What is the latest random weed resistance survey telling us about paraquat and 2,4-D?

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Take home message

- Resistance to the Group 22 herbicides paraquat and paraquat + diquat has been found in feathertop Rhodes grass (*Chloris virgata*) and tall fleabane (*Conyza sumatrensis*), respectively
- 2,4-D (Group 4) resistance has been found in 5 and 8% of common sowthistle and wild radish populations respectively from the northern cropping region
- Group 22 herbicides are important components of the double knock strategy commonly used for effective control of many northern region weeds. Alternative herbicide options for this use practice are limited
- To manage herbicide resistance, alternative herbicide and non-chemical tactics should be used in combination.

Background

2,4-D and paraquat are important herbicides for the management of difficult to control weeds in the northern cropping region of Australia. 2,4-D is commonly used either as a stand-alone treatment in crop and fallow or as the first knock in a fallow double knock application for broadleaf weed control. 2,4-D is an important herbicide for the control of weeds including fleabane and common sowthistle.

Paraquat and paraquat+diquat (e.g. Spray.Seed®) have been the go-to second knock herbicides for double knock strategies. This tactic has provided improved control of weeds, compared to single knock applications, including fleabane, feathertop Rhodes grass, awnless barnyard grass and common sowthistle.

The effectiveness of these two herbicides is under great threat due to the development of herbicide resistance. As a result of a reliance on these herbicides and in the absence of other tactics, resistance has recently developed in key weed species.

In a 2020 field survey, paraquat resistance was identified in feathertop Rhodes grass, paraquat + diquat resistance in tall fleabane and 2,4-D amine resistance in common sowthistle and wild radish in the northern region. All fleabane populations were susceptible to 2,4-D.

This paper presents results from the random field survey for resistance conducted in 2020 and discusses options for the management of paraquat and 2,4-D resistance. As resistance is caused by an over-reliance on specific herbicides, managing resistance requires the use a range of weed management tactics in combination. Apply tactics to achieve maximum control and control any survivors to stop seed set.

Methodology

A national field survey for resistance took place in 2020. For the 'northern' component of the survey reported here, fields were selected at random on properties where permission had been given to survey. Seeds were collected from target weeds that had survived herbicide application in crop or fallow. These seeds were then planted, and seedlings treated at the upper label recommended rate of herbicide to assess for resistance (survivors of treatment). After treatment with herbicides, survival counts were made and percent survival used to characterise populations as susceptible (0% survival), developing resistance (1–19% survival) and resistant (>19% survival).

This paper will focus on the herbicides paraquat, paraquat + diquat and 2,4-D in relation to key northern region weeds.

Results

Paraquat and paraquat + diquat resistance

Paraquat resistance was found in 8% of feathertop Rhodes grass populations (Table 1, Figure 1) in Queensland. In this survey, there weren't any populations of FTR with viable seed collected in New South Wales, however, this weed is becoming more common throughout many of the farming regions in NSW, especially along roadsides. The majority of the paraquat resistant populations were on the Darling Downs, but there were also resistant populations in Central Queensland and the Border region near Goondiwindi.

Fleabane populations were tested for resistance against paraquat + diquat (Spray.Seed®) as this product is registered for control of fleabanes rather than a paraquat only herbicide. Our survey targeted the collection of fleabane species including flaxleaf fleabane (*Conyza bonariensis*), tall fleabane (*C. sumatrensis*) and Canadian fleabane (*C. canadensis*). Two populations were resistant to paraquat + diquat and both of these were located on the Eastern Downs of Queensland and geographically quite close to each other. Originally these were identified and previously reported as *C. bonariensis*, however, their identification has recently been confirmed as *C. sumatrensis* by the Queensland Herbarium.

2,4-D resistance

Sowthistle is one of the most common and widespread weeds in the northern grain region. Test results showed 5% of populations from this region resistant to 2,4-D and a further 32% as developing resistance (Table 1, Figure 2).

While wild radish is less common, with only 24 populations collected from the northern grain region, 8% of populations (2 populations) were identified as resistant with a further 33% (8 populations) identified as developing resistance (Table 1). The two resistant populations were located in Queensland. One near the Qld/NSW border and the other near Kingaroy.

All tested flaxleaf fleabane populations from the northern region were susceptible to 2,4-D. There were only two tall fleabane populations collected in the survey and neither had viable seed so could not be tested for resistance.

Table 1. Percent (%) of weed populations from the northern grain region identified as developing resistance (1–19% survivors) and resistant (>19% survivors) to 2,4-D, paraquat and paraquat + diquat.

Herbicide	Weed	Developing resistance (%)	Resistant (%)
Paraquat	Feathertop Rhodes grass (*Chloris virgata*)	0	8
Paraquat + diquat	Tall fleabane (*C. sumatrensis*)	0	100 (2 populations)
2,4-D	Common sowthistle (*Sonchus oleraceus*)	32	5
	Wild radish (*Raphanus raphanistrum*)	33	8 (2 populations)

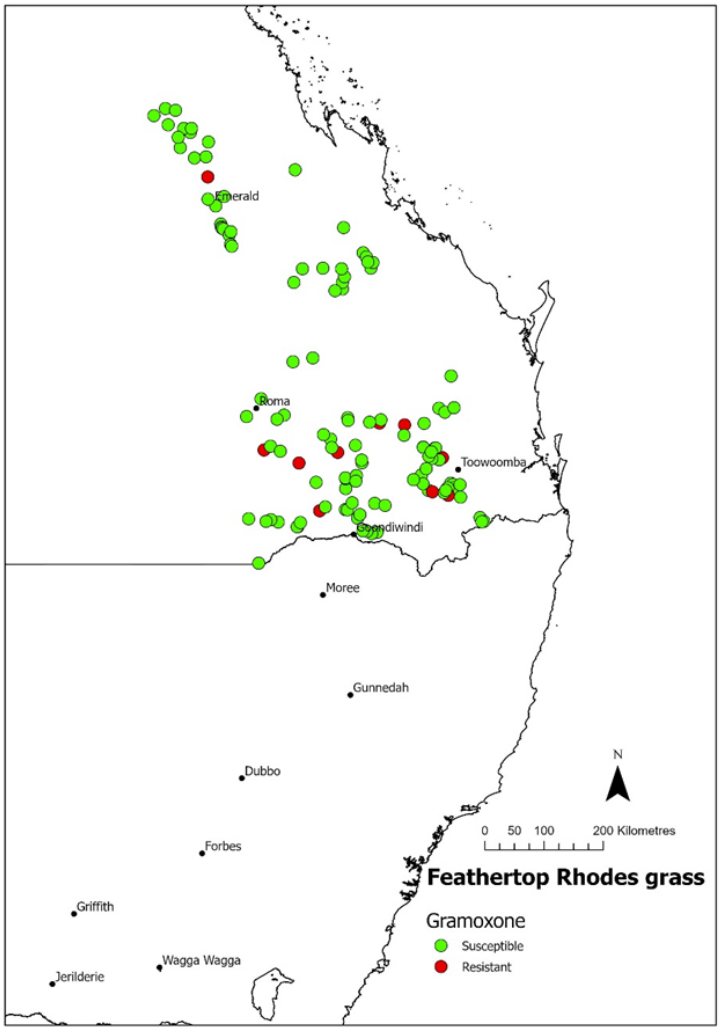

Figure 1. Incidence of paraquat resistance in feathertop Rhodes grass populations collected as part of a 2020 random field survey. Populations were classified as susceptible (green/pale dots) (0% survivors), or resistant (red/dark dots) (>19% survivors).

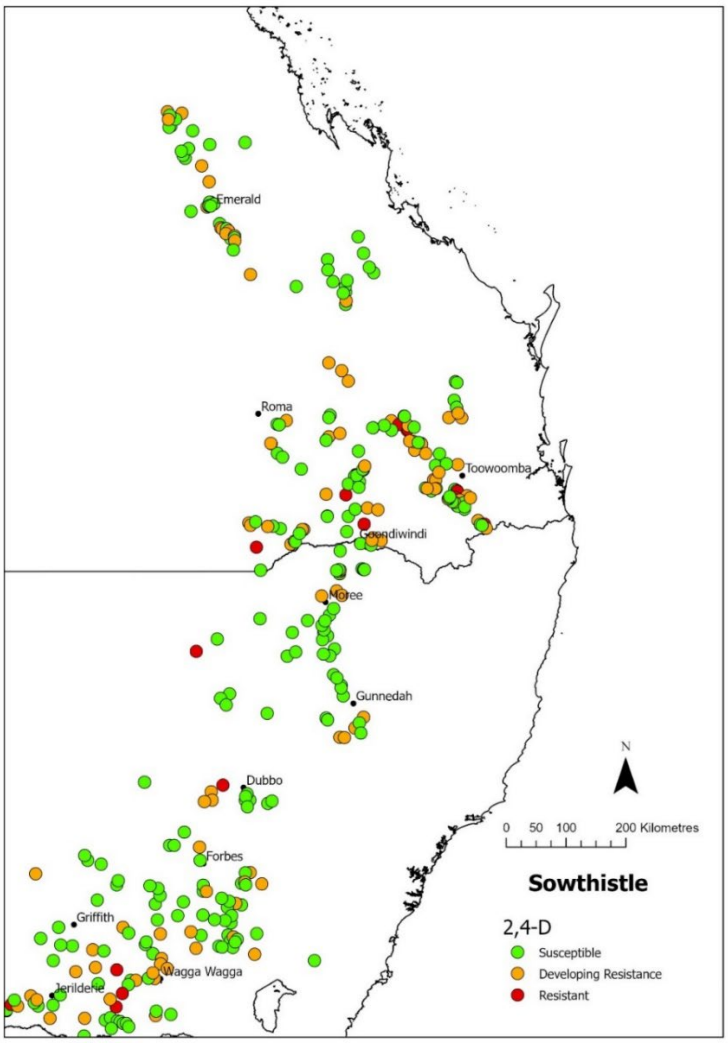

Figure 2. Incidence of 2,4-D resistance in common sowthistle populations collected as part of a 2020 random field survey. Populations were classified as susceptible (green/pale dots, 0% survivors), developing resistance (orange dots, 1–19% survivors) or resistant (red/dark dots,>19% survivors).

Discussion

Paraquat and paraquat + diquat resistance

The 2020 resistance survey, has for the first time as part of the national surveillance project, identified Group 22 (paraquat + diquat) resistance in both feathertop Rhodes grass and tall fleabane. Paraquat resistance in feathertop Rhodes grass has not been previously reported in Australia. However, paraquat resistance has previously been detected in tall fleabane (Asaduzzaman *et al.,* 2021). This resistance has also been reported in Brazil, Malaysia, Sri Lanka and Taiwan (Heap 2024). Paraquat + diquat resistance in tall fleabane has previously been identified in Japan (Heap 2024).

The resistance to paraquat and paraquat + diquat may be due to selection with these herbicides being used as the second knock as part of the double knock tactic on glyphosate resistant feathertop Rhodes grass and fleabane, respectively. As the first knock herbicide (glyphosate) is not effective, the second knock herbicide has to do all the heavy lifting.

Herbicide alternatives to paraquat/diquat are limited. Research by Werth *et al.,* (2021) evaluated glufosinate as a double knock partner for the control of flaxleaf fleabane and feathertop Rhodes grass. Glufosinate was found to provide effective control of both species as the second knock partner.

Research by the Northern Grower Alliance (NGA) explored the efficacy of saflufenacil (eg. Sharpen®) as a second knock treatment for broadleaf weeds (Daniel *et al.,* 2018). The study found that this herbicide was as effective as paraquat and may have a useful fit as a second knock for broadleaf weeds such as flaxleaf fleabane and common sowthistle. However, the study also found that there weren't any alternative second knock herbicides that provided effective control of either tall fleabane or Canadian fleabane.

2,4-D resistance

Resistance to 2,4-D has been identified in common sowthistle and wild radish for the first time in the northern region as part of this national survey. The previous 2016 survey showed 100% of populations from the northern region were susceptible to 2,4-D. Previous cases of 2,4-D resistance for both weeds have been identified in farming systems of southern Australia by Boutsalis *et al.,* (2023) and in wild radish in Western Australia by Owen and Beckie (2020). In South Australia and Victoria, 39 and 7% of wild radish samples, respectively, were resistant to 2,4-D, and 6 and 3% of sowthistle populations exhibited resistance. In Western Australia, 39% of wild radish populations were resistant to 2,4-D.

A 2016 herbicide resistance survey identified 8% of northern region sowthistle populations as resistant to glyphosate and 67% resistant to chlorsulfuron (Broster *et al.,* 2023), with this most recent survey finding no resistance to glyphosate, however, 67% resistance to chlorsulfuron in Queensland, 75% in northern NSW and 87% in southern NSW. So alternative knockdown herbicide options to 2,4-D for sowthistle are starting to become limited.

Resistance management strategies

It is important for industry to manage weed populations with a range of diverse control tactics to minimise the spread of resistance and to preserve important and effective herbicides. Stopping seed set is important to reduce the spread of resistance and deplete the weed seed bank.

Some tactics for the management or prevention of herbicide resistance include:

- Test for resistance to know which herbicides are still effective on your weed populations.
- Stop weed seed set at any cost to reduce the spread of resistance and deplete the weed seed bank.
- Closely monitor weed control efforts and apply a follow up treatment when required.
- Residual herbicides – being mindful of crop rotation plans to ensure no damage to subsequent crops.
- Crop rotation to enable the use of different herbicides and to avoid crops where limited in-crop herbicide options are available.
- Grow a competitive crop – recent research has shown a competitive crop can greatly suppress the growth of in-crop feathertop Rhodes grass and sowthistle. Fleabane is known to be poorly competitive in crop.
- Targeted control of patches and low-density weed populations. Optical sprayers can be used to apply targeted application of registered alternative herbicides to low density weed populations.
- Cultivation – where necessary strategic cultivation can be used to re-set the seedbank and remove large plants. Apply before seed set. Feathertop Rhodes grass, fleabane and sowthistle all have relatively short-lived seed banks.
- Does harvest weed seed control have a role to play? – This tactic has been very effective for wild radish in the western and southern cropping regions. Feathertop Rhodes grass, common sowthistle and fleabane seeds are produced indeterminately and sowthistle and fleabane both

have wind-dispersed seeds, so HWSC is only going to capture a smaller percent of the total seed being produced.

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