# The Influence of Dutch Elm Disease and Plant Water Stress on the Foliar Nutrient Content of American and Siberian Elm

Bruce R. Roberts and Keith F. Jensen

Plant Physiologists, Crops Research Division, ARS, U.S. Forest Service, USDA, P.O. Box 365, Delaware, Ohio 43015.

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ABSTRACT

Two-year-old seedlings of American elm (susceptible to Dutch elm disease) and Siberian elm (resistant to Dutch elm disease) were inoculated with *Ceratocystis ulmi* or subjected to plant water stress by withholding water. Nutrient analyses made on the foliage of all seedlings at the end of the experiment showed a significant difference in phosphorus and nitrogen content between species, but no difference in calcium or potassium. Inoculated seedlings of both species exhibited significantly lower levels of potassium and phosphorus when compared to stressed and noninoculated control plants. Water-stressed seedlings of both species showed a similar pattern of transpiration for the duration of the experiment. After 4 weeks, however, transpiration in inoculated Siberian elm was twice that of inoculated American elm when compared to corresponding healthy plants. The relationship of these findings to the development of symptoms in Dutch elm disease is discussed. Phytopathology 60:1831-1833.

*Additional key words: Ulmus americana, Ulmus pumila.*

The effect of nutrition on the development of symptoms in Dutch elm disease has been reported by numerous authors (1, 5, 10, 14, 15, 17). But studies dealing with the nutrient status of trees already infected with *Ceratocystis ulmi* (Buism.) C. Moreau are lacking. The present study was designed to determine the effect of Dutch elm disease (DED) and plant water stress on the concn of calcium, potassium, phosphorus, and nitrogen in the foliage of resistant and susceptible elms. Seedlings subjected to plant water stress were included in this study, as DED, a vascular wilt, is known to result in xylem dysfunction (9) and resulting loss in turgidity. Thus, a comparison of inorganic nutrients could be made between diseased and water deficient samples from resistant and susceptible species.

Materials and Methods.—Two-year-old seedlings of American elm (*Ulmus americana* L.) and Siberian elm (*Ulmus pumila* L.) actively growing in the greenhouse under natural conditions in 7-inch polystyrene containers were used in this study. The potting medium in each container, a mixture of sand, soil, and peat (1:1:1), was enclosed in a plastic bag which was securely fastened around the stem to prevent evaporation from the soil surface.

Thirty seedlings of each species were divided into six groups of five plants each. Two groups of each species were randomly given one of the following treatments: (i) inoculated; (ii) water-stressed; or (iii) control. After assigning treatments, each group of seedlings was placed in the greenhouse in a randomized block design replicated twice.

Before starting the experiment, the potting medium in each container was watered to field capacity. On the first day of treatment, seedlings in the inoculated group were inoculated with *C. ulmi* using the technique described by Gregory (7). Each inoculated plant received 3 cc of a suspension containing $3.6 \times 10^4$ conidia per cc. The suspension was a mixture of three isolates from different geographical areas. Seedlings assigned the stress treatment were left unwatered, while all other plants were rewatered with the approx amt of moisture lost by transpiration. Transpiration was determined gravimetrically by weighing each container on alternate days during the week. When the majority of stressed seedlings exhibited incipient wilt, all stress-treated plants were rewatered to field capacity. The drying cycle was then repeated a second time. The experiment was terminated after 4 weeks, when half of the inoculated American elm seedlings showed foliar symptoms of DED. At this time, the foliage from each seedling was removed, dried at 105 C for 24 hr, and ground in a Wiley mill for chemical analysis. Analyses were made on the foliage from each seedling. Total nitrogen was determined by the micro-Kjeldahl technique. Potassium, calcium, and phosphorus were determined from a foliar sample ashed at 450 C overnight. Potassium was measured with a flame photometer, calcium by the calcium oxalate method, and phosphorus by the phosphomolybdate technique.

Results and Discussion.—The stressed seedlings of both species exhibited a slight increase in transpiration during the first week (Fig. 1). This same phenomenon has been reported for other woody species (2, 11), and probably reflects the distended condition of the guard cells which accompanies initial stages of plant-moisture stress. Inoculated seedlings of both species also showed a slight increase in transpiration at the end of the 1st week. Other workers (11, 12, 13) have reported similar findings in comparing transpiration in healthy and inoculated plants.

The pattern of transpiration of susceptible and resistant species inoculated with *C. ulmi* was similar to that reported in an earlier study (11). After 4 weeks, transpiration of inoculated *U. americana* was only 35% of the noninoculated controls, while transpiration in *U. pumila* was 70% of corresponding healthy plants. Although the foliar symptoms associated with DED were prevalent on susceptible *U. americana* seedlings, no symptoms were observed on any resistant *U. pumila* plants.

A summary of the nutrient content of foliage from all seedlings in the experiment is in Table 1. A sig-

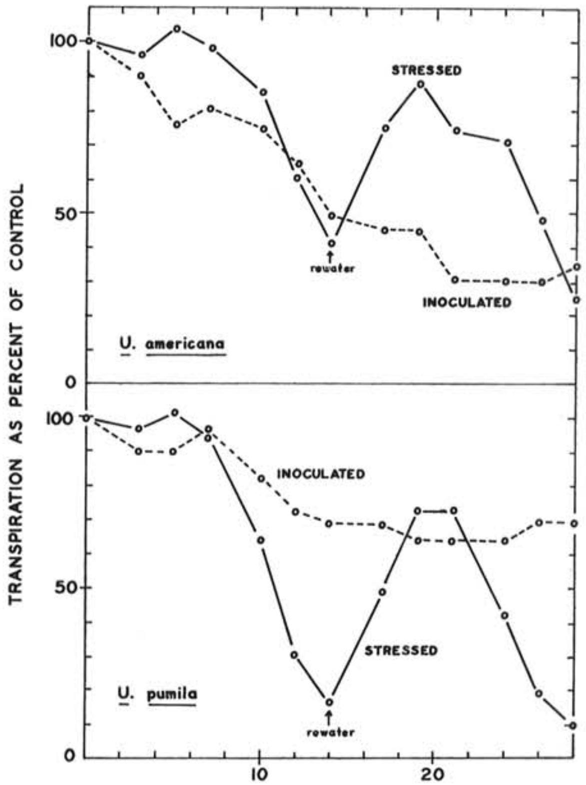


**Fig. 1.** Transpiration of inoculated and water-stressed seedlings of American and Siberian elm. Values are expressed as a percentage of corresponding noninoculated controls, and represent the average of 10 seedlings.

nificance level of .05 was used in all cases. No significant difference in calcium content was observed either between species or between treatments. Since calcium is an immobile ion after its initial deposition, both species of elm used in this study must accumulate calcium at about the same rate per unit wt. Calcium immobility may also have masked any treatment effect because of the large amt of calcium present in the original material. Very limited information is available concerning the effect of calcium on the development of symptoms in DED. Elgersma (5) reported no alteration in symptom

TABLE 1. The effect of Dutch elm disease and plant water stress on the foliar nutrient content of *Ulmus americana* and *U. pumila*

| Species | Treatment | Nutrient content | | | |
|---|---|---|---|---|---|
| | | N[a] | K | Ca[a] | P |
| | | *mg* | *ppm* | *mg* | *ppm* |
| *U. americana* | Control | 2.6 | 122 | 14.9 | 37 |
| | Inoculated | 2.6 | 93 | 15.4 | 34 |
| | Stressed | 2.8 | 122 | 14.6 | 39 |
| *U. pumila* | Control | 2.8 | 111 | 14.8 | 30 |
| | Inoculated | 2.8 | 105 | 14.4 | 24 |
| | Stressed | 3.0 | 126 | 16.5 | 31 |

[a] Values expressed as mg/g dry wt.

development in resistant and susceptible elm seedlings grown in nutrient culture without calcium.

Potassium concn was significantly lower in diseased plants than in water-stressed or control seedlings. No difference was found in the potassium content between resistant and susceptible species. Phosphorus concn was also significantly lower in diseased plants than in water-stressed or control plants. In addition, the level of phosphorus was significantly higher in *U. americana* than in *U. pumila*.

Both potassium and phosphorus are very mobile elements within a plant, and are readily translocated from one site to another. Hence, the lower levels of these elements observed in the foliage of diseased seedlings could occur as a result of changes in host metabolism caused by the presence of *C. ulmi*. These changes could either occur initially as the elements move up in the transpiration stream, or at some later time during recycling. This explanation is suggested by the results of Yarwood & Jacobson (16), who found that radiophosphorus accumulates in infected host tissue of a number of plant diseases.

The role of potassium in disease resistance has been suggested (6, 8), but its specific role in DED development is not clear (14, 15). Dastur & Bhatt (3, 4) showed higher potassium levels in wilt-resistant flax plants than in susceptible plants from the same species; however, we observed no significant difference in potassium concn between resistant and susceptible elm species.

Although no difference in nitrogen content was observed between inoculated, stressed, or control seedlings, there was a significant difference between the two species tested. We found greater levels of total nitrogen in resistant plants (*U. pumila*) than in susceptible plants (*U. americana*). The fact that nitrogen concn was not affected in the same way as potassium or phosphorus may be due to the larger amount of nitrogen in plant material. Thus, although the pathogen probably absorbs nitrogen in the stem, this amt represents a much smaller percentage of the total concn than in the case of potassium or phosphorus.

Banfield (1), Zentmyer & Wallace (17), and Parker et al. (10) attributed some reduction in DED development to the presence of nitrogen. The fact that we observed a higher nitrogen content in resistant plants suggests that this element may be important in determining the level of resistance exhibited by some species of elm.

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