AUSTRALIAN Glyphosate Sustainability Working Group

Name of research project:	**Mechanisms, evolution and inheritance of resistance**
Research organisation(s):	University of Adelaide
GRDC Project code (Where applicable):	UA00158
Key contacts: (Include names, phone number(s), e-mail and details of which state they reside in or are responsible for)	Christopher Preston Jenna Malone
Project objectives:	Herbicide resistance is a major threat to profitable grain production. Herbicide resistance limits the options available to growers to control weeds in an efficient and cost-effective manner. Herbicide resistance has become widespread across Australian cropping systems with extensive resistance in a number of weed species to Group A and B herbicides. This has resulted in greater reliance on other herbicides. Several of these herbicides have become key components of integrated weed management systems, but are themselves under threat of resistance. Glyphosate is the most widely used herbicide in Australia; however, the continuing evolution of resistance to glyphosate threatens the utility of this herbicide. Glyphosate resistance occurs through several mechanisms and this introduces complexity around the management and spread of resistance. Some mechanisms can be easily managed using glyphosate mixtures with other herbicides, for others this is not effective. This is further complicated by several resistant species being polyploids (brome grass and barnyard grass) and the inheritance of one mechanism being non-Mendelian. Better understanding of the evolution of this complex resistance may result in better management choices. Clethodim has become a key herbicide for annual ryegrass management in break crops; however, resistance to clethodim is threating the utility of this herbicide. This is complicated by the fact that higher rates of clethodim have been widely used to control populations resistant to lower rates. Many broadleaf weeds in Australia have evolved resistance to Group B herbicides. The Group I phenoxy herbicides have become important products

	to control these weeds. These herbicides have been robust herbicides for weed control, but are now starting to fail widely across Australia. There are a limited number of alternative herbicide groups (Groups C, F and H) for use and resistance to Groups C and F is occurring in the same species with resistance to Groups B and I. High levels of 2,4-D resistance mean that mixtures of Group I herbicides with other herbicides are unlikely to work. Understanding the evolutionary dynamics of high level 2,4-D resistance and multiple resistance in broadleaf weeds will help develop strategies to delay the evolution of multiple resistance. The increasing resistance to trifluralin has resulted in the development of Boxer Gold and Sakura as alternative pre-emergent herbicides. These three herbicides plus the recently registered Rustler will be a mainstay of ryegrass management for many years to come, unless resistance renders them useless. A field selected population of ryegrass with resistance to triallate and prosulfocarb (but not Boxer Gold or Sakura) has been identified. Understanding the evolutionary dynamics of resistance to prosulfocarb will aid better rotations of pre-emergent herbicides to delay the onset of resistance. Rustler (propyzamide) has recently been registered for use in canola. Cross-resistance to propyzamide from trifluralin resistance already exists; however, anecdotal information suggests these populations are moderately well controlled by propyzamide under field applications. Understanding the relationship between trifluralin and propyzamide resistance in ryegrass and the likelihood of selection of cross-resistance will improve strategies to delay resistance.
Project period: Start and finish dates	01/07/2015 to 30/06/2020
Project outcomes and status:	Research has been undertaken to better understand the evolution, mechanisms and inheritance of resistance to herbicides, focusing on resistance to clethodim in annual ryegrass, resistance to triallate and prosulfocarb in annual ryegrass, resistance to Group I herbicides in common sowthistle and Indian hedge mustard, Group F resistance in common sowthistle and glyphosate resistance in brome grass, barnyard grass, common sowthistle and feathertop Rhodes grass.

	Research on 5 different populations has established that there are multiple genes leading to clethodim resistance in annual ryegrass with different patterns of inheritance. This likely explains the increasing resistance as rates increase and points to further increasing rates being an unsustainable tactic. Resistance to Group J herbicides was identified in several annual ryegrass populations. These populations came to note due to failure of triallate, but have cross-resistance to prosulfocarb. Boxer Gold (prosulfocarb + S-metolachlor) and Sakura (pyroxasulfone) are still able to control these populations. Populations of common sowthistle from SA were identified with resistance to 2,4-D. These populations also had resistance to dicamba, clopyralid, triclopyr and fluroxypyr. This broad cross-resistance to Group I herbicides will make common sowthistle control more difficult. Resistant plants fail to effectively translocate 2,4-D around the plant and this likely explains the broad cross resistance to Group I herbicides. Populations of feathertop Rhodes grass from roadsides in SA are much more tolerant of glyphosate than other populations. These populations carry mutations target site mutations that reduce binding of glyphosate. Different target site mutations lead to different levels of resistance.
Links to any relevant websites or specific documents you feel are relevant and may be of interest.	http://onlinelibrary.wiley.com/doi/10.1002/ps.4493/abstract http://onlinelibrary.wiley.com/doi/10.1002/ps.4512/abstract