Effects of Glyphosate Formulations on Cotyledon Structure and Chlorophyll Fluorescence in Cotton.

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INTRODUCTION

Engame is a proprietary blend of glyphosate in 79% AMADS, 1- aminomethanamide dihydrogen tetraoxosulfate. AMADS is a molecular complex formed upon heating a proprietary mixture of sulfuric acid and urea, and has a pH of approximately 2. The glyphosate–AMADS formulation forms necrotic lesions on the leaf or cotyledon surfaces and has improved herbicide performance as a result of faster uptake and translocation.

The objectives of this research were to describe their effects of the Engame and Roundup WeatherMax formulations on plant surfaces and subcellular structures, and to describe the effects using fluorescence.

MATERIALS AND METHODS

Glyphosate was applied at 0.8 kg ai/ha with a pneumatic track sprayer. Fluorescence induction curves were collected with a Hansatech Instruments HandyPEA fluorimeter. Samples for scanning and light microscopy were taken from 1-24 h post spraying and fixed and embedded as previously described (Vaughn et al. 1990 Protoplasma 156:117-129). Samples were flat embedded and the cotyledon pieces were cut from the blocks and oriented so that the cross sections of the material were obtained.

RESULTS

The effects of the Roundup WeatherMax™ and Engame™ formulations of glyphosate were compared on cotton cotyledons and leaves. Epidermal damage to cotton cotyledons and leaves was observed within one hour after application of Engame™, but no perturbations were observed with Roundup WeatherMax™. Scanning electron microscopy of either glyphosate-resistant or glyphosate-sensitive cotton cotyledons following Engame™ treatment showed that cuticular waxes were displaced, forming a pit and leaving a collar of wax at the pit periphery. Light microscopy of Engame™-treated leaves showed numerous areas where the epidermal and, more rarely, the mesophyll cells beneath the epidermal cells were collapsed. In the mesophyll cells, the tonoplast had burst, leaving chloroplasts spread throughout the cell, no longer appressed to the cell wall.

Chlorophyll fluorescence induction curves were partially quenched by 4 HAT with Roundup WeatherMax™ and Engame™, in both glyphosate-sensitive and -resistant varieties. Perturbations by Engame™ were greater than WeatherMax ™ indicating a greater degree of indirect photoinhibition of PS II. By 24 HAT, there was a greater decrease in fluorescence and in the performance index (PI) with Engame™. At 72 HAT, there was nearly complete photoinhibition of PS II with Engame™ in the sensitive variety although in the resistant variety fluorescence parameters indicated recovery from the injury. Rapid and sustained photoinhibition of PS II and over-reduction of PS II may account of the greater efficacy of the Engame™ formulation of glyphosate.

These data show that the Engame ™ formulation of glyphosate enhances the uptake of the herbicide as witnessed by the enhanced indirect photoinhibition and ultrastructural damage.

Figure 1. Surface damage from Engame to cotyledons at 24 HAT.

Figure 1. Surface damage to leaves at 72 HAT. Note yellowing of leaf on right, a glyphosate sensitive variety. Leaf on left is from a glyphosate resistant cotton.

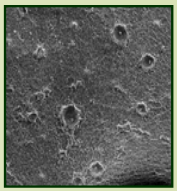

Fig. 3. Cotton cotyledon surface at 2 h after Engame treatment.

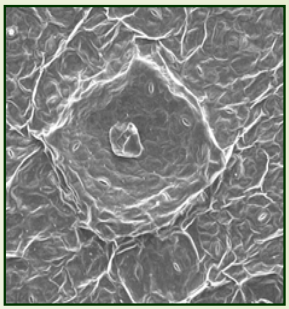

Fig. 4. Enlargement of pit area.

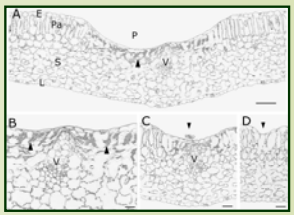

Figure 5a-d. Light micrographs of cotton cotyledons treated with the Engame formulation of glyphosate. A. A low magnification cross-section of an area through one of the pits (P) created by spraying with Engame. Both the epidermal (E) cells and top layer palisade (Pa) cells are affected in the pit area but not elsewhere in the cotyledon. S= spongy mesophyll, V = vascular tissue. B. A higher magnification area in the pit tissue, showing the abnormal clustering of chloroplasts (arrowheads). C. Accumulation of cuticular material in a pit (arrowhead). D. A very small pit (arrowhead). Bars = 100µm.

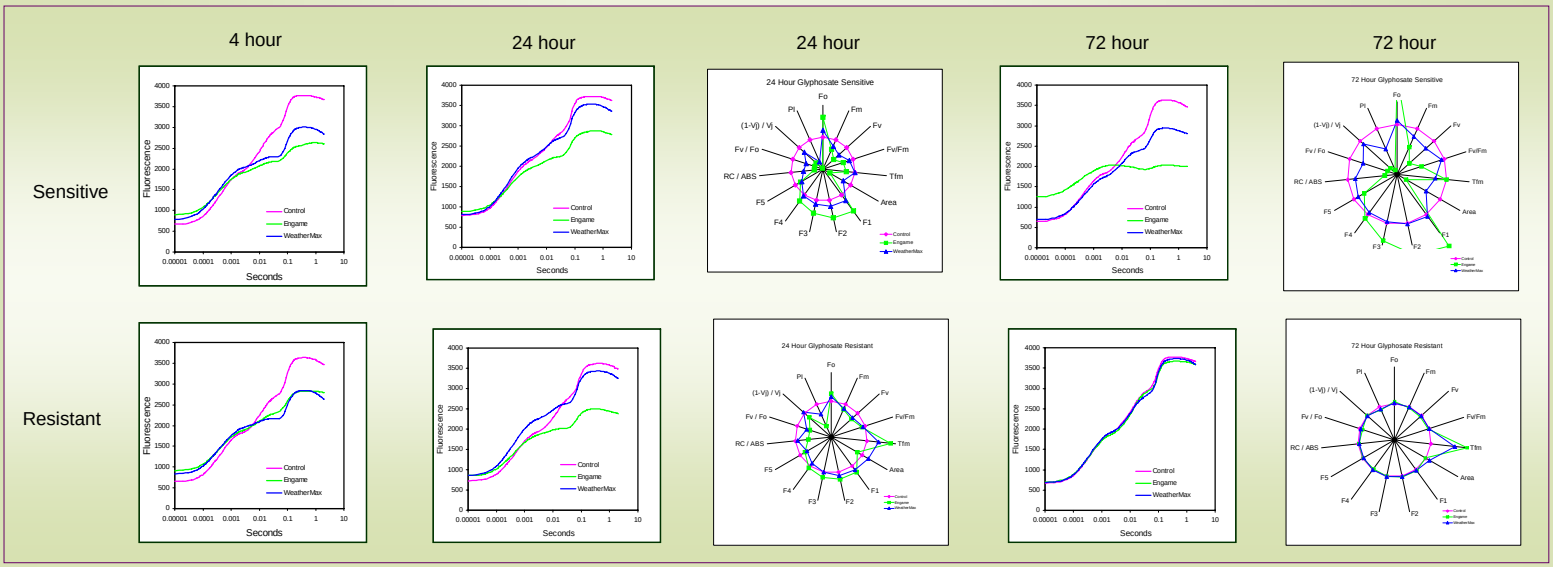

Figure 6. Fluorescence curves and radar plots of fluorescence parameters derived from the curves for glyphosate-resistant and glyphosate-sensitive cotton leaves. Cotyledons responded similarly.