# Weeds to watch out for!: 200 Australian weeds and their risk of evolving herbicide resistance

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As part of two recent projects on herbicide resistance, a large number of weeds have been analysed to determine their innate likelihood to evolve and change in response to continued selection by herbicides. While the weeds tested are prevalent in Queensland and northern NSW, many are also more widely distributed around Australia.

Fortunately, only 23 species (12%) scored in the high risk range (a score of six or more) – though these include several important grasses as well as damaging environmental weeds like fireweed and parthenium weed (see Table 1). Almost half of all species assessed are at low risk of resistance (scoring less than three), and the remainder at moderate risk. Despite being at low risk of resistance, some low-scoring species are nevertheless important and highly prevalent weeds, both of cropping (eg nutgrass, bladder ketmia) and non-cropping areas (eg salvinia, alligator weed).

**It's important to remember that there is no relationship between resistance risk and weediness, invasiveness, or ease of control.**

**Table 1**. Weeds at high risk of herbicide resistance

| Common Name | Botanical name | Score (out of 10) |
|---|---|---|
| Needle Burr | *Amaranthus spinosus* | 8.1 |
| Sweet summer grass | *Brachiaria eruciformis* | 8.1 |
| Flaxleaf fleabane | *Conyza bonariensis* | 7.6 |
| Silver grass | *Vulpia* spp | 7.6 |
| Liverseed grass | *Urochloa panicoides* | 7.2 |
| Cumbungi | *Typha* spp | 7.0 |
| Feathertop Rhodes grass | *Chloris virgata* | 7.0 |
| Arrowhead | *Sagittaria montevidensis* | 6.9 |
| Awnless Barnyard grass | *Echinochloa colona* | 6.9 |
| Barnyard grass | *Echinochloa crus-galli* | 6.9 |
| Cobbler's pegs | *Bidens pilosa* | 6.9 |
| Common sowthistle | *Sonchus oleraceus* | 6.9 |
| Milkweed | *Euphorbia heterophylla* | 6.9 |
| Parthenium weed | *Parthenium hysterophorus* | 6.9 |
| Thickhead weed | *Crassocephalum crepidioides* | 6.5 |
| Barley grass | *Hordeum leporinum* | 6.3 |
| Crowsfoot grass | *Eleusine indica* | 6.3 |
| Large crab grass | *Digitaria sanguinalis* | 6.3 |
| Northern barley grass | *Hordeum glaucum* | 6.3 |
| Paradoxa grass | *Phalaris paradoxa* | 6.3 |
| Annual ryegrass | *Lolium rigidum* | 6.1 |
| Fireweed | *Senecio madagascarensis* | 6.1 |
| Serrated tussock | *Nasella trichotoma* | 6.1 |

**What does it mean for weed managers?**

Weed managers, regardless of what industry or organisation they belong to, have a toolkit of weed management tactics available to them for each species. Where a species is at high risk, it is vital not to rely on a single herbicide. Most weed managers have multiple problems competing for scarce resources – labour, time, money and attention – and risk assessments can be used by managers to help them decide how to organise their resources. From a resistance management perspective, it makes sense to devote more time to planning and monitoring, and increase the diversity of tactics, to species that we believe are at the highest risk of evolving herbicide resistance.

**How the risk assessment works**

A range of plant biological and ecological factors that could help determine how easily a species adapts to changes or stresses in its environment, such as the frequent use of one particular herbicide group were evaluated. Plant characteristics that relate to the ability to respond to selection pressure include:

- the number of descendants a survivor of the selection event (eg a herbicide spray) produces – more descendants (more seeds) means the population can change more rapidly
- the amount of each generation that is affected by the selecting agent – the greater the proportion of each generation that emerges and is sprayed, the faster the population's average response to that herbicide changes to favour the gene that provides the ability to survive
- whether the method of reproduction (selfing, out-crossing, vegetative) promotes or reduces genetic diversity and 'sharing' between parent plants
- the speed of generation turnover relative to when selection events are applied – in general terms, the number of generations per year. More rapid turnover of generations means more rapid selection and re-selection for the trait that allows plants to survive a particular herbicide

This list was broken down into the following characteristics:

- fecundity (number of seeds/bulbs (propagules) produced per year);
- annual emergence pattern and proportion emerging within the year;
- mating system (selfing or outcrossing);
- reproductive method; and
- number of generations per year.

Each characteristic has a different weighting, based on modelling and assessments of species with known resistance. Different levels of each characteristic score higher or lower within the weighted range. Tables 2-6 show the characteristics in detail and how the scoring system works. Species that produce a lot of seed, germinate readily, and produce more than one generation per year are the highest-scoring, and thus most at risk, weed species.

**Table 2.** Fecundity score

| Rating | Guideline (maximum propagules/year) | Score |
|---|---|---|
| Very large | >100,000 | 10 |
| Large | 10,000-100,000 | 6 |
| Medium | 1000-10,000 | 3 |
| Small | <1000 | 1 |

**Table 3.** Annual emergence score

| Rating | Guideline (proportion emerging/year) | Score |
|---|---|---|
| Large, single cohort | >70% | 10 |
| Large, multiple cohorts | >70% | 9 |
| Medium, single cohort | 10-70% | 6 |
| Medium, multiple cohorts | 10-70% | 5 |
| Small | <10% | 0 |

**Table 4.** Mating system score

| Rating | Score |
|---|---|
| Primarily outcrossing | 0.5 |
| Commonly either outcrossing or selfing | 1 |
| Primarily selfing | 0.5 |

**Table 5.** Reproductive method score

| Rating | Score |
|---|---|
| Sexual only | 1 |
| Both | 1 |
| Vegetative only | 0.5 |

**Table 6.** Generations per year score

| Rating | Score |
|---|---|
| Frequently multiple | 5 |
| Sometimes multiple | 2 |
| Single | 0 |
| Perennial | -2 |
| Perennial with multi-year juvenile period | -6 |

The maximum risk assessment score is 27. The species risk score is usually reported as an indexed score out of ten, obtained by dividing the raw score by 2.7.

## Weed risks and management risks

Of course, the inherent biology of a weed, and the risk of resistance that comes with it, is not the only contributing factor as to whether a weed population actually develops herbicide resistance. Management – the use of herbicides and other methods to control weeds – is just as important as species biology. Frequent use of a single herbicide can lead to resistance even in relatively low-risk species, and will certainly lead to more rapid selection in high-risk species. The use of a diversity of tactics, or predominately non-herbicide tactics, reduces the likelihood of resistance becoming a problem – such as in some non-cropping situations, where the use of herbicides is infrequent compared to other options. And some types of herbicide are very easy to select resistance for, as resistant individuals are already quite common. Many brassica weeds in Australia, despite having a low inherent risk of resistance, are resistant to Group B herbicides – but this is likely because group B herbicides are very easy to select resistance for (as are Group A's), so lack of diversity in control tactics poses a proportionally large risk.

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