Characterisation and Management of Herbicide Resistance in Barley Grass (*Hordeum glaucum* Steud.)

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ABSTRACT

Hordeum glaucum has emerged as a problematic weed in cereal and broadleaf crops of South Australia (SA). Recent reports from growers and agricultural advisors in SA have indicated an increase in the incidence of *H. glaucum* in field crops. The increase in the incidence was suspected due to the evolution of herbicide resistance and an increase in seed dormancy in *H. glaucum* populations. Initially, dose response studies confirmed high levels of resistance to (aryloxyphenoxypropanoate) APP acetyl-coenzyme A carboxylase (ACCase)-inhibiting herbicides in the populations where growers had reported control failures with ACCase-inhibiting herbicides. As a result of previous reports of an increase in seed dormancy and confirmation of herbicide resistance in *H. glaucum*, it was considered important to investigate herbicide resistance status and seedbank behaviour of field populations of this weed species. Therefore, studies were conducted to characterise herbicide resistance, study seedbank behaviour, inheritance of resistance, fitness penalties associated with herbicide resistance and alternative herbicides for the management of ACCase-inhibiting herbicide-resistant *H. glaucum* in field peas. A field survey was undertaken in the Upper North and Eyre Peninsula regions of SA in October 2012. Of the 90 *H. glaucum* populations screened for resistance to quizalofop, 14% exhibited some level of resistance and 86% were susceptible. Resistance to ALS-inhibiting herbicides (imazamox+imazapyr and sulfosulfuron) was low (3% to 12% populations). The majority of *H. glaucum* populations emerged rapidly (median T_{50} = 8d), but some populations displayed an extremely slow emergence pattern with T_{50} >20 d. There was no direct linkage between seed dormancy and herbicide resistance. The majority of *H. glaucum* populations showed a low level or no seedbank persistence but a few populations persisted for one year (up to 20% seedbank persistence). Dose–response studies confirmed that *H. glaucum* populations had variable levels of resistance to both ACCase and ALS-inhibiting herbicides, with greater resistance to ACCase-inhibiting herbicides. Gene sequencing

confirmed the presence of previously known mutations Ile-1781-Leu, Ile-2041-Asn and Gly2096Ala in the *ACCase* gene of some *H. glaucum* populations. No amino acid substitution was found in the *ALS* gene of resistant populations, but the reversal of SU resistance by malathion (a cytochrome P450 inhibitor) and susceptibility to sulfometuron suggest that non-target site mechanisms confer resistance to ALS-inhibitors in this species. The mode of inheritance of resistance to ACCase-inhibiting herbicides was identified as a single gene with a partially-dominant allele. Fitness studies conducted under intraspecific competition and/or interspecific competition in pots and the field with wheat and lentil revealed that the amino acid substitution at 1781 position of the ACCase gene did not impose any fitness costs, but there was some evidence for fitness cost associated with Ile-2041-Asn mutation in *H. glaucum* populations. To identify alternative herbicides to control ACCase-inhibiting herbicide-resistant *H. glaucum*, a range of pre- and post-emergent herbicides were examined in field peas. The results of this investigation suggest that propyzamide or pyroxasulfone applied PP and POST imazamox could be used effectively in the field for the management of ACCase-inhibiting herbicide-resistant *H. glaucum* in South Australia.

PUBLICATIONS ARISING FROM THIS THESIS

- Shergill LS, Malone J, Boutsalis P, Preston C, Gill GS (2015) Target-site point mutations conferring resistance to ACCase-inhibiting herbicides in smooth barley (*Hordeum glaucum*) and hare barley (*Hordeum leporinum*). Weed Science 63(2):408-415

- Shergill LS, Fleet B, Preston C, Gill G (2015) Incidence of herbicide resistance, seedling emergence and seed persistence of smooth barley (*Hordeum glaucum*) in South Australia. Weed Technology 29(4):782-792

- Shergill LS, Malone J, Boutsalis P, Preston C, Gill G (2015) Multiple resistance to ACCase and ALS-inhibitors in *Hordeum glaucum* Steud. Pest Management Science: Submitted

- Shergill LS, Malone J, Boutsalis P, Preston C, Gill G (2015) Inheritance and mechanism of quizalofop resistance in smooth barley (*Hordeum glaucum*) biotype from South Australia. Weed Science: Submitted

- Shergill LS, Boutsalis P, Preston C, Gill G (2015) Fitness costs associated with 1781 and 2041 ACCase–mutant alleles conferring resistance to herbicides in *Hordeum glaucum* Steud. Crop Protection: Submitted

- Shergill LS, Fleet B, Preston C, Gill G (2015) Management of ACCase-inhibiting herbicide-resistant smooth barley (*Hordeum glaucum*) in field pea (*Pisum Sativum*) with alternative herbicides. Weed Technology: In-press

- Shergill LS, Preston C, Boutsalis P, Malone J, Gill G (2014) Amino acid substitutions in *ACCase* gene of barley grass (*Hordeum glaucum* Steud.) associated with resistance to ACCase-inhibiting herbicides. Pages 7-10 In Proceedings of 19th Australasian Weeds Conference Hobart, Tasmania, Australia: Tasmanian Weed Society

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