



# GRDC COASTAL WEEDS WORKSHOPS

## Pre-emergent herbicides in coastal NSW grain production



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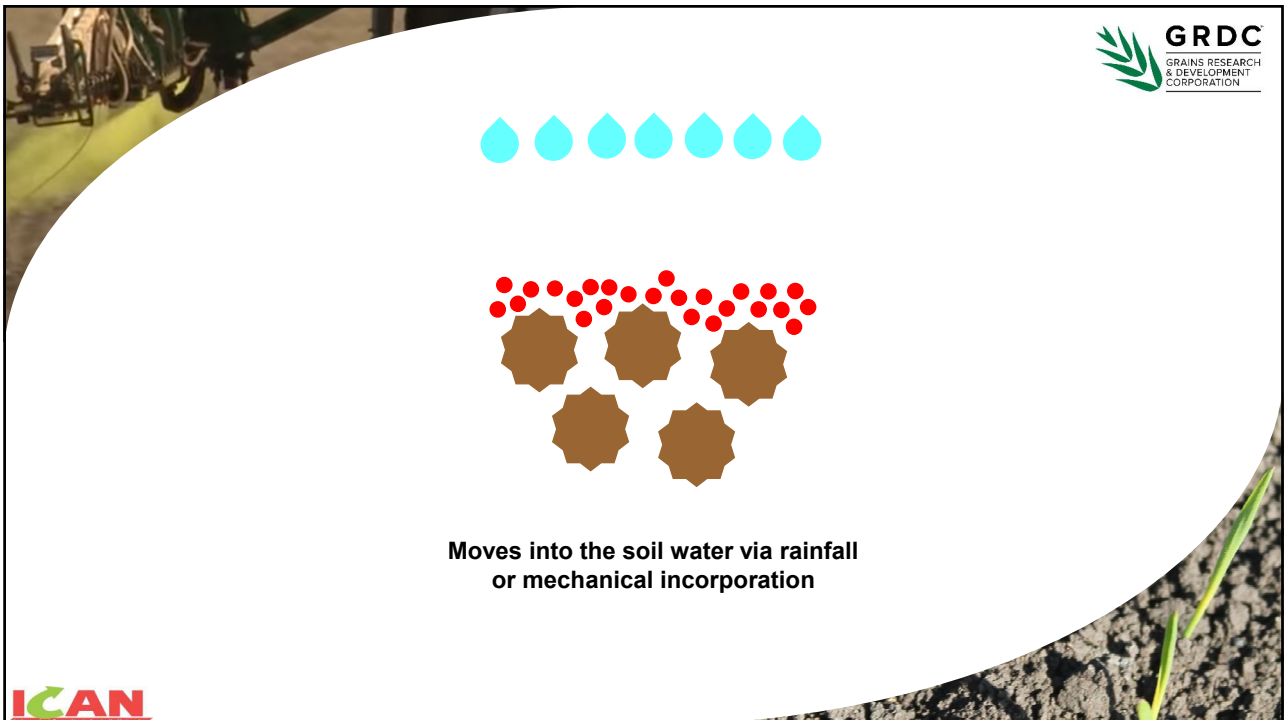
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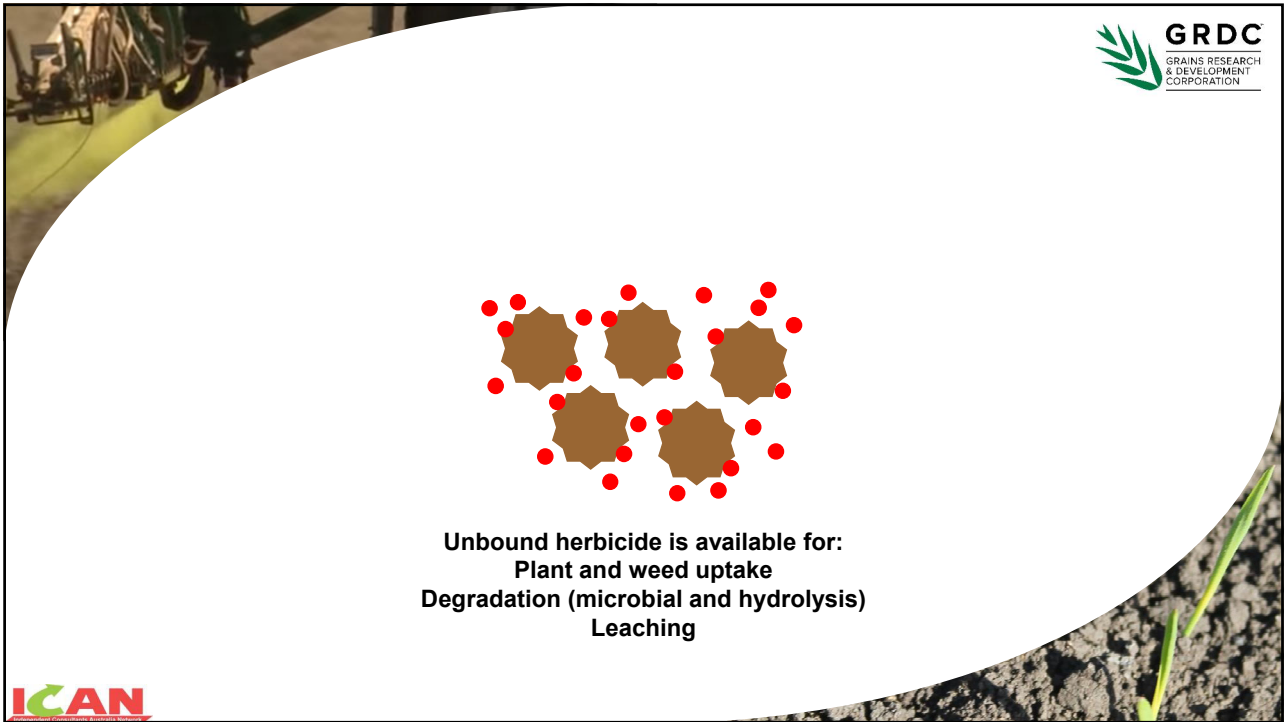
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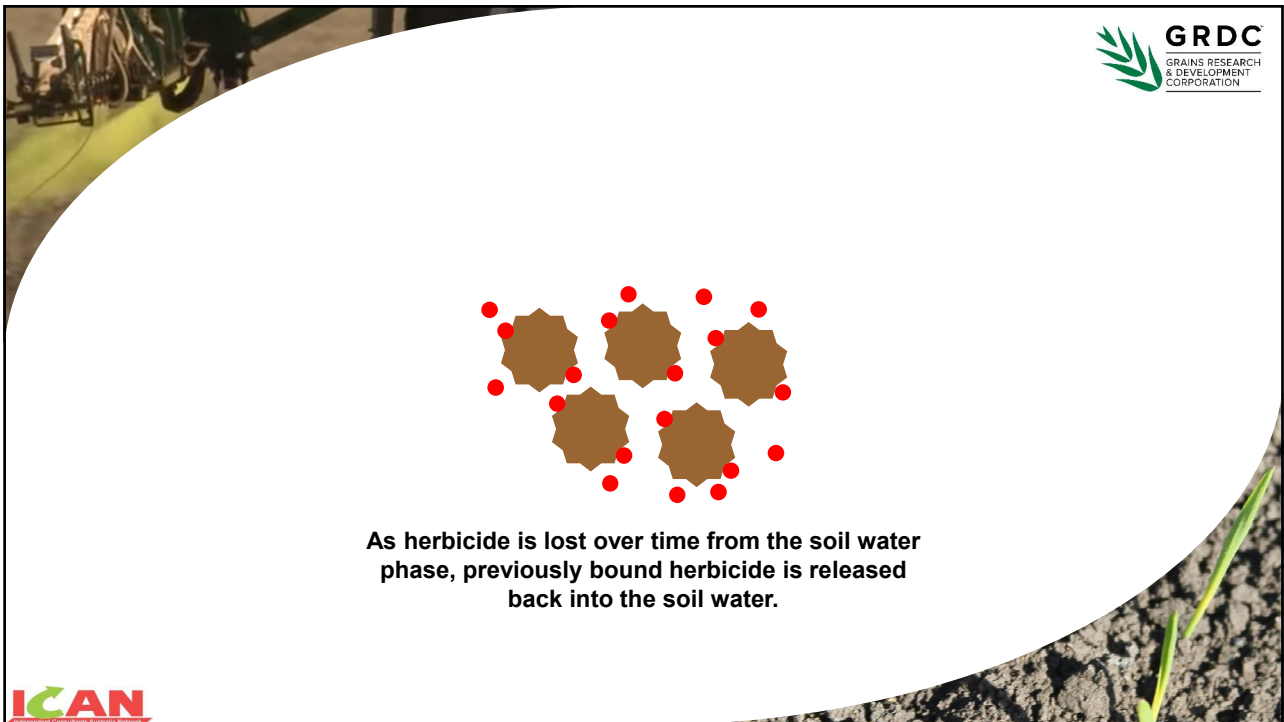


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Unbound herbicide is available for:  
Plant and weed uptake  
Degradation (microbial and hydrolysis)  
Leaching

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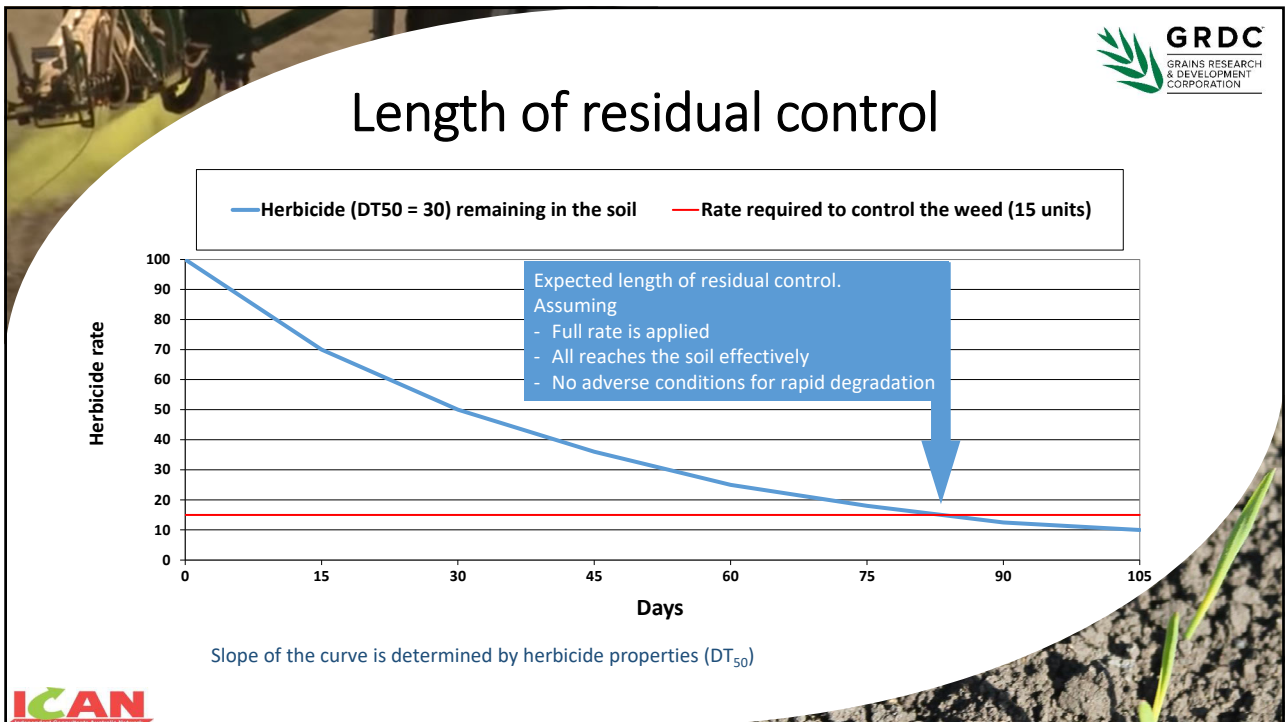


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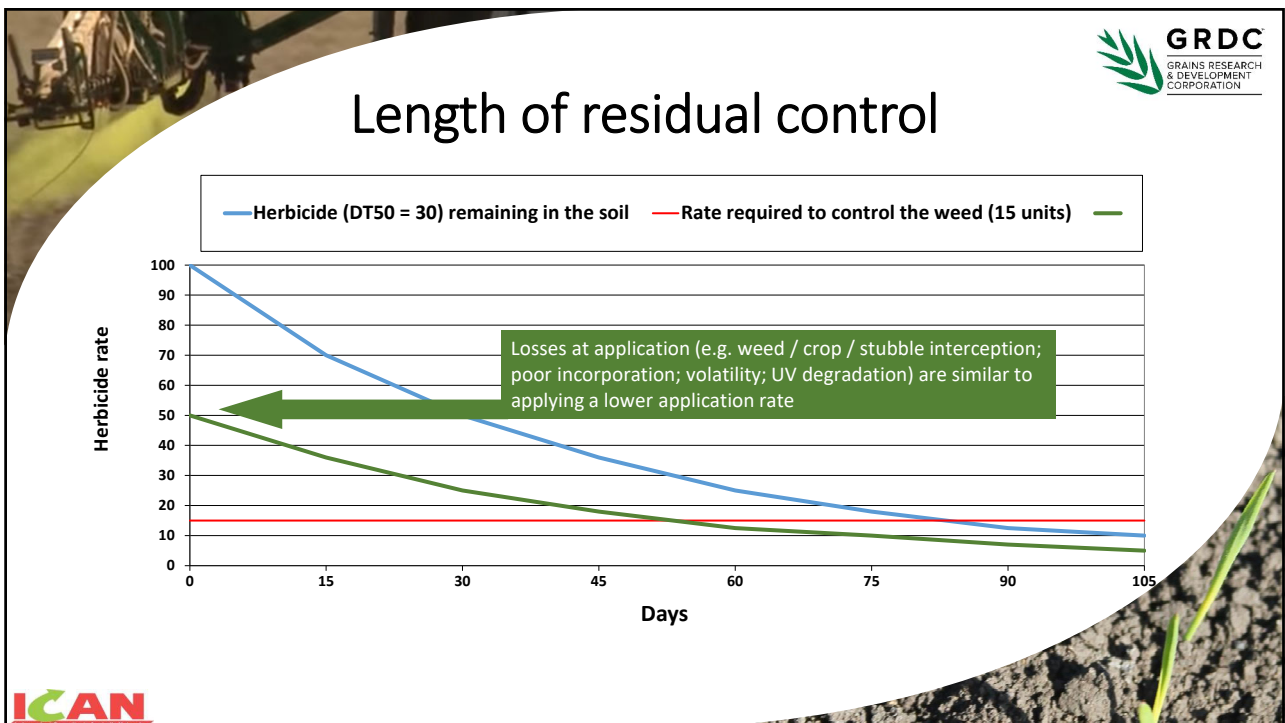
As herbicide is lost over time from the soil water phase, previously bound herbicide is released back into the soil water.

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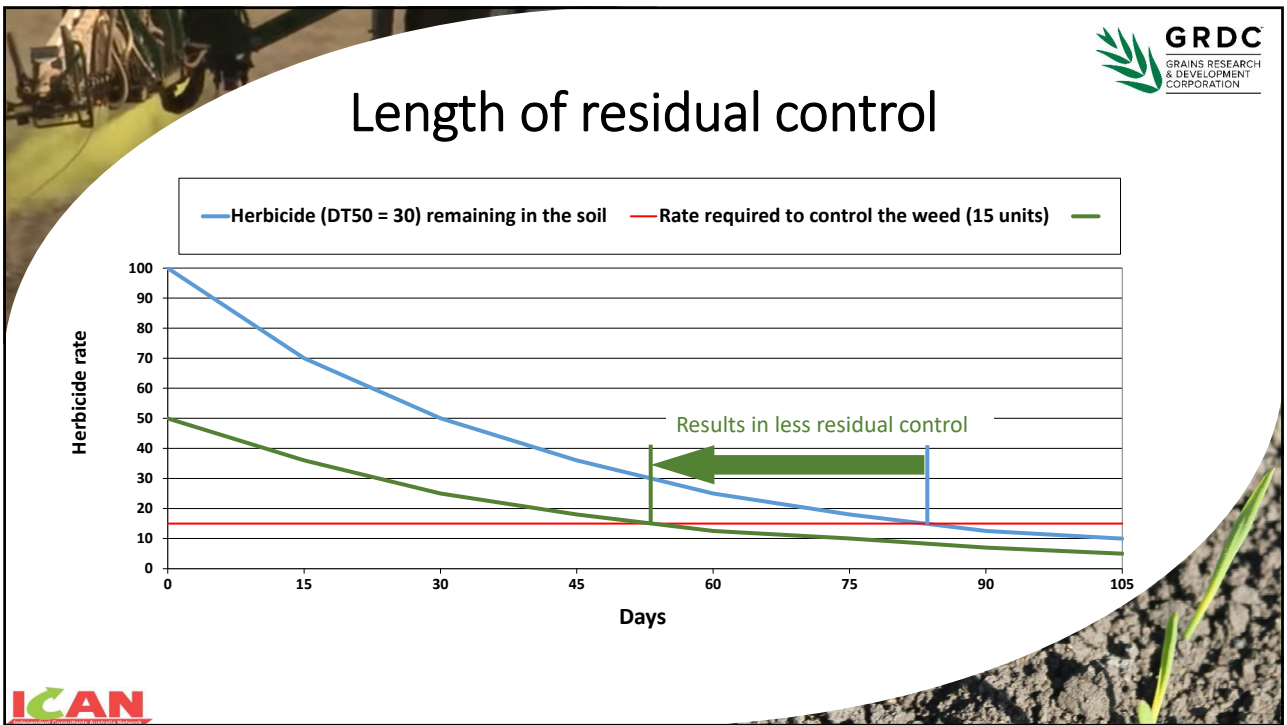
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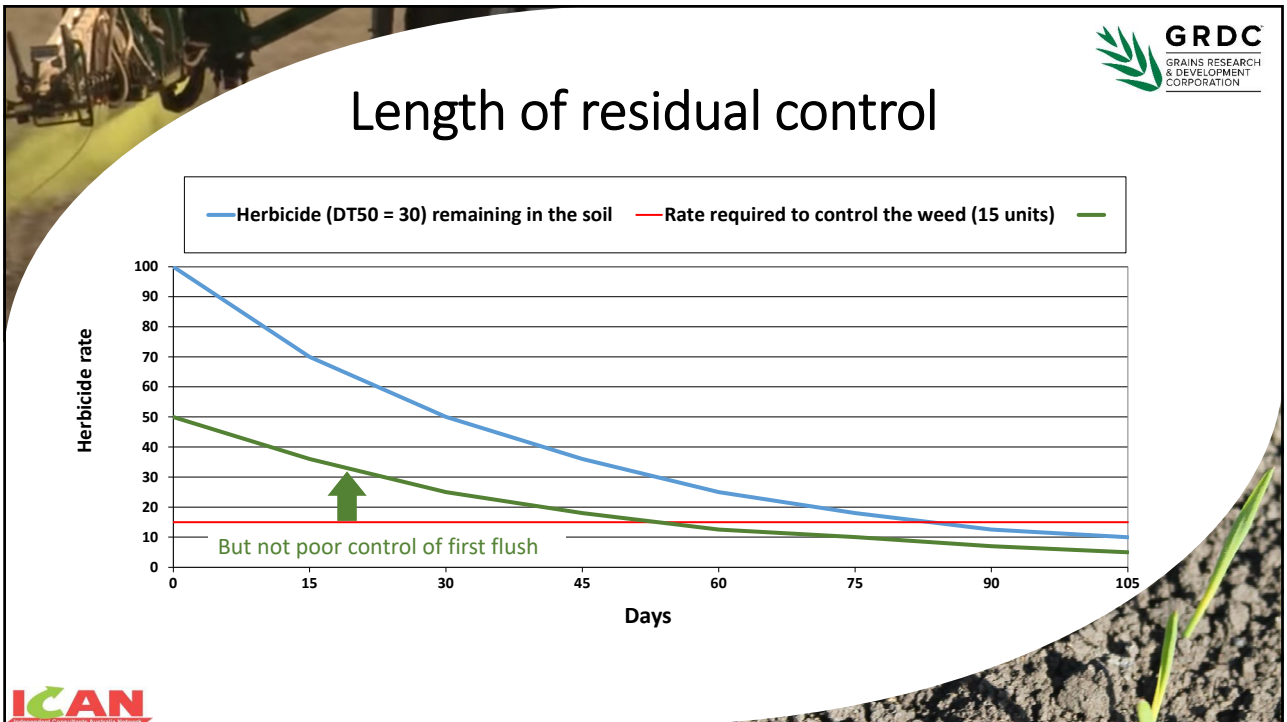
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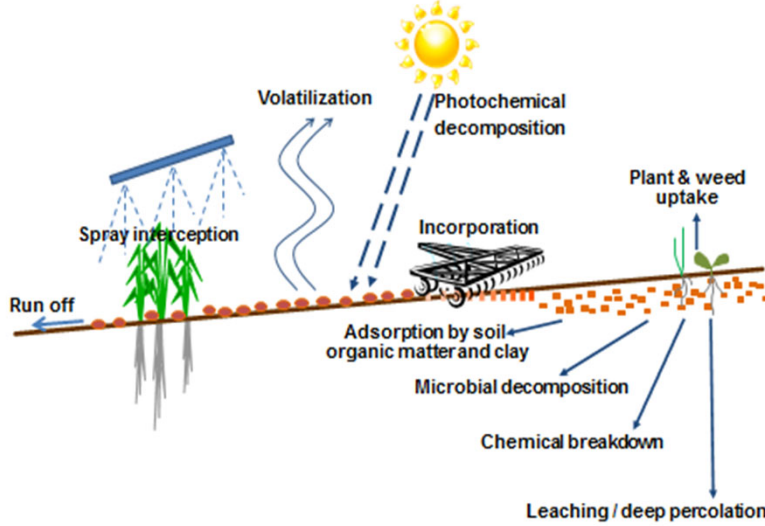
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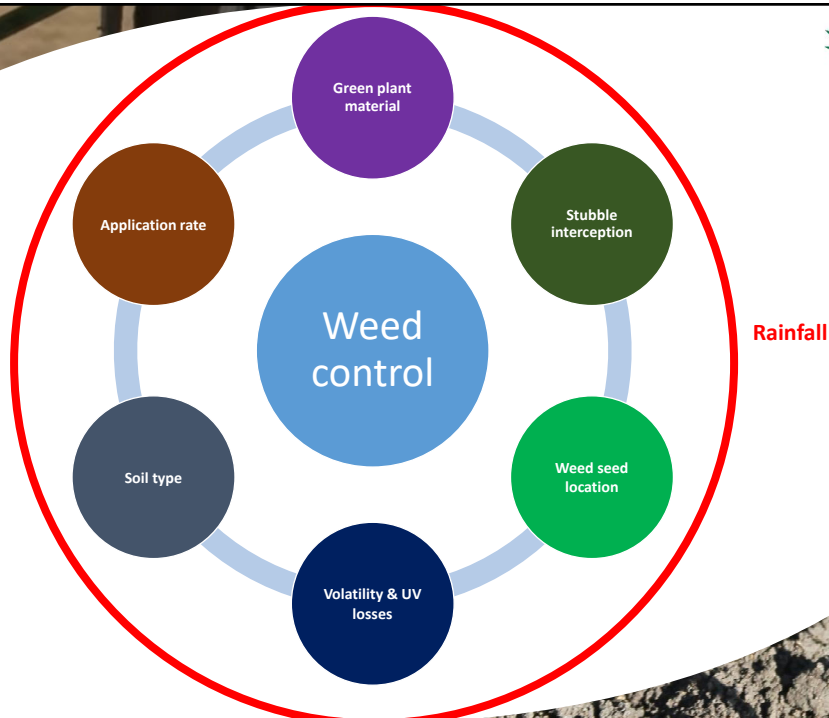
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# Interactions with the environment



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## Green material at application

Heavy weed burden / mixed with a knockdown herbicide  
Or, early post-emergent use patterns



Spray deposited on green leaf will enter live plants.

Not available in soil for residual control.

Application set up – targeting the soil or weeds?

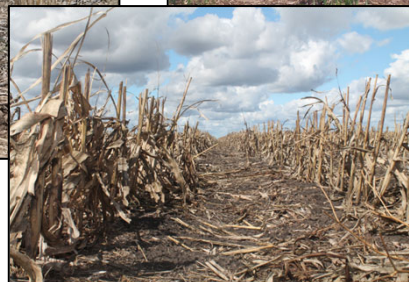


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## Stubble / trash considerations

How much spray will reach the ground?



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# Application

Bare soil & no weeds

- Spray setup & water rate not overly important

Applying residuals with heavy stubble

- Target for residual is the soil.
- Big, heavy, fast moving droplets



Compromise set up with knockdowns

	Preferred set up			
	Residuals	Translocated	Coverage sensitive	
		Glyphosate, Group 4	Paraquat, Group 14	Fungicides/insecticides
Water rates L/ha	100 - 200	70 – 90	100 - 200	200
Spray quality	VC +	VC+	M-C to C	M-C




# Spray set up

Can cover most application situations with 2 sets of nozzles.  
 Example below assumes 10-16 kph preferred application speed

	Glyphosate (& Group 4)	Paraquat (& Group 14, fungicides)
Nozzle 1 TeeJet AIXR lilac (025) 	@ 3 bar (VC) 14 kph = 85 L/ha  OK for gly Legal for 2,4-D at that pressure	@ 5.5 bar (M-C) 16 kph = 101 L/ha 12 kph = 134 L/ha 10 kph = 160 L/ha 8 kph = 200 L/ha (fung) High coverage set up
Nozzle 2 Teejet TTI lilac (025) 	@ 3 bar (UC) 14 kph = 85 L/ha Very low drift set up	Do not use







## Spray set up

Using same nozzles.  
Example below assumes 10-16 kph preferred application speed

	Residuals alone No stubble or weeds	Residual + Glyphosate (& Group 4)	Residual + Paraquat (& Group 14)
Nozzle 1 <b>TeeJet AIXR lilac (025)</b>	@ 4.5 bar (C) 12 kph = 120 L/ha 10 kph = 145 L/ha	Not ideal for glyphosate Not legal for 2,4-D	@ 4.5 bar (C) 10 kph = 145 L/ha <b>Ok compromise</b>
Nozzle 2 <b>TeeJet TTI lilac (025)</b>	@ 6 bar (XC) 14 kph = 120 L/ha 12 kph = 140 L/ha	@ 6 bar (XC) 16 kph = 105 L/ha <b>Compromise (if not too many weeds / stubble)</b>	<b>Do not use</b>



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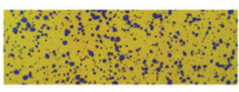
## Water sensitive paper & SnapCard app

Measure soil coverage at soil surface

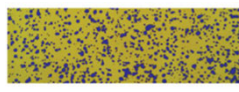
- In both the interrow and stubble line

Mark's rule of thumb for **low mobile** herbicides

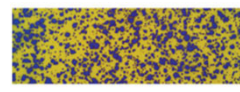
- 15% coverage as minimum
- >20% is better
- <15% requires either stubble removal or change to sprayer setup (or switch to a more mobile herbicide)



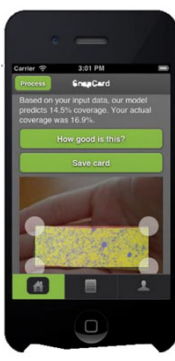
11%




17%

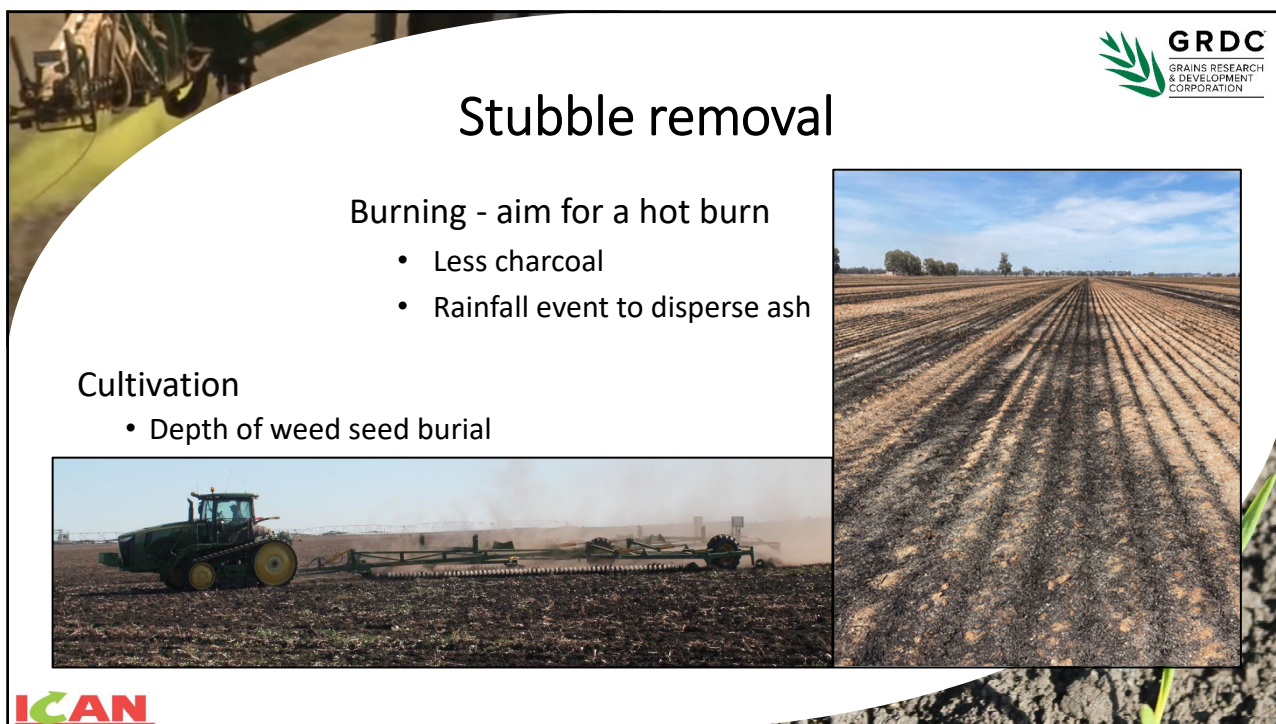


27%





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## Stubble removal

Burning - aim for a hot burn

- Less charcoal
- Rainfall event to disperse ash

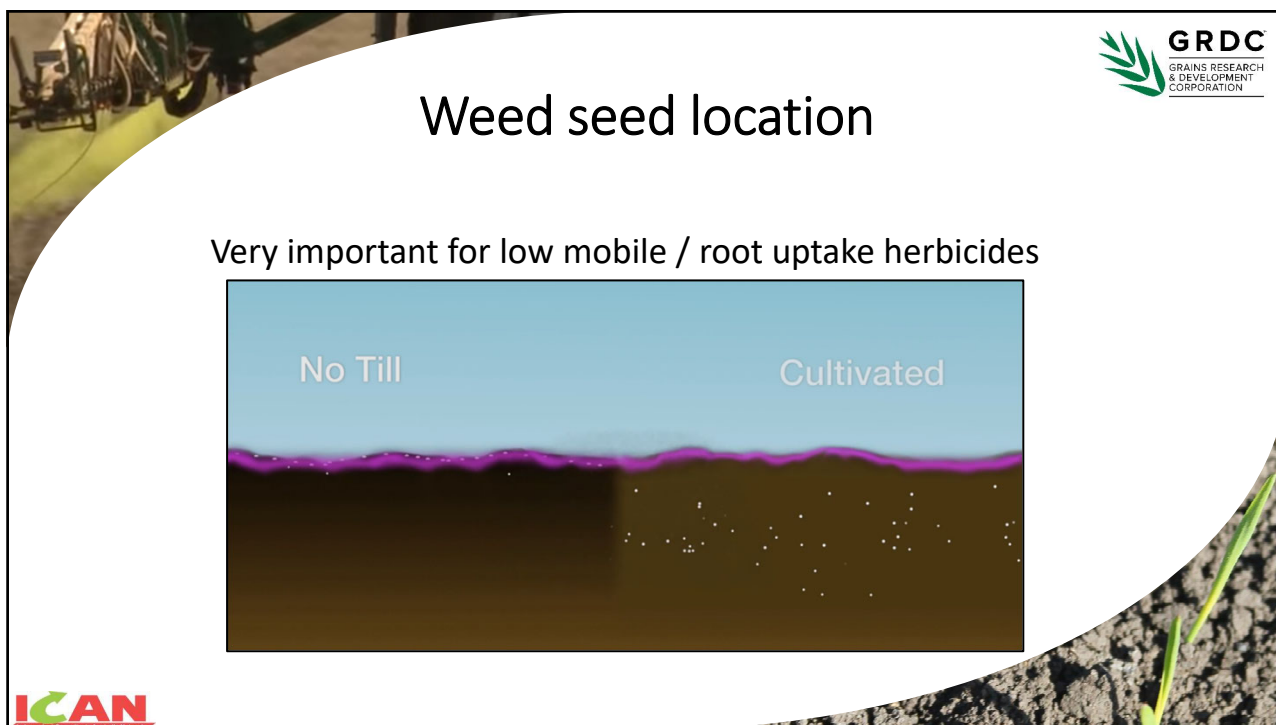
Cultivation

- Depth of weed seed burial



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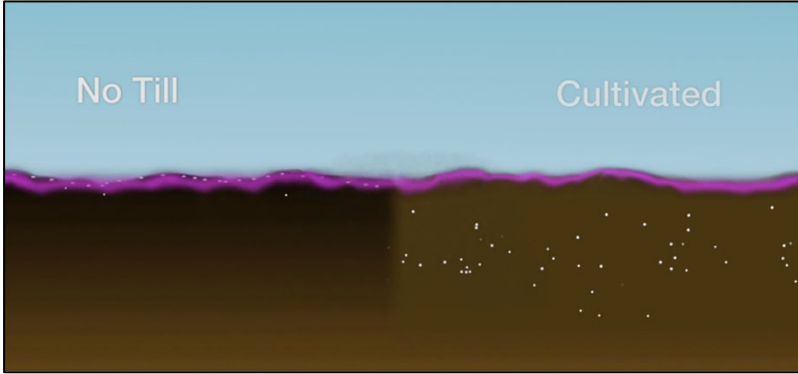
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## Weed seed location

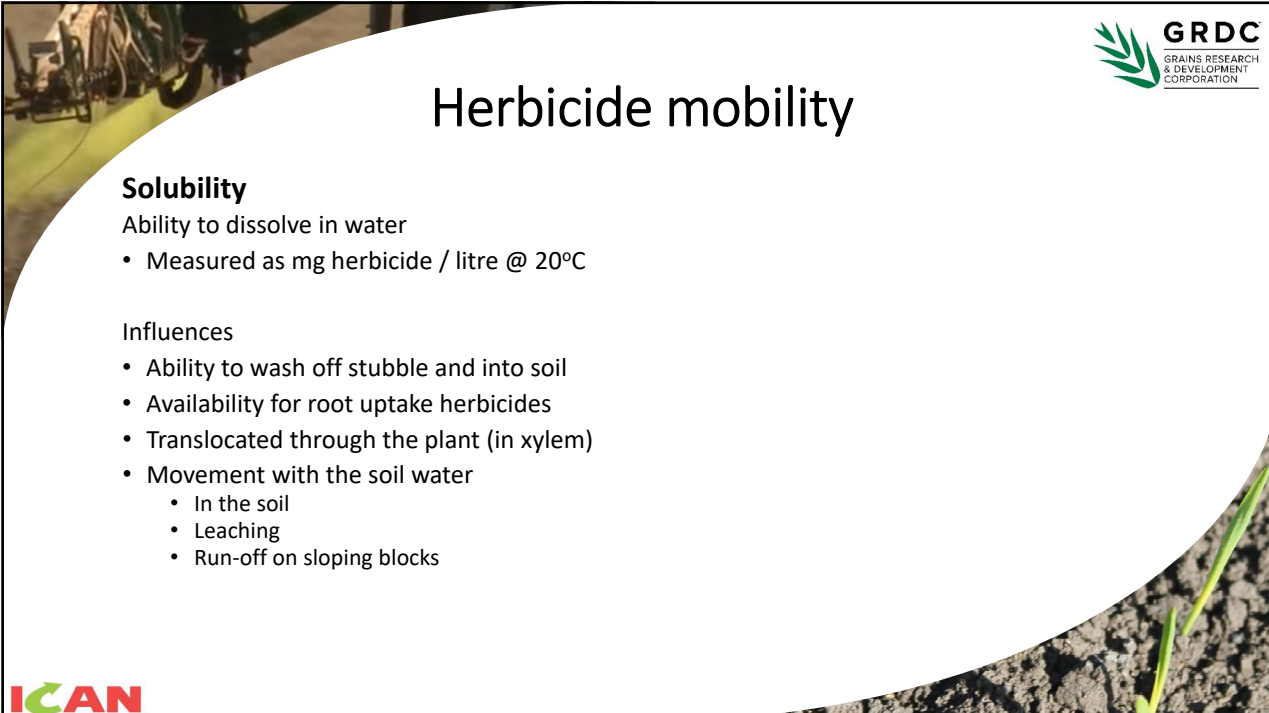
Very important for low mobile / root uptake herbicides




The diagram shows two soil profiles. The left profile, labeled 'No Till', shows a thin layer of purple weed seeds at the surface. The right profile, labeled 'Cultivated', shows the purple weed seeds buried deep within the soil. The soil is depicted in shades of brown and tan, with a blue sky above.

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## Herbicide mobility

**Solubility**  
Ability to dissolve in water

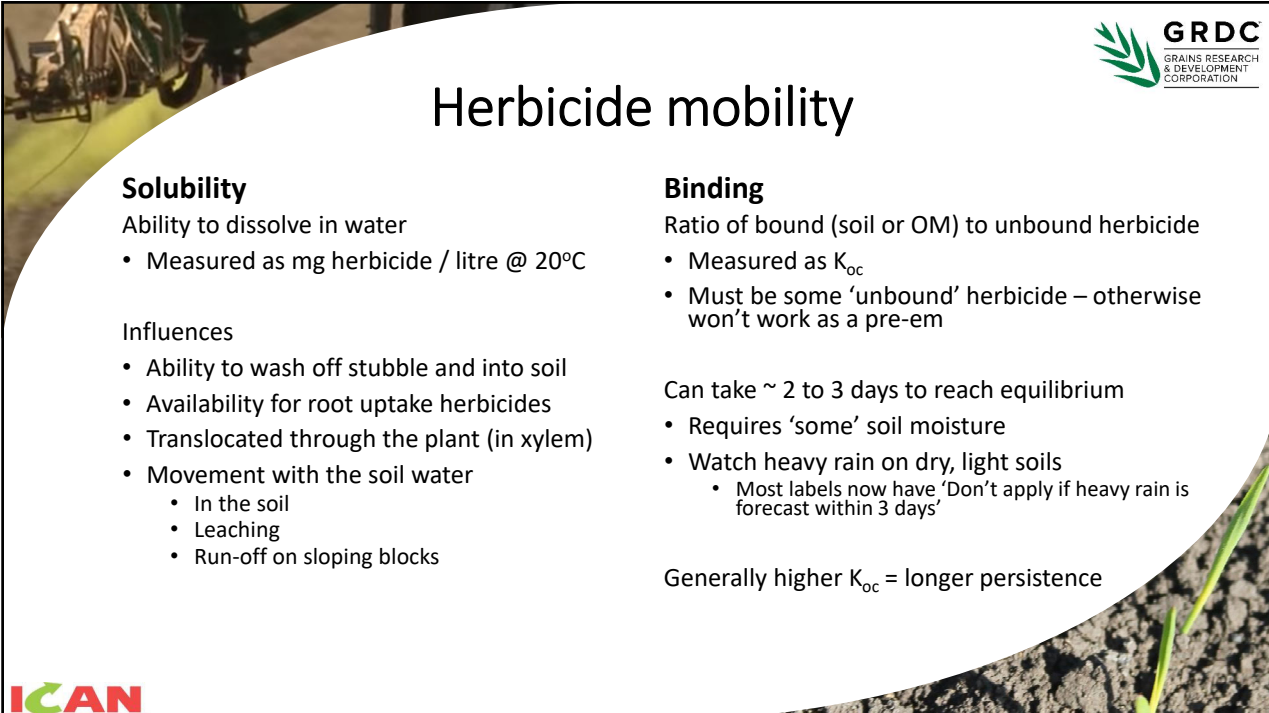
- Measured as mg herbicide / litre @ 20°C


**Influences**

- Ability to wash off stubble and into soil
- Availability for root uptake herbicides
- Translocated through the plant (in xylem)
- Movement with the soil water
  - In the soil
  - Leaching
  - Run-off on sloping blocks



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## Herbicide mobility

**Solubility**  
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**Binding**  
Ratio of bound (soil or OM) to unbound herbicide

- Measured as  $K_{oc}$
- Must be some 'unbound' herbicide – otherwise won't work as a pre-em

Can take ~ 2 to 3 days to reach equilibrium


- Requires 'some' soil moisture
- Watch heavy rain on dry, light soils
  - Most labels now have 'Don't apply if heavy rain is forecast within 3 days'

Generally higher  $K_{oc}$  = longer persistence




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## Herbicide mobility




Tight binding.	Relatively tight binding.	Low mobility.	Some mobility.	Mobile.
Won't wash off stubble after spray has dried.	More difficult to wash off stubble after spray has dried.	Requires significant rainfall to remove from stubble.	Will wash off stubble with adequate rainfall.	Relatively easy to wash off stubble.
<b>pendimethalin</b> <b>trifluralin</b>	<b>tri-allate (Avadex)</b> <i>aclonifen (Mateno)</i> <i>prosulfocarb (Arcade)</i>	<b>diuron</b> <b>flumioxazin (Terrain/Valor)</b> <i>diflufenican (Brodal)</i> <i>isoxaben (Gallery)</i> <i>napropamide (Devrinol)</i> <i>propyzamide</i> <i>trifludimoxazin (Voraxor)</i>	<b>atrazine</b> <b>terbuthylazine (Terbyne)</b> <i>bixlozone (Overwatch)</i> <i>cinmethylin (Luximax)</i> <i>pyroxasulfone (Sakura)</i> <i>simazine</i>	<b>All Group 2(B)</b> <b>All Group 4(I)</b> <b>amicarbazon (Amitron)</b> <b>hexazinone (Velpar)</b> <b>metribuzin (Sencor)</b> <b>s-metolachlor (Dual)</b> <i>saflufenacil (Voraxor)</i> <i>carbetamide (Ultra)</i> <i>fomesafen (Reflex)</i> <i>mesotrione (Callisto)</i> <i>metazachlor (Tenet)</i>



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## Ability to wash off stubble



Tight binding.	Relatively tight binding.	Low mobility.	Some mobility.	Mobile.
pendimethalin trifluralin	tri-allate (Avadex)	diuron flumioxazin (Terrain/Valor)	atrazine terbuthylazine (Terbyne)	All Group 2(B) All Group 4(I) amicarbazon (Amitron) hexazinone (Velpar) metribuzin (Sencor) s-metolachlor (Dual)

Can't use moisture for incorporation

←


May not perform well in very dry soils

→


More likely to leach

Better suited to high trash  
Better suit to deeper weed seeds

Application setup increasingly important to maximise spray deposition onto the soil & location re weed seeds



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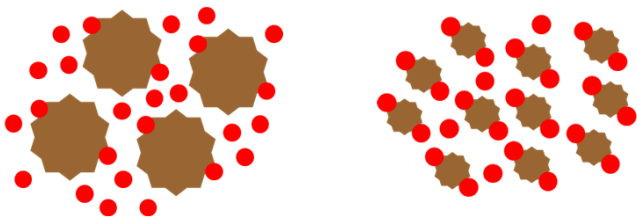



## Soil texture & binding

Lighter / low organic matter soils (lower CEC) have less binding sites


- Less binding sites = more available herbicide in soil water
- Can mean
  - More potential for root uptake
  - Increased mobility
  - Sometimes results in faster degradation
- CEC < 2 = extreme caution when using any residuals


} Potential for crop damage increases  
} Some labels recommend lower use rates





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## Balance - sugarcane

- Cover cane sett with 75-100 mm soil
- and
- Use rate depends on soil type

	Common description	Clay content %	Suitable Balance rates
<b>Light soils</b>	e.g. sands, loamy sand, light sandy loam, light silty loams	less than 15%	100-125 g/ha
<b>Medium soils</b>	e.g. sandy loam, silty loam, sandy clay loam, loam	15-33%	100-150 g/ha
<b>Heavy soils</b>	e.g. heavy loams, clay loams, clays, dark earths	greater than 33%	100-200 g/ha


DO NOT apply at any rate to soils with CEC < 3, or with clay content less than 10%, or with organic carbon < 0.8%

DO NOT apply > 125 g/ha or higher to soils with < 1% organic carbon, unless the CEC is > 9.5

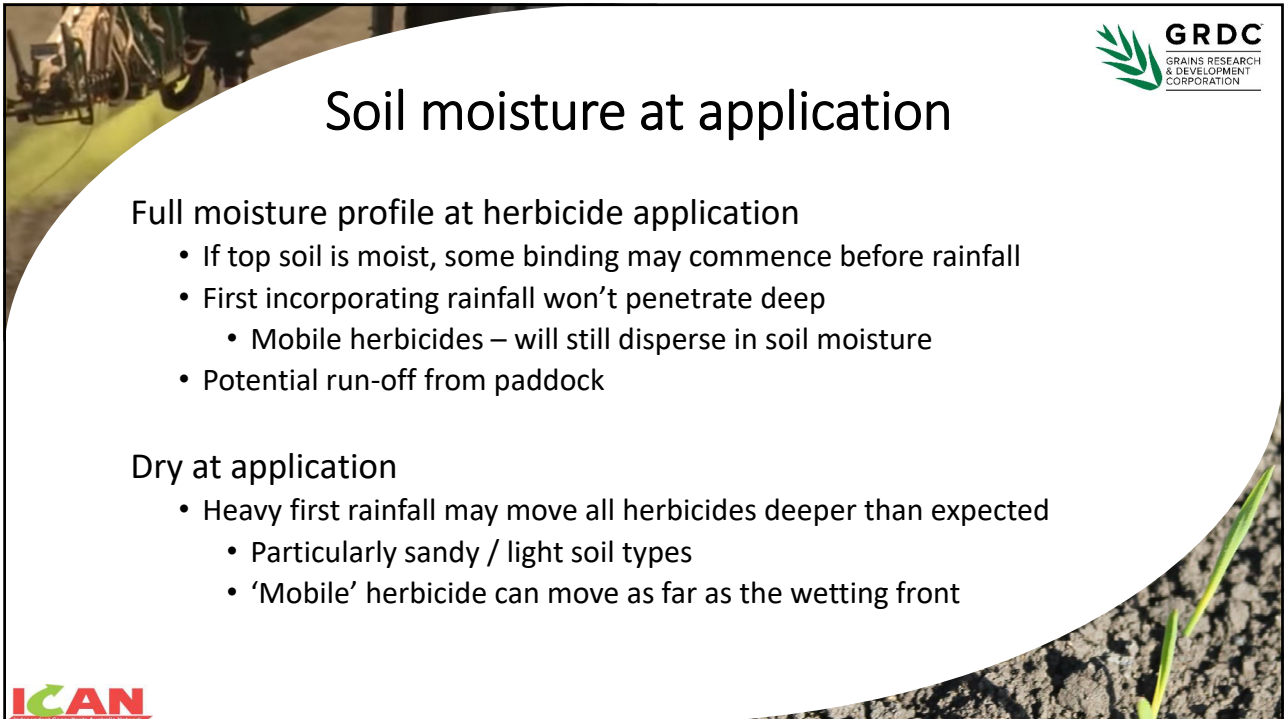
DO NOT apply > 125 g/ha to soils of < 4.5 (C.E.C.)


	Typical CEC
Krasnozem high pH & OM low pH & OM	10-20 2-6
Chocolate high pH & OM low pH & OM	30-40 3-7
Podzolic	3-10
Alluvial light & sandy heavy clay	10-20 20-30
Dune sand	0-5

<http://www.dpi.nsw.gov.au/agriculture/resources/soils/structure/cec>



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## Soil moisture at application

**Full moisture profile at herbicide application**

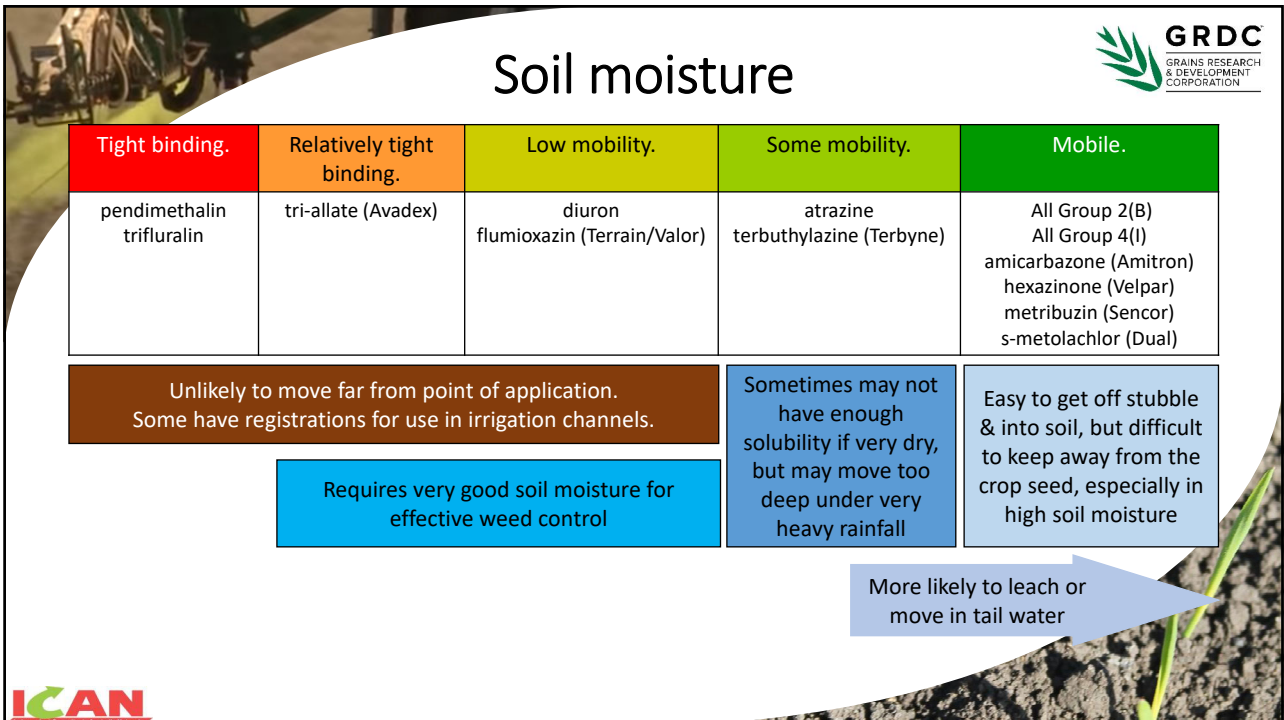
- If top soil is moist, some binding may commence before rainfall
- First incorporating rainfall won't penetrate deep
  - Mobile herbicides – will still disperse in soil moisture
- Potential run-off from paddock


**Dry at application**

- Heavy first rainfall may move all herbicides deeper than expected
  - Particularly sandy / light soil types
  - 'Mobile' herbicide can move as far as the wetting front



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## Soil moisture

Tight binding.	Relatively tight binding.	Low mobility.	Some mobility.	Mobile.
pendimethalin trifluralin	tri-allate (Avadex)	diuron flumioxazin (Terrain/Valor)	atrazine terbutylazine (Terbyne)	All Group 2(B) All Group 4(I) amicarbazone (Amitron) hexazinone (Velpar) metribuzin (Sencor) s-metolachlor (Dual)


Unlikely to move far from point of application.  
Some have registrations for use in irrigation channels.

Requires very good soil moisture for effective weed control

Sometimes may not have enough solubility if very dry, but may move too deep under very heavy rainfall

Easy to get off stubble & into soil, but difficult to keep away from the crop seed, especially in high soil moisture

More likely to leach or move in tail water



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# Crop safety

## 1. Species tolerance

Crop can tolerate the amount of herbicide applied

Requires rapid metabolism

- Tolerance decreases with
  - Water logging
  - Slow emergence / deep sowing / cold temperatures
  - Other residual herbicides
- Tolerance normally increases after commencement of photosynthesis

Especially important for highly mobile herbicides

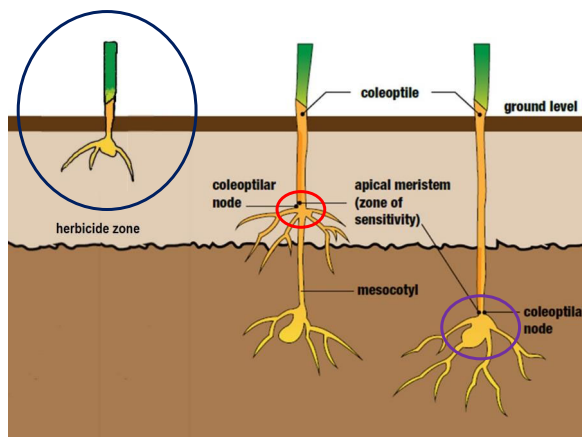
Key for anything we apply PSPE, or early post-emergent



# Seed position in the soil

Weed seeds near the surface (in herbicide zone) – root uptake herbicides work best

Weed seeds at depth (below herbicide zone) – coleoptilar node (shoot) uptake required.  
**Root uptake only herbicides less effective.**




Wheat & barley keep the roots and coleoptilar node below the herbicide zone (for low mobile herbicides). Ideally >3 cm, but not too deep.

Oats, sorghum, maize push the coleoptilar node upwards, so generally have less herbicide tolerance.

**Worst case scenario – weed seeds germinating at depth in moisture but very dry soil in the herbicide zone.**





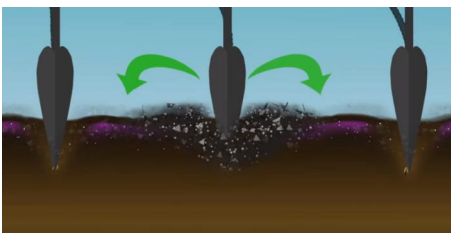
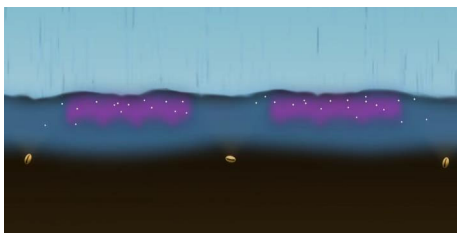



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## Crop safety


### 3. Removal from the furrow (horizontal separation)

- IBS with knife point & press wheels
- Works best with low-mobile herbicides
- Ensure seed slot is firmly closed
- Optimise speed of travel (soil throw) to the soil conditions
- Previous cultivation = weeds in the planting line



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## Crop safety

### 4. Early post-emergent application

Examples


- Spinnaker post in soybeans
- Atrazine / Dual Gold post in sorghum
- Post-emergent residuals in cane

Sprayer set-up – optimised for soil or foliage uptake?



- For most, primary performance comes from soil uptake

Best results

- Crop growing well. No stress
- Good soil moisture
- Be aware of cumulative activity with pre-plant residuals
- Directed application may help



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## Volatilisation & photodegradation

**Photodegradation**



- Relatively minor loss pathway
- Dual (s-metolachlor)
  - Incorporate within 7-10 days for best results if no rainfall / irrigation
- Stomp (pendimethalin), triazines, diuron
  - Some losses if no rainfall for 'weeks' over summer

**Volatility**

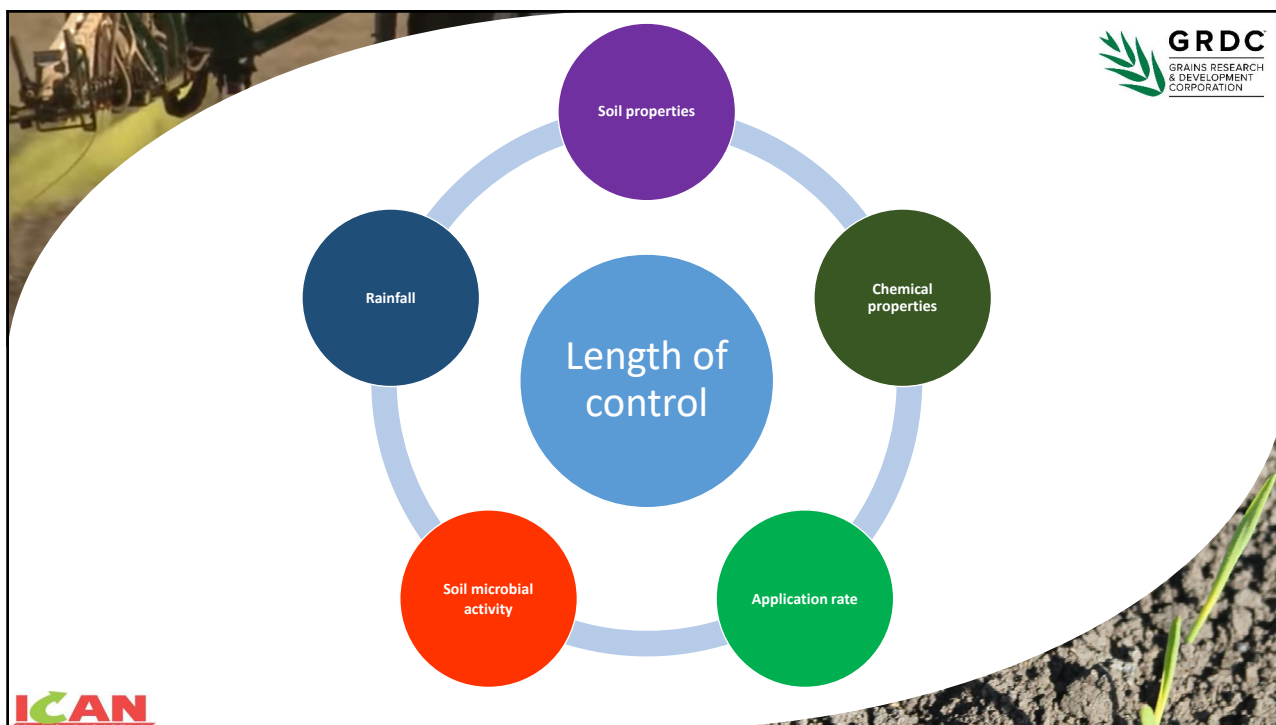
- Not important for most herbicides
- Trifluralin requires full incorporation

**Most ryegrass herbicides for winter cereals require incorporation**

- Mostly for efficacy / environment
- Avadex / Luximax - also helps reduce volatility losses

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## Length of persistence

### Soil properties

- Heavy soils often longer persistence, but less ‘available’
- Lighter soils more available, but often less persistent
  - Residuals may ‘run out’ quicker
  - ‘Damage’ more visual if it occurs

### Soil pH

- IMI persist longer in acid soils
  - Tighter binding
- SUs & triazines persist longer in alkaline soils
  - Microbial breakdown in all soils
  - Additional hydrolysis in neutral / acid soils



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## Chemical properties

MOA	Short Normally unlikely to cause issue the following year	Variable Carry-over will depend on individual situation			Long Expect carry-over from year to year
2	Raptor	Sempre	Spinnaker		imazapic
3				Stomp	trifluralin
4	2,4-D, dicamba, fluroxypyr		Tordon		
5	metribuzin	Terbyne	atrazine, Amitron	diuron, hexazinone	
14	Terrain / Valor, Sharpen				
15	Dual Gold				
27		Balance			



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## Length of residual control

Short residual herbicides – can use rate to increase persistence

Flumioxazin (Terrain) – average DT<sub>50</sub> = 18 days

- |              |  |
|--------------|--|
| 30 g/ha      | knockdown in fallow                                      |
|              | • no plantback except canola 5 months                    |
| 90-120 g/ha  | knockdown in sugarcane                                   |
| 210-280 g/ha | weeks of residual in soybeans                            |
| 350-700 g/ha | months of residual in sugarcane                          |
| 700 g/ha     | fencelines, irrigation channels                          |
|              | • plantback (months) – soybean 5, mung bean 8, canola 12 |



## Length of residual control

Short residual herbicides – Plantbacks reflect rate

	Amicide® Advance		
	Up to 500 mL/ha	500-980 mL/ha	980 – 1500 mL/ha
Cotton	10	14	21
Sorghum	3	7	10
Soybean	14	14	21

	Starane® Advanced		
	225 mL/ha	450 mL/ha	900 mL/ha
Cotton	14	14	28
Sorghum	7	7	7
Soybean	7	7	14





## Soil microbiological activity

### Soil microbiological activity

- Neutral pH
- Adequate oxygen
  - Not waterlogged
- Warm temperature
- Food source (stubble or the herbicide)
  - Mostly in the top 0-10cm, as that is where most OM resides
- Soil moisture – weeks of moist topsoil over warmer months
  - Dry 0-15cm = minimal breakdown occurring



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## Soil microbial activity

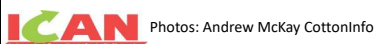
### #soilyourundies

Buried 27/11/18. 50mm rain 5 days before burial

Middle photo 25/1/19 (8.5 weeks)

Left – fully irrigated cotton (6 irrigations)

Right – wheat stubble (no rainfall)

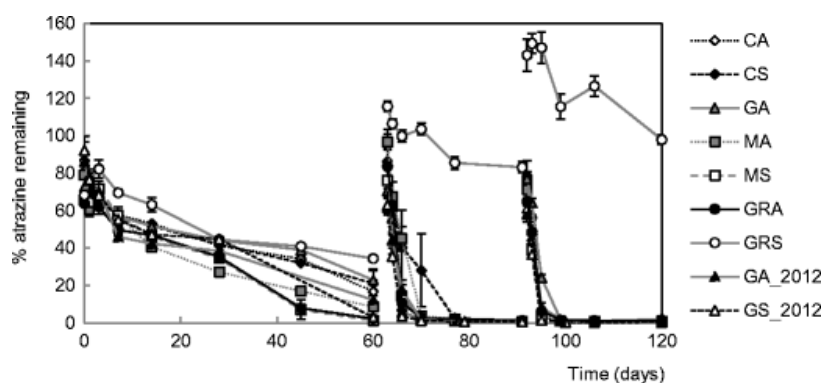


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## Enhanced microbial degradation

Atrazine - 9 soils (4 UK farms) with no history of s-triazine use for > 5 years



Source: Yale et. al. (2017) Microbial changes linked to the accelerated degradation of the herbicide atrazine in a range of temperate soils



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## Rainfall

### Rainfall

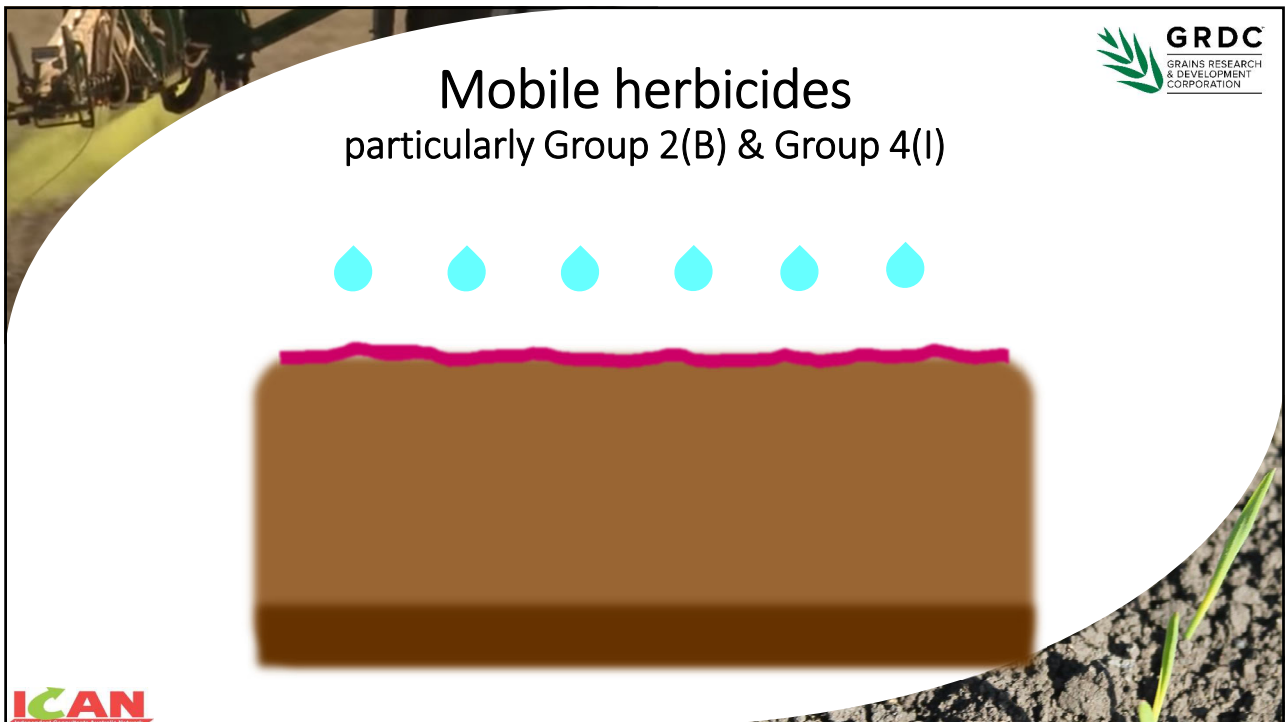
- Important for microbial breakdown
- Consider weeks of moist top soil over warmer months

### Mobile herbicides

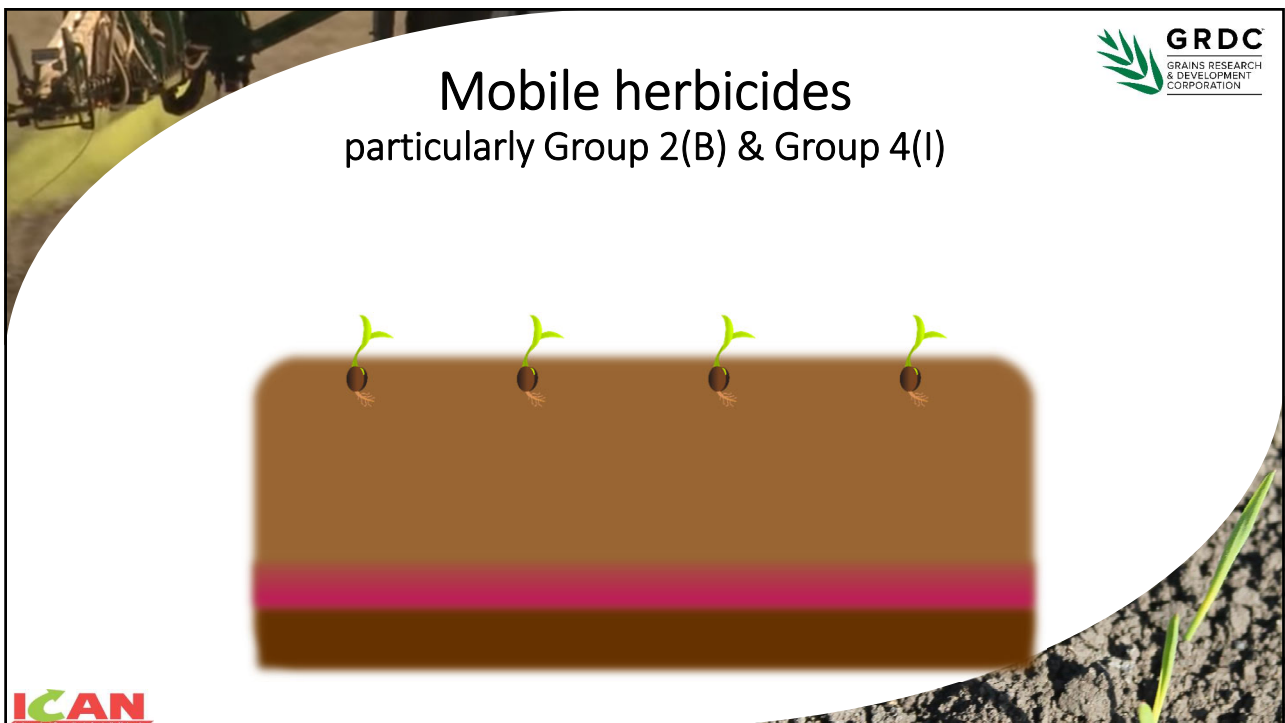
- May be lost to leaching / runoff
  - Esp. light soils under heavy rainfall
- Accumulation down the profile




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## Environmental concern

Active	Mobility	Use rate (gai/ha)	Algal toxicity (mg/L)	Persistence
Sempre	Very high	49 – 98	0.0053	Short
imazapic	Very high	72 – 96	0.051	Long
pendimethalin	Very low	1000 – 1500	0.004	Moderate – long
trifluralin	Very low	576 – 1440	0.0122	Long
metribuzin	Very high	560 (soy)	0.0266	Short
Terbyne	High	1050	0.012	Short
atrazine	High	1980 – 2970	0.059	Moderate
Amitron	Very high	350 – 700	0.035 <sup>1</sup>	Moderate
diuron	Moderate	1710	0.0027	Moderate – long
hexazinone	Very high	~500	0.0145	Moderate – long
Terrain/Valor	Moderate	350	0.000852	Short
Dual Gold	Very high	960 – 1920	0.017	Short

**ICAN** PPDB unless otherwise stated  
<sup>1</sup> APVMA PRS

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## Key residual herbicides in coastal systems

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## s-metolachlor (e.g. Dual® Gold)

Soybean	Mung bean	Maize	Sorghum	Cane	Fallow
Pre, PSPE	Pre, early-post (Dual only)	Pre	<b>Must use safener</b> Pre, PSPE Early-post (Dual & Bouncer only)	Pre, Post	Dual label only

- Group 15(K)
- Stronger on grasses, but has some BL activity
- Works best if incorporated within 7-10 days
- Mobile
  - Will wash off / through stubble
  - Potential to move into seed zone
  - Potential to leach / run-off paddock
- Relatively fast breakdown
  - Unlikely to have major plantback issues


Can work well if applied to wet soil

Ideally incorporate (mechanical / rainfall / irrigation) to 3-4cm only


Highest crop injury risk

- Applied at planting to dry, light soil
- Heavy irrigation / rainfall to quickly fill profile
- Cold soil or remaining waterlogged
- Planter concentrates treated soil in the furrow

'Watered up' via flood irrigation - movement into seed zone + run-off in tail water



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## pendimethalin (e.g. Stomp®)

Soybean	Mung bean	Maize	Sorghum	Cane	Fallow
Pre (double incorporated)		Pre (not incorporated)		PSPE	

- Group 3(D)
- Stronger on grasses, but has some BL activity
- Low mobility
  - Significant tie up in heavy stubble / trash
  - Stays mostly in 0-2cm
    - Crop selectivity via vertical separation
    - Poorer control of deep germinating weeds
- Moderate to long persistence

Different incorporation strategies on label

Soy / mung – double incorporation


- Physically move herbicide to weeds in full cut system

Maize – not incorporated


- Vertical separation for crop safety
- Higher rate to account for losses

Cane - shallow mechanical incorporation or ~25mm overhead irrigation

- Add imazapic for weed seeds at depth



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## PPO inhibitors


	Soybean	Mung bean	Maize	Sorghum	Cane	Fallow
acifluorfen Blazer®	Pre, post	Post				
flumioxazin Terrain®/Valor®	Pre, PSPE	Pre	Pre		90 g/ha knockdown 350-700 g/ha residual	30 g/ha No residual

- Group 14(G)
- Stronger on broadleaves
  - Flumioxazin – useful grass control at residual rates
- Mobility
  - Blazer – mobile in soil water
  - Valor – low mobility
    - Weeds germinating from depth may escape
    - Heavy trash may reduce performance
    - Need good soil moisture for efficacy, but waterlogging increase crop injury


Short persistence  
 Need increased rate to get residual & grass activity  
 Blazer 1-2 L/ha post-em broadleaf  
 3-4 L/ha for residual + grasses

Valor 30 g/ha broadleaf knockdown only in fallow  
 210-280 g/ha residual BL and grasses

- Soybeans at planting and PSPE
- Maize – 1 month before planting
- Mung beans – 2 months before planting



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## triazines & diuron


	Soybean	Mung bean	Maize	Sorghum	Cane	Fallow
atrazine			Pre, PSPE, post		Pre, post	To sorghum
terbuthylazine (Terbyne®)			Pre, PSPE, post			To mung, soybean, winter cereals
ametryn					Pre, directed post	
diuron					Post	

- Group 5(C)
- Stronger on BL, but has some grass activity
- Work best under good moisture
- Diuron less mobile than triazines
- Triazines all moderately mobile
  - Will wash off / through stubble
  - Potential to leach with ongoing rainfall
  - Ametryn slightly less mobile than others
  - Better than diuron on deeper germinating weeds

Persistence  
 Terbyne – short to moderate  
 Atrazine / ametryn – moderate (to long)  
 Diuron – moderate to long


Atrazine label has long plantbacks

- But subject to accelerated degradation



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## triazinones



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	Soybean	Mung bean	Maize	Sorghum	Cane	Fallow
Metribuzin	Pre					
Hexazinone					+ diuron or + imazapic	
Amicarbazone					Pre, post	

- Group 5(C)
- Stronger on BL, but useful grass activity
- Work best under good moisture
- All very mobile
  - Will wash off / through stubble
  - Incorporation by rainfall or overhead irrigation
  - Potential to move into seed zone
  - Potential to leach with ongoing rainfall

Persistence


Metribuzin – short

Hexazinone – moderate to long


- 2 year plantback on label

Amitron – (short to) moderate

- 500 mL/ha = 4 week residual claim
- 800 mL/ha = 8 weeks
- 1000 mL/ha = 10-14 weeks
- [but has 24 month plantback on label]



## imidazoles



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	Soybean	Mung bean	Maize	Sorghum	Cane	Fallow
	IT varieties only					
imazapic (Impose®)					PSPE, post	Long plantbacks
imazethapyr	Spinnaker® PSPE, post	Spinnaker Pre	Lightning® Post			
imazapyr				Intervix® Post		
imazamox	Raptor® Post					

- Group 2(B)
- Stronger on BL, but useful grass activity
- Work best under good moisture
- All very mobile
  - Will wash off / through stubble
  - Incorporation by rainfall or overhead irrigation
  - Potential to move into seed zone
  - Potential to leach with ongoing rainfall

Persistence


Imazamox – short


Imazethapyr – moderate (to long)

Imazapyr – long

Imazapic – **very** long

All – persistence is longer in acid soils






## imazapic plantbacks

Other critical comments are the same except the Impose label now has added

- Recropping intervals start after soil is wet to 5cm
- At least ½ the rainfall requirement needs to be in the first half of the plantback period

	Generic label (old Flame® label)		New Impose® label
	Fallow 200 mL/ha	Cane, peanuts 400 mL/ha	
Soybean	Not stated	0	4 (+ 200mm)
Peanuts, Mung bean, IT cereals	3	0	
Faba bean		Not stated	
Chickpea	4	4	8 (+ 200mm)
Lupins, Pasture legumes	Not stated	5	
Lucerne	4 (+ 200mm)	4 (+ 200mm)	15 (+ 500mm)
Wheat, Barley			
Maize	10 (+ 500mm)	10 (+ 500mm)	18 (+ 500mm)
Sorghum		18 (+ 500mm)	
Dryland cotton	10 (+ 550mm)	10 (+ 550mm)	24 (+ 550mm)
Irrigated cotton	24	24	
Sunflower	24	24	24
Other crops	36	36	36

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## flumetsulam (e.g. Broadstrike®)

Soybean	Mung bean	Maize	Sorghum	Cane	Fallow
Pre, PSPE		PSPE, post			

- Group 2(B)
- Broadleaves only (minor effect on some grasses e.g. wild oats, setaria)
- Mobile
  - Rain will incorporate
  - Ok to use with low-moderate stubble
  - Potential to move into seed zone
- Moderate persistence
  - Unlikely to have major plantback issues

Crop tolerance

- More effect at top label rate
- Actively growing crop will out grow symptoms (yellowing)
- Waterlogging, other herbicides, other stress exacerbates injury

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## Additional information

<a href="https://grdc.com.au/resources-and-publications/resources/herbicide-behaviour">https://grdc.com.au/resources-and-publications/resources/herbicide-behaviour</a>
Pesticide Properties Database. University of Hertfordshire <a href="http://sitem.herts.ac.uk/aeru/iupac/">http://sitem.herts.ac.uk/aeru/iupac/</a>
Herbicide Handbook. Weed Society of America
How Herbicides Work. Alberta Agriculture and Rural Development
GRDC Pre-emergent Herbicide video – Pt 1 Solubility & binding <a href="https://www.youtube.com/watch?v=s63GYyflzw&amp;t=0s">https://www.youtube.com/watch?v=s63GYyflzw&amp;t=0s</a>
GRDC Pre-emergent Herbicide video – Pt 2 Incorporation by sowing <a href="https://www.youtube.com/watch?v=LJNjuMWS57U&amp;t=0s">https://www.youtube.com/watch?v=LJNjuMWS57U&amp;t=0s</a>



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