EVOLUTION AND SPREAD OF PARAQUAT RESISTANT BARLEY GRASSES (*Hordeum glaucum* Steud. and *H. leporinum* Link)

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ABSTRACT

The bipyridilium herbicide paraquat, a non-selective post emergence herbicide, inhibits Photosystem I (PSI) by diverting electrons from ferredoxin and subsequently producing superoxide. This herbicide acts rapidly on plants and leaves no residual effects on soil. Paraquat has been employed for weed control in crops and pastures for more than three decades in South Australia and is still extensively used. Since 1990, there have been three paraquat-resistant populations of *Hordeum glaucum* documented from lucerne and no-till wheat. Resistance usually occurs following persistent use of paraquat for more than 12 years with at least one application each year. Recent reports suggest that the incidence of paraquat resistance in *Hordeum* spp. is increasing from lucerne (*Medicago sativa* L.) fields. For this reason, this project was designed to investigate new resistant populations of *Hordeum* spp; to assess the role of gene flow in spreading resistance; to determine the fitness of resistant individuals in accelerating resistance evolution; and to identify genetic relationships between resistant and susceptible populations using DNA markers.

A random survey of *Hordeum* spp. populations was conducted in 1999 through the mid-north and lower north of South Australia. There were 50 *Hordeum* populations collected and tested for paraquat resistance. Of these, one population of *H. glaucum* collected from a lucerne field, 1.4 km from Jamestown, was found to be highly resistant to paraquat. A second survey in 2001 targeted lucerne fields and adjacent fields between Jamestown and

Spalding and between Waterloo and Kapunda. From 23 populations collected, five additional paraquat-resistant populations of *H. glaucum* and one paraquat-resistant population of *H. leporinum* were identified with high levels of resistance.

The mechanism of paraquat resistance in *Hordeum* spp. is not fully elucidated, but it is not related to modification of the binding site at PS I, enhanced paraquat metabolism or reduced paraquat uptake. Previous studies have proposed a decrease of paraquat translocation within resistant individuals as the mechanism of resistance. This mechanism is affected by temperature, with the level of resistance decreasing when temperature is increased. Therefore, it is possible to compare resistant mechanisms among paraquat-resistant populations of *Hordeum* spp. using a temperature test. In the present study, the new paraquat-resistant populations demonstrated a similar response to temperature, indicating they may have a similar mechanism of resistance, to previously known populations.

The frequency of gene flow through pollen movement was assessed between paraquat-resistant and -susceptible populations of *H. leporinum* through pot experiments for two consecutive years. Gene flow through pollen movement did occur at a very low frequency, about 0.1 %. A s the anthers of *H. glaucum* are never exposed, gene flow could not be expected between paraquat-resistant and susceptible *H. glaucum.* With this low or non-existent frequency of pollen flow, it is concluded that, in *Hordeum* spp., gene flow through seed dispersal plays a more vital role in resistance spread than pollen movement.

The fitness of homozygous and heterozygous resistant, as well as homozygous susceptible, individuals was compared using plants from a single cross in the absence of herbicide application. There was no significant difference in growth and productivity among these three genotypes. The number of tillers increased at a similar rate over time. Likewise, plant dry weight, number of seed per plant and the weight of 100 seeds were not significantly different. Germinabilty tests found that the seed of paraquat-resistant and -susceptible individuals germinated evenly. This means that when conditions are suitable, resistant individuals will grow as well as susceptible individuals.

Using randomly amplified polymorphic DNA (RAPD) markers; the genetic relationship among paraquat-resistant and -susceptible populations of *Hordeum* spp. was examined. The results showed that individual paraquat-resistant populations of *H. glaucum* and *H. leporinum* had no polymorphic genotypes. In contrast, paraquat-susceptible populations contained polymorphic genotypes. The findings also showed that some paraquat-resistant populations within each species had identical genetic backgrounds. These were *H. glaucum* populations SHG8 and SHG9, and *H. leporinum* populations THL1 and THL3. This indicated the likelihood of gene flow between the fields these populations were collected. However, other paraquat-resistant populations demonstrated genetic dissimilarity, such as that between SHG7 and SHG8 or between THL1 and THL2. This suggests that independent evolutionary events remain important for resistant evolution in fields. These findings suggested management strategies should

incorporate methods to prevent the evolution of paraquat resistance and, at the same time, minimise seed dispersal of resistant populations between fields.

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