Establishing a PourThru Sampling Program for Geraniums

Brian E. Whipker, William C. Fonteno, Todd J. Cavins, James L. Gibson
Department of Horticultural Science
North Carolina State University

Providing a proper nutritional program is essential for growing top quality plants. Sampling the root substrate for pH and electrical conductivity (EC) with the PourThru extraction method is a quick and simple check of the nutritional status of the crop and can provide clues about a crop's performance before deficiency or toxicity symptoms appear.

Geraniums make a large contribution to the bottom line of most greenhouse operations and should be included in a PourThru monitoring program. Geraniums are particularly sensitive to low pH, which can result in iron and /or manganese toxicity. Routine PourThru sampling will enable growers to detect unfavorable trends before they become nutritional problems.

Sampling Procedures

Sampling results are only good if they represent the whole crop. How to set up a sampling program, which crops to sample, and the number of samples to collect are all factors to consider. Below are instructions for taking representative PourThru samples for in-house testing.

Crop Factors

Consider taking separate samples within a crop if there are large variations in the substrate type used (different manufacturers or ingredients), the fertilizer type or rates used (acidic or basic types), or planting dates.

Frequency

The PourThru extraction method is a quick and simple way to monitor your crop's nutritional status. The speed of this method makes weekly sampling possible. Ideally sampling should be done weekly, but in practice it may not be possible. If time availability is a concern, consider selecting the "Top 10 Crops of Concern", based on their economic value or if they tend to have nutritional problems. Then divide the crops you plan to sample into 2 groups of 5 and alternately sample each group every other week.

The frequency of testing depends on the size of the container used for production, as smaller volumes of substrate are more susceptible to rapid changes in pH than larger, more buffered volumes of substrate. For plugs, test pH twice each week (some growers test every three days). Weekly testing should be sufficient for crops such as flats of bedding plants and 4" pots. For long-term crops grown in larger containers (such as 6" pots), monitoring every two weeks may be sufficient to avoid out-of-range substrate pH.

Number of Samples to Collect

For routine analysis, one should collect and analyze a minimum of 5 individual pots (or for bedding plants a minimum of 5 cell packs) from plants treated the same. As a general rule, sample 5 pots per 1,000 pots of similarly treated plants. Results from each of the 5 samples can then be averaged for a single "interpretation value". (Do not combine the 5 samples for a single test.) (A sampling form is provided.) If the 5 values vary widely in pH or EC you may need to increase your sample size.

Other Tips

- If you have taken steps to correct an EC or pH problem, then one should resample those plants at least weekly. If needed, one can sample as frequently as every other day.
- If results seem atypical, consider resampling before making drastic changes, especially to the substrate pH.
- For more information on PourThru techniques, extra charts, graphs and general guidelines check out our WEB sites:
http://www2.ncsu.edu/hortsublab/
http://www2.ncsu.edu/floriculture/

How to Collect the Leachate

1. **Irrigate your crop one hour before testing** (Figure 1a). Make sure the pots are watered to container capacity. If your automatic irrigation system is variable, water the pots/flats you plan to sample by hand. If you are using constant liquid feed, irrigate with fertilizer solution as usual. If you use periodic feeding (weekly, etc.): a) irrigate with clear water, b) test a day or two before you are to fertilize, and c) test on the same day in the fertilizing cycle each time.

2. **Place saucer under container.** After the container has drained for an hour, place a plastic saucer under the containers to be sampled (Figure 1b). If you are testing seedling geraniums in bedding plant flats, pull out one cell pack and place it in the saucer (Figure 1c).

3. **Pour enough distilled water on the surface of the container to get 50 ml of leachate** (Figure 1d). The amount of water needed will vary with container size, crop and environmental conditions. Use the values in Table 1 as guides.

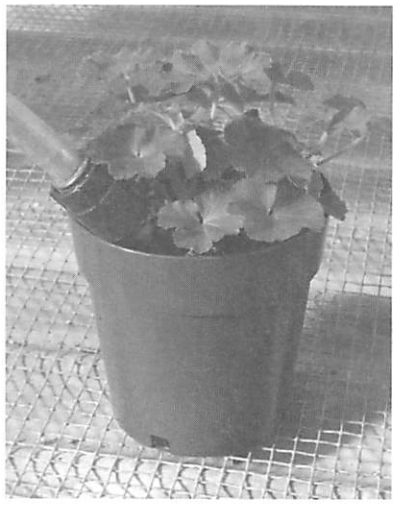

Figure 1a. Irrigate containers thoroughly.

Figure 1b. Saucer for pots.

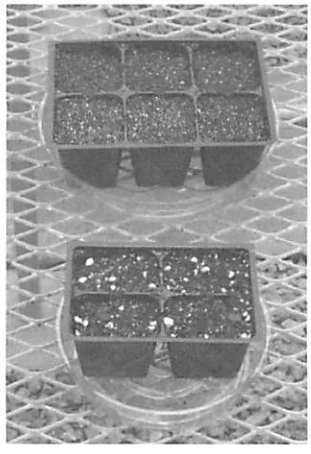

Figure 1c. Saucers for cell packs.

Figure 1d. Applying water for extraction.

4. **Collect leachate for pH and EC** (Figure 1 e). Make sure you get about 50 ml of leachate each time you test (Figure 1f). Leachate volumes over 60 ml will begin to dilute the sample and give you lower EC readings.

Figure 1e. Collected leachate for testing.

Figure 1f. Collect 50 ml (2.5 ounces) for testing.

5. **Calibrate your pH and EC meters prior to testing** (Figure 1g). Your test results are only as good as your last calibrations. You should calibrate your instruments every day that you use them. Always use fresh standard solutions. Never pour used solution back in the original bottle.

Figure 1g. Calibration standards for testing.

6. **Measure pH and EC of your samples** (Figure 1h). Test your extracts as soon as possible. EC will not vary much over time provided there is no evaporation of the sample. The pH will change within 2 hours. Record your values on the charts specific to each crop.

Figure 1h. Testing leachate samples.

Testing, Interpreting, and Managing Substrate pH

The pH of the substrate, is very important to plant nutrition. The pH directly affects the availability of many plant nutrients, especially micronutrients.

Too low of a pH (below 5.8) can result in increased micronutrient availability that can lead to phytotoxic responses in geraniums. For example, a low pH may increase the availability of iron and manganese and result in iron and / or manganese toxicity.

At the other end of the spectrum, a pH above 6.8 can lead to micronutrient deficiency problems, especially with iron. Both excessively low and high pH's should be avoided with geranium production. Figure 2 lists the optimal pH range for geraniums.

Table 1. Amount of water to apply to various containers to obtain 50 ml (2.5 ounces) of extract*.

Container Size	Water to add**	
	milliliters	*ounces*
4 inch 5 inch 6 inch	75	2.5
6.5 inch azalea	100	3.5
1 quart	75	2.5
4 quart	150	5.0
12 quart	350	12.0
Flats 606 (36 plants) 1203 (36 plants) 1204 (48 plants)	50	2.0

**Containers should be brought to full container capacity 30 to 60 minutes before applying these amounts.*
***These amounts are estimates. Actual amounts will vary depending on crop, substrate type, and environmental conditions.*

Testing and Interpreting Substrate pH

You should test your crop substrate pH on a routine basis. Growers should test the pH of substrate prior to use, to assure the pH has been properly adjusted.

We have developed pH recording charts for your use (Figure 3). The target pH range, upper decision range, and the lower decision range have been established. If the substrate pH climbs into or above the upper pH decision range, action should be taken to lower pH. If the substrate pH drops into or below the lower pH decision range, action should be taken to raise pH.

Adjusting Substrate pH

Substrate pH does change over time due to many factors. The four main factors affecting substrate pH are ❶ the initial components and amendments used in developing the substrate, including the liming charge; ❷ the alkalinity content of your irrigation water; ❸ the fertilizer(s) applied to the crop; and ❹ the species being grown. Obviously, once into prodiction you cannot change the species being grown or change the substrate composition, but you can make adjustments to your watering and fertilization programs.

Lowering Substrate pH. Listed below (in preferred order) are immediate steps to take to lower substrate pH if it climbs into or above the upper decision range:

❶ Acidify the irrigation water to an endpoint pH of 5.8[a].
❷ Switch from a basic (nitrate-based) fertilizer to acidic (ammonium-based) fertilizer.
❸ Apply an iron sulfate ($FeSO_4 \cdot 7H_2O$) drench using 3 lb per 100 gallons of water. Lightly mist off any solution on the foliage after application.
❹ Acidify the irrigation water to an endpoint pH of 5.1[a].

If you frequently encounter an increase in your substrate pH, you should consider employing the following long-term steps (listed in preferred order) to keep the pH from rising:

1. Reduce the initial lime charge of your substrate before planting.
2. Acidify your irrigation water down to pH 5.1 prior to use.
3. Try using an acidic (ammonium-based) fertilizer throughout the cropping period.

Increasing Substrate pH. Listed below (in preferred order) are immediate steps to take to raise substrate pH if it drops into or below the lower decision range:

1. Stop neutralizing the alkalinity of your irrigation water (if you are currently acidifying your water).
2. Switch from acidic (ammonium-based) fertilizers to basic (nitrate-based) fertilizers.
3. Apply flowable limestone products as a substrate drench. Start with a 1 quart per 100 gallons rate. Lightly mist off any solution on the foliage after application.

If you frequently encounter a decrease in your substrate pH, you should consider employing the following long-term steps (listed in preferred order) to keep the pH from dropping:

1. Increase the initial lime charge of your substrate before planting.
2. Try using a basic (nitrate-based)

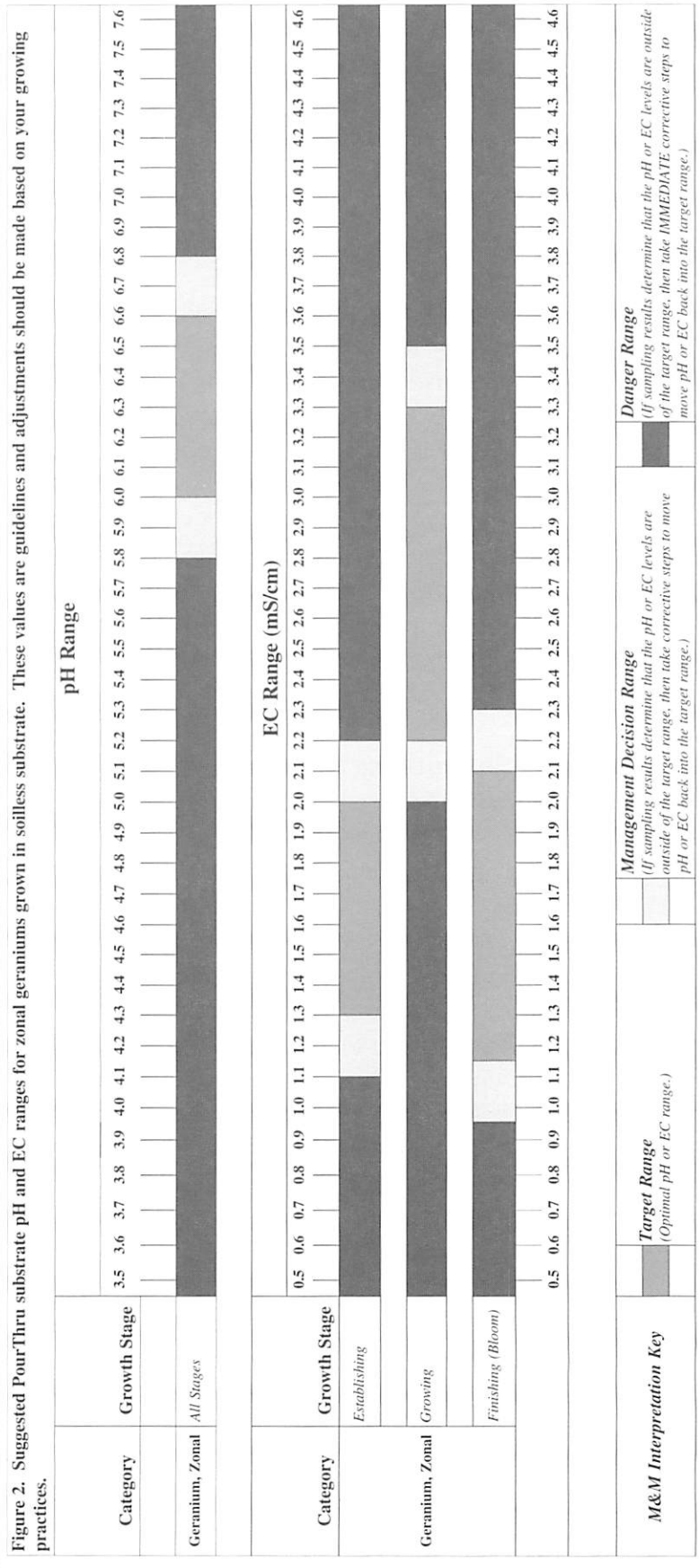

Figure 2. Suggested PourThru substrate pH and EC ranges for zonal geraniums grown in soilless substrate. These values are guidelines and adjustments should be made based on your growing practices.

fertilizer throughout the cropping period.

❸ Inject potassium bicarbonate ($KHCO_3$) into your irrigation water to raise the alkalinity. Start with 13.4 oz per 100 gallons. This will supply 1 meq/L of alkalinity and also supplies 39 ppm K with every watering (so reduce potassium feed accordingly).

Testing, Interpreting, and Managing Substrate EC

Soluble salts are the total dissolved salts in the root substrate (root medium) at any given time and are measured in terms of electrical conductivity (EC). A conductivity meter measures the passage of electrical current through a solution. The higher the EC content, the easier it is for electric current to move through the solution and the higher the EC value. The EC of the substrate provides an insight to the nutrient status of the crop. One needs to keep in mind that not all of the salts measured by an EC meter are fertilizer salts. An EC meter measures the sum of all salts in a solution, but does not provide details on the type or amount of each salt present.

High EC. Growers need to be aware of substrate EC levels because excess salts can accumulate when: ❶ leaching during irrigation is insufficient; ❷ the amount of fertilizer applied is greater than what is required by the plant; or ❸ when the irrigation water contains a high amount of dissolved elements.

Excessively high EC readings are associated with poor plant shoot and root growth. Plant symptoms often begin on the lower leaves as leaf chlorosis and progress to necrotic leaf tip margins. If the root substrate is allowed to dry down, plants may also exhibit wilting symptoms because of dieback of the root tips, which further inhibit water and fertilizer uptake. High EC has also been linked with the increased incidence of *Pythium* root rot.

Low EC. At the opposite end of the spectrum, when the EC content of the substrate is too low, plant growth can be stunted or lower leaf discoloration can result from the lack of fertilizer. Usually nitrogen is the most typical nutrient deficiency symptom, manifesting itself as lower leaf yellowing.

Factors Affecting EC

Fertilizers. Floriculture crops are usually fertilized with a constant liquid fertilization (CLF) or a weekly basis, so EC levels of the root substrate can be used to measure the nutrient status of the crop. Substrate EC levels are more consistent with the CLF irrigation method than with a single weekly fertilization. Substrate EC levels with the weekly fertilization regime can vary greatly due to: ❶ the timing after a fertilization that the sample was taken and ❷ the number of clear irrigations that were applied between the fertilizer applications. The nutrient contribution of slow release fertilizers can also be monitored with regular substrate testing. Most fertilizer materials, except urea, contribute to the EC content of the substrate, and the most common ones are nitrates (NO_3), potassium (K), calcium (Ca), magnesium (Mg), sulfates (SO_4), and bicarbonate (HCO_3). Organic materials also contribute to the EC content after they have been changed from an insoluble to soluble form. One can also monitor the accuracy of their fertilizer injector to ensure the fertilizer application rate is on target.

Irrigation Water. In some areas, elevated substrate EC levels can be caused by high concentrations of calcium (Ca), magnesium (Mg), sulfates (SO_4), sodium (Na), or bicarbonate (HCO_3) in the irrigation water.

Irrigation Method. Past irrigation recommendations have specified that a sufficient amount of water be applied so the entire volume of root substrate is moistened and 10 to 20% leaching of water out the bottom of the container

occurs. Leaching prevents excess soluble salts from building up in the root substrate. This is still the easiest and most efficient irrigation method. However, with increased concern of run-off and water conservation, irrigation and fertilization practices are changing to reduce or eliminate leaching. The fertilization rate can often be decreased by 25% to 50% and still maintain adequate EC levels if using a reduced leaching irrigation system or a flood irrigation system.

The negative effects of high EC are more pronounced for growers who grow on the dry side. If the root substrate is allowed to dry down, plants may also exhibit wilting symptoms because of dieback of the root tips, which further inhibit water and fertilizer uptake. It is especially important for dry growers to monitor their EC levels to ensure they are within the acceptable range to avoid root damage. If one suspects that their EC levels are too high, be sure to maintain adequate moisture levels within the substrate.

Substrate Type. Some substrates have a fertilizer starter charge added which increases the substrate EC. These mixes are generally used for growing established plants. The type of substrate in your mix can also influence the substrate EC level. Sphagnum peat has a very low chemical content, while composted pine bark and coir usually have a slight EC charge. It is a good idea to test any new substrate mix prior to use to ensure it meets your specifications.

Crop Factors. When establishing an EC monitoring and management program one needs to match the fertilizer application rate with the fertilizer demands of the crop. There are two main parameters which need to be considered: ❶ the crop's nutrient demands and ❷ the stage of development. Each are discussed below.

Nutrient Demands. Crops vary in their fertility requirements for optimal growth. Geraniums are moderate feeders and grow best when the PourThru EC levels for actively growing plants are between 2.0 to 3.3 mS/cm (Figure 2).

Stage of Crop Development. The nutrient demands of a crop vary by development stage. Plugs and cutting which are rooting require lower levels of fertility and fertilizer demands increase as they become established. Actively growing plants have the highest nutrient demands. Finally, nutrient demands decrease as a plant sets buds and flowers. In fact, extensive research has shown that flower longevity is increased when fertilizer rates are decreased or terminated at visible bud or just prior to flowering.

An EC monitoring plan for geraniums should be fine-tuned to account for the crop's nutrient demands and stage of development. Figure 2 contains the target EC levels for establishment, active growth, and bloom stages of growth for plants using the PourThru extraction method. Table 2 contains interpretative EC values for the 1:5, 1:2, saturated media extract (SME), and PourThru extraction procedures.

Testing and Interpreting Substrate EC

You should test your crop substrate EC on a routine basis to detect trends over time. Samples can be analyzed either within the operation or sent to a commercial lab. Growers should test their substrate EC prior to use, to assure the EC is within the proper range.

We have developed EC recording charts for your use with the PourThru extraction method (Figure 4). The target EC range for the active growth phase of the crop has been filled in. During the first 2 weeks after transplanting, growers should gradually increase the substrate EC to the target level. Use the EC values listed in Figure 2 during the plant establishment phase as a guideline. Also as the crop blooms, growers should gradually decrease the EC levels. EC values for the finishing stage are also listed in Figure 2.

If the substrate EC climbs into or above the upper EC decision range, action should be taken to lower EC. If the substrate EC drops into or

below the lower EC decision range, action should be taken to raise EC.

Adjusting Substrate EC

The substrate EC changes over time due to many factors. The four main factors affecting substrate EC are: ❶ the initial components and amendments used in developing the substrate, including the substrate type and initial nutrient charge; ❷ fertility regime; ❸ the plant's nutrient demands; and ❹ the crop's development stage. Obviously, after the crop has been planted one cannot change the species being grown or the substrate composition, but you can make adjustments to your fertilization program as the plant grows.

Steps to Lower EC. Listed below (in preferred order) are immediate steps to take to lower substrate EC if it climbs into or above the upper decision range:

❶ Decrease the fertilization rate or decrease the frequency of fertilization (irrigate with clear water).

❷ Leach to reduce the salts level. The root substrate should be irrigated normally allowing for 20% leaching, then followed immediately with another irrigation. After this, the root substrate should be allowed to dry to the usual stage, and if further leaching is required, the double-irrigation treatment can be repeated. Recheck the EC level to make sure it is within the acceptable range.

Steps to Increase EC. Listed below (in preferred order) are immediate steps to take to raise substrate EC if it drops into or below the lower decision range:

❶ Increase the fertilization rate. Apply a fertilizer like calcium nitrate ($Ca(NO_3)_2$) + potassium nitrate (KNO_3), 20-10-20, or Excel® 15-5-15 Cal-Mag at the rate of 300 to 400 ppm N. A corrective N fertilization will return the lower leaves to the normal green color within 1 to 2 weeks. Do not overapply. It is important to correct nutrient deficiency when symptoms first appear because lower leaf drop or necrosis cannot be reversed.

❷ Increase the fertilization frequency. Use a constant fertilization rate of 200 to 250 ppm N and discontinue any clear water irrigations until the EC levels are within the acceptable range.

Points to Remember.

❶ If using calcium nitrate ($Ca(NO_3)_2$) + potassium nitrate (KNO_3), remember to supply P, Mg, and micro-nutrients to the plants.

❷ If using 20-10-20 or 20-20-20, remember to supply Ca and Mg to the plants.

Conclusion

This PourThru program is designed for growers to Monitor and Maintain their crops, It is a simple program for rapidly determining a crop's pH and EC. It is a program that allows growers to change their focus to prevention instead of cure, and action instead of reaction. If growers adopt this proactive program and follow it carefully, nutritional problems can be virtually eliminated.

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[a] See North Carolina State University Horticulture Information Leaflet 558 for more details. Available at: http://www2.ncsu.edu/floriculture/

Figure 3. PourThru pH chart for geraniums.

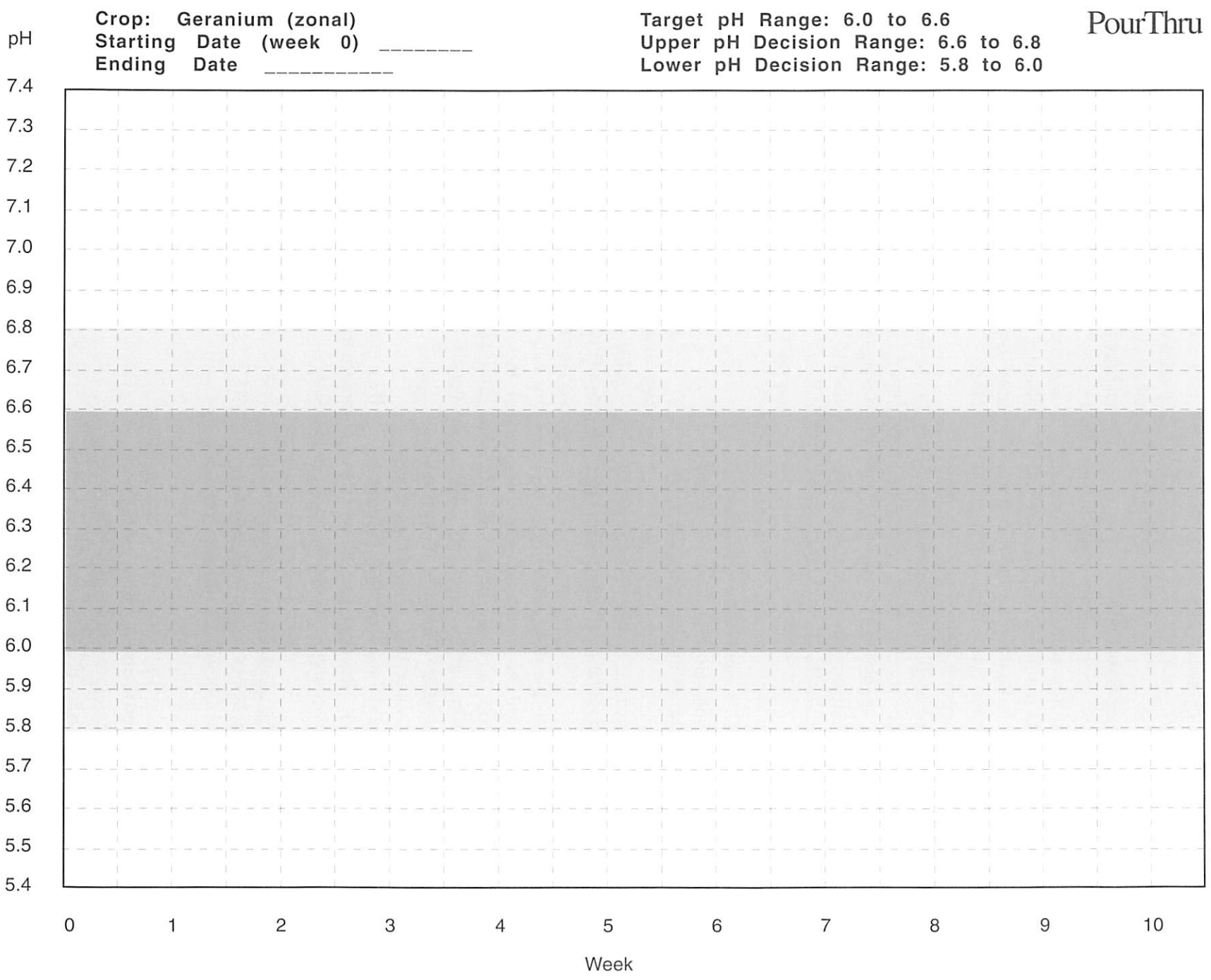
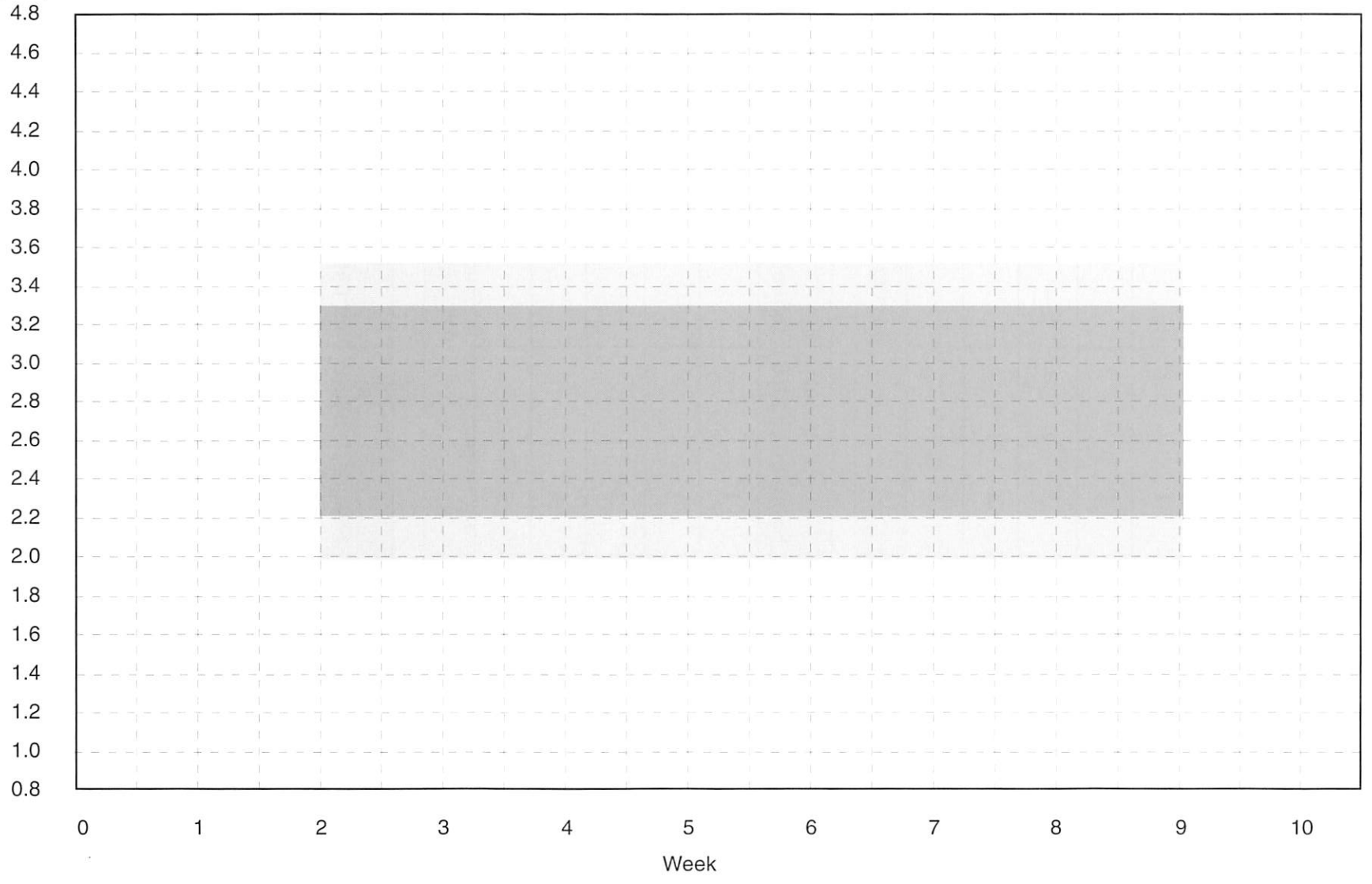


Figure 4. PourThru EC chart for geraniums.

PourThru

Crop: Geranium (zonal)
Starting Date (week 0) _____
Ending Date _____

Target EC Range: 2.2 to 3.3 mS/cm
Upper EC Decision Range: 3.3 to 3.5 mS/cm
Lower EC Decision Range: 2.0 to 2.2 mS/cm



PourThru Sampling Form

	Samples	ml added	ml out	pH	EC	Comments
Crop: ________						
Date: ________	1					
	2					
Location: ________	3					
	4					
	5					
			Average			

	Samples	ml added	ml out	pH	EC	Comments
Crop: ________						
Date: ________	1					
	2					
Location: ________	3					
	4					
	5					
			Average			

	Samples	ml added	ml out	pH	EC	Comments
Crop: ________						
Date: ________	1					
	2					
Location: ________	3					
	4					
	5					
			Average			

Table 2. EC interpretation values (mS/cm) for various extraction methods[1].

1 : 5	1 : 2	SME	PourThru[2]	Indication
0 to 0.12	0 to 0.25	0 to 0.75	0 to 1.0	**Very Low.** Nutrient levels may not be sufficient to sustain rapid growth.
0.12 to 0.35	0.26 to 0.75	0.76 to 2.0	1.0 to 2.6	**Low.** Suitable for seedlings, bedding plants and salt sensitive plants.
0.36 to 0.65	0.76 to 1.25	2.0 to 3.5	2.6 to 4.6	**Normal.** Standard root zone range for most established plants. Upper range for salt sensitive plants.
0.66 to 0.89	1.26 to 1.75	3.5 to 5.0	4.6 to 6.5	**High.** Reduced vigor and growth may result, particularly during hot weather.
0.9 to 1.10	1.76 to 2.25	5.0 to 6.0	6.6 to 7.8	**Very High.** May result in salt injury due to reduced water uptake. Reduced growth rates likely. Symptoms include marginal leaf burn and wilting.
> 1.1	> 2.25	> 6.0	> 7.8	**Extreme.** Most crops will suffer salt injury at these levels. Immediate leaching required.

[1] Adapted from: On-site testing of growing media and irrigation water. 1996. British Columbia Ministry of Agriculture.
[2] Due to the variability of the PourThru technique results, growers should always compare their results to the SME method to establish acceptable ranges.