SIMULATION MODELING TO PREDICT THE EVOLUTION AND DYNAMICS OF GLYPHOSATE RESISTANCE IN BARNYARDGRASS IN COTTON

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Abstract

Barnyardgrass (*Echinochloa crus-galli*) is an important herbicide-resistant weed worldwide. In Midsouth, barnyardgrass resistance has been confirmed for a number of herbicides, including propanil, quinclorac, clomazone, and imazethapyr. Glyphosate-resistant barnyardgrass is likely to evolve in glyphosate-resistant cotton, and proactive measures are vital to mitigate such a situation. A glyphosate-resistance simulation model has been developed to i) simulate the risks of barnyardgrass resistance to glyphosate under various management practices in Roundup Ready™ flex cotton and ii) to identify best management practices for resistance mitigation/management. The STELLA™ modeling software was used for performing various simulations. For a given management scenario, 250 model runs were performed for a 30-year period. Resistance is considered to have evolved if >20% of the barnyardgrass seedbank is comprised of resistant seeds. The model predicted that there is about 80% chance for resistance to evolve in about 10 years of continuous cultivation of Roundup Ready™ Flex cotton, which received five glyphosate applications (i.e., glyphosate-only program) in a growing season. When residual herbicides such as Reflex® (14 d pre-plant) or Cotoran® (at planting) were included in the glyphosate-only program, the risk was reduced to 60% and the onset of resistance was delayed for up to 15 years. A well-diversified herbicide program with overlaying residual herbicides (Reflex® 14 d pre-plant fb Gramaxone®+Cotoran® at planting fb Roundup®+Dual Magnum® first post fb Roundup®+Dual Magnum® second post fb Roundup®+Caparol® at third post fb MSMA®+Valor® at layby) showed no risk for glyphosate resistance within the 30-year simulation period. However, timely activation of these residual herbicides is important for better results. Additionally, application timings should correspond to barnyardgrass emergence pattern. For example, SelectMax®, an effective grass herbicide, was more effective in delaying glyphosate resistance in barnyardgrass when applied at first post compared to when applied at second post, because applications at the second post corresponds to a relatively larger cohort. Rotating glyphosate-resistant and glufosinate-resistant cotton traits delayed the onset of glyphosate resistance for up to 18 years, whereas the GlyTol® technology, which allows for the application of glyphosate and glufosinate on the same crop, was more effective in delaying resistance. A number of non-chemical strategies, including cultivation, cover crops, and altering planting dates have been found to be invaluable in delaying resistance; these strategies could be integrated with herbicide-programs for achieving sustainable weed management. More importantly, seedbank management is critical. When simulations were performed with an initial seedbank level of 200 seeds m^{-2}, the probability of resistance was only about 25% as opposed to about 80% chance for resistance when the initial seedbank was ten-fold larger. Thus, prevention of weed seed production and seedbank renewal will not only prevent future weed interferences but also delay the evolution of herbicide-resistant weeds. Future works will test different 'what if' scenarios in order to better understand the factors that contribute most to the evolution of resistance and thereby devise appropriate strategies to delay resistance evolution.