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pH Management: Problem ID, Optimal Ranges, and Corrective Procedures

This updated e-GRO Alert includes an extensive listing of optimal pH ranges for greenhouse plants, diagnostic photos of high pH and low pH problems, and corrective procedures.

The Greenhouse production in the Southeastern U.S. offers a unique situation of experiencing both high and low pH induced plant disorders.

with low alkalinity levels and low content of mineral salts (low electrical conductivity). The water quality is excellent and many Midwestern green-

The coastal portion of North Carolina has high levels of alkalinity which can lead to iron deficiency induced by elevated substrate pHs. Production there necessitates acid injection similar to the Midwest and Great Plains.

When moving away from the coast, one enters new territory with drastically different management requirements. This area has pure irrigation water

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Figure 1. Initial signs of interveinal chlorosis of the upper leaves. This indicates that iron is limited. In most cases it is likely due to elevated substrate pH levels above 6.5.

e-GRO Alert

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houses would love to have it! Low alkalinity water requires a change in management strategy. There is no buffering in the water because of the lack of alkalinity so fertilizer type can impact the substrate pH and cause it to quickly drift upward with basic types of fertilizer or downward with acidic fertilizer types.

Thus, symptoms of elevated substrate pH and excessively low substrate pH are frequently encountered. Recently an ornamental pepper sample was submitted to the clinic with low pH symptoms. The purpose of this e-GRO Alert is to familiarize you with the visual symptom when the substrate pH has gone adrift.

In greenhouse production we often rely upon reading the leaves for symptoms when diagnosing nutritional problems. We typically classify plants into one of three pH groups. The **Petunia Group** can experience high pH induced iron deficiency resulting in interveinal chlorosis (Fig. 1). It might actually be better to label these plants

as being inefficient at iron uptake under elevated pH conditions. Besides petunias, calibrachoa, gerbera, hydrangea, pansy, snapdragon, and vinca all will quickly develop iron deficiency symptoms if the pH is elevated. Typically symptomology will begin when the pH increases above the 6.3 to 6.8 range.

To manage this situation, the substrate pH should be monitored to ensure that it is within the acceptable range (Table 3). The corrective procedures below assume you are first working to manage excessive alkalinity with acid injection. If the substrate pH is just beginning to drift too high, switching to an acidic fertilizer may help (Table 1). If corrective procedures are required, applying a 10% excessive leaching irrigation of chelated iron (Table 1).

On the opposite end of the spectrum is the **Geranium Group** that experience lower leaf symptoms if the pH is too low. These plants can also be considered to be extra efficient at iron uptake. When the pH drops too low, the avail-

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ability of micro-nutrients, especially iron and manganese, increase. If a plant is efficient at taking up these elements in excess, then the leaves develop symptoms that can vary from a bronzing with marigolds (Fig. 2) or geraniums to a blackish-purple spotting with cosmos, dahlia, fuchsia, gerbera (Fig. 3), pepper or tomatoes.

Prevention is the best course here. Monitoring the substrate pH will aid you in determining if the pH is drifting too low. Corrective procedures for low

pH are listed in Table 2.

Switching to a basic fertilizer when the substrate pH is nearing the lower limit will help stabilize the pH. If the pH is below the recommended range, then corrective procedures will need to be implemented. Flowable lime is one option. Typically a rate of 2 quarts per 100 gallons of water will increase the substrate pH by roughly 0.5 pH units. Two quarts can be used through the injector. Additional applications can be made if needed. Potassium bicarbonate can



Figure 2. Bronzing of the lower foliage caused by low substrate pH.

Option	Rate / Notes
Use an Acidic Fertilizer	-20-10-20, etc -Extremely acidic: 21-7-7 (avoid using this with cold growing because it can lead to NH ₄ -N toxicity) •Apply as a irrigation. •Best to use just when the substrate pH begins to increase near the upper pH limit.
Acid Water Drench	-Use sulfuric acid to acidify your irrigation water to pH 4.0 to 4.5. •Apply as a substrate drench •Rinse foliage ASAP
Iron Drench	-Iron-EDDHA: mix 5 oz in 100 gallons of water -or- -Iron-DTPA: mix 5 oz in 100 gallons of water -or- -Iron sulfate: mix 4-8 oz in 100 gallons of water •Apply as a substrate drench with sufficient volume to leach the pot. •Rinse foliage ASAP •Use with caution on iron efficient plants (geraniums)

also be applied. The rate of 2 pounds per 100 gallons of water will increase the substrate pH by roughly 0.8 pH units. This treatment will also provide excessive potassium and cause a spike in the substrate electrical conductivity (EC). So the following day a leaching irrigation with clear water is required to restore the nutrient balance (the ratio of K:Ca:Mg) and lower the EC level. As

always, remember to re-check your substrate pH to determine if reapplications are needed.

The final classification is the **General Group** which rarely exhibits pH induced symptoms and includes chrysanthemums and poinsettias. This leads to a story from a few years ago. A grower called who was trying to troubleshoot their garden mum

crop. This was in June, and instead of the normal vigorous growth, the plants had stalled and were only about half their typical size for that time of year. No other leaf symptoms were present. The EC levels were within the acceptable range, but the pH was low at 4.5. We discussed options and a recommendation was made on how to increase the pH to the 5.8 to 6.2 range. Two weeks

Table 2. Corrective procedures to increase the substrate pH.	
Option	Rate / Notes
Flowable Lime	<p>-Use 1 to 2 quarts per 100 gallons of water.</p> <ul style="list-style-type: none"> •Apply as a substrate drench with sufficient volume to leach the pot. •Rinse foliage. •Avoid damage to your injector by using rates of 2 quarts per 100 gallons of water, or less •Can split applications
Hydrated Lime	<p>-Mix 1 pound in 3 to 5 gallons of WARM water. Mix twice. Let settle. Decant liquid and apply thru injector at 1:15.</p> <ul style="list-style-type: none"> •Caustic (rinse foliage ASAP and avoid skin contact) •Apply as a substrate drench with sufficient volume to leach the pot. •Rinse foliage ASAP
Potassium Bicarbonate (KHCO ₃)	<p>-Use 2 pounds per 100 gallons of water</p> <ul style="list-style-type: none"> •Apply as a substrate drench with sufficient volume to leach the pot. •Rinse foliage ASAP •Provides 933 ppm K •Leach heavily the following day with a complete fertilizer to reduce EC levels and restore nutrient balance. •Rates greater than 2 pounds per 100 gallons of water can cause phytotoxicity!

later he called back and expressed his amazement and reported how the plants had doubled in size by just getting the pH back to the acceptable range. As a person who is called

upon to troubleshoot production problems, this situation has always been intriguing. From the experience with the garden mum crop, we wanted to know if plants classified in

the General Group were actually unaffected by low pH problems. To test this, we at North Carolina State University grew a petunia and poinsettia crop with three levels of lime, to

provide a low, marginally low, and normal substrate pH conditions. In these two experiments, no lower leaf symptoms appeared. What did occur with the low pH conditions was less growth (Fig. 4). With petunias, plant growth was 29% less when plants were grown at pH 4.8 instead of pH 5.1. At an extremely low pH of 3.3, plants were even more stunted.

The same thing occurred with poinsettias (Fig. 5). Growth was less and bract coloration was delayed at pH 2.8 when compared to either pH 4.7 or 6.0. For Viking Red poinsettias, they appear to be more adaptable to a lower pH of 4.7 than what we typically recommend between pH 5.8 and 6.3.

The take home message here is plants

in the General Group are more adaptable to low pH conditions, but are not as immune as we thought. They may not develop leaf symptoms that alert you that there is a problem. Slowed or stunted growth is sometimes difficult to notice if it involves the entire crop. Because reading the leaves is not possible, growers will need to monitor their crop's pH to determine if the crop is within the acceptable range. This will ensure a normal rate of growth.

In summary, symptoms of sub-optimal pH will occur if the pH is too high or too low. A pH monitoring program will help ensure your crop's pH is on track. Hopefully this article will help improve your diagnostic skills if your pH drifts outside the optimal range.



Figure 3. Blackish-purple spotting on the lower leaves due to low substrate pH.

Stunted growth with low pH



3.3

59%

4.8

29%

5.1 pH

-- *Dry weight Reduction*

Figure 4. Stunted growth of petunias at low pH.

Stunted growth with low pH



pH: 2.9

4.7

6.0

Figure 5. Viking Red poinsettias stunted at pH 2.9.

Table 3. Recommended pH Ranges for Greenhouse Crops Grown In Soilless Substrates¹.

Specie (Scientific Name)	Specie (Common Name)	pH Category
<i>Abelia species</i>	Abelia	III - pH 5.8 - 6.2
<i>Abutilon</i>	Abutilon, Flowering Maple	IV - pH 6.0 - 6.5
<i>Acalypha pendula</i>	Chenille plant	II - pH 5.5 - 5.8
<i>Acalypha wilkesiana</i>	Copperleaf, Joseph's coat	IV - pH 6.0 - 6.5
<i>Achillea</i>	Yarrow	III - pH 5.8 - 6.2
<i>Acorus gramineus</i>	Sweet Flag	IV - pH 6.0 - 6.5
<i>Aegopodium</i>	Bishop's weed, Ground elder, Snow-on-the-mountain	III - pH 5.8 - 6.2
<i>Aeonium haworthii</i>	Pinwheel	II - pH 5.5 - 6.0
<i>Aeonium hybrid</i>	Pinwheel	II - pH 5.5 - 6.0
<i>Agastache</i>	Hyssop	IV - pH 6.0 - 6.5
<i>Agave</i>	Agave	III - pH 5.8 - 6.2
<i>Ageratum houstonianum</i>	Ageratum	III - pH 5.8 - 6.2
<i>Ajuga</i>	Ajuga, Bugleweed	III - pH 5.8 - 6.2
<i>Alcea</i>	Hollyhock	III - pH 5.8 - 6.2
<i>Allium species</i>	Allium (ornamental)	III - pH 5.8 - 6.2
<i>Alocasia</i>	Alocasia, Elephant's ear	IV - pH 6.0 - 6.5
<i>Aloe</i>	Aloe	IV - pH 6.0 - 6.5
<i>Aloysia triphylla</i>	Lemon beebrush, Lemon verbena	III - pH 5.8 - 6.2
<i>Alternanthera</i>	Alternanthera, Joseph's Coat)	II - pH 5.5 - 5.8
<i>Alyssum</i>	Alyssum	II,III - pH 5.5 - 6.2
<i>Anagallis hybrid</i>	Pimpernel	II - pH 5.5 - 5.8
<i>Anethum graveolens</i>	Dill	III - pH 5.8 - 6.2
<i>Angelonia</i>	Angelonia, Angel flower, Summer snapdragon	III - pH 5.8 - 6.2
<i>Anisodonteia</i>	Cape mallow	IV - pH 6.0 - 6.5
<i>Anthericum saundersiae</i>	Grass lily	III - pH 5.8 - 6.2
<i>Antirrhinum</i>	Snapdragon	II - pH 5.5 - 5.8
<i>Aquilegia</i>	Columbine	III - pH 5.8 - 6.2
<i>Arabis species</i>	Rockcress, Cress, Mountain rock, Wallcress	III - pH 5.8 - 6.2
<i>Arctotis hybrid</i>	African daisy	IV - pH 6.0 - 6.5
<i>Argyranthemum frutescens</i>	Marguerite daisy	III - pH 5.8 - 6.2
<i>Armeria maritima</i>	Seathrift, Sea Pink	III - pH 5.8 - 6.2
<i>Arrhenatherum species</i>	Oatgrass, Buttongrass	IV - pH 6.0 - 6.5
<i>Artemisia stelleriana</i>	Dusty miller	III - pH 5.8 - 6.2
<i>Artemisia dracunculus</i>	Tarragon	II - pH 5.5 - 5.8
<i>Asparagus densiflorous 'sprengeri'</i>	Asparagus fern	III - pH 5.8 - 6.2

Table 3. Recommended pH Ranges for Greenhouse Crops Grown In Soilless Substrates, Continued.

Specie (Scientific Name)	Specie (Common Name)	pH Category
<i>Aster dumosus</i> (<i>A. novi-belgii</i>)	New York aster	III - pH 5.8 - 6.2
<i>Asteriscus maritimus</i>	Gold Coin Daisy	III - pH 5.8 - 6.2
<i>Athyrium filix-femina</i>	Lady fern	III - pH 5.8 - 6.2
<i>Aubrieta deltoidea</i>	Common aubrieta, False rockcress	IV - pH 6.0 - 6.5
<i>Aurinia saxatilis</i>	Basket of gold, Golden alyssum	III,IV - pH 5.8 - 6.5
<i>Baptisia hybrid</i>	False indigo, Wild indigo	III,IV - pH 5.8 - 6.5
<i>Begonia hybrid</i>	Begonia Hybrid	II,III - pH 5.5 - 6.2
<i>Begonia Rex</i>	Begonia Rex	IV - pH 6.0 - 6.5
<i>Begonia semperflorens-cultorum</i>	Wax begonia	II - pH 5.5 - 5.8
<i>Begonia tuberhydrida</i>	Dragon Wing® begonia	III - pH 5.8 - 6.2
<i>Begonia tuberosus</i>	Tuberous Begonia	II - pH 5.5 - 5.8
<i>Begonia x tuberhybrida</i>	<i>Begonia x tuberhybrida</i>	IV - pH 6.0 - 6.5
<i>Bellis perennis</i>	Bellis, Lawn daisy	III - pH 5.8 - 6.2
<i>Berberis thunbergii</i>	Barberry	III - pH 5.8 - 6.2
<i>Bergenia crassifolia</i> , <i>B. cordifolia</i>	Bergenia, Elephant-eared saxifrage, Elephant's ears	III - pH 5.8 - 6.2
<i>Berlandiera hybrid</i>	Berlandiera, Greeneyes	III - pH 5.8 - 6.2
<i>Bidens hybrid</i> , <i>B. ferulifolia</i>	Bidens	III - pH 5.8 - 6.2
<i>Boltonia species</i>	Thousand flower aster, Wild aster	III - pH 5.8 - 6.2
<i>Bouteloua curtipendula</i>	Sideoats grama	III - pH 5.8 - 6.2
<i>Brachyscome hybrid</i>	Brachyscome	II - pH 5.5 - 5.8
<i>Bracteantha (Xerochrysum) bracteata</i>	Strawflower	II,III - pH 5.5 - 6.2
<i>Briza species</i>	Quaking grasses	IV - pH 6.0 - 6.5
<i>Browallia hybrid</i>	Browallia, Amethyst flower, Sapphire flower	III - pH 5.8 - 6.2
<i>Buddleia</i>	Buddleia, Butterfly bush	III - pH 5.8 - 6.2
<i>Buxus</i>	Boxwood	III - pH 5.8 - 6.2
<i>Caladium bicolor</i>	Caladium	II,III - pH 5.5 - 6.2
<i>Calamagrostis</i>	Calamagrostis	III - pH 5.8 - 6.2
<i>Calibrachoa</i>	Calibrachoa	II - pH 5.5 - 5.8
<i>Callicarpa</i>	Beautyberry	III - pH 5.8 - 6.2
<i>Callirhoe</i>	Callirhoe	III - pH 5.8 - 6.2
<i>Calocephalus</i>	Calocephalus	IV - pH 6.0 - 6.5
<i>Calycanthus</i>	Sweetshrub	III - pH 5.8 - 6.2
<i>Calylophus</i>	Calylophus	III - pH 5.8 - 6.2
<i>Campanula</i>	Campanula	III - pH 5.8 - 6.2
<i>Campanula carpatica</i>	<i>Campanula carpatica</i>	III - pH 5.8 - 6.2

Table 3. Recommended pH Ranges for Greenhouse Crops Grown In Soilless Substrates, Continued.

Specie (Scientific Name)	Specie (Common Name)	pH Category
<i>Canna</i>	Canna	III - pH 5.8 - 6.2
<i>Capsicum</i>	Pepper, Christmas Pepper	II,III - pH 5.5 - 6.2
<i>Carex</i>	Carex	III - pH 5.8 - 6.2
<i>Catharanthus roseus</i>	Vinca	II - pH 5.5 - 5.8
<i>Caryopteris</i>	Caryopteris	III - pH 5.8 - 6.2
<i>Ceanothus</i>	Ceanothus	III - pH 5.8 - 6.2
<i>Celosia</i>	Celosia	II,III - pH 5.5 - 6.2
<i>Centaurea</i>	Centaurea	III - pH 5.8 - 6.2
<i>Centradenia</i>	Centradenia	IV - pH 6.0 - 6.5
<i>Cephalanthus</i>	Buttonbush	III - pH 5.8 - 6.2
<i>Cerastium</i>	Cerastium	III - pH 5.8 - 6.2
<i>Ceratostigma</i>	Ceratostigma	III - pH 5.8 - 6.2
<i>Cestrum</i>	Cestrum	IV - pH 6.0 - 6.5
<i>Chaenomeles</i>	Quince	III - pH 5.8 - 6.2
<i>Chamaecyparis</i>	False Cypress	III - pH 5.8 - 6.2
<i>Chasmanthium</i>	Chasmanthium	IV - pH 6.0 - 6.5
<i>Chrysocephalum</i>	Chrysocephalum	IV - pH 6.0 - 6.5
<i>Clematis</i>	Clematis	III - pH 5.8 - 6.2
<i>Cleome</i>	Cleome	III - pH 5.8 - 6.2
<i>Clethra</i>	Clethra	III - pH 5.8 - 6.2
<i>Coleus</i>	Coleus	III - pH 5.8 - 6.2
<i>Colocasia</i>	Colocasia	III - pH 5.8 - 6.2
<i>Convolvulus</i>	Convolvulus	III - pH 5.8 - 6.2
<i>Cordyline</i>	Cordyline	III - pH 5.8 - 6.2
<i>Coreopsis</i>	Coreopsis	III - pH 5.8 - 6.2
<i>Coriandrum</i>	Coriandrum	III - pH 5.8 - 6.2
<i>Cornus</i>	Dogwood	III - pH 5.8 - 6.2
<i>Corydalis</i>	Corydalis	III - pH 5.8 - 6.2
<i>Cosmos</i>	Cosmos	III - pH 5.8 - 6.2
<i>Cotinus</i>	Cotinus	III - pH 5.8 - 6.2
<i>Cotyledon</i>	Cotyledon	III - pH 5.8 - 6.2
<i>Crassula coccinea</i>	<i>Crassula coccinea</i>	II - pH 5.5 - 5.8
<i>Crassula hybrid</i>	Crassula hybrid	II - pH 5.5 - 5.8
<i>Crassula muscosa</i>	<i>Crassula muscosa</i>	III - pH 5.8 - 6.2
<i>Crassula muscosa pseudolycopodiodes</i>	<i>Crassula muscosa pseudolycopodiodes</i>	II,III - pH 5.5 - 6.2

Table 3. Recommended pH Ranges for Greenhouse Crops Grown In Soilless Substrates, Continued.

Specie (Scientific Name)	Specie (Common Name)	pH Category
<i>Crassula ovata</i>	Jade	II,III - pH 5.5 - 6.2
<i>Crassula ovata arborescens</i>	Jade	II - pH 5.5 - 5.8
<i>Crassula pellucida</i>	<i>Crassula pellucida</i>	II - pH 5.5 - 5.8
<i>Crassula radicans</i>	Stonecrop	II - pH 5.5 - 5.8
<i>Crassula tetragona</i>	Miniature Pine Tree	II - pH 5.5 - 5.8
<i>Cuphea</i>	Cuphea	IV - pH 6.0 - 6.5
<i>Cyperus</i>	Cyperus	IV - pH 6.0 - 6.5
<i>Dahlia, Cutting</i>	Dahlia, Cutting	III - pH 5.8 - 6.2
<i>Delosperma</i>	Delosperma	III - pH 5.8 - 6.2
<i>Delphinium</i>	Delphinium	III - pH 5.8 - 6.2
<i>Deschampsia</i>	Deschampsia	IV - pH 6.0 - 6.5
<i>Deutzia</i>	Deutzia	III - pH 5.8 - 6.2
<i>Dianthus</i>	Dianthus	III - pH 5.8 - 6.2
<i>Dianthus caryophyllus</i>	Carnation, Clove pink	IV - pH 6.0 - 6.5
<i>Dianthus gratianopolitanus</i>	Cheddar pink	IV - pH 6.0 - 6.5
<i>Diascia</i>	Diascia	III - pH 5.8 - 6.2
<i>Dichondra hybrid</i>	Dichondra hybrid	II,III - pH 5.5 - 6.2
<i>Dichromena</i>	Dichromena	III - pH 5.8 - 6.2
<i>Didelta</i>	Didelta	II - pH 5.5 - 5.8
<i>Dieffenbachia</i>	Dieffenbachia	III - pH 5.8 - 6.2
<i>Digitalis</i>	Digitalis	III - pH 5.8 - 6.2
<i>Dracaena</i>	Dracaena	III - pH 5.8 - 6.2
<i>Duranta</i>	Duranta	IV - pH 6.0 - 6.5
<i>Echeveria</i>	Echeveria	IV - pH 6.0 - 6.5
<i>Echeveria hybrid</i>	Echeveria hybrid	II,III - pH 5.5 - 6.2
<i>Echeveria nodulosa x hybrid</i>	Echeveria	III - pH 5.8 - 6.2
<i>Echinacea</i>	Echinacea	III - pH 5.8 - 6.2
<i>Ensete</i>	Ensete	III - pH 5.8 - 6.2
<i>Epilobium</i>	Epilobium	III - pH 5.8 - 6.2
<i>Equisetum</i>	Equisetum	IV - pH 6.0 - 6.5
<i>Eragrostis</i>	Eragrostis	IV - pH 6.0 - 6.5
<i>Eranthemum</i>	Eranthemum	IV - pH 6.0 - 6.5
<i>Erigeron</i>	Erigeron	IV - pH 6.0 - 6.5
<i>Erysimum</i>	Erysimum	III - pH 5.8 - 6.2
<i>Eucalyptus</i>	Eucalyptus	III - pH 5.8 - 6.2
<i>Euonymus alatus</i>	Burning Bush	III - pH 5.8 - 6.2

Table 3. Recommended pH Ranges for Greenhouse Crops Grown In Soilless Substrates, Continued.

Specie (Scientific Name)	Specie (Common Name)	pH Category
<i>Euonymus fortunei</i>	<i>Euonymus fortunei</i>	III - pH 5.8 - 6.2
<i>Eupatorium capillifolium</i>	<i>Eupatorium capillifolium</i>	III - pH 5.8 - 6.2
<i>Eupatorium rugosum</i>	<i>Eupatorium rugosum</i>	III - pH 5.8 - 6.2
<i>Euphorbia</i>	Euphorbia	III - pH 5.8 - 6.2
<i>Euphorbia cotinifolia</i>	<i>Euphorbia cotinifolia</i>	III - pH 5.8 - 6.2
<i>Euryops</i>	Euryops	III - pH 5.8 - 6.2
<i>Evolvulus</i>	Evolvulus	C - pH 6.0 - 6.5
<i>Exochorda</i>	Pearl Bush	III - pH 5.8 - 6.2
<i>Felicia</i>	Felicia	II,III - pH 5.5 - 6.2
<i>Festuca</i>	Festuca	III - pH 5.8 - 6.2
<i>Forsythia</i>	Forsythia	III - pH 5.8 - 6.2
<i>Fuchsia hybrid</i>	Fuchsia hybrid	IV - pH 6.0 - 6.5
<i>Gaillardia</i>	Gaillardia	III - pH 5.8 - 6.2
<i>Galium</i>	Galium	III - pH 5.8 - 6.2
<i>Gaura</i>	Gaura	III - pH 5.8 - 6.2
<i>Gazania</i>	Gazania	IV - pH 6.0 - 6.5
<i>Genista lydia</i>	<i>Genista lydia</i>	III - pH 5.8 - 6.2
<i>Geranium</i>	Geranium	III,IV - pH 5.8 - 6.5
<i>Gerbera</i>	Gerbera	III - pH 5.8 - 6.2
<i>Geum</i>	Geum	III - pH 5.8 - 6.2
<i>Glechoma</i>	Glechoma	III - pH 5.8 - 6.2
<i>Gomphrena</i>	Gomphrena	II - pH 5.5 - 5.8
<i>Graptopetalum</i>	Graptopetalum	III - pH 5.8 - 6.2
<i>Graptophyllum</i>	Graptophyllum	III - pH 5.8 - 6.2
<i>Graptoveria</i>	Graptoveria	III - pH 5.8 - 6.2
<i>Gypsophila</i>	Baby's Breath	III,IV - pH 5.8 - 6.5
<i>Haloragis</i>	Haloragis	III - pH 5.8 - 6.2
<i>Hamelia</i>	Hamelia	IV - pH 6.0 - 6.5
<i>Haworthia</i>	Haworthia	III - pH 5.8 - 6.2
<i>Hebe</i>	Hebe	III - pH 5.8 - 6.2
<i>Hedera</i>	Hedera	III - pH 5.8 - 6.2
<i>Helenium</i>	Helenium	III - pH 5.8 - 6.2
<i>Helichrysum</i>	Helichrysum	IV - pH 6.0 - 6.5
<i>Helichrysum petiolare</i>	Licorice Plant	III - pH 5.8 - 6.2
<i>Helichrysum thianschanicum</i>	Licorice Plant	III - pH 5.8 - 6.2
<i>Helictotrichon</i>	Helictotrichon	III - pH 5.8 - 6.2

Table 3. Recommended pH Ranges for Greenhouse Crops Grown In Soilless Substrates, Continued.

Specie (Scientific Name)	Specie (Common Name)	pH Category
<i>Heliopsis</i>	Heliopsis	III - pH 5.8 - 6.2
<i>Heliotropium</i>	Heliotropium	IV - pH 6.0 - 6.5
<i>Heliotrope (Heliotropium)</i>	Heliotrope	IV - pH 6.0 - 6.5
<i>Hemerocallis</i>	Hemerocallis	IV - pH 6.0 - 6.5
<i>Herniaria</i>	Herniaria	III - pH 5.8 - 6.2
<i>Hesperozygis</i>	Hesperozygis	III - pH 5.8 - 6.2
<i>Heuchera</i>	Heuchera	II - pH 5.5 - 5.8
<i>Heucherella</i>	Heucherella	IV - pH 6.0 - 6.5
<i>Hibiscus</i>	Hibiscus	II - pH 5.5 - 5.8
<i>Hybrid Hibiscus</i>	Hybrid Hibiscus	III - pH 5.8 - 6.2
<i>Hibiscus acetosella</i>	<i>Hibiscus acetosella</i>	IV - pH 6.0 - 6.5
<i>Hibiscus syriacus</i>	Rose of Sharon	II - pH 5.5 - 5.8
<i>Hosta</i>	Hosta	III,IV - pH 5.8 - 6.5
<i>Hop Humulus</i>	Hop Humulus	III - pH 5.8 - 6.2
<i>Hydrangea</i>	Hydrangea	III - pH 5.8 - 6.2
<i>Hylotelephium</i>	Hylotelephium	III,IV - pH 5.8 - 6.5
<i>Hypericum</i>	St. John's-Wort	III - pH 5.8 - 6.2
<i>Iberis</i>	Iberis	III - pH 5.8 - 6.2
<i>Ilex crenata</i>	Japanese Holly	III - pH 5.8 - 6.2
<i>Ilex verticillata</i>	Ilex verticillata	III - pH 5.8 - 6.2
<i>Ilex x meserveae</i>	Blue Holly	III - pH 5.8 - 6.2
<i>Impatiens hawkeri</i>	<i>Impatiens hawkeri</i>	IV - pH 6.0 - 6.5
<i>Impatiens walleriana</i>	<i>Impatiens walleriana</i>	III - pH 5.8 - 6.2
<i>Imperata</i>	Imperata	III - pH 5.8 - 6.2
<i>Iochoroma</i>	Iochoroma	III - pH 5.8 - 6.2
<i>Ipomoea</i>	Ipomoea	III - pH 5.8 - 6.2
<i>Iresine</i>	Iresine	IV - pH 6.0 - 6.5
<i>Isotoma</i>	Isotoma	III - pH 5.8 - 6.2
<i>Itea virginica</i>	Sweetspire	III - pH 5.8 - 6.2
<i>Juncus</i>	Juncus	III - pH 5.8 - 6.2
<i>Juniperus</i>	Juniperus	III - pH 5.8 - 6.2
<i>Kalanchoe fedtschenkoi</i>	South American Air Plant	II - pH 5.5 - 5.8
<i>Kalanchoe pumila</i>	<i>Kalanchoe pumila</i>	II - pH 5.5 - 5.8
<i>Kalanchoe thyrsiflora</i>	<i>Kalanchoe thyrsiflora</i>	III - pH 5.8 - 6.2
<i>Kniphofia</i>	Kniphofia	III - pH 5.8 - 6.2
<i>Koeleria</i>	Koeleria	III - pH 5.8 - 6.2
<i>Kolkwitzia amabilis</i>	Beaut Bush	III - pH 5.8 - 6.2

Table 3. Recommended pH Ranges for Greenhouse Crops Grown In Soilless Substrates, Continued.

Specie (Scientific Name)	Specie (Common Name)	pH Category
<i>Lamiastrum</i>	Lamiastrum	III - pH 5.8 - 6.2
<i>Lamium</i>	Lamium	III - pH 5.8 - 6.2
<i>Lamium maculatum</i>	Dead Nettle	IV - pH 6.0 - 6.5
<i>Lampranthus blandus</i>	<i>Lampranthus blandus</i>	II - pH 5.5 - 5.8
<i>Lantana</i>	Lantana	III - pH 5.8 - 6.2
<i>Laurentia</i>	Laurentia	III - pH 5.8 - 6.2
<i>Laurus nobilis</i>	Sweet Bay	III - pH 5.8 - 6.2
<i>Lavandula</i>	Lavandula	IV - pH 6.0 - 6.5
<i>Lavendula</i>	Lavendula	II - pH 5.5 - 5.8
<i>Leucanthemum</i>	Leucanthemum	III - pH 5.8 - 6.2
<i>Leycesteria</i>	Pheasant Berry	III - pH 5.8 - 6.2
<i>Leymus</i>	Leymus	III - pH 5.8 - 6.2
<i>Liatris</i>	Liatris	III - pH 5.8 - 6.2
<i>Ligularia</i>	Ligularia	IV - pH 6.0 - 6.5
<i>Linum</i>	Linum	III - pH 5.8 - 6.2
<i>Liriope</i>	Liriope	III - pH 5.8 - 6.2
<i>Lithodora</i>	Lithodora	III - pH 5.8 - 6.2
<i>Lobelia</i>	Lobelia	II,III - pH 5.5 - 6.2
<i>Lobelia erinus</i>	<i>Lobelia erinus</i>	III - pH 5.8 - 6.2
<i>Lobularia</i>	Lobularia	IV - pH 6.0 - 6.5
<i>Lonicera</i>	Lonicera	III - pH 5.8 - 6.2
<i>Lophospermum</i>	Lophospermum	IV - pH 6.0 - 6.5
<i>Lotus</i>	Lotus	IV - pH 6.0 - 6.5
<i>Lupinus</i>	Lupinus	III - pH 5.8 - 6.2
<i>Luzula</i>	Luzula	III - pH 5.8 - 6.2
<i>Lycium</i>	Goji Berry	III - pH 5.8 - 6.2
<i>Lygeum</i>	Lygeum	III - pH 5.8 - 6.2
<i>Lysimachia</i>	Lysimachia	III - pH 5.8 - 6.2
<i>Lysimachia congestiflora</i>	<i>Lysimachia congestiflora</i>	IV - pH 6.0 - 6.5
<i>Lysimachia nummularia</i>	<i>Lysimachia nummularia</i>	III - pH 5.8 - 6.2
<i>Mandevilla</i>	Mandevilla	III - pH 5.8 - 6.2
<i>Mecardonia</i>	Mecardonia	III - pH 5.8 - 6.2
<i>Melampodium</i>	Melampodium	III - pH 5.8 - 6.2
<i>Melinus</i>	Melinus	III - pH 5.8 - 6.2
<i>Melissa</i>	Melissa	III - pH 5.8 - 6.2
<i>Mentha</i>	Mentha	III - pH 5.8 - 6.2

Table 3. Recommended pH Ranges for Greenhouse Crops Grown In Soilless Substrates, Continued.

Specie (Scientific Name)	Specie (Common Name)	pH Category
<i>Microbiota</i>	Siberian Cypress	III - pH 5.8 - 6.2
<i>Mimulus</i>	Mimulus	II - pH 5.5 - 5.8
<i>Miscanthus</i>	Miscanthus	III - pH 5.8 - 6.2
<i>Monarda</i>	Monarda	III - pH 5.8 - 6.2
<i>Monopsis</i>	Monopsis	IV - pH 6.0 - 6.5
<i>Muehlenbeckia</i>	Muehlenbeckia	III - pH 5.8 - 6.2
<i>Muhlenbergia</i>	Muhlenbergia	IV - pH 6.0 - 6.5
<i>Musa</i>	Musa	III - pH 5.8 - 6.2
<i>Myosotis</i>	Myosotis	II - pH 5.5 - 5.8
<i>Nemesia</i>	Nemesia	II - pH 5.5 - 5.8
<i>Nemesia hybrid</i>	Nemesia hybrid	II - pH 5.5 - 5.8
<i>Nepeta</i>	Nepeta	III - pH 5.8 - 6.2
<i>Nierembergia</i>	Nierembergia	IV - pH 6.0 - 6.5
<i>Ocimum</i>	Ocimum	III - pH 5.8 - 6.2
<i>Oenothera</i>	Oenothera	III - pH 5.8 - 6.2
<i>Oenothera</i>	Evening Primrose	III - pH 5.8 - 6.2
<i>Ophiopogon</i>	Ophiopogon	IV - pH 6.0 - 6.5
<i>Ophiopogon planiscapus</i>	<i>Ophiopogon planiscapus</i>	IV - pH 6.0 - 6.5
<i>Oplismenus</i>	Oplismenus	III - pH 5.8 - 6.2
<i>Origanum</i>	Origanum	II - pH 5.5 - 5.8
<i>Orostachys</i>	Orostachys	III - pH 5.8 - 6.2
<i>Osteospermum</i>	Osteospermum	III - pH 5.8 - 6.2
<i>Osteospermum hybrid</i>	Osteospermum hybrid	III - pH 5.8 - 6.2
<i>Otacanthus</i>	Otacanthus	III - pH 5.8 - 6.2
<i>Oxalis</i>	Oxalis	III - pH 5.8 - 6.2
<i>Oxalis articulata</i>	<i>Oxalis articulata</i>	III - pH 5.8 - 6.2
<i>Oxalis crassipes</i>	<i>Oxalis crassipes</i>	III - pH 5.8 - 6.2
<i>Oxalis succulenta</i>	<i>Oxalis succulenta</i>	III - pH 5.8 - 6.2
<i>Oxalis vulcanicola</i>	<i>Oxalis vulcanicola</i>	III - pH 5.8 - 6.2
<i>Ozothamnus</i>	Ozothamnus	II,III - pH 5.5 - 6.2
<i>Panicum</i>	Panicum	IV - pH 6.0 - 6.5
<i>Papaver nudicaule</i>	<i>Papaver nudicaule</i>	IV - pH 6.0 - 6.5
<i>Papaver orientale</i>	<i>Papaver orientale</i>	IV - pH 6.0 - 6.5
<i>Parthenocissus quinquefolia</i>	Virginia Creeper	III - pH 5.8 - 6.2
<i>Paspalum</i>	Paspalum	III - pH 5.8 - 6.2
<i>Pelargonium</i>	Pelargonium	IV - pH 6.0 - 6.5

Table 3. Recommended pH Ranges for Greenhouse Crops Grown In Soilless Substrates, Continued.

Specie (Scientific Name)	Specie (Common Name)	pH Category
<i>Pennisetum alopecuroides</i>	<i>Pennisetum alopecuroides</i>	III,IV - pH 5.8 - 6.5
<i>Pennisetum macroctacium</i>	<i>Pennisetum macroctacium</i>	III - pH 5.8 - 6.2
<i>Pennisetum messiacum</i>	<i>Pennisetum messiacum</i>	III - pH 5.8 - 6.2
<i>Pennisetum orientale</i>	<i>Pennisetum orientale</i>	III - pH 5.8 - 6.2
<i>Pennisetum purpureum</i>	<i>Pennisetum purpureum</i>	III - pH 5.8 - 6.2
<i>Pennisetum purpureum</i>	Pearl Millet	III - pH 5.8 - 6.2
<i>Pennisetum setaceum</i>	<i>Pennisetum setaceum</i>	III - pH 5.8 - 6.2
<i>Pennisetum villosum</i>	<i>Pennisetum villosum</i>	III - pH 5.8 - 6.2
<i>Penstemon</i>	Penstemon	III - pH 5.8 - 6.2
<i>Pentas</i>	Pentas	IV - pH 6.0 - 6.5
<i>Pericallis</i>	Pericallis	III - pH 5.8 - 6.2
<i>Perilla</i>	Perilla	IV - pH 6.0 - 6.5
<i>Peristrothe</i>	Peristrothe	IV - pH 6.0 - 6.5
<i>Perovskia</i>	Perovskia	III - pH 5.8 - 6.2
<i>Persicaria</i>	Persicaria	III - pH 5.8 - 6.2
<i>Petroselinum crispum</i>	<i>Petroselinum crispum</i>	III - pH 5.8 - 6.2
<i>Petunia, Vegetative</i>	Petunia, Vegetative	II - pH 5.5 - 5.8
<i>Phalaris</i>	Phalaris	III - pH 5.8 - 6.2
<i>Philodendron</i>	Philodendron	III - pH 5.8 - 6.2
<i>Phlomis</i>	Phlomis	III - pH 5.8 - 6.2
<i>Phlox</i>	Phlox	III,IV - pH 5.8 - 6.5
<i>Phlox hybrid</i>	Phlox hybrid	III - pH 5.8 - 6.2
<i>Phormium</i>	Phormium	IV - pH 6.0 - 6.5
<i>Physocarpus opulifoliosus</i>	Ninebark	III - pH 5.8 - 6.2
<i>Platycodon</i>	Platycodon	III - pH 5.8 - 6.2
<i>Plectranthus</i>	Plectranthus	IV - pH 6.0 - 6.5
<i>Pogonatherum</i>	Pogonatherum	III - pH 5.8 - 6.2
<i>Polemonium</i>	Polemonium	III - pH 5.8 - 6.2
<i>Portulaca</i>	Portulaca	IV - pH 6.0 - 6.5
<i>Portulacaria afra</i>	<i>Portulacaria afra</i>	III - pH 5.8 - 6.2
<i>Potentilla</i>	Potentilla	III - pH 5.8 - 6.2
<i>Potentilla fruticosa</i>	Bush Cinquefoil	III - pH 5.8 - 6.2
<i>Primula</i>	Primula	II,III - pH 5.5 - 6.2
<i>Pulmonaria</i>	Pulmonaria	II - pH 5.5 - 5.8
<i>Raoulia</i>	Raoulia	III - pH 5.8 - 6.2
<i>Ratibida</i>	Ratibida	III - pH 5.8 - 6.2

Table 3. Recommended pH Ranges for Greenhouse Crops Grown In Soilless Substrates, Continued.

Specie (Scientific Name)	Specie (Common Name)	pH Category
<i>Rhamnus frangula</i>	Buckthorn	III - pH 5.8 - 6.2
<i>Rhodanthe</i>	Rhodanthe	III - pH 5.8 - 6.2
<i>Rhododendron</i>	Rhododendron	III - pH 5.8 - 6.2
<i>Roses Rosa</i>	Roses Rosa	III - pH 5.8 - 6.2
<i>Rosmarinus</i>	Rosmarinus	III - pH 5.8 - 6.2
<i>Rudbeckia</i>	Rudbeckia	III - pH 5.8 - 6.2
<i>Russelia</i>	Russelia	III,IV - pH 5.8 - 6.5
<i>Sagina subulata</i>	<i>Sagina subulata</i>	III - pH 5.8 - 6.2
<i>Salvia</i>	Salvia	III - pH 5.8 - 6.2
<i>Salvia argentea</i>	<i>Salvia argentea</i>	III - pH 5.8 - 6.2
<i>Salvia coccinea</i>	<i>Salvia coccinea</i>	II - pH 5.5 - 5.8
<i>Salvia elegans</i>	<i>Salvia elegans</i>	II,III - pH 5.5 - 6.2
<i>Salvia greggii</i>	<i>Salvia greggii</i>	III - pH 5.8 - 6.2
<i>Salvia guaranitica</i>	<i>Salvia guaranitica</i>	III - pH 5.8 - 6.2
<i>Salvia leucantha</i>	<i>Salvia leucantha</i>	III - pH 5.8 - 6.2
<i>Salvia longispicata x farinacea</i>	<i>Salvia longispicata x farinacea</i>	III - pH 5.8 - 6.2
<i>Salvia nemerosa</i>	<i>Salvia nemerosa</i>	III - pH 5.8 - 6.2
<i>Salvia officinalis</i>	<i>Salvia officinalis</i>	III - pH 5.8 - 6.2
<i>Salvia splendens</i>	<i>Salvia splendens</i>	III - pH 5.8 - 6.2
<i>Salvia verticillata</i>	<i>Salvia verticillata</i>	III - pH 5.8 - 6.2
<i>Sambucus</i>	Elderberry	III - pH 5.8 - 6.2
<i>Sanchezia</i>	Sanchezia	III - pH 5.8 - 6.2
<i>Santolina</i>	Santolina	III - pH 5.8 - 6.2
<i>Sanvitalia</i>	Sanvitalia	III - pH 5.8 - 6.2
<i>Satureja</i>	Satureja	IV - pH 6.0 - 6.5
<i>Scabiosa</i>	Scabiosa	III - pH 5.8 - 6.2
<i>Scaevola</i>	Scaevola	II - pH 5.5 - 5.8
<i>Schizanthus</i>	Schizanthus	III - pH 5.8 - 6.2
<i>Scirpus</i>	Scirpus	III - pH 5.8 - 6.2
<i>Scoparia</i>	Scoparia	IV - pH 6.0 - 6.5
<i>Scutellaria</i>	Scutellaria	III - pH 5.8 - 6.2
<i>Sedeveria hybrid</i>	<i>Sedeveria hybrid</i>	II - pH 5.5 - 5.8
<i>Sedum</i>	Sedum	III - pH 5.8 - 6.2
<i>Sedum hybrid</i>	<i>Sedum hybrid</i>	III - pH 5.8 - 6.2
<i>Sedum lineare</i>	<i>Sedum lineare</i>	II - pH 5.5 - 5.8
<i>Sedum rupestre</i>	<i>Sedum rupestre</i>	III - pH 5.8 - 6.2

Table 3. Recommended pH Ranges for Greenhouse Crops Grown In Soilless Substrates, Continued.

Specie (Scientific Name)	Specie (Common Name)	pH Category
<i>Sedum spathulifolium</i>	<i>Sedum spathulifolium</i>	II - pH 5.5 - 5.8
<i>Sedum (Hylotelephium)</i>	Sedum (Hylotelephium)	III,IV - pH 5.8 - 6.5
<i>Senecio talinoids mandralis</i>	<i>Senecio talinoids mandralis</i>	II - pH 5.5 - 5.8
<i>Senecio vitalis</i>	<i>Senecio vitalis</i>	II - pH 5.5 - 5.8
<i>Sesleria</i>	Sesleria	IV - pH 6.0 - 6.5
<i>Setaria</i>	Setaria	III,IV - pH 5.8 - 6.5
<i>Silene</i>	Silene	II - pH 5.5 - 5.8
<i>Soleirolia</i>	Soleirolia	III - pH 5.8 - 6.2
<i>Solenostemon</i>	Solenostemon	IV - pH 6.0 - 6.5
<i>Sphaeralcea</i>	Sphaeralcea	IV - pH 6.0 - 6.5
<i>Spirea Spiraea</i>	Spirea Spiraea	III - pH 5.8 - 6.2
<i>Stachys</i>	Stachys	III - pH 5.8 - 6.2
<i>Stipa</i>	Stipa	III - pH 5.8 - 6.2
<i>Streptocarpella</i>	Streptocarpella	IV - pH 6.0 - 6.5
<i>Streptocarpus</i>	Streptocarpus	IV - pH 6.0 - 6.5
<i>Strobilanthes</i>	Strobilanthes, Persian Shield	III - pH 5.8 - 6.2
<i>Sutera</i>	Sutera	II - pH 5.5 - 5.8
<i>Symphoricarpos</i>	Coral Berry	III - pH 5.8 - 6.2
<i>Syngonium</i>	Syngonium	III - pH 5.8 - 6.2
<i>Syringa</i>	Lilac	III - pH 5.8 - 6.2
<i>Tanacetum</i>	Tanacetum	III - pH 5.8 - 6.2
<i>Thuja occidentalis</i>	Arborvitae	III - pH 5.8 - 6.2
<i>Thunbergia</i>	Thunbergia	III - pH 5.8 - 6.2
<i>Thymus</i>	Thyme	III - pH 5.8 - 6.2
<i>Tiarella</i>	Tiarella	II - pH 5.5 - 5.8
<i>Torenia</i>	Torenia	II,III - pH 5.5 - 6.2
<i>Tradescantia</i>	Tradescantia	III - pH 5.8 - 6.2
<i>Tradescantia species</i>	Tradescantia species	III - pH 5.8 - 6.2
<i>Trifolium</i>	Trifolium	III - pH 5.8 - 6.2
<i>Tropaeolum</i>	Tropaeolum	III - pH 5.8 - 6.2
<i>Tunera</i>	Tunera	IV - pH 6.0 - 6.5
<i>Verbascum</i>	Verbascum	III - pH 5.8 - 6.2
<i>Verbena</i>	Verbena	II,III - pH 5.5 - 6.2
<i>Verbena bonariensis</i>	Verbena	II,III - pH 5.5 - 6.2
<i>Verbena hybrid</i>	Verbena hybrid	III - pH 5.8 - 6.2
<i>Veronica</i>	Veronica	II,III - pH 5.5 - 6.2

Table 3. Recommended pH Ranges for Greenhouse Crops Grown In Soilless Substrates, Continued.

Specie (Scientific Name)	Specie (Common Name)	pH Category
<i>Viburnum</i>	Viburnum	III - pH 5.8 - 6.2
<i>Viburnum nudum</i>	<i>Viburnum nudum</i>	III - pH 5.8 - 6.2
<i>Viola</i>	Viola	II - pH 5.5 - 5.8
<i>Weigela</i>	Weigela	III - pH 5.8 - 6.2
<i>Zauschneria</i>	Zauschneria	III - pH 5.8 - 6.2
<i>Zinnia elegans</i>	Zinnia	III - pH 5.8 - 6.2

¹ Information compiled from the Proven Winners website and other sources.

pH Group Ranges for Greenhouse Crops	
Group	pH Range
I	4.5 - 5.5
II	5.5 - 5.8
III	5.8 - 6.2
IV	6.0 - 6.5