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PHYSIOLOGICAL AND MORPHOLOGICAL RESPONSE OF GLYPHOSATE-RESISTANT AND NON-GLYPHOSATE-RESISTANT COTTON SEEDLINGS TO ROOT-ABSORBED GLYPHOSATE

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Abstract

The level of tolerance in herbicide-resistant plants may vary among different tissues or growth stages. Studies were conducted to determine relative tissue sensitivity in glyphosate-resistant (GR) and non-GR cotton seedlings to the herbicide glyphosate (Roundup). Glyphosate is often applied as a pre-plant treatment in minimal tillage cotton production systems to remove any unwanted, emerged vegetation. Timing of these glyphosate applications may be in close proximity to the time of planting and seedling emergence. As glyphosate leaches from roots of nearby senescing weeds, it may be absorbed into the roots of cotton seedlings. Therefore, cotton seedlings were grown in hydroponic solutions containing technical grade glyphosate to ensure constant exposure to glyphosate. In all tissues, GR cotton required a greater concentration of glyphosate to reach 50% fresh weight reduction than non-GR cotton. Glyphosate inhibited the growth on non-GR cotton cotyledons, hypocotyls, and roots 50% at concentrations of 23, 69, and 27 µM glyphosate, respectively. In contrast, growth of GR cotton cotyledons, hypocotyls, and roots was inhibited by 50% at 3.5-, 8-, and 5-fold greater glyphosate concentrations, respectively, than non-GR cotton tissues. Correspondingly, shikimic acid, an intermediate in the shikimic acid pathway, which accumulates upon 5-enolpyruvyl 3-shikimate phosphate synthase (EPSP synthase) inhibition, reached levels of 17.3, 21.6, and 8.8 µM g-1 fresh weight at 1 mM glyphosate in non-GR cotyledons, hypocotyls, and roots, respectively. In contrast, shikimic acid levels in GR cotton were 4.2, 14.0, and 8.2 µM g-1 fresh weight at 1 mM glyphosate for cotyledons, hypocotyls, and roots, respectively. Thus, roots of GR and non-GR cotton accumulate similar amounts of shikimic acid, whereas GR cotyledons and hypocotyls accumulated less shikimic acid than the corresponding non-GR cotton in response to glyphosate treatments. Additionally, glyphosate inhibited the development of lateral roots at concentrations of 0.01 or 0.1 µM glyphosate greater, in GR and non-GR cotton, respectively. Lateral roots of GR and non-GR cotton inhibited by glyphosate appeared shorter and were surrounded by a thick layer of necrotic cells or root exudate which was not present in roots from plants grown in media not containing glyphosate. The quantity of GR CP4-EPSP synthase was 4.7 and 6.6 times greater in cotyledons than in hypocotyls and roots, respectively. Tissues from dark-grown GR cotton seedlings contained 1.2-2.1 times less Cp4-EPSP synthase than their light grown counterparts. Because lateral root development was inhibited, fresh weight was reduced, and shikimic acid accumulated following treatment with glyphosate in both GR and non-GR cotton, potential exists for glyphosate to negatively affect cotton seedling establishment.