

Summary for public release DAN2003

Project title: <i>Sustainable insect management through improved insect resistance monitoring</i>		
Project details:	CRDC project ID:	DAN2003
	CRDC goal:	1. Increase productivity and profitability on cotton farms
	CRDC key focus area:	1.3 Protection from biotic threats and environmental stresses
	Principal researcher:	Lisa Bird
	Organisation:	NSW Department of Primary Industries
	Start date:	1.7.19
	End date:	30.6.22
Objectives	• Objective 1. Determine if the frequency of resistance is changing in <i>Helicoverpa armigera</i>, cotton aphid, mites and green mirids to insecticides. • Objective 2. Investigate the mechanism of new resistance in <i>H. armigera</i>. • Objective 3. Investigate the mechanism of new resistance in cotton aphid, mites and green mirids. • Objective 4. Investigate the efficacy of registered insecticides under development on <i>H. armigera</i>, cotton aphid, mites and green mirids. • Objective 5. Investigate the role of molecular testing for IPM insecticides in <i>H. armigera</i>, cotton aphid, mites and green mirids. • Objective 6. Project review and industry feedback on research priorities. • Objective 7. Determine whether established methods in lepidopteran resistance testing are suitable for use on <i>S. frugiperda</i>.	
Background	Insecticide resistance is a major threat to sustainable cotton production. Field resistance results in reduced insecticide efficacy and results in major economic, environmental and social costs to industries and communities. While the introduction of transgenic cotton has reduced reliance on insecticides for control of <i>Helicoverpa</i> spp., chemical insecticides remain the primary method of pest control for species not controlled by Bt toxins, and which have become more prominent in cotton. Chemical insecticides also remain important for managing <i>Helicoverpa</i> spp. in other broad-acre farming systems which are important rotational options for cotton growers. Globally new insecticidal actives are becoming more difficult to bring to market and it will become increasingly important to retain efficacy in available products. Therefore, stewardship of key chemical insecticides is essential to support sustainable management of leaf-feeding pests of cotton and cross-sector management of pivotal selective <i>Helicoverpa</i> spp. insecticides. In addition to resistance selected in endemic pest species, incursions from neighbouring countries also represent a risk to product efficacy and industry sustainability, particularly for highly migratory pests which have developed resistance in countries where insecticide use is not well regulated. Rapid detection and characterisation of resistant variants in endemic pest populations, or those which establish from exotic incursions, has a high level of practical importance for increasing capacity to enact emergency management responses to mitigate risk of lost productivity. Industry-endorsed strategies underpin responses to emerging resistance issues and provide a platform to promote adoption of key recommendations that support product stewardship (IRMS in cotton and <i>Helicoverpa</i> RMS in grains). While molecular technologies in resistance diagnostics continue to improve, field-based surveillance by bioassay is currently the mainstay of resistance programs because it provides a direct measure of practical field resistance and is critical to ensuring that industries retain efficacy of as many rotational options as possible.	

Research activities	• Review, develop and implement an integrated resistance surveillance program incorporating four major insect pests of cotton. • Conduct annual resistance testing in <i>H. armigera</i>, cotton aphids, two-spotted mites and green mirids and deliver annual outputs to industry. • Characterise indoxacarb resistance in a second field-derived variant of <i>H. armigera</i> by quantitative genetic analysis • Characterise indoxacarb resistance in two field-derived variants of <i>H. armigera</i> by genotype-by-sequencing analysis • Determine acute toxicity and sub-lethal effects of an entomopathogen in <i>H. armigera</i> and <i>S. frugiperda</i>. • Conduct studies of insecticide toxicity in adult and larval stages of <i>S. frugiperda</i> and <i>H. armigera</i> to inform bisexual attract-and-kill strategies. • Establish of baseline susceptibility to indoxacarb, chlorantraniliprole, emamectin benzoate, spinetoram, pyrethroids and methomyl in <i>S. litura</i>. • Investigate baseline dose-response to for selective insecticides in geographically diverse populations of Australian <i>S. frugiperda</i>.
Outputs	• Annual delivery of resistance surveillance outcomes in four major insect pests of cotton (<i>H. armigera</i>, aphids, mites, mirids) from 2019-2022. • Annual resistance testing results reported to TIMS Technical Panel and used by the TIMS Committee to ratify the IRMS from 2019-2022. • Resistance results and recommendations disseminated to industry through engagement with CottonInfo, CPMG and cotton communications team. • A complementary program of Helicoverpa resistance surveillance in grains provided mutual benefits to both the cotton industry. • Improved understanding of the genetic and molecular basis of indoxacarb resistance in <i>H. armigera</i>. • Calibration of baseline responses in <i>S. frugiperda</i> and <i>S. litura</i> to registered insecticides and establishment of diagnostic doses for resistance surveillance. • Acute toxicity and sub-lethal effects of an entomopathogen determined.
Impacts	The ongoing success of the cotton industry depends on effective strategies that support growers to proactively manage resistance across a range of important insect pests. Consequences of resistance either as a result of insecticide overuse or inability to detect incursions reduces international competitiveness through reduced yield and/or quality. Field failures caused by resistance also lead to environmental and commodity contamination, further resistance selection, beneficial insect destruction leading to secondary pest outbreaks and escalation of concerns about risks to human health. From 2019 to 2022 this project delivered a rigorous and cost-effective program for rapid detection of resistance to facilitate timely alerts to industry of emerging issues and increase capacity to mitigate resistance risk. Importantly, resistance surveillance is a key component of the industry endorsed Insecticide Resistance Management Strategy (IRMS). This project has delivered information critical for evaluating the effectiveness of this strategy and provide an evidence-based platform for review and revision of the IRMS in response to quantitative shifts in resistance frequency. Ultimately, this project has provided decision support recommendations to growers and advisers to enhance sustainable insect management in cotton production and important rotational crops in the broader cotton system. The project has also investigated other insect pest species that may emerge as threats to the cotton production system such as the highly invasive species <i>S. frugiperda</i> and the endemic species <i>S. litura</i> which has potential to become an issue for management in newly established growing regions of northern Australia. Investigations of insecticide toxicity and resistance profiling in these species will assist growers to optimise the cost of management within an IPM framework. Knowledge of resistance risk in these species will also contribute to the process of developing an IRMS for northern Australian growing regions.

Key publications	Bird LJ, Drynan LJ, Walker PW (2020) Relative fitness and stability of resistance in a near-isogenic strain of indoxacarb resistant <i>Helicoverpa armigera</i> (Lepidoptera: Noctuidae). <i>Pest Management Science</i> 76:4077-4085 Bird L, Miles M, Quade A, Spafford H (2022) Insecticide resistance in Australian <i>Spodoptera frugiperda</i> (J.E. Smith) and development of testing procedures for resistance surveillance. <i>PLoS ONE</i> 17(2): e0263677
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