VOLATILE METHYL KETONE SEED-GERMINATION INHIBITORS FROM Amaranthus palmeri S. WATS. RESIDUES

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(Received June 1, 1987; accepted September 24, 1987)

Abstract—The effects of nine methyl ketones previously identified in the mixture of volatiles released by Amaranthus palmeri (AMAPA) residues upon onion, carrot, AMAPA, and tomato seed germination were determined. Three-day exposures to these volatiles significantly inhibited germination of all assay seeds, and the degree of inhibition was dependent upon seed species, exposure time, and concentration. Based on the degree of inhibition observed in both time- and concentration-dependent assays, the following activity series was obtained: 2-octanone, 2-nonanone > 2-undecanone > 2-heptanone > 2-hexanone, 3-methyl-2-butanone, 2-pentanone, 3-hydroxy-2-butanoine > 2-butanone. The activities of these compounds appear to be additive and dependent on relative volatility and hydrophilicity.

Key Words—Allelopathy, volatile allelochemicals, methyl ketones, germination inhibitors, onion, Allium cepa, carrot, Daucus carota, Palmer amaranth, Amaranthus palmeri, tomato, Lycopersicon esculentum.

INTRODUCTION

The presence of Amaranthus palmeri (AMAPA) residues in the soil reduces fresh weight accumulation in onions and carrots and markedly decreases seedling field establishment in carrots (Menges, 1985). Classic natural products iso-

1 Name of companies or commercial products are given solely for the purpose of providing specific information; their mention does not imply recommendation or endorsement by the U.S. Department of Agriculture over others not mentioned.
lation techniques (Bradow, 1985, Fischer and Quijano, 1985) and solid-phase separation techniques applied to water extracts of soil containing AMAPA residues (Bradow and Connick, 1987) failed to isolate any inhibitory factors from either AMAPA residues or soil containing such residues.

However, volatiles emitted both by AMAPA residues and soil containing the residues were highly inhibitory of germination in onion, carrot, AMAPA, and tomato (Bradow and Connick, 1987). A number of volatile organic compounds associated with AMAPA seedhead, stem, and root residues were subsequently identified (Connick et al., 1987), and two of these volatiles, 2-heptanone and 2-heptanol, were shown to be potent inhibitors of seed germination. The high bioactivity of 2-heptanone and the detection of six other methyl ketones in the volatile mixtures associated with AMAPA residues led to the present examination of the seed germination effects produced by the identified methyl ketones (plus 2-hexanone and 2-octanone detected under anaerobic conditions), tested individually and in selected binary combinations. This paper describes the concentration and exposure-time dependence of these effects observed with nine C₄–C₁₁ methyl ketones associated with AMAPA residues.

METHODS AND MATERIALS

All chemicals used in these assays were purchased from Aldrich Chemical Company (Milwaukee, Wisconsin). Assay seeds were either purchased from commercial sources or were gifts of Dr. R.M. Menges, USDA, Weslaco, Texas.

Time-Dependent Seed-Germination Bioassays. The desiccator seed-germination assay technique has been previously described (Bradow and Connick, 1987; Connick et al., 1987). Briefly, seeds of onion, carrot, AMAPA, or tomato were spread on double sheets of deionized water-saturated Whatman No. 1 filter paper placed on the porcelain plates of separate 2.5-liter (160-mm-ID) glass desiccators. Circles (22 mm diam.) had been removed from the filter paper sheets to facilitate diffusion of volatiles, and the filter paper circles were divided into eight equal segments (replicates) containing the same number of seeds (25 AMAPA, or 20 of the other species). Each desiccator well contained a 10-ml glass beaker resting on 50 g of pure sand in a crystallizing dish (100 x 50 mm). The sand was moistened with 10 ml of deionized water. The central beakers were left empty in the controls. In the time-dependence study, a volume equivalent to 34.4 µM of a volatile test compound was placed in the central beaker, and the separate seed species were incubated for 72 hr before germination evaluation (3-day data). Radicle protrusion was the germination criterion. All evaluations were made in dim light under an exhaust safety hood. The volatile