MANAGING HERBICIDES AND HERBICIDE INJURY

In February we had the pleasure of meeting Professor Andy Robinson and welcoming him, in person, to the PotatoLink project. While visiting Australia, Professor Robinson took time out of a busy schedule to take part in our Ballarat workshop and field walk. Professor Robinson is a highly regarded extension agronomist and academic from North Dakota State University and the University of Minnesota. Before heading our way, he presented a webinar on chemical weed control and herbicide injury. By Paulette Baumgartl

WATCH THE WEBINAR

This article summarises key points from Prof Robinson's webinar regarding best management for weeds and how to recognise the difference between herbicide injury and diseases or defects in your potato crops. The webinar is available to watch any time via the PotatoLink website. at this link:
http://bitly.ws/BFEY

When no pre-emergent herbicide has been applied, a post-emergent treatment is the only option - A. Robinson

WEED CONTROL TOOLBOX

Potato growers have many options to control weeds, from prevention and cultural management to mechanical and physical weed control, and chemical and biological methods. With so many choices, the key to success is knowing which method to use, and how to combine them for maximum impact.

As the name suggests, **prevention and cultural management** are all about growing potatoes in a way that inhibits weed growth. This includes factors like row width, canopy closure, water and fertiliser management.

Creating shade and reducing weed space promotes potato growth and can reduce the volume of herbicides needed for chemical weed control. Likewise, taking care not to transfer seeds from one area to another can help prevent the spread of weeds (as well as disease).

Mechanical and physical weed removal also play a role. Each pass across a field disrupts the soil and prevents weed growth. Hilling can also be an opportunity to remove weeds.

Chemical weed control, or herbicides, is the primary method used by most potato growers. Herbicides facilitate reduced tillage (which is good for maintaining soil structure), can target specific weeds, and are effective for treating large acreage.

Choosing the right herbicide requires careful consideration of factors including variety sensitivity, the weed spectrum present, timing, and cost.

Timing is particularly crucial when using herbicides. Pre-emergent herbicides provide a window of 3-5 weeks for weed control, giving potato plants time to grow, form a canopy and prevent weed emergence. But the effectiveness of pre-emergent herbicides can be impacted by weather conditions, often beyond the grower's control.

Also note that slow growing weeds need a slower acting herbicide, i.e., a herbicide with lower water solubility. Conversely, if quick action is required, a herbicide that dissolves quickly in water is more suitable.

PRE-PLANT (KNOCKDOWN) HERBICIDES

Knockdown herbicides, as the name suggests, are applied just prior to planting and designed to work rapidly. They can also be useful in reducing a seedbank.

Glyphosate remains a popular choice in Australia but can cause herbicide injury if mismanaged.

Table 1 highlights the man advantages and challenges of the typical knockdown herbicides used in Australia.

Herbicide - Active (trade name)	Targets	Advantages	Challenges
Glyphosate (Round up*)	All weeds - burndown, good for pre-plant, can be a problem during growth	▪ Translocates ▪ Low water volume ▪ Adjuvants can be added to improve results ▪ Good on grasses ▪ Can withstand sunlight and warm temperatures ▪ Low cost	▪ Weed resistance ▪ Potential damage to potato plant
Paraquat and diquat (Gramaxonae, Spray seed)	All weeds	▪ Kills on contact ▪ High volume of water needed ▪ Herbicide resistance low	▪ No contact, no kill ▪ Injury to plant ▪ Sunlight is needed ▪ Human safety

Table 1. Common pre-plant (knockdown) herbicides used in Australia (Source: A. Robinson). Always refer to directions on the label
*Or other generic herbicides with the same active ingredient.

PRE-EMERGENT HERBICIDE

Pre-emergent herbicides prevent germinated weed seedlings from becoming established.

For maximum efficacy, several factors should be considered:

- As they require 10-20mm of water to activate, if no rainfall is expected irrigation is required.
- Incorporating the herbicides through tillage or water can also improve their effectiveness.
- Timing is paramount: apply before weed seeds germinate.
- With the right knowledge, tank mixing herbicides can expand the weed control spectrum.
- Soil factors, including pH, organic matter, texture, and moisture need to be considered before application to ensure optimal results.

Metribuzin injury - A. Robinson

Wrinkly leaves caused by herbicide injury from metolachlor - A. Robinson

Table 2. Common pre-emergent herbicides used in Australia (Source: A. Robinson). Always refer to directions on the label

Herbicide - Active (trade name)	Targets	Advantages	Challenges
Metribuzin (Sencor, Mentor)	Broadleaves, grasses	▪ Good general weed control ▪ Water soluble ▪ More active in soils with pH > 7.5, low organic matter, stressed plants	Foliar: symptoms can be severe when applied when plant metabolism is slowed, or within 3 days after periods of cool, wet, or cloudy weather. Can affect sensitive cultivars, can cause venal chlorosis.
Linuron (Linex)	Blackberry, nightshades, broadleaves	▪ Great on fat hen ▪ Good on nightshades ▪ 1/12th as soluble as metribuzin – needs more water to activate but lasts a lot longer. ▪ Late PRE herbicide treatment ▪ Tank mixes well with metribuzin and S-metolachlor	▪ Linuron binds to OM, will be less effective (don't use in high OM soils) ▪ Limited weeds controlled ▪ Cost
Metobromuron (Soleto)	Broadleaves	▪ Good control of many small-seeded broadleaves	-
EPTC (Eptam)	Nut grass, broadleaves	▪ Incorporation is key - fertigate, tillage	▪ Cost ▪ Photodegrades so needs to be tilled in immediately
Metolachlor, prosulfocar (Boxer gold)	Grasses, Nightshades, Fat Hen, Redroot Amaranth, Toad Rush	▪ Ideal for resistance management ▪ Versatile ▪ Good compatibility with other herbicides	Irrigation or rainfall is required to a depth of 3 to 5 cm and should occur within 7 days of application.

Table 2 (over page) highlights the main advantages and challenges of the typical pre-emergent herbicides used in Australia.

POST EMERGENT HERBICIDES

Most post emergent herbicides fall into two categories, **graminicides and desiccants**.

Graminicides target weedy grasses and should be used on weeds less than 15 cm tall (Table 3).

- Use the full label rate, as a reduced rate will lessen efficacy and could lead to herbicide resistance.
- Add an adjuvant to help break the barrier on the leaf surface and get more herbicide in the plant.
- Use a high volume of water to achieve good spray coverage on leaves.

Desiccants prevent specific functions within the plant, such as interfering with photosynthesis or disrupting cell membranes. The internal structure collapses and the plant dies, drying out almost as rapidly as if it had been burned (Table 4).

Glyphosate is not considered a 'true' desiccant, as plants take weeks, rather than days, to die.

Trade name	Active	Targets
Fusilade*	Fusilade	Grasses
Select, Clethodim*	Clethodim	Grasses

Table 3: Common **grass herbicides** used in Australia (Source: A. Robinson).
Always refer to directions on the label.
*Or other generic herbicides with the same active ingredient.

Trade name	Active	Targets
Reglone	Diquat	Potato foliage
Spray Seed**	Paraquat + diquat	Weed destruction

Table 4: Common **desiccants** used in Australia (Source: A. Robinson).
Always refer to directions on the label.
**DO NOT use SPRAY.SEED® 250 for potato haulm desiccation.

AN INTEGRATED, COMBINED APPROACH IS ALWAYS BEST

As every grower knows, an integrated approach usually yields the best results. Timely application of herbicides appropriate to the specific needs of the crop and the weed pressure it is under is a useful tool.

Combining this with good cultural management practices, such as crop rotation and cover cropping, is the best way to reduce weed pressure and avoid herbicide resistance.

HERBICIDE INJURY

Herbicide injury can cause a variety of problems for potato growers, including reduced stand, slow canopy closure, damaged leaves, malformed tubers, reduced yield and quality, and unacceptable accumulation of contaminants in the tuber.

There are three main ways herbicide injury can occur: **soil carryover, foliar exposure,** and **seed contamination.** Common modes of 'unwanted herbicide transport' include drift (Figure 1), tank contamination (tank and/or boom not cleaned out properly), misapplication, volatisation, or sometimes even a broken hose.

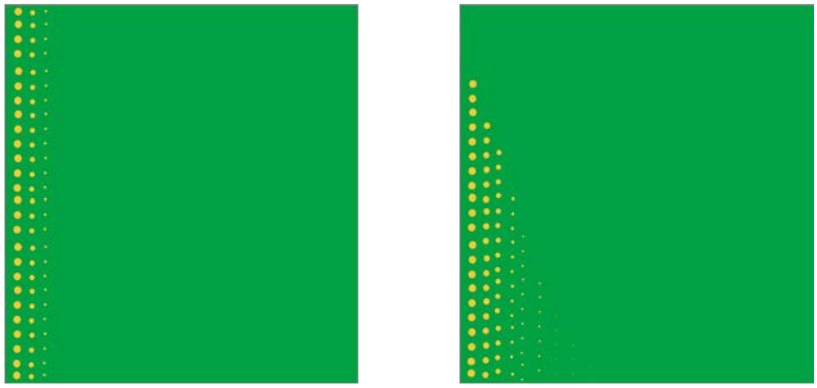

Figure 1: Typical patterns caused by herbicide drift (Source: A. Robinson)

SOIL CARRYOVER

Microbial decomposition, together with UV light and other environmental factors, generally breaks down herbicides in soil.

However, if conditions are too cold, dry or wet for microbial activity, or hard pans are present that trap herbicide within the profile, then some products can persist. Herbicides can also potentially be released from treated materials that have not broken down before planting.

Signs of soil carryover include slow emergence, pruned or brown roots, stunted plants, shortened stolons, and early tuber set or malformation.

If large areas or whole fields show symptoms, this can indicate contamination via a sprayer (tank contamination).

FOLIAR EXPOSURE

Herbicides can also cause damage through foliar exposure. This can occur via particle drift, inversion, contamination of spraying equipment, volatilisation, misapplication, contaminated water, and more.

Symptoms of foliar exposure include leaf injury and tuber cracking or malformations. The specific symptoms vary depending on the herbicide's mode of action. These can include twisting of leaves and stems, cupped leaflets, wrinkled leaflet margins, misshapen tubers, yellowing of youngest leaves, and elongated and wrinkled leaflets.

Herbicides that translocate within the plant can potentially damage both the leaves, especially young leaves, and the underground tubers (Figure 2).

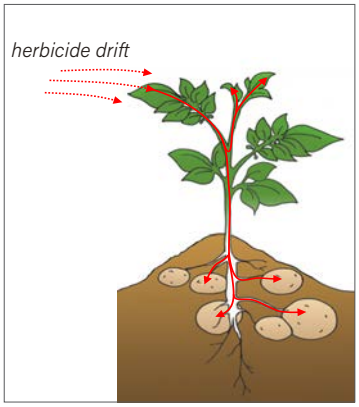

Figure 2: Translocating herbicides can cause chemical build up in tubers (Source: A. Robinson)

Contact herbicides will affect what they touch, including both young and old leaves equally.

In addition to direct damage, herbicide injury increases plant stress, which can result in tuber cracking or malformations in tubers.

GLYPHOSATE DAMAGE

Glyphosate is a commonly used herbicide with wide benefits in agriculture. However, it can have negative effects on crop growth and development if misused. Accidental exposure to glyphosate can cause yellowing of new leaflets, stunting of plant growth, and reductions in plant height and leaf size.

These effects can be particularly pronounced at higher application rates, where leaves can become chlorotic and necrotic.

The often subtle effects of glyphosate drift, or other herbicide injury, can make identification challenging, even for experienced experts. Patterns in the field can provide some helpful clues: if symptoms are present throughout the field, the issue may be related to nutrient deficiencies. However, if only the edges of the field are affected, herbicide drift may be the culprit (Figure 1).

In addition to its effects on foliage, glyphosate can have negative impacts on tuber development during the early bulking stages. Exposure can result in smaller, irregularly shaped tubers that have folds, cracks, knobs, and 'elephant hide'. Even minute amounts of glyphosate can cause significant damage to tuber development, ultimately leading to reduced yields and lower quality crops.

Glyphosate can also leave residues in seeds. These affect seed germination and plant growth. When seeds are contaminated with glyphosate residues, typical symptoms include erratic and slow emergence, bending and twisting of leaves, multiple stems from a single eye, and "cauliflower" or

"candelabra" formations of stems with no dominant growing point.

IS IT HERBICIDE INJURY OR SOMETHING ELSE?

Identifying herbicide injury in plants is not always straightforward as many other causes have similar symptoms.

In potatoes, high turgor pressure and rapid tuber growth can cause cracking, while drought stress and fertility stress can cause discoloured leaves. Potato virus Y can cause mosaic patterns, small leaflets, and wavy leaf margins.

To properly diagnose whether it is herbicide injury or something else, consult your local agronomist, take samples and test, test, test. It is essential to document the symptoms immediately and collect multiple samples for laboratory analysis.

Prevention is always better than cure. It is crucial to check previous herbicides used in the field, communicate with neighbouring farmers about sensitive crops, and work closely with seed growers to ensure seed is clean.

Proper tank cleanout procedures and training for spray system users are essential. Herbicides should always be kept separately to other pesticides in clearly labelled containers.

WHAT TO DO IF YOU SUSPECT HERBICIDE DAMAGE ON A LARGE SCALE?

If you suspect herbicide injury has occurred, it's important to document it immediately because symptoms may decrease over time, making it more difficult to capture. A laboratory analysis is also necessary. When sampling, take multiple leaves and/or tubers and use clean gloves and an unused bag. Comparing affected and non-affected areas is also recommended, as is sampling multiple intensities of damage.

Chain of custody is also essential, especially if the issue becomes litigious. Chronological documentation of the individuals who take custody of the sample should be maintained, and a third party can be used to verify when and where samples were taken.

After sampling, gently clean the samples if necessary and store refrigerated. Samples need to be kept cool and preferably shipped overnight to the laboratory. Information on how to sample and get tests for herbicides can be found at **z.umn.edu/injury.**

Left: Edge of fields or lower point in field – herbicide residues accumulate in low spot causing carry over. Right: Tank/boom contamination - A. Robinson

Left: Two seed lots, one with glyphosate contamination in seed and one with no contamination. Right: 'Cauliflower sprouts' due to glyphosate exposure - A. Robinson

Left: Fluorescent green foliage from glyphosate drift on a seed paddock. Right: Extremely malformed tubers - A. Robinson

Left: Uneven irrigation can also cause malformed tubers - J Ekman. Right: Diseases and fertility deficiencies can display symptoms similar to herbicide injury - A. Robinson

KEY POINTS

- Pre-emergent herbicides usually require 10-20mm of water to activate.
- Incorporate pre-emergent herbicides through tillage or water for improved effectiveness.
- Apply pre-emergent herbicides before weed seeds germinate.
- Tank mixing herbicides can expand the weed control spectrum.
- Consider soil factors such as pH, organic matter, texture, and moisture, adjust rates and application timing accordingly.
- While herbicides are extremely useful tools, especially when used within an integrated approach, accidental exposure can significantly reduce potato yield and quality.
- Herbicide injury can occur through soil carryover, foliar exposure, and seed contamination.
  - Soil carryover can cause slow emergence, pruned or brown roots, stunted plants, shortened stolons, and early tuber set or malformation.
  - Foliar exposure can occur due to particle drift, inversion, contamination of spraying equipment, volatilisation, misapplication, contaminated water, and more.
  - Symptoms of foliar exposure include leaf injury and tuber cracking or malformations, which can vary depending on the herbicide's mode of action.

GLYPHOSATE DAMAGE:

- Glyphosate can cause yellowing of new leaflets, stunting of plant growth, and chlorotic and necrotic leaves.
- Glyphosate exposure can result in smaller, irregularly shaped tubers with folds, cracks, knobs, and 'elephant hide'.
- Even extremely low levels of contamination can have a significant impact on tuber growth, quality and yield.
- Glyphosate residues in seeds can cause erratic and slow emergence patterns, bending and twisting of leaves, multiple stems from an eye, and enlarged stems.

FACTORS THAT CAN MIMIC HERBICIDE INJURY:

- Environmental stress, nutritional imbalance, diseases, and genetics; drought stress can reduce plant growth; irregular soil moisture can result in cracked and deformed tubers; nutrient stress can cause leaf discolouration.
- High turgor pressure and rapid tuber growth can cause early cracking and larger cracks.
- Potato Virus Y can cause mosaic effects on leaves, wavy leaf margins and deformed tubers.

WHAT TO DO IF YOU SUSPECT HERBICIDE DAMAGE ON A LARGE SCALE?

- Document symptoms immediately because they may decrease over time.
- Sample multiple leaves and/or tubers, compare affected and non-affected, and sample multiple intensities of damage.
- Chain of custody is important if this becomes litigious.
- Clean and store samples properly and ship them to a laboratory.

HOW TO PREVENT HERBICIDE INJURY:

- Check previous use of potentially persistent herbicides or bioassay soil.
- Communicate and cooperate with neighbours.
- Follow tank cleanout instructions and have specific herbicide-only equipment.
- Train spray applicators to ensure spray drift does not occur.
- Keep herbicides separately from other pesticides.

SOURCES

Information for this article has been sourced from the webinar "Herbicide damage and weed management in potatoes" (Professor Andrew Robinson)

https://potatolink.com.au/resources/webinar-recording-herbicide-damage-and-weed-management-in-potatoes