RESPONSE OF TOMATO TO SULPHUR NUTRITION AND SO₂

A. STRATIGAKOS and D. P. ORMROD

Department of Horticultural Science, University of Guelph, Guelph, Ontario, Canada N1G 2W1

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Abstract. Tomato (Lycopersicon esculentum Mill.) plants, cultivar Fireball, were grown with 1.6, 16 or 80 ppm (mg L⁻¹) sulphate-S in nutrient solution added daily to the rooting medium. Exposure to 0.1 ppm gaseous SO₂ had no significant effect on growth variables. Exposure to 0.4 ppm SO₂ decreased leaf area. The uptake of SO₂ followed a diurnal pattern that was similar for all sulphate-S levels. Exposure to 0.1 or 0.4 ppm SO₂ resulted in significant increases in both total S and sulphate-S. The ratio of sulphate-S to total S increased after 0.4 ppm SO₂ exposure. Comparison of actual total S content with that predicted on the basis of uptake of SO₂ indicated a loss of S from plants exposed to 0.4 ppm SO₂. For plants supplied with 1.6 ppm S, exposure to 0.1 ppm SO₂ increased chlorophyll a content while plants receiving 80 ppm S had decreased chlorophyll a and b following 0.1 ppm SO₂ exposure.

1. Introduction

Sulphur dioxide at low concentrations can act as a S nutrient source for plants low in S (Cowling and Lockyer, 1976; Faller, 1971; Thomas et al., 1943). At sufficiently high concentrations, SO₂ can cause injury to plants (Cormis and Bonte, 1981) which includes decreased chloroplast integrity, reduced photosynthetic activity, and formation of necrotic lesions. Sulphur dioxide is absorbed through the stomates (Black, 1982) and is thought to be metabolized by essentially the same pathway as that of sulphate-S taken up through the roots (Garsed and Read, 1977). In the presence of water in the intercellular spaces, SO₂ is oxidized to sulphite and sulphate and is then taken up by the cells and metabolized. It has been suggested that an end product of SO₂ metabolism could regulate sulphate uptake by cells (Smith, 1980). If this is the case the amount of S present initially in the plant may have an effect on plant uptake of SO₂ and consequently, on plant response to SO₂. Pahlich (1975) suggested that injury to plant tissue resulting from exposure to SO₂ may be less severe if the endogenous S pool is low and the plant is capable of metabolizing and utilizing the S from the absorbed SO₂. The purpose of the present study was to investigate the effect of combined treatments of S-nutrition and SO₂ exposure.

2. Materials and Methods

Tomato plants of the cultivar Fireball were grown from seed in a standardized controlled environment (Ormrod et al., 1980). Ten seeds were sown in each 12 cm plastic pot containing a perlite-vermiculite-peat mixture (1 : 1 : 3 by volume). Eighteen pots for each experiment were placed randomly in a controlled environment chamber and their positions changed weekly. Seedlings were thinned to one plant per pot at one week after emergence by determining modal cotyledonary leaf length and selecting the plant with...
leaf length nearest the overall modal length. Irradiance at canopy level of 325 \( \mu \text{mol m}^{-2} \text{s}^{-1} \) was supplied by 80% cool white fluorescent lamp and 20% incandescent lamp input wattage. Photoperiod and thermoperiod were 16 h with a 25/20 °C day/night temperature and 70 ± 5% relative humidity. Pots were irrigated daily with Hoagland's solution (Hoagland and Arnon, 1950) modified to contain 1.6, 16 or 80 ppm (mg L\(^{-1}\)) S supplied as sulphate. The pH of the nutrient solutions was adjusted to 6.2 ± 0.1.

The SO\(_2\) exposure system consisted of continuous stirred tank reactor (CSTR) chambers (Heck et al., 1978). At 30 days from seeding, when the plants were beginning to flower, they were transferred from the growth chambers to exposure chambers. Environmental conditions in the CSTR chambers were similar to those for growth except that the irradiance was provided by 50% high pressure sodium lamp and 50% metal halide lamp input wattage. Irrigation with nutrient solutions was continued. Plants were allowed to acclimate to the CSTR chamber environment for 12 hr.

Plants were supplied with 1.6, 16 or 80 ppm sulphate and exposed continuously to 0.0 or 0.1 ppm (\(\mu \text{L L}^{-1}\)) SO\(_2\) for five consecutive days in the first experiment. In a subsequent experiment plants with the above-noted sulphate nutrition levels were exposed to 0 or 0.4 ppm SO\(_2\) for five consecutive days. In both experiments the three nutrition treatments and two SO\(_2\) (0 and 0.1 or 0 and 0.4 ppm) treatments were combined in a 3 \times 2 factorial design using six CSTR chambers with each nutrition-SO\(_2\) combination placed in a separate chamber. Each experiment consisted of four replicates run over time. There were two plants per chamber in some replicates and three plants per chamber in others. Sulphur dioxide was metered from a tank containing 1500 ppm SO\(_2\) in N\(_2\) and monitored with a Thermo Electron Series 43 fluorescent SO\(_2\) analyzer calibrated with tank SO\(_2\) traceable to the National Bureau of Standards.

Plants were harvested immediately following the five day exposure. Each plant was separated into leaf and stem portions. Fresh wt was measured and leaf area (one side) determined with a LiCor Area Meter, Model LI-3000. Leaves and stems were dried in a forced draft oven at 70 °C for seven days. Dry wt was recorded and the tissue ground through a 20 mesh screen in a Wiley mill and analyzed for total S and sulphate-S. Sulphur dioxide uptake on a leaf area basis was calculated over the duration of the exposure based on the difference between inlet and outlet SO\(_2\) concentration in the CSTR chamber, with adjustments for flow-through rate and chamber and pot sorption of SO\(_2\).

Dried and ground samples were wet-ashed in a BD40 Technicon block digester at 150 °C for 1 hr and 215 °C for 2 hr. A Technicon Autoanalyzer manifold developed for determination of total S in plant material was used. The manifold permitted the automatic mixing of small, precise volumes of sample and BaCl\(_2\), resulting in the precipitation of BaCO\(_4\) which was then measured colorimetrically. Recovery of S from National Bureau of Standards reference plant tissue was 96%. Sulphate S was measured after decolorizing with HCl-treated charcoal and extraction with Sinclair's solution (Sinclair, 1974) using the same manifold and colorimeter as for total S analysis with some minor modifications.