Teaching Methods

A Laboratory Exercise on Dilution Ratio and Water Flow of a Venturi-type Proportioner

David R. Hershey' and Susan Sand[2]

Additional index words. education, Hozon, fertilizer injector, laboratory exercise

Summary. A Venturi-type proportioner (VP), trade name Hozon, can be used for an inexpensive, hands-on laboratory exercise that demonstrates the effect of water pressure on dilution ratio and water flow. Using electrical conductivity (EC) meters to determine solution concentration allows students to discover that the dilution ratio increases with water pressure, from 1:10 at 15 psi to 1:15 at 55 psi. The greater dilution at higher pressure can be explained by measuring the water flow, which is 2.3 gal/min (8.7 literszmin^{-1}) at 15 psi but 3.5 gal/min (13.2 literszmin^{-1}) at 55 psi. Experiments relating water pressure to dilution ratio provide experience in use and calibration of VPs and EC meters, as well as graph preparation and interpretation.

[1]*Assistant Professor.*

[2]*Graduate Student.*

Department of Horticulture University of Maryland, College Park, MD 20742-5611.

Venturi-type proportioner

AVenturi-type proportioner (VP) (trade name Hozon) is used widely in horticulture to dilute stock solutions of fertilizers or pesticides (Boodley, 1981; Mastalerz, 1977). However, the VP has three major disadvantages. The first drawback is its low dilution ratio of ≈ 1:15. (The first number of the dilution ratio is always one, and it represents the stock solution volume. The second number represents the volume of the diluted solution and also represents the dilution.) The second drawback is its low maximum flow rate of 3 gal/min (11.3 literszmin^{-1}) (Nelson, 1991). The final drawback is its variation in dilution with water pressure. The dilution can vary from 12 to 17 because of water pressure differences (Boodley, 1981).

The purpose of these exercises is for students to examine the dependence of dilution and water flow of a VP on water pressure. The low cost and wide availability of VPs make the experiments presented here well suited for a laboratory exercise in an introductory horticulture or greenhouse management course. These procedures also could be used by commercial horticulturists to assure fertigation accuracy, which reduces environmental pollution from excessive fertilizer applications.

Pressure

A VP is attached to a tap water faucet equipped with a 0- to 60-psi pressure regulator and a 0- to 60-psi pressure gauge. We used a Hyponex-brand VP with built-in backflow prevention. The standard l-inch hose attached to the outlet of the VP is placed in a sink or drain, and the tap water pressure adjusted to 15, 25, 35, 45, or 55 psi (0.10, 0.17, 0.24, 0.31, 0.38 MPa). We used a 7-foot (2-m) length of hose with no restriction of the water flow. At each pressure, the VP siphon tube is placed in a bucket of20 g Peters calciumnitrate (15.5N-0P-0K)/liter. When the water pressure is stable, the hose is transferred to an empty, tared 5-gallon plastic bucket for 30 sec. The volume of the diluted solution is measured by weighing the bucket on a solution balance, since 1 liter of solution has a mass of 1 kg. The electrical conductivity (EC) of the diluted solution is measured using a pocket EC meter (Hershey, 1988; Sand and Hershey, 1989).

Standardcurve

The dilution ratio is determined using the solution EC and a standard curve (Fig. l), which is prepared by manually diluting the calcium nitrate stock solution and measuring the EC. An EC meter with automatic temperature compensation to 25C (Sand and Hershey, 1990) is most accurate for this procedure. Twenty milliliters of stock solution is added to between 180 ml (for 1:10 dilution ratio) and 380 ml of tap water (for 1:20). Graduated cylinders measure stock solution and tap water volumes. The EC of the tap water will not affect the results as long as it remains constant. The tap water EC in the trials reported here was 0.2 mmho/cm (0.2 dSzm^{-1}) at 77 F (25C).

Graphing

Students graph the dilution and water flow against the water pressure

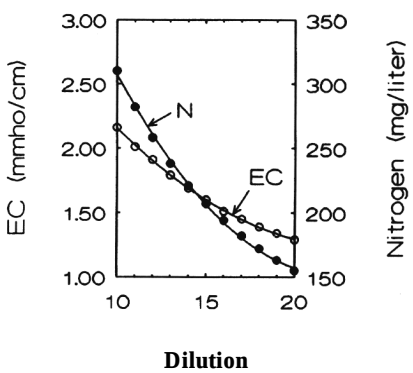

Fig. 1. ***Electrical conductivity and nitrogen concentration of Peters calcium nitrate (15.5N-0P-0K) when a 20 gzliter^{-1} stock solution (3100 mg N/liter) was diluted manually 10- to 20-fold. Regressions are: N concentration = 1.04x^2-46.1x + 664 (r^2 = 0.999, n = 11) and EC= 0.00502x^2- 0.237x + 4.02 (r^2 = 0.999, n = 11).***

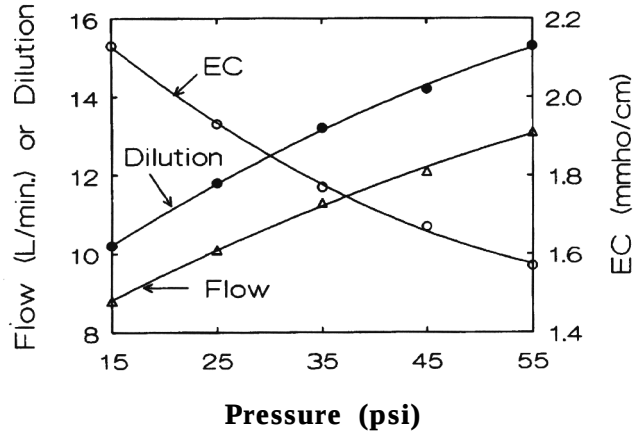

Fig. *2. Dilation, water flow, and electrical conductivity of diluted solution for a Venturi-type proportioner operating with water pressure of 15 to 55 psi. Regressions of means are: Dilution = $0.1x^2 + 1.86x + 8.46$; Flow = $-0.0714x^2 + 1.49x + 7.4$; EC = $0.01862x^2 - 0.249x + 2.36$. For each regression, $r^2 = 0.999$ and n = 5.*

(Fig. 2). The dilution should increase from ≈ 10 at 15 psi to 15 at 55 psi (Fig. 2). This is a lower range than the 12 to 17 usually reported (Boodley, 1981). The water flow increases with pressure, from 2.3gal/min (8.71iterszmin^{-1}) at 15 psi to 3.5gal/min (13.2 iterszmin^{-1}) at 55 psi. The maximum rate of 3.5 gal/min was 17% greater than the cited maximum of 3 gal/min (11.3 iterszmin^{-1}) (Nelson, 1991). The EC at 77F (25C) of the diluted solution declined from 2.1 mmho/cm at 15 psi to 1.6 mmho/cm at 55 psi. The VP dilutions were slightly less than normally cited values (Boodley, 1981), while the maximum water flow was slightly greater (Nelson, 1991).

The experiments reported here would be a simple laboratory exercise for a lower-division horticulture course that would provide experience in calibration and use of VPs and EC meters, use of a balance to estimate solution volume, and preparation and interpretation of graphs and standard curves. The calibration procedures would be useful for VP users to perform to assure accurate fertigation, since water pressure has a major influence on the dilution ratio.

Literature Cited

Boodley, J. W. 1981. The commercial greenhouse handbook. Van Nostrand Reinhold, New York.

Hershey, D.R. 1988. Measuring electrical conductivity with an inexpensive, digital, pocket-size meter. HortScience 23:402.

Mastalerz, J. W. 1977. The greenhouse environment. Wiley, New York.

Nelson, P. V. 1991. Greenhouse operation and management, 4th ed. Prentice-Hall, Englewood Cliffs, N. J.

Sand, S. and D.R. Hershey. 1990. Pocket electrical conductivity meters with and without automatic temperature compensation. HortScience 25:708.