the same water potentials did, in fact, give the same readings when both tissues were used in the same instrument. The one exception was the pine needles where we did observe a difference of up to one bar in water potential between the 2 needles of the same fascicle.

It is possible that the strength or elastic modulus of the cell wall may play an important role in determining the pressure at which sap is expressed from the leaf since the J-14 press works by mechanical pressure applied to the surfaces of the leaf. The pressure in the Scholander bomb is applied with compressed air and therefore is transmitted equally to all surfaces of the leaf. This, of course, includes the intercellular surfaces. This fundamental difference in the way the 2 instruments operate may explain the considerable variability encountered in these measurements. The high correlation coefficient for the pine supports this hypothesis. The pressure at which sap is expressed from the xylem elements is the endpoint for both techniques. Cell collapse and the filling of intercellular spaces did not appear to occur.

Additional support for this idea comes from the successful efforts to use the J-14 press to measure leaf matric potential in maize (6). Comparisons of J-14 measurements with a Scholander bomb yielded a correlation coefficient equal to 1.0 and a slope of 1.93. In these experiments, the corn leaves were frozen and thawed prior to measurement. This procedure ruptures the plasma membrane allowing water to fill the intercellular air spaces. These results suggest that when the intercellular spaces are filled with a noncompressible fluid the J-14 press and the Scholander pressure bomb provide comparable data.

In conclusion, it appears that despite the significant correlation between J-14 measurements and Scholander pressure bomb measurements of leaf water potential, the variation in J-14 measurements for a given Scholander value precludes using the J-14 to predict the "true" leaf water potential. Where crude estimates of leaf water potential are required, or comparative measurements needed, the low cost and ease of use of the J-14 may warrant further consideration.

Literature Cited


Terrazole Suppression of Denitrification

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Abstract. In a laboratory incubation study with soil inoculum, terrazole [5-ethoxy-3(trichloromethyl)-1,2,4 thiadiazole] at 0.02 to 200 ppm in liquid culture suppressed N2 and N2O evolution and increased NO3-N retention. A Cecil clay soil, treated with terrazole at concentrations of 0.5 and 2.0 ppm, retained more NO3-N than the control in a greenhouse study.

The recent discovery that nitrapyrin [2-chloro-6-(trichloromethyl)pyridine] is an effective chemical inhibitor of the denitrification process indicates that denitrification influences crop yields to a greater extent than is recognized currently, regardless of the form of N applied (3). Inhibition of denitrification with nitrapyrin resulted in a 15 to 20% increase in sweet corn yield in field evaluations using all NO3-N fertilizers (3). In laboratory studies with NO3-N, the addition of nitrapyrin increased NO3-N retention and decreased the evolution of N2 and N2O (1, 4). Results from both field and laboratory studies indicate that nitrapyrin directly suppresses the denitrification process which is in addition to the indirect effect obtained by suppression of nitrification. Suppression of nitrification reduces NO3-N available to be denitrified by maintaining applied ammonical fertilizers in the NH4 form.

Terrazole is being evaluated currently as a nitrification inhibitor under the trade name Dwell 4E by Olin Chemical Co. (2). Terrazole is similar to nitrapyrin in that both consist of a heterocyclic-N-derivative (pyridine and azole, respectively) which contain, among other substitutions, a trichloromethyl group. In general, heterocyclic-N-derivatives, which have trichloromethyl or trichloroethyl substitutions, exhibit a strong inhibition of denitrification in laboratory studies (unpublished data). Since terrazole is used currently as a soil fungicide and is being evaluated as a nitrification inhibitor, the additional benefit of denitrification suppression would further increase the usefulness of this chemical in the horticultural industry.

The following experiments were conducted to evaluate the potential of terrazole as a denitrification inhibitor: 1) evaluation of the effectiveness of terrazole in suppressing the denitrification process in a laboratory incubation study; and 2) evaluation of terrazole on NO3-N dissipation from a Cecil clay soil in a greenhouse study.

Laboratory study. Short-term evaluations of the effect of terrazole on denitrification were performed in a liquid medium
inoculated with soil bacteria (6). We combined 100 ml of autoclaved media (nutrients/liter: 3 g KNO₃, 0.8 g KH₂PO₄, 0.2 g K₂HPO₄, 0.2 g MgSO₄·7H₂O, 0.1 g CaCl₂, 1 mg Fe as Fe-EDTA, 1% dextrose and 0.1% yeast extract) plus 10 ml of preincubated soil bacterial inoculum in 125-ml Erlenmeyer flasks. The flasks were capped, degassed in a vacuum for 30 min, backfilled with He, and then terrazole (Dwell 4E) injected into the flasks. The flasks were allowed to incubate for 24 hr at 25°C before samples (10 ml) from the flask atmosphere were removed for analysis. The flasks again were degassed and refilled with He. This procedure was performed at 24-hr intervals for 72 hr. Dinitrogen and N₂O concentrations of the atmospheres within the flasks were determined by gas chromatography (4). The experiment was terminated after a 72-hr incubation, and the medium NO₃-N level determined with a specific ion electrode (5).

The study consisted of a completely randomized design containing 6 terrazole levels and 24 replications. All terrazole treatments reduced N₂ and N₂O evolution (Fig. 1). Polynomial regression analysis indicated a linear relationship between chemical concentration and decreased total μg N₂-N evolved (R² = 0.94). Reductions in total μg N₂O-N evolved were similar with all terrazole concentrations and can be described by a 3rd-order polynomial (R² = 0.94). Nitrate remaining in the incubation medium increased as the terrazole concentration increased, with chemical concentration effects on NO₃-N remaining after a 72-hr incubation exhibiting a quadratic relationship (R² = 0.99).

### Greenhouse study

The effect of terrazole on soil NO₃-N levels was compared to the known denitrification inhibitor nitrapyrin (1, 3, 4) in a 30-day greenhouse study. Pots containing 150 g of a Cecil clay soil were separated into 5 groups consisting of 24 pots with each group receiving one of the following treatments: 0.5 and 2.0 ppm terrazole, 0.5 and 2.0 ppm nitrapyrin, and a control (H₂O only). All calculations were on a chemical weight/soil weight basis. Treatments were delivered in a 10-ml aliquot with an aqueous solvent. Soils in each container were supplied then with 25 ml of a basal salts medium which delivered 75 mg of NO₃-N per container. A tray was placed under each container and all leachates were added back to the container so that no leaching of NO₃-N occurred. Soils were kept in an anaerobic state by maintaining 1.37 cm of water in the tray under each container. An additional 75 mg NO₃-N was added to each pot at 3-day intervals, giving a total of 750 mg NO₃-N added to each container during the experimental period. The entire volume of soil in each container was placed in a 250-ml Erlenmeyer flask after 30 days. 150 ml of H₂O added and the flask agitated for 15 min on a wrist-action shaker. Soils were filtered then and the NO₃-N concentration of the effluent determined with a NO₃ specific ion electrode (5).

Terralzone increased NO₃-N retention in the Cecil clay soil (Table 1). Treatments of 0.5 or 2 ppm terrazole significantly increased NO₃-N retention over the control with the highest concentration of terrazole giving the greatest NO₃-N recovered. Both levels of nitrapyrin significantly increased NO₃-N retention in the soil in comparison to the control. These results demonstrate that terrazole, like nitrapyrin, increased the retention of soil NO₃-N and indicates a reduction in the rate of denitrification since NO₃-N was the only source of N supplied. The results presented in Table 1 are consistent with previous reports (1, 3, 4) which have identified nitrapyrin as an inhibitor of denitrification and indicates that terrazole is effective also in reducing soil denitrification.

The recommended rate of terrazole for denitrification inhibition is 0.125–0.25 kg/ha. Significant inhibition of denitrification in liquid media was obtained with terrazole concentrations as low as 0.02 ppm, which is well below field application rates. In the soil study, 0.5 ppm terrazole (equivalent to 1 kg/ha) effectively reduced denitrification. Therefore, terrazole rates of 0.25 kg/ha or less should be sufficient to inhibit denitrification and increase NO₃ available to growing plants. Results from this study indicate a high potential of terrazole and nitrapyrin to inhibit denitrification.

### Literature Cited