-29 Peat-Lite Special	50		0
15-15-15 Geranium Spec.	246		0
15-16-17 Peat-Lite Spec.	196		0
15-17-17 Hi-Mag Peat-Lite	445		0
15-20-25 Poinsettia Finisher	272		0
15-30-15 Hi-Phos Special	662		0
15.5-0-0 Calcium Nitrate		400	116
16-4-12 Easter lily Special		75	0
20-0-20 Hi-Cal Peat-Lite		19	30
20-2-20 Lo Phos Special	805		0
20-5-30 Potash Special	122		0
20-7-19 Conifer Grower	375		0
20-10-20 Peat-Lite Special	406		0
20-10-20 General Purpose	392		0
20-19-18 Peat-Lite Special	611		0
20-20-20 General Purpose	558		0
21-7-7 Acid Special	1556		0
21-7-7 Azalea Neutral	367		0
24-8-16 Tropical Foliage	667		0
24-8-16 Western	667		0
30-10-10 Hi-Nitro	1038		0

decreased. Magnesium deficiency is overcome by applying a separate magnesium sulfate (epsom salts) drench to crops on a regular basis (monthly). Do not add magnesium sulfate to the fertilizer stock tank as precipitate can form. Apply 8 ounces of magnesium sulfate in 100 gallons of water monthly to maintain adequate magnesium in your media for plant growth.

Low Alkalinity: Low alkalinity is a problem in east central to northeast Minnesota and northern Wisconsin. Low alkalinity water has little effect on media pH. As a result, media pH is determined primarily by the initial pH of the media and the 'acidity' or 'basicity' of the fertilizer that is used during production. Acidity and Basicity of different common fertilizers are shown in Table 2.

The most common problems associated with growing crops using low alkalinity water in a soilless media are 1) calcium deficiency and 2) low pH induced iron/manganese toxicity. Calcium mobility is low and calcium movement occurs mainly outside the cytoplasm in the apoplasm. Since Ca+ is readily replaced by other cations from its binding sites of the exterior surface of the plasma membrane, the Ca+ requirement of a plant increases as the external concentration of heavy metals, sodium chloride, other cations (Mg, K, NH_4), or protons (pH decreases) increases. In other words, as pH decreases, the requirement for calcium increases (Lund, 1970). Calcium requirement for growth differs greatly with plant species (Loneragen and Snowball, 1969). In general, monocots require significantly less calcium than dicots. Recommended calcium levels in tissue for different plant species are shown in Table 3.

Incidence of Ca+ deficiency increases greatly on low transpiring organs, such as bracts, compared to other plant tissues when growth rate is high (high temperature) and/ or humidity is high (low transpiration). Calcium deficiency problems can be avoided by adding gypsum to the growing media, using calcium nitrate based fertilizers and/or spraying with calcium nitrate. Gypsum adds calcium to the media without greatly increasing pH. In general 5-10 pounds of gypsum should be added per yard of soilless media mix when growers have low water alkalinity. Fertilize with Ca+ containing fertilizers. Common calcium nitrate containing fertilizers are some of the 'Dark Weather Feeds'. Other fertilizers that contain calcium are shown in Table 2. In addition, calcium nitrate can be sprayed directly on the foliage. Spray 1/3 ounce (9.5 grams) per gallon on plants every other week.

Growth resulting from fertilizing with calcium nitrate versus ammonium nitrate or urea differs. High ammonium nitrate/urea in growing media greatly inhibits cation uptake and can depress growth by inducing magnesium (Manolakis and Ludders, 1977) or calcium deficiency (Pill et al., 1978). Growers in the north central region of the United States often experience ammonium buildup in the media in late winter and early spring when growing conditions are typically darker and cooler than other times of the year. Excess ammonium nutrition is typically associated with a fall in media pH (Findenegg et al.,

Table 3. Tissue calcium requirements for a variety of common agricultural crops.

Plant	Calcium	Magnesium	Iron/Manganese
African Violet	0.6 - 1.7	0.7 - 1.1	70-320/35-490
Reiger Begonia	0.7 - 2.4	0.3 - 0.8	80-390/35-190
Wax Begonia	1.3 - 2.1	0.6 - 1.0	100-260/90-355
Fuchsia	1.6 - 2.4	0.4 - 0.7	95-335/75-220
Seed Geranium	1.2 - 2.1	0.2 - 0.4	120-340/110-285
Gerbera	0.9 - 4.2	0.3 - 2.8	80-130/65-260
Gloxinia	1.5 - 2.2	0.4 - 0.5	70-150/95-170
Hibiscus	1.9 - 2.3	0.5 - 0.7	60-75/135-180
Thanksgiving Cactus	0.7 - 0.9	1.6 - 2.2	105-110/35-130
Impatiens	2.9 - 3.3	0.6 - 0.8	405-685/205-490
New Guinea Impatiens	1.9 - 2.7	0.3 - 0.8	160-890/140-245
Vinca	1.4 - 1.6	0.4 - 0.5	95-150/165-300

impatiens, seed geraniums and African marigolds are all susceptible to micronutrient toxicity. Iron/ Manganese tissue levels should not exceed 500 ppm in these species (Table 3). Iron/ manganese toxicity primarily occur on these crops when the pH is below 6.0.

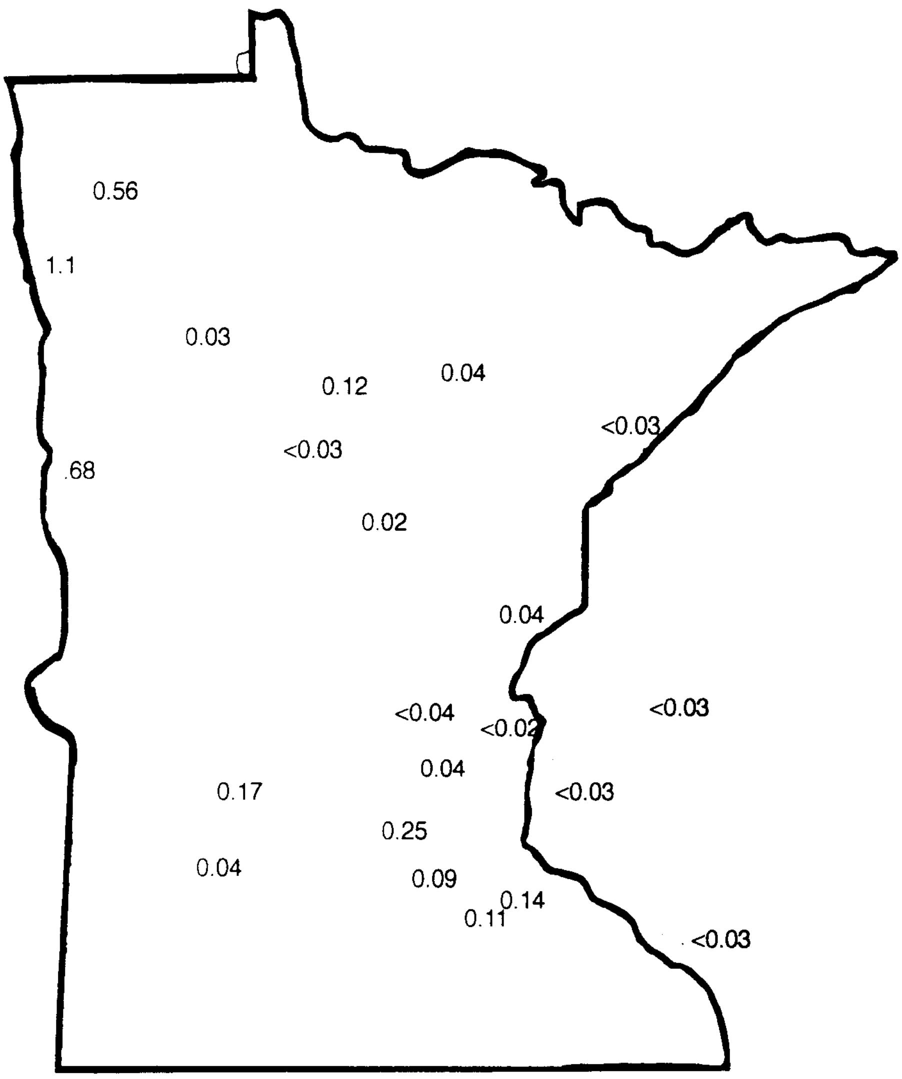

Figure 3. Boron levels (ppm) in well water in different Minnesota.

Symptoms of iron/manganese toxicity on New Guinea impatiens are stunting of growth, and stunted, twisted, malformed upper leaves. In seed geraniums iron/ manganese toxicity is typified by stunted leaf expansion (especially lower leaves), and brown spotting and marginal leaf edge burn on the lower leaves. African marigolds usually show 'scorching' or browning of the lower leaves when manganese/ iron build up in the tissue. Often high manganese levels will induce deficiencies of other mineral nutrients such as iron, magnesium and calcium (Heenan and Campbell, 1981).

The easiest way to solve a high manganese problem is to simply increase the media pH to over 6.0. In addition, stop applying micronutrients through the feed program, i.e. use only calcium nitrate, potassium nitrate, and a phosphorus source in your fertilizer. Manganese toxicity can be combated by adding magnesium (Lohnis, 1960). High manganese intolerance can be quickly screened by applying manganese to a single leaf (Horst, 1982). Plants must grow out of this condition-there is no quick cure!

High Sodium/Chloride:
Sodium (Na) levels in Minnesota well water vary from 2 to 60 ppm (Figure 2). Much of this sodium is in the form of NaCl, or 'table salt'. Sodium affects plant growth primarily through effects on the ability of a plant to 1) take up water, and 2) take up other

positively changed ions/nutrients. Interestingly, some sodium has a beneficial effect on some plants: sugar beet, turnip, swiss chard, Rhodes grass, cabbage, radish, cotton, pea, flax, wheat and spinach

Table 4. Acceptable boron tissue levels in common floriculture crops.

Crop	Tissue Level (ppm)
Wax Begonia	30 - 40
Fuchsia	25 - 35
Seed Geranium	35 - 60
Gerbera	25 - 50
Hibiscus	20 - 25
Impatiens	50 - 60
Vinca	25 - 40

(Marschner, 1971; Makmur et al., 1978). In contrast, some species notably tomato can be quite sensitive to the presence of sodium (Makmur, 1978) in the media.

We suspect chloride (Cl-) toxicity is more widespread that sodium toxicity. Chloride toxicity was demonstrated on grapes, fruit trees, and in leguminous species (Greenway and Munns, 1980). Little work has been conducted on Cl- effects on greenhouse crops. Cl- toxicity is obvious in many species by marginal chlorosis and necrosis on mature leaves (Sykes, 1992; Maas, 1993).

In general, high salinity in soil increases calcium-related physiological disorders such as bract edge burn in poinsettias, tip burn in lettuce, and blossom end rot in tomato via Na+ inhibition of Ca^+ uptake or by decreasing soil water potential (Sonneveld and Ende, 1975). In particular high salinity in combination with high alkalinity can result in reduced Ca^+ solubility by precipitation of $CaCO_3$ resulting in reduced Ca^+ availability for plant uptake. High salinity can also cause excessive phosphorus uptake (Cerda et al., 1977) causing phosphorus toxicity. Therefore, high phosphorus levels in combination with high salinity can reduce growth.

Maintain sodium/chloride levels at lower levels (that of your water) by watering until fertilizer solutions leach from the base of the pot. Do not apply high levels of phosphorus when using soilless media with higher sodium/ chloride in your irrigation water. In some cases, Ca deficiency may occur if water alkalinity is high. Therefore, monitor tissue levels of calcium regularly on sensitive crops. Alternatively, foliar feed calcium or add $CaSO_4$ (calcium sulfate) or gypsum to the media to combat sodium/chloride induced calcium deficiency. Lastly, demand for potassium increases in saline media, therefore, increase potassium nutrition (Chow et al., 1990).

Boron Deficiency and Toxicity:
Boron deficiency is a common problem throughout the world, in particular, areas that have high rainfall often have boron deficiency expressed in plants since it is readily leached from the soil. Boron deficiency is most common with growers who use 'city' water or are from northern Wisconsin or Northeastern Minnesota where irrigation water contains little boron. Boron deficiency symptoms become more obvious under high light conditions (MacInnes and Albert, 1969). Symptoms of boron deficiency include terminal bud/ new leaf death/ distortion, inhibition of stem elongation, interveinal chlorosis on old leaves, flower/bud drop (Gupta, 1979). Recommended tissue levels of boron for common floriculture crops are shown in Table 4. Boron deficiency is alleviated by applying

boron through the fertilizer solution, by drenching with borax, or spraying with boric acid.

In contrast to boron deficiency, boron toxicity is common in Northwestern Minnesota and North Dakota (Figure 3). Boron levels in media may increase when municipal waste is added to growing media (Purves and Mackenzie, 1974). Symptoms of boron toxicity include, leaf marginal or tip chlorosis and/or necrosis. As with high sodium/chloride levels, regular leaching of media is recommended to control boron toxicity due to high levels of boron in the irrigation water. Alternatively, reverse osmosis units can be used to clean the water prior to watering.

References:

Biernbaum, J.A. 1994. Water Quality. In "Tips on Growing Bedding Plants" Ohio Flor. Assoc., Columbus, OH. pp. 65-76.

Bottrill, D.E., J.V. Possingham, and P.E. Kriedemann. 1970. The effect of nutrient deficiencies on photosynthesis and respiration in spinach. Plant Soil, 32:424-438.

Cerda, A., F.T. Bingham, and G. Hoffman. 1977. Interactive effect of salinity and phosphorus on sesame. Soil Sci. Soc. Am. J., 41:915-918.

Chow, W.S., M.C. Ball, and J.M. Naderson. 1990. Growth and photosynthetic response of spinach to salinity: implication of K+ nutrition for salt tolerance. Aust. J. Plant. Physiol., 17:563578.

Edwards, D.G., and C.J. Ascher. 1982. Tolerance of crop and pasture species to manganese toxicity. In. "Proceedings of the Ninth International Plant Nutrition Colloquium, Warwick, England" (A. Sciafe, ed.), pp. 145-150. Commonw. Agric. Bur., Farnham Royal, Bucks.

Findenegg, G.R., M. Salihu, and N.A. Ali. 1982. Internal self-regulation of H+-ion concentration in acid damaged and healthy plants of Sorghum bicolor (L.) Moench. In "Proceedings of the Ninth International Plant Nutrition Colloquium, Warwick, England" (A. Sciafe, ed.), pp. 174-179. Commonw. Agric. Bur., Farnham Royal, Bucks.

Gupta, U.C. 1979. Boron nutrition of crops. Adv. Agron., 31:273-307.

Heenan, D.P., and L.C. Campbell. 1981. Influence of potassium and manganese on growth and uptake of magnesium by soybeans (Glycine max (L.) Merr. cv Bragg). Plant Soil, 61:447-456.

Lohnis, M.P. 1960. Effect of magnesium on calcium supply on the uptake of manganese by various crop plants. Plant Soil, 12:339-376.

Loneragan, J.F., and K. Snowball. 1969. Calcium requirements in plants.

"Boron deficiency can be a problem in Northeastern Minnesota and Northern Wisconsin where well water has little boron."

Aust. J. Agric. Res., 20:465-478.

Lund, Z.F. 1970. The effect of calcium and its relation to several cations in soybean root growth. Soil Sci. Soc. Am. Proc., 34:456-459.

Maas, E.V. 1993. Salinity and

citriculture. Tree Physiol., 12:195-216.

MacInnes, C.B., and L.S. Albert. 1969. Effect of light intensity and plant size on rate of development of early boron deficiency symptoms in tomato root tips. Plant Physiol., 44:965-967.

Makmur, A., G. Gerloff, and W.H. Gabelman. 1978. Physiology and inheritance of efficiency in potassium utilization in tomatoes. (Lycopersicon esculentum Mill.) grown under potassium stress. J. Amer. Soc. Hort. Sci., 103:5450549.

Manolakis, E., and P. Ludders. 1977. Die wirkung gleihmassiger und jahreszeitlich abwechselnder ammonium- und nitraternahrung auf apfelbaume. I. Einfluss auf das vegetative wachstum. Gartenbauwissenschaft, 42:1-7.

Marschner, H. 1971. Why can sodium replace potassium in plants? Proc. 8th Colloq. Int. Potash Inst. Bern., pp. 50-63.

Pill, W.G., V.N. Lambeth, and T.M. Hinckley. 1978. Effects of nitrogen forms and level on ion concentrations, water stress, and blossom-end rot incidence in tomato. J. Amer. Soc. Hort. Sci., 1031:265-268.

Purvis, D., and E.J. Macenzie. 1974. Phytotoxicity due to boron in municipal compost. Plant Soil, 40:231-235.

Sonneveld, C., and J. van den Ende. 1975. The effect of some salts on head weight and tipburn of lettuce and on fruit production and blossom-end rot of tomatoes. Neth. J. Agric. Sci., 23:192201.

Sykes, S.R. 1992. The inheritance of salt exclusion in woody perennial fruit species. Plant Soil, 146:123-129.

Terry, N., and A. Ulrich. 1974. Effects of magnesium deficiency on the photosynthesis and respiration of leaves of sugar beet. Plant Physiol., 54:379-381.