Herbicide Resistance

…but first Blue Sky V's Red Dirt

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WHAT IS HERBICIDE RESISTANCE

Herbicide ***resistance*** is the ability of a weed biotype to survive a herbicide application, where under normal circumstances that herbicide applied at the recommended rate would kill the weed.

Tolerance is NOT resistance

WHAT CAUSES HERBICIDE RESISTANCE

- Consequence of naturally occurring mutations and evolutionary processes
- Individuals less susceptible to a specific herbicide are selected for and increase in population over time through successive generations

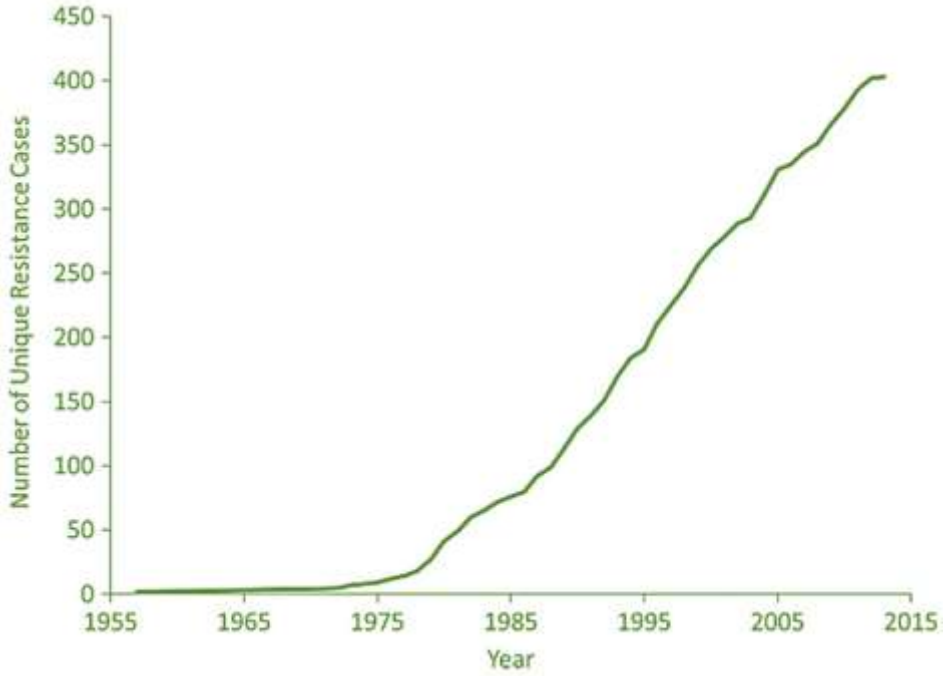
HERBICIDE RESISTANCE VERSES MISSES/FAILURE

Possible reasons for poor performance should be investigated along with the possibility of resistance:

- Chemical rate / Calibration
- Application Method
- Weed Size and condition (Moisture stress,etc)
- Environmental conditions (Temperate and Humidity)
- Other

HERBICIDE RESISTANCE- GLOBAL SCALE

- There are 500 unique cases (species x site of action) of herbicide resistant weeds globally, 256 species (149 dicots and 107 monocots) across 70 countries.



Heap, I. The International Survey of Herbicide Resistant Weeds. Online. Internet. Tuesday, June 4, 2019. Available www.weedscience.com

MODES OF ACTION (MOA)

Select a Mode of Action Group Letter to learn more

Group **A** | B | C | D | F | G | H | I | J | K | L | M | N | O | Q | R | Z

Group A#: Inhibitors Of Fat Synthesis/AACase Inhibitors

Chemical Family

- Aryloxyphenoxypropionates (FOPs) e.g. diclofop
- Cyclohexanediones (DIMs) e.g. clethodim
- Phenylpyrazoles (DENs) e.g. pinoxaden

Mode of Action

- Inhibit the production of acetyl co-enzyme A carboxylase (ACCase) enzyme, which prevents the biosynthesis of fatty acids
- Further formation of cell membranes in the growing points is prevented, leading to death

Symptoms

- Slow to appear (7-14 days)
- Initial symptoms appear in young leaves which turn pale or yellow and are easily pulled from the plant
- Anthocyanin discoloration (reddish-blue pigmentation) may occur on stems and leaves

Resistance Mechanism

- Both target site and non-target site
- Resistance is due to an altered ACCase binding site or enhanced metabolism of the herbicide

Confirmed Group A Resistant Weeds in Australia*

Grass Weeds

Annual ryegrass
Annual veld grass
Barley grass
Brome grass
Crabgrass
Crowsfoot grass
Lesser Canary grass
Paradoxa grass
Wild oat

Herbicide group	Years of application before resistance is likely
A	6-8
B	4
C	10-15
D	10-15
F	10
I	>20
L	>15
M	12-15

“It is difficult to accurately predict the rate at which resistance will increase until herbicides of a particular mode or site of action are exclusively applied over an extended period of time”

TYPES OF RESISTANCE

Single Herbicide Resistance
- Resistance to one herbicide, one MOA

Cross Resistance:
- Resistance to two or more herbicides with the same MOA
- Single resistance mechanism

Multiple Resistance:
- Resistant to two or more herbicides with different MOA
- May be the result of two or more different resistance mechanisms

THEORETICAL EXAMPLE OF HERBICIDE RESISTANCE DEVELOPMENT AFTER RESISTANCE HAS EVOLVED

Lag Phase: Resistance levels low and scattered. Mainly driven by *in situ* evolution.

Exponential Phase: Resistance levels and distribution increasing rapidly. A combination of further *in situ* evolution and spread to other fields via pollenand/or seed movement.

Identifying herbicide resistance early is difficult. Through the first few years of selection, resistant weeds only make up a small proportion of the total weed populations. These ‘escapes’ may be mistaken for weather, application or herbicide performance issues. The question of resistance may not arise until 30-40% of the population is resistant. (Herbicide Resistance Action Committee)

HERBICIDE RESISTANCE- AUSTRALIAN CONTEXT

- Reported annual ryegrass resistance in 1982.
- There are 50 weed species with resistance to herbicides from 11 modes of action (MOA).
- 23 grass species resistant to eight modes of action
- 27 broadleaf weed species resistant to seven modes of action.
- Majority in grain cropping

Australian Herbicide Resistance Initiative (AHRI)

- GRDC initiative launched in 1998
- research group with the University of Western Australia

HERBICIDE RESISTANCE IN **QLD**

Grass weeds	Group	Other States
Wild oats (Avenafatua)	A,B,Z	
Wild oats (Avenasterilis)	A, Z	B
Crowsfoot grass (Eluesine indica)	A #	
Crowsfoot grass (Eluesine indica)	L #	
Liverseed grass (Urochloa panicoides)	C	M
Awnless barnyard grass (Echinochloa colona)	M	
Feathertop Rhodes grass (Chloris virgata)	M	
Sweet summer grass (Brachiaria eruciformis)	M	
Broadleaf weeds	**Group**	**Other States**
Wild radish (Raphanus raphanistrum)	B	C,F,I,M
African turnip weed (Sisymbrium thellungii)	B	
Common sowthistle (Sonchus oleraceus)	B	I,M
Fleabane (Conyza bonariensis)	M	B
Black bindweed (Polygonum convolvulus)	B	
Turnip weed (Rapistrum rugosum)	B	
Black nightshade (Solanum nigrum)	L #	
Pennsylvania cudweed (Gamochaeta pensylvanica)	L #	
Small square weed (Mitracarpus hirtus)	L #	

resistance not only from grains production systems

Weed resistance survey data from University of Adelaide and Charles Sturt University through investment from GRDC (Feb 2018).

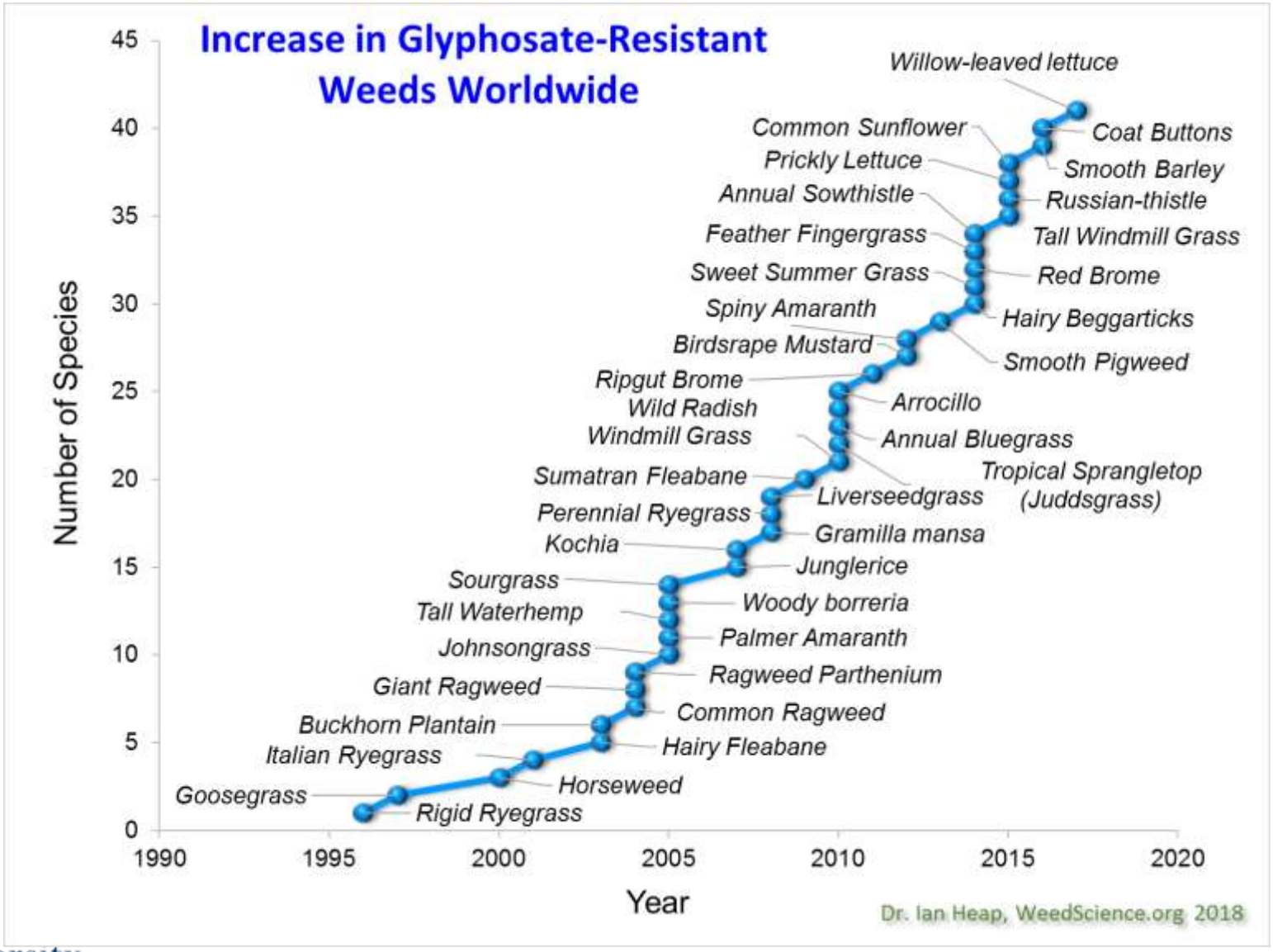
EVOLUTION OF HERBICIDE RESISTANCE

Four main factors that influence this:

1. Intensity of selection pressure
    - Failure to control weeds will lead to increases in weed populations
2. Frequency of use of herbicide or mode of action (MOA) group
    - More often a herbicide/MOA is used the higher the selection pressure and risk of resistance for that herbicide/MOA
3. Frequency of resistance present in untreated populations
    - Higher the frequency of resistant genes in population the quicker resistance will occur. (e.g Group B- high, Group M- low)
4. The biology and density of the weed
    - large weed populations, seed number and short seed bank life evolve resistance faster than those with small populations, seed numbers and long seed bank lives.

consider the multiplier effect

FREQUENCY OF USE…



HERBICIDE RESISTANCE TESTING

1. Quick-Tests
   - Testing of seedlings and small plants during the season
   - For each herbicide to be tested 50 plants are required
   - After appearance of new leaves (5-7 days) plants are treated.
   - 4-6 week process

2. Seed Testing
   - Testing of seed at the end of the season
   - This seed is generally submitted to a commercial testing service.
   - Approximately 3000 seeds of each weed (an A4-sized envelope full of good seed heads) is required for a multiple resistance test.

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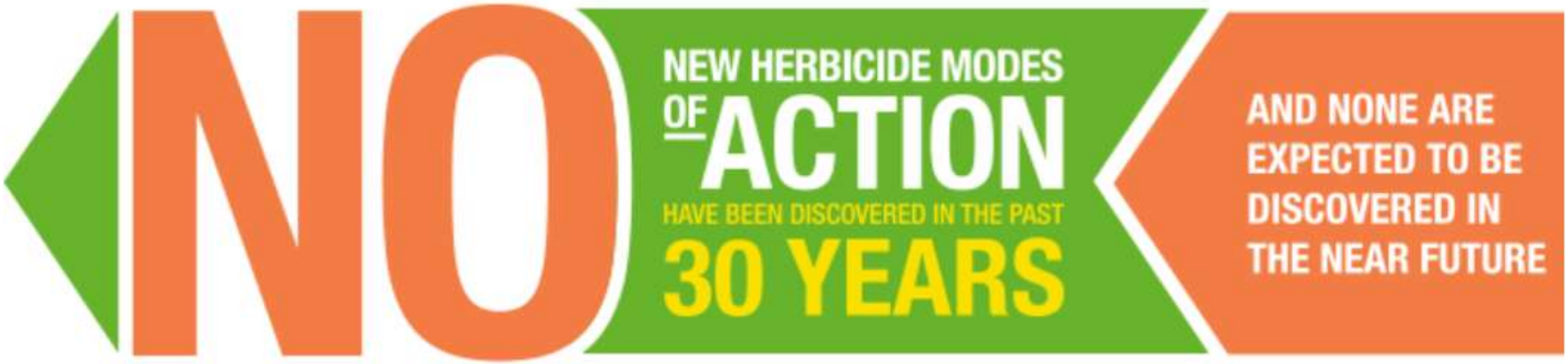
Importance of Mixing and Rotating Mode of Actions



Source: Duke, 8 (2012). Why have no new herbicide modes of action appeared in recent years?

With the outlook for new MOA bleak, we need to look after the herbicides we have.

It is critical to both mix and rotate herbicide MOA's. For example, if trifluralin is applied once in every 3 years in rotation with other herbicides, one of the herbicides fails within about 11 years. However, using trifluralin in 2 out of 3 years, when mixed with Sakura® or Boxer Gold®, will double the time before one of the herbicides fail. [1]

LOOKING FORWARD

- Stopping (or slowing) the evolution of herbicide resistance and prolonging the life of important herbicide chemistry relies on reducing selection pressure for resistance through :
  - Optimisation of chemical efficacy,
  - Varying chemical application types/MOA,
  - Know your enemy, but ALSO
  - Integrated weed management practices.

"The sustainable use of cost effective herbicides **and the development of alternative management tools** are critical for effective weed control and profitability farming into the future"

TAKE HOME MESSAGE- INTEGRATED WEED MANAGEMENT

- "Prevention is better than cure"
  - Be proactive vs reactive
- "Know your value proposition"
  - The cheapest chemical option may not be the best
- "These more than one way to skin a cat"
  - Consider non-chemical control options
- "Drones…The sky's the limit!"
  - Understand the potential role of drones as a sensor platforms for data acquisition, analysis and the role of AI.

p.s.. don't forget Biosecurity (limit importation and natural spread)

FURTHER INFORMATION?

Australian Herbicide Resistance Initiative (AHRI)
https://ahri.uwa.edu.au/

Grains Research and Development Corporation
https://grdc.com.au/

QDAF
https://www.daf.qld.gov.au/

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