

# Triazoles as Plant Growth Regulators and Stress Protectants

*R. Austin Fletcher and Angela Gilley*

Department of Environmental Biology  
University of Guelph  
Guelph, Ontario  
Canada, N1G 2W1

*Narendra Sankhla and Tim D. Davis*

Texas A & M University  
Texas Agricultural Experiment Station  
Dallas, Texas 75252  
USA

- I. Introduction
- II. Translocation and Efficacy of Application Methods
- III. General Plant Responses to Triazoles
  - A. Morphological Effects
  - B. Physiological Effects
  - C. In Vitro Responses
- IV. Mode of Action
  - A. Primary Effects
    - 1. Gibberellin
    - 2. Sterols
    - 3. Abscisic Acid
  - B. Secondary Effects
    - 1. Cytokinins
    - 2. Ethylene
    - 3. Polyamines
- V. Stress Protection
  - A. Drought
  - B. Low Temperature
  - C. High Temperature

- D. Environmental Pollutants and Other Stresses
- VI. Potential and Current Applications
  - A. Ornamentals
    - 1. Bedding Plants
    - 2. Potted Plants
    - 3. Foliage Plants
    - 4. Woody Ornamentals
    - 5. Geophytes
    - 6. Orchids
  - B. Turf and Amenity Grasses
  - C. Arboriculture and Vegetation Management
  - D. Agronomic Crops
  - E. Vegetable Crops
  - F. Spice Crops
  - G. Fruit and Nut Species
    - 1. Pome Fruits
    - 2. Stone Fruits
    - 3. Nut Crops
    - 4. Small Fruits
    - 5. Viticulture
    - 6. Tropical and Subtropical Fruits
- VII. A Novel Seed Treatment Technology
- VIII. Summary
- Literature Cited

## I. INTRODUCTION

In the late 1960s, several compounds from the chemical class of 1-substituted imidazoles and 1, 2, 4-triazoles were commercially developed and successfully used for the treatment of plant and human fungal infections. These azole fungicides and antimycotics include the most active compounds known today for controlling plant diseases and human mycoses (Buchel 1986). The azole fungicides belong to the large group of ergosterol biosynthesis inhibitors that interfere with the biosynthesis of fungal steroids. Certain azole compounds interfere with the biosynthesis of gibberellins and influence the morphogenesis of plants, indicating their possible use as plant growth regulators. Hence, several triazole derivatives (Table 3.1; Fig. 3.1) were developed and recommended for use worldwide as either fungicides or plant growth regulators (PGRs).

The triazoles are the largest and most important group of systemic compounds developed for the control of fungal diseases in plants and animals (Siegel 1981). Commercial products have both fungitoxic and plant growth regulating properties, irrespective of whether they were