WEEDS MANUAL

NATIONAL

December 2025

Integrated weed management of flaxleaf fleabane

Title:
Integrated weed management of flaxleaf fleabane

GRDC Project: NGN – Developing control strategies for key problem weeds in north-west and north-east New South Wales ICN2404-002RTX, ICN2403-002RTX

Published: December 2025

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Find the publication 'Integrated weed management of flaxleaf fleabane' on the GRDC website:

COVER: Flaxleaf fleabane rosette growth stage.
PHOTO: Mark Congreve (ICAN)

Herbicides mentioned within this publication and their active constituent(s)

Not all these herbicides are registered for control of fleabane. Some products mentioned may have been included in experimental trials in combination with other herbicides. Herbicides not specifically registered for fleabane control have been included in this publication to demonstrate their performance against fleabane; specific advice should be obtained before using a herbicide that does not list fleabane control on the label. In some cases, the herbicides have been included in trials to show that they are not effective against fleabane.

Not all brands of the same active ingredient may contain the same registered use patterns. Always use products registered for control of the weed and in the use situation according to the product label.

Herbicide	**Active ingredient**
Adigor®	440 g/L methyl esters of canola oil fatty acids
Alliance®	250 g/L amitrole + 125 g/L paraquat dichloride
Ally®	600 g/kg metsulfuron methyl
Amicide® Advance	700 g/L 2,4-D (as the dimethylamine and monoethylamine salts)
Amicide® 625	625 g/L 2,4-D (as the dimethylamine and diethanolamine salts)
B-Power	100 g/L butafenacil
Balance®	750 g/kg isoxaflutole
Basta®	200 g/L glufosinate-ammonium
Biffo®	200 g/L glufosinate-ammonium
Bonza®	417 g/L paraffin oil
Callisto®	480 g/L mesotrione
CanDo®	500 g/L ethyl esters of canola oil fatty acids
Colex-D®	456 g/L 2,4-D (as the choline salt)
Crucial®	600 g/L glyphosate (as potassium, monoethylamine and ammonium salts)
FallowBoss® Tordon®	300 g/L 2,4-D + 75 g/L picloram + 7.5 g/L aminopyralid (all as the triisopropanolamine salt)
Flagship 400 EC	400 g/L fluroxypyr (as the methyl heptyl ester)
Frequency®	60 g/L topramezone + 60 g/L cloquintocet-mexyl
Garlon® 600	600 g/L triclopyr (as the butoxyethyl ester)
Glean®	750 g/kg chlorsulfuron
Glyphosate 450	450 g/L glyphosate (as the isopropylamine salt)
Goal®	240 g/L oxyfluorfen
Gramoxone® 360 Pro	360 g/L paraquat dichloride
Grindstone®	240 g/L aminopyralid (as the triisopropanolamine salt)
Guerrilla®	300 g/L paraquat dichloride + 12 g/L amitrole
Hammer®	400 g/L carfentrazone-ethyl
Hasten®	704 g/L ethyl and methyl esters of canola oil fatty acids with 196 g/L non-ionic surfactants

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Herbicide	Active ingredient
Hellcat®	200 g/L glufosinate-ammonium + 3.6 g/L carfentrazone-ethyl
Hotshot®	140 g/L fluroxypyr (as the methyl heptyl ester) + 10 g/L aminopyralid (as the triisopropanolamine salt)
Lontrel® 300	300 g/L clopyralid (as the triisopropanolamine salt)
Lontrel® Advanced	600 g/L clopyralid (as the dimethylamine salt)
MCPA LVE	570 g/L MCPA (as the 2-ethyl hexyl ester)
Monsoon®	300 g/L bromoxynil (as the octanoyl ester) + 150 g/L fluroxypyr (as the methyl heptyl ester)
Nufarm Dropzone®	500 g/L 2,4-D (as the dimethylamine and monoethylamine salts)
Palmero® TX	750 g/kg terbuthylazine + 75 g/kg isoxaflutole
Paradigm®	200 g/kg halauxifen (as the methyl ester) + 200 g/kg florasulam
Paraquat 250	250 g/L paraquat dichloride
Picoflex®	240 g/L picloram (as the potassium salt)
Pixxaro®	250 g/L fluroxypyr (as the meptyl ester) + 16.25 g/L halauxifen (as the methyl ester) + 16.25 g/L cloquintocet-mexyl
Reflex®	240 g/L fomesafen
Rexade®	150 g/kg pyroxsulam + 50 g/kg halauxifen (as the methyl ester) + 318.6 g/kg cloquintocet
Sharpen®	700 g/kg saflufenacil
Shirquat®	250 g/L paraquat dichloride
Spray.Seed®	135 g/L paraquat dichloride + 115 g/L diquat dibromide
Starane® Advanced	333 g/L fluroxypyr (as the methyl heptyl ester)
Surpass® 300	300 g/L 2,4-D (as the isopropyl amine salt)
Talinor®	175 g/L bromoxynil (as octanoate) + 37.5 g/L bicyclopyrone + 9.4 g/L cloquintocet-mexyl
Tenet®	500 g/L metazachlor
Terbyne® Xtreme	875 g/kg terbuthylazine
Terrad'or®	700 g/L g/kg tiafenacil
Tordon® 242	420 g/L MCPA (as the potassium salt) + 26 g/L picloram (as the potassium salt)
Tordon® 75-D	300 g/L 2,4-D + 75 g/L picloram (both as the triisopropanolamine salt)
Treazac®	25g/L aminopyralid + 30 g/L halauxifen (as the methyl ester) + 30 g/L cloquintocet-mexyl
Uptake®	582 g/L paraffinic oil + 240 g/L alkoxylated alcohol non-ionic surfactants
Valor ®	500 g/kg flumioxazin
Voraxor®	250 g/L saflufenacil + 125 g/L trifludimoxazin

® Registered trademark

Responsible use of herbicides

- Always read and fully understand the product label before applying any product.
- Only apply a product to weed species it is registered for and within the application parameters specified on the product label, including registered use patterns.

At the time of publication, the following herbicides were registered for control of flaxleaf fleabane in broadacre crop and fallow situations. This is a summary only of product registrations. Please refer to the product label for application rates and full comments.

Fallow

Mode of action	Herbicide	Weed size	Comments
4	2,4-D amine[#] e.g. Dropzone	Cotyledon to 12 leaf, prior to stem elongation	In a mixture with glyphosate + AMS. Use higher label rate for spring/summer applications. A double-knock of paraquat applied 7–14 days later may improve results.
		Rosette to flowering	Apply via optical spot sprayer.
	2,4-D choline e.g. Colex-D	Cotyledon to 12 leaf, prior to stem elongation	In a mixture with glyphosate + AMS. Use higher label rate for spring/summer applications.
		Stem elongation to flowering	As above, followed by a second knock of paraquat.
		Rosette to mature	Apply via optical spot sprayer using the higher rate for late flowering/mature plants or plants under moisture stress.
	Picloram + 2,4-D e.g. Tordon 75-D	Up to 25 cm	Qld, NSW only. Apply in a mixture with glyphosate, prior to winter cereals. Picloram remains active in the soil for extended periods.
	Fluroxypyr[#] e.g. Flagship	Rosette to flowering	Apply via optical spot sprayer using the higher rate for late flowering/mature plants or plants under moisture stress.
5	Terbuthylazine e.g. Terbyne	Pre-emergent	Qld, NSW only. Residual control. Add a compatible knockdown partner if weeds have already emerged.
5 + 27	Terbuthylazine + isoxaflutole e.g. Palmero TX	Pre-emergent	Residual control. Add a knockdown partner if weeds have already emerged.
6 + 4	Bromoxynil + fluroxypyr e.g. Monsoon	Rosette to flowering	Apply via optical spot sprayer using the higher rate for late flowering/mature plants or plants under moisture stress.
9	Glyphosate[#] e.g. Crucial	Cotyledon to 12 leaf, prior to stem elongation	Apply in a mixture with 2,4-D amine, using the higher registered rate for spring/summer applications.
		Stem elongation to flowering	Follow the above application with a double-knock of either paraquat or tiafenacil within 7–14 days.
	Note: Most glyphosate products do not contain a registration for the control of fleabane. Glyphosate resistance is present in many field populations and fleabane is a weed that is regarded as difficult to kill even in non-resistant populations.		
10	Glufosinate[#] e.g. Biffo	2–6 leaf	Ensure excellent application coverage and temperature below 33° C and relative humidity above 50%. Under cool (below 10° C), dry and low relative humidity conditions, speed of action and control may be reduced.
		Up to 40 cm tall[#]	Apply via optical spot sprayer. Ensure excellent application coverage and temperature below 33° C and relative humidity above 50%. Under cool (below 10° C), dry and low relative humidity conditions, speed of action and control may be reduced.
10 + 14	Glufosinate + carfentrazone e.g. Hellcat	2–6 leaf	Ensure excellent application coverage and temperature below 33° C and relative humidity above 50%.
14	Butafenacil e.g. B-Power	Knockdown	Apply in a mix with a glyphosate or paraquat-based knockdown partner.
	Flumioxazin[#] e.g. Valor	Pre-emergent and knockdown control at the residual application rates	Check plant-back periods to individual crops and herbicide use rates.
	Saflufenacil e.g. Sharpen	1–6 leaf	In a mix with a crop oil.
		Rosette to commencement of bolting	Suppression only – control may be reduced and regrowth may occur.
	Saflufenacil + trifludimoxazin e.g. Voraxor	Up to 6 leaf	In a mix with crop oil.
	Tiafenacil e.g. Terrad'or	Stem elongation to flowering	Apply in a mix with CanDo adjuvant +/- paraquat as a second pass of a double-knock program, following an application of Crucial + Dropzone applied 7–14 days earlier.

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Mode of action	Herbicide	Weed size	Comments
22	Paraquat + diquat e.g. Spray.Seed	Up to flowering	Use higher end of the label rate for larger plants. As activity is largely contact only, control of larger plants is variable and not assured.
	Paraquat e.g. Gramoxone		Apply via optical spot sprayer. Rosette to flowering plants. Use higher rate on late flowering/ mature plants or plants under moisture stress.
22 + 34	Paraquat + amitrole e.g. Guerilla		Water rates of 80 L/ha or greater is recommended. Additional surfactant may be added if required.
27	Isoxaflutole e.g. Balance	Pre-emergent	Add a knockdown partner if weeds have already emerged.

Winter cereals – early post-emergent

MOA	Herbicide	Weed size	Comments
2 + 4	Pyroxsulam + halauxifen e.g. Rexade	Cotyledon to 4 leaf (5 cm)	When applied in a mix with MCPA (suppression only). Wheat and triticale only.
	Florasulam + halauxifen e.g. Paradigm	Up to 4 leaf (6 cm)	When applied in a mix with MCPA LVE. Add Lontrel Advanced for improved control. Crop growth stage from 3 to 5 leaf (depending on MCPA rate and crop) and flag leaf emergence.
4	2,4-D amine# e.g. Amicide Advance	Up to 6 leaf rosettes	
	Aminopyralid e.g. Grindstone	Up to 4 leaf	Northern NSW, Qld only. In mixture with fluroxypyr plus either MPCA or metsulfuron.
	Clopyralid e.g. Lontrel Advanced	5 cm rosettes	Apply when crops are 5 leaf to booting.
	Fluroxypyr + halauxifen e.g. Pixxaro	2–6 leaf	Apply with Uptake spraying oil. Apply when crops are 3 leaf to flag leaf.
	Halauxifen + aminopyralid e.g. Trezac	2–6 leaf	Northen NSW, Qld only. In mix with Uptake. Apply when cereals are 3 leaf to first node.
27	Topramezone e.g. Frequency	Up to 6 leaf	In a mix with bromoxynil and crop oil. Apply when crops are 2 leaf to 2 node.
27 + 6	Bicyclopyrone + bromoxynil e.g. Talinor	Up to 4 leaf	Wheat, barley only, from GS12 to GS32. Apply in a tank mix with Hasten spray oil. Suppression only.
32 + 15 + 12	Aclonifen + pyroxasulfone + diflufenican e.g. Mateno Complete	Pre-emergent of weed	Apply to wheat (not durum) from 1 leaf to 3 tiller growth stage or triticale from 2 leaf to 3 tiller growth stage.

Winter cereals – late season

14	Saflufenacil# e.g. Sharpen	Reduction of seed-set	Late application – apply between crop growth stage BBCH71 and BBCH83. Apply in a mix with crop oil.

Winter cereals – pre-emergent

14	Saflufenacil + trifludimoxazin e.g. Voraxor	Pre-emergent	Rate selected depends on time to sowing.
27	Mesotrione e.g. Callisto	Pre-emergent	Incorporate by sowing or apply as a split application (IBS and PSPE).

Broadleaf crops – pre-emergent

MOA	Herbicide	Use pattern	Comments
5 + 27	Terbuthylazine + isoxaflutole e.g. Palmero TX	IBS or PSPE Chickpeas	NSW, Vic, SA, WA, Qld only.
14	Fomesafen e.g. Reflex	Pre-sowing or PSPE Chickpeas, faba beans, field peas, narrow leaf lupins, vetch, lentils (pre-sow only)	Suppression
	Flumioxazin# e.g. Valor	Pre-sowing (IBS) Chickpeas, faba bean, field peas	Residual control. Add a knockdown partner if weeds have already emerged.
	Saflufenacil + trifludimoxazin e.g. Voraxor	Chickpeas, faba beans, field peas	
15	Metazachlor e.g. Tenet	Canola	Incorporate by sowing.

Use pattern is not on the label of all herbicide brands. Always check that the brand of herbicide you are using is approved for the use pattern.

Contents

Summary

Flaxleaf fleabane (*Conyza bonariensis*) is a highly invasive weed species of broadacre farming systems in Australia. It is notorious for its resilience and rapid spread, and it favours situations devoid of competition from other species. It is particularly well suited to no-till fallows, roadsides and other areas where managers seek to apply knockdown herbicides to maintain weed-free conditions and lack of competition from other species. As a surface-germinating weed, it is very well suited to no-till fallows and to exploiting any gaps in the crop canopy.

Fleabane presents several challenges.

- In high numbers, it competes with crops for water, nutrients and sunlight, significantly reducing crop yields.
- In the fallow, individual plants use stored moisture and nitrogen, with up to 60% yield reduction in the following crop reported from trials in south-western NSW (Haskins, 2011). Where fleabane populations were uneven the previous summer, the impact on the subsequent crop is often expressed as suppressed patches of plant growth, indicating areas of reduced soil moisture and nitrogen.
- Flaxleaf fleabane has developed resistance to multiple herbicides, particularly glyphosate and Group 2 herbicides, making it harder and more expensive to manage through chemical means alone. The need for repeated herbicide applications increases the cost of crop production. Mechanical interventions, where required, often have other detrimental effects on soil structure and erosion.
- Control during the winter crop phase is critical to management in the subsequent fallow. There are a range of effective herbicides for knockdown control of fleabane in winter cereals. Post-emergent control options are limited in most broadleaf crops, so residual herbicides applied at planting are generally required. Where autumn germinations are not controlled, or residual herbicides not used (or used but have run out), there are few options for controlling established weeds or spring fleabane germinations in many winter crops. Provided soil moisture is available in spring, these established plants will rapidly take off once day length starts to increase and the crop canopy is opened following grain harvest.
- **If control is left until after the harvest period, plants will generally be too large for effective herbicide control and poor control is a common outcome – often requiring mechanical intervention for consistent control of larger plants.**

Effective fleabane management requires a comprehensive integrated approach that combines cultural, chemical and mechanical strategies implemented throughout the year. This manual provides land managers with a summary of the integrated control strategies for flaxleaf fleabane in Australia.

Table 1: South Australian trials measured a substantial increase in stored soil moisture at the end of the fallow, which correlated to higher levels of fleabane control

% Fleabane control	Increase in stored soil moisture relative to fallow with untreated fleabane
52% control	17 mm
62% control	29 mm
80% control	45 mm
99% control	71 mm

Source: adapted from Fleet and Gill, 2013

1. Introduction to the fleabane family

Several species of fleabane weeds (*Conyza sp.*) are present in Australia. The Conyza genus sits within the Asteraceae family. (Note: some references use the genus name *Erigeron* as a synonym for *Conyza*).

Weed description

The most widespread and problematic species in Australia is flaxleaf fleabane (*Conyza bonariensis*); however, tall fleabane (*Conyza sumatrensis*) and sometimes Canadian fleabane (*Conyza canadensis*) can be problematic in individual paddocks.

Figure 1: Comparison of the growth habit of flaxleaf fleabane and tall fleabane

Tall fleabane (*Conyza sumatrensis*) – erect plant, much taller, larger leaves, pyramid inflorescence, brighter green leaves – growing among flaxleaf fleabane (*Conyza bonariensis*) – smaller plants with candelabra inflorescence, smaller blue-green leaves. Photo: Mark Congreve

Figure 2: Flaxleaf (left) and tall fleabane (right) at different growth stages.

Photos: Mark Congreve

Table 2: Characteristics of the main fleabane species

Characteristic	Flaxleaf fleabane	Tall fleabane
Mature plant height	Up to 1 m	2 m
Stem branching	Branches from the ground, especially if physically damaged e.g. grazing	Branches only at the inflorescence
Inflorescence shape	Candelabra	Pyramid
Flower colour	White to pink	Greenish white
Leaf colour	Grey-green	Green

Source: Peltzer and Douglas, 2021

A key to identifying different *Conyza* species can be found at plantnet.rbgsyd.nsw.gov.au/cgi-bin/NSWfl.pl?page=nswfl&lvl=gn&name=Conyza

2. Biology and ecology of flaxleaf fleabane

Understanding the biology and ecology of flaxleaf fleabane is key to implementing successful control strategies.

Within the fleabane family, flaxleaf fleabane is the most important species affecting Australian broadacre grains production. Therefore, most of the biology and ecology research has been conducted on this species.

Seed production, dormancy and dispersal

Fleabane species are characterised by their ability to reproduce and spread rapidly via wind-dispersed seeds. Seeds are small and best suited to germination on or very near the soil surface. Seedlings establish well in the absence of competition from other species. This makes the species exceptionally well adapted to no-till farming systems and other areas devoid of plant competition, for example, sprayed roadsides. Uncontrolled plants on roadsides and other bare areas adjacent to cropping paddocks are often a major source of ongoing seed recruitment into adjoining paddocks.

Flaxleaf fleabane seed production correlates with plant biomass, with in excess of 110,000 seeds per plant recorded under Australian growing conditions – of which up to 80% is viable (Wu et al., 2007).

Seeds are small and lightweight, with each seed having a pappus to assist with wind dispersal. Fleabane seed is often dispersed across the landscape via winds associated with summer storms. Fleabane seed can also disperse with overland water flow.

In the absence of high-velocity winds associated with large storm fronts, the majority of fleabane seed will be dispersed downwind of the parent at a distance relative to the release height, wind speed and humidity. Under lower humidity conditions, the angle of the pappus hairs widens, slowing the rate of fall and increasing the potential distance of movement from the parent plant.

Table 3: Calculated flaxleaf fleabane wind dispersal from the parent plant relative to release height, wind speed and humidity

Release height	30% humidity			90% humidity		
	Wind speed					
	15 km/h	25 km/h	35 km/h	15 km/h	25 km/h	35 km/h
0.2 m	3 m	5 m	7 m	3 m	4 m	6 m
0.4 m	6 m	10 m	14 m	5 m	9 m	12 m
0.6 m	9 m	15 m	21 m	8 m	13 m	18 m
0.8 m	12 m	20 m	28 m	10 m	17 m	24 m
1.0 m	15 m	25 m	35 m	13 m	21 m	30 m

Source: Green, 2010

Figure 3: High volumes of seed are produced and can often be found around the base of the parent plant

Photos: Mark Congreve

Figure 4: Extensive germination of fleabane in barley in June

New flaxleaf fleabane seedling emerging around the base of mature plant, which was not controlled prior to sowing. Photos: Chris Davey

Figure 5: If not controlled, autumn germinating seedlings will develop a large tap root and sit under the crop canopy all winter

Autumn germinating flaxleaf fleabane seedlings in fallow with root systems already tapping into stored soil moisture – May 2025, Croppa Creek, NSW. Photos: Mark Congreve

Rainfall patterns trigger germination

It is common to find individual plants germinating over an extensive range of climatic conditions.

In northern grains regions with milder winters, fleabane can germinate over extended periods. However, it is uncommon to see large germinations across the hottest months of summer, presumably due to the soil surface typically drying rapidly following an isolated rainfall event.

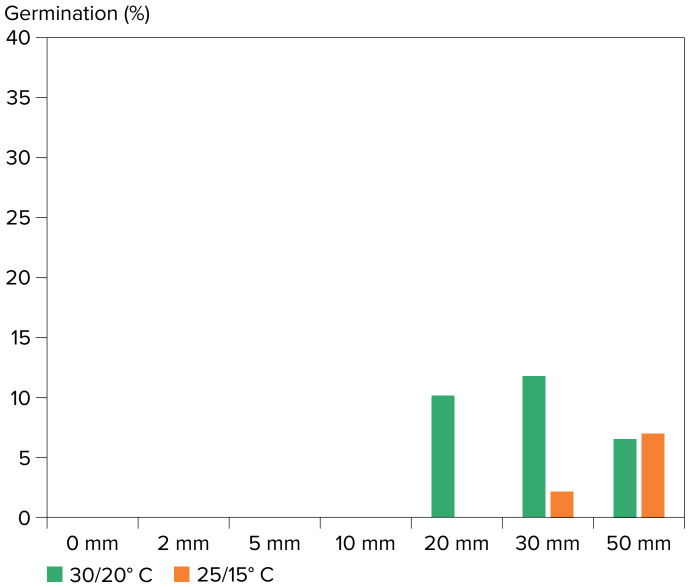
Previous research from the northern grains region has shown that the majority of field germinations occur in late autumn and early winter, with less than 1% of field populations germinating in spring (Wu et al., 2007). Spring germinating flaxleaf fleabane populations have been shown to produce only 70% of the seed produced by overwintering populations (Green, 2010).

The base, optimal and maximum temperature for seedling germination has been calculated at approximately 4.2° C, 20° C and 35° C, respectively (Wu et al., 2007).

More recent observations suggest that problematic fleabane germinations are also occurring in late winter to spring. It is not clear if this represents a change in fleabane emergence patterns, weeds not being noticed until weed growth accelerates with increasing day length in spring, herbicide tactics employed early in the winter crop for other weeds subsequently controlling autumn/winter germinating plants, or a combination of these factors.

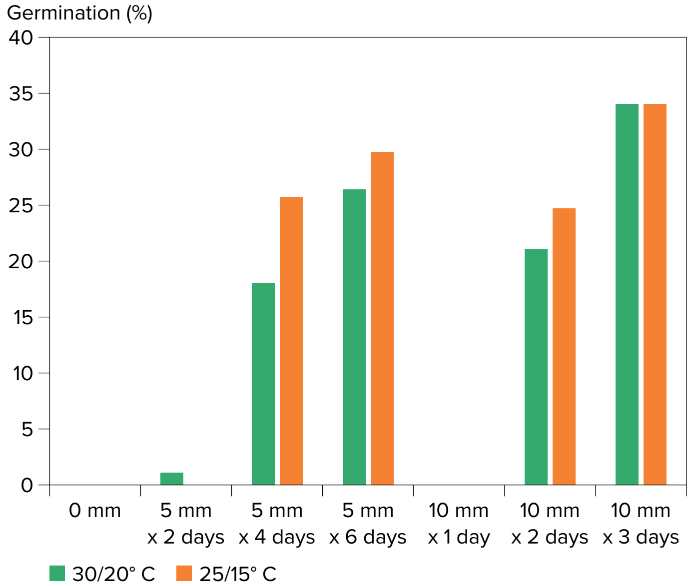
A pot study conducted at the University of Adelaide Roseworthy campus in 2012 demonstrated the potential for fleabane to germinate from August to October. However, this study did not commence until July, so did not compare germination relative to autumn emergence patterns (Fleet, Preston & Gill 2015).

Figure 6: Percentage of fleabane seed germinating following different amounts of simulated rainfall applied as a single event



Source: Werth et al., 2017

Figure 7: Percentage of fleabane seed germinating following different amounts of simulated rainfall applied as multiple events over consecutive days



Source: Werth et al., 2017

It appears that establishment is favoured when the soil surface remains wet for several consecutive days (Figure 6 and Figure 7). This will generally occur as a result of consecutive days of rainfall. However, where evaporation conditions are not excessive and therefore the soil surface is not subject to rapid drying, a single large rainfall event may also trigger strong germination. When either of these situations occur, there can be a massive germination (tens to hundreds of seedlings per m^2) where there is a heavy seedbank present in the soil.

In the northern grain region, where widespread populations of fleabane seeds are present across the landscape, a significant rainfall event that keeps the soil surface damp for multiple days in either autumn or spring is typically the trigger for a large fleabane germination.

However, low levels of fleabane plants can often be found germinating after any rainfall event. It is often these low-level, scattered germinations that can make management strategies problematic for growers. Low plant numbers can make it difficult to justify a spray application after every rainfall event. If these individual plants are allowed develop past early rosette stage, then they are less likely to be able to be controlled with subsequent herbicide applications.

Figure 8: It is common to find seedlings establishing in the stubble line, making spray coverage harder

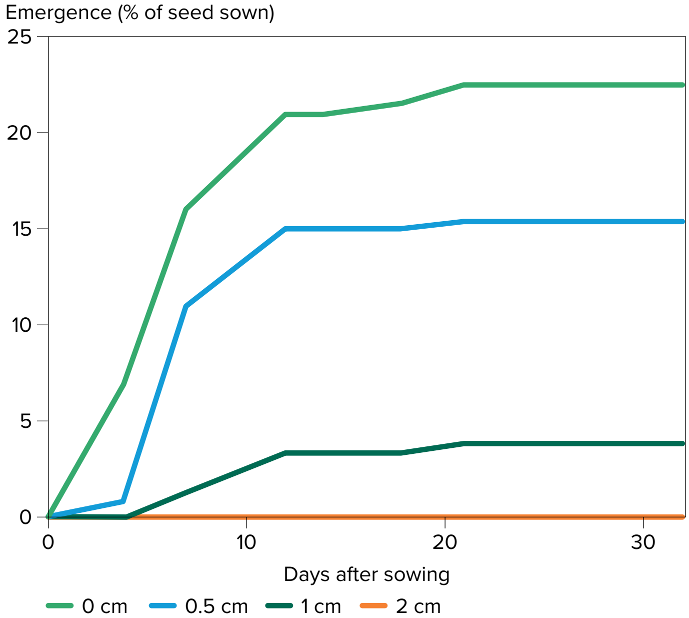
Under conditions of limited soil moisture, it is common to observe scattered plants establishing directly in the old stubble line. It is likely that this location will remain moist for longer after a single rainfall event when compared to the inter-row area. Photo: Mark Congreve

Summary: *A large rainfall event, especially if over several days, is likely to be the primary trigger for a significant fleabane germination. Residual herbicides applied in the fallow should be applied before the rainfall event. Monitor paddocks following the rainfall event and be prepared to implement a double-knock herbicide strategy targeted at small weeds as soon as weed germination has occurred and paddock conditions allow for sprayer access.*

Germination depth and persistence

The majority of seeds will germinate on the soil surface, or to a burial depth of 0.5 cm. Smaller numbers can germinate from 1 cm depth, while commonly no germinations are observed in trials from seed buried 2 cm or more.

Figure 9: Emergence of flaxleaf fleabane from a vertosol soil at different seed burial depths

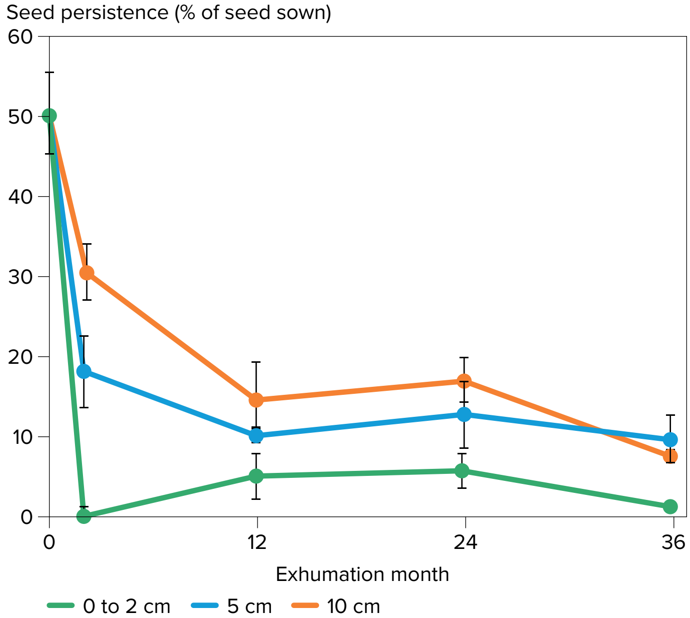


Source: Wu et al., 2007

As fleabane seed is virtually unable to establish from greater than 2 cm burial depth, cultivation can be a useful management tool in situations where there is an excessive seedbank to manage. However, burying seed will increase seed persistence in the soil (Figure 10). Buried seed exhumed at a later date, i.e. further cultivation to the paddock, could result in further weed germination on the next rain event.

In this same study, persistence was compared across 2 soil types, with the lighter soil type having both higher initial germination and slightly increased length of soil persistence (Figure 11).

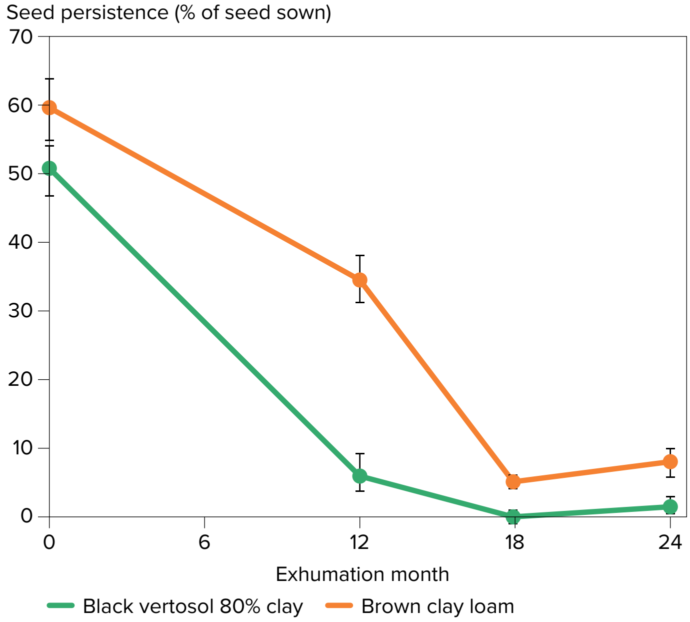
Figure 10: Effects of burial depths on the seed persistence of flaxleaf fleabane on a vertosol soil



Expressed as percentage seedling emergence from the original 350 seeds buried. Weed seeds were exhumed from depth and a germination test applied at the indicated time points. The vertical bars represent standard errors of the mean.

Source: Wu et al., 2007

Figure 11: Seed persistence of flaxleaf fleabane buried at 0 to 2 cm on a heavy soil (black vertosol 80% clay) and a lighter sodosol soil (brown clay loam)



Source: Wu et al., 2007

Figure 12: Effect of fleabane establishment following different seeding operations in the same field

Top: Cereal crop was established using a tyne seeder, with very little fleabane establishment. Middle: Crop was established using a low-disturbance disc seeder, allowing seedlings to establish. Bottom: An area of the paddock that was not sown, showing the previous fleabane carcass and subsequent seedling germination.
Photos: Angus Butterfield, Birchip Cropping Group

Soil disturbance by the sowing operation may also affect fleabane establishment should this operation bury a significant portion of the seed. Figure 12 shows fleabane germination where there was significant soil disturbance from a tyne seeder versus minimal soil disturbance from a disc seeder, and compared to an area of the paddock that was not planted.

Growth habit

Late-autumn emerging flaxleaf fleabane are almost always taller and have a larger rosette, a deeper taproot, a higher root:shoot ratio and a higher number of branches per plant than spring-germinating cohorts (Green, 2010).

Root system development

Flaxleaf fleabane develops a strong taproot and an extensive network of feeder roots nearer the soil surface. Therefore, it is well adapted to surviving, even in absence of ongoing rainfall, and will continue to extract stored soil moisture from depth.

Root system development is one factor that makes it difficult to control larger fleabane plants.

As a single application strategy, contact herbicides (for example, paraquat, glufosinate, Group 14 herbicides) are more effective on very small rosettes. These herbicides will burn off above-ground leaf material but will not have significant translocation to the roots, so extensive regrowth can be common where the plant has already developed a significant root system. **Product labels of these herbicides will be very descriptive as to the maximum weed size for reliable results – often limited to approximately 4 to 6 leaf weed size and before commencement of stem elongation.**

Fully translocated herbicides (for example, glyphosate, Group 4 herbicides) are typically required as the foundation of control programs; however, note that glyphosate resistance is now common in many populations. While these herbicides can translocate throughout the plants, including the roots, results are increasingly variable as weed size increases. Increasing volume of underground root mass is a key factor leading to increased variability of results as plant size increases.

Above-ground weed size is not always an accurate reflection of weed age or root development. When fleabane germinates in autumn or early winter and is present under a competitive crop, the above-ground biomass is often suppressed; however, root development continues. This can often result in a relatively small plant present immediately post-harvest, often resembling a relatively recently emerged seedling; however, this individual may already have a well-established root system and may be several months old.

At stem elongation, the ratio of roots to shoots has been measured to be 60% higher in overwintering flaxleaf fleabane than in spring-germinating plants.

Table 4: Root to shoot ratio of flaxleaf fleabane germinating in either late autumn or spring

	Fleabane root to shoot ratio at 3 growth stages		
	Bolting	**Flowering**	**Seed maturity**
Late autumn emergence	0.47 (±0.02)	0.79 (±0.03)	0.69 (±0.02)
Spring emergence	0.29 (±0.02)*	0.33 (±0.02)*	0.32 (±0.02)*

Values are means with standard error in parenthesis.
* denotes statistical significance.

Source: Green, 2010

For post-emergent herbicide applications, it may be difficult to get enough herbicide into the relatively small above-ground leaf area relative to the amount of translocated herbicide required to control the large underground root mass.

Before commencing a herbicide control program, dig up some fleabane plants to check the root development relative to the above-ground biomass. This will assist in understanding the likely weed age and provide insight as to the likely level of difficulty for control using herbicides.

Figure 13: Fleabane tap root development

Fleabane develops an extensive root system, which assists its survival under drying fallow conditions. Flaxleaf fleabane age and root development may not correspond with above-ground plant biomass. It is critical to ensure herbicide control is undertaken before extensive root development has commenced. Large, elongated fleabane will have an extensive root network and a very large tap root. It will be extremely difficult to achieve consistent control of large plants with any herbicide strategy. Photos: Mark Congreve

Stem elongation

Initial fleabane growth is quite slow. European studies have shown that flaxleaf fleabane can take up to 11 weeks to commence stem elongation; however, flowering can occur within 3 weeks of the commencement of bolting (Thebaud and Abbott, 1995).

Australian studies (Green, 2010) showed similar trends, in that late autumn establishing populations took just over 11 weeks (917 growing degree days) to commence bolting. However, spring-emerging plants commenced bolting in 8 weeks (1045 growing degree days).

Plants will remain at the rosette stage where day length is under 10 hours (Wu, 2007).

Typically, flaxleaf fleabane will require an additional 400 growing degree days to move from the commencement of stem elongation to the commencement of flowering (Green, 2010).

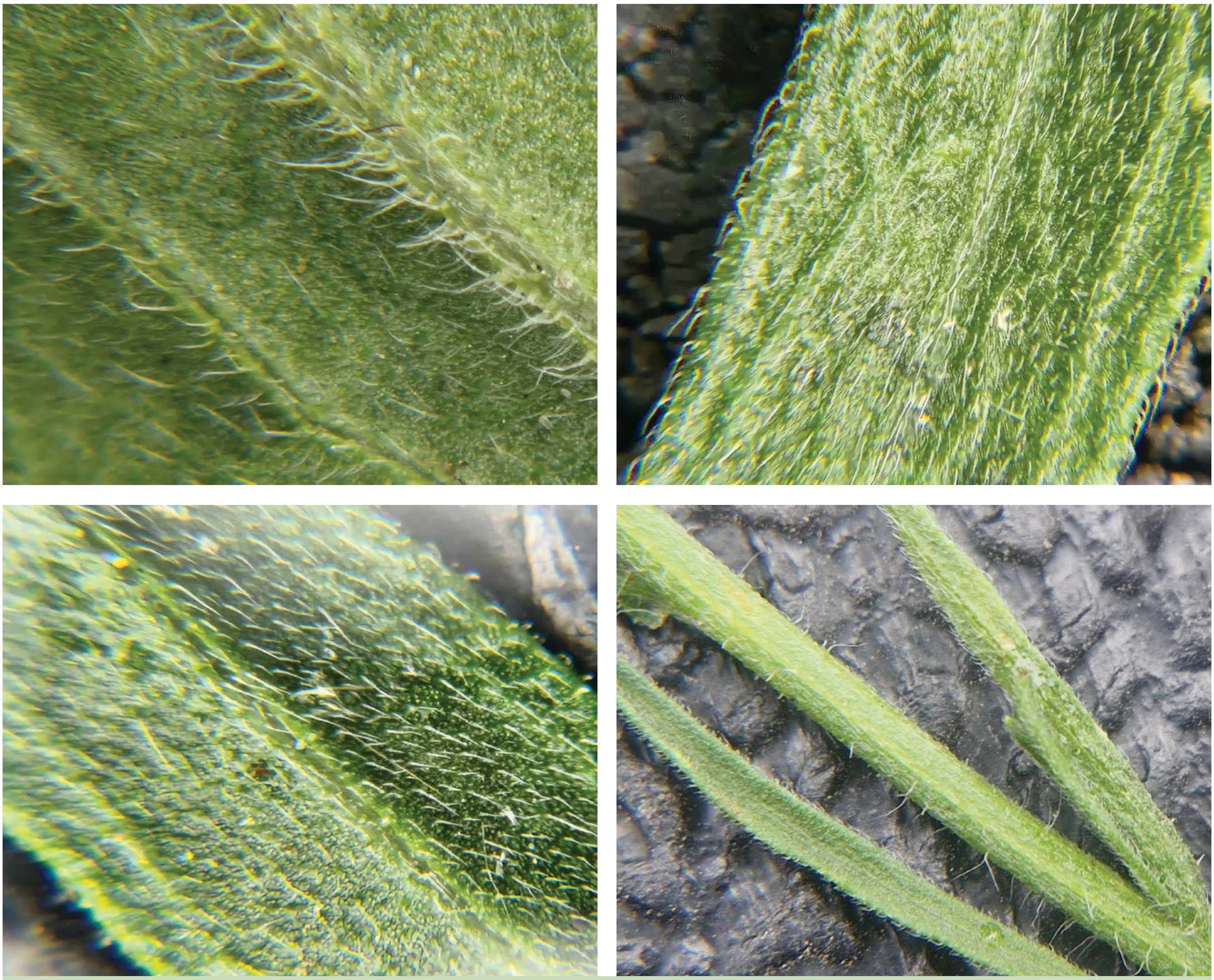
For effective herbicide control it is important to control populations at the small rosette growth stage, and well prior to stem elongation. **Growers targeting elongated/flowering flaxleaf fleabane are dealing with weeds that emerged at least 2 to 3 months prior.**

Flaxleaf fleabane plants typically have 4 to 6 basal buds near the soil surface, which are responsible for its branched stem elongation. This is particularly noticeable where the primary stem has been damaged via grazing, mechanical removal or regrowth following the application of contact herbicides (Wu 2007).

Leaf surface and the impact on spray deposition and leaf uptake

Leaves of fleabane plants are covered by an extensive network of trichomes (fine leaf hairs).

Figure 14: A magnified view of the leaf surfaces



Magnified view of the leaf surface of tall fleabane (top) and flaxleaf fleabane (bottom). Photos: Mark Congreve

Trichomes can be particularly problematic for droplet retention and leaf uptake of many of the key herbicides used for fleabane control. For high levels of herbicide uptake, spray droplets must first be able to be retained on the leaf surface, and then the droplet must be able to contact the leaf cuticle in order for the herbicide to transfer from the droplet into the leaf. If the spray droplet remains suspended on the trichomes and does not contact the leaf cuticle, the droplet will dry and the herbicide within the droplet will crystallise without coming into contact with the leaf surface. Should the droplet dry while still suspended on the trichomes, minimal/no leaf uptake will have occurred.

Achieving good leaf cuticle contact on hairy surfaces such as fleabane leaves is likely to require a good surfactant system within the formulation to reduce the droplet surface tension. This will result in greater droplet retention, while also allowing the droplet to slide down the hairs and contact the leaf cuticle. It is best to choose a formulation containing a quality surfactant package, as choosing the right tank-mixed surfactant can be challenging. Adding a very 'high-spreading' surfactant that causes the greatest reduction in droplet surface tension is likely to provide the best droplet adherence and maximise the spread of the droplet across the trichomes and onto the cuticle. However, these same high-spreading surfactant properties will also significantly reduce droplet size and increase the drift risk for spray applications. These smaller, very high-spreading droplets will also evaporate extremely fast under high Delta T (summer) conditions, meaning subsequently less time on the leaf surface for uptake. This can be particularly problematic for water-soluble herbicides (for example, glyphosate, glufosinate, Group 4 herbicides).

Spray droplet size is also an important consideration, especially for summer applications.

Due to off-target spray drift concerns, all 2,4-D applications must be applied with a minimum of very coarse (VC) spray quality. Very large droplets have much greater weight and will fall much faster than smaller droplets. This is very useful to control the direction of droplet travel and ensure the droplets reach the canopy and are less subject to off-target movement. However, a very fast-moving large droplet will be much more difficult to retain on the leaf surface and will be much more likely to bounce and/or shatter when contacting the leaf surface.

Pro tip

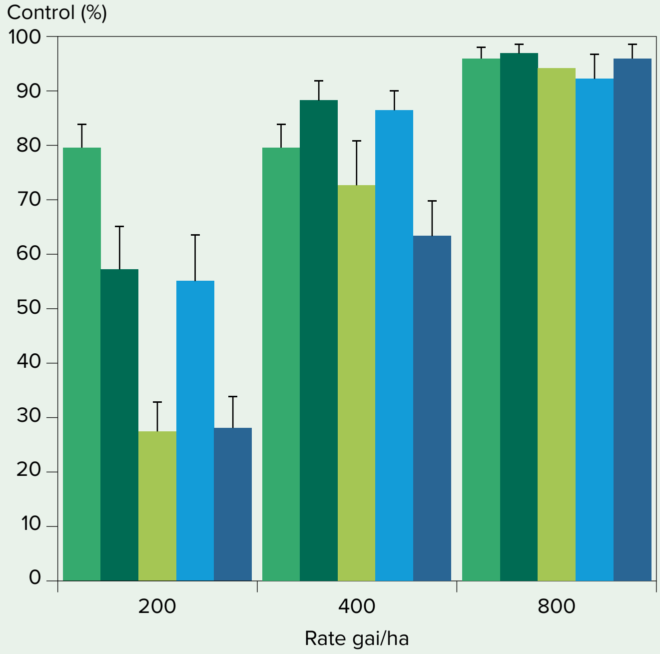
Even in the absence of glyphosate resistance, fleabane is generally poorly controlled by glyphosate at typical fallow application rates. Only a small number of glyphosate labels claim control of fleabane, and typically this is on small weed sizes when used in a mixture with 2,4-D. However, glyphosate will commonly be the base of most fallow sprays, especially where a mixed range of weed species is present.

There are many different glyphosate formulations available in Australia that contain a wide range of glyphosate salts and associated surfactant systems. Different formulations will result in different levels of droplet spread and droplet survival under varying environmental conditions. Likewise, there is an equally large range of possible tank-mixed surfactants available, all which will result in different droplet behaviour characteristics when added to the spray tank.

It is almost impossible to obtain information on how each different formulation affects droplet size, leaf retention, droplet spread and drying time – either for the glyphosate formulation if used alone, or how it interacts with different tank-mixed surfactants (or partner herbicides). At best, you will be guessing when making tank mixes of tank-mixed surfactants and different formulations. It is highly possible that some tank-mix combinations and added surfactants may result in less herbicide uptake into the leaf.

Where glyphosate is to be used as the base for fallow spray applications, the safest strategy is to use a premium glyphosate formulation containing a quality in-built surfactant system. This strategy allows you to be more confident that the in-built surfactant system has been optimised to maximise leaf retention and uptake for that individual glyphosate formulation.

Figure 15: Outdoor pot trial evaluating the performance of 3 different glyphosate products on flaxleaf fleabane when applied alone (columns 1 to 3 from left) at varying application rates, and a fourth glyphosate formulation applied in a tank mix with two different surfactants (columns 4 and 5)



Source: Boutsalis et al., 2018

As can be seen, when a robust application rate was applied to this glyphosate-susceptible population, there was little observable difference between formulation or added surfactant. However, at rates where less than full control was achieved, there was a level of difference between formulations and surfactants. You will have no easy way of knowing the surfactants in the formulation and how they will perform in a tank mix. The simplest and most reliable strategy is to choose a glyphosate formulation known to contain a premium surfactant package.

Additionally, as droplet size increases, the total number of droplets produced from a given spray volume decreases rapidly. (Doubling droplet diameter results in 8 times fewer droplets produced for the same volume of carrier.) Even for a well-translocated product like 2,4-D, spray volume should be increased to at least 70 to 80 L/ha when applying at VC spray quality in light stubble cover, or in an early post-emergent cereal crop. As either stubble or crop interception further increases, or extremely coarse (XC) or ultra coarse (UC) nozzles are selected, spray application volumes should be further increased.

For applications of products where VC spray quality is not mandatory, better leaf deposition may generally be expected by selecting a nozzle that provides a medium (M) to coarse (C) spray quality, especially in situations where lower spray volume applications are to be used.

Smaller droplets have a slower terminal velocity. When encountering the catching surface, slower-moving smaller droplets have greater chance of leaf retention, provided they are not lost to drift before reaching the target. Ensure a low boom height is maintained if using smaller droplets. Smaller droplets will also evaporate much faster than very large droplets.

It becomes particularly challenging under summer (high Delta T) conditions to balance good leaf retention, drying time on the leaf, spray drift management and operational efficiency.

If there was one specific application set-up or surfactant system that was ideal for all situations, then we would all be using it!

Check product labels for spray quality and application set-up recommendations for all herbicides being applied, noting that this may vary between formulations. Always use the droplet size recommended on the product labels and consider if carrier volumes need to be increased to offset lower levels of droplet coverage when applying larger droplets.

For many herbicide applications, efficacy is influenced by spray droplet retention and the amount of herbicide entering the leaf. Attention to correct herbicide application may be the difference between a good result and a poor result.

3. Herbicide resistance

Glyphosate resistance in flaxleaf fleabane was first confirmed in 2010 in Australia, with paraquat resistance first confirmed in 2016. In tall fleabane, resistance to both glyphosate and paraquat was first recorded in 2018 (Heap, 1993–2024).

The frequency of glyphosate resistance is high, at least in the northern grains regions where the majority of resistance testing has been undertaken.

Historically, there has been minimal testing for resistance to paraquat in random surveys. A large study from 2020 to 2021 did not detect paraquat resistance in flaxleaf fleabane, although this study did detect 2 populations of paraquat-resistant tall fleabane from Queensland. While random surveys have typically not identified paraquat-resistant populations to date, some growers and agronomists are reporting observations of flaxleaf fleabane populations with expected high levels of paraquat resistance, particularly from southern NSW and northern Victoria.

How resistant are populations?

A controlled outdoor pot study at the Waite Campus of the University of Adelaide, South Australia, in 2012 demonstrated R/S (resistant/susceptible) factors between 4.7 and 23.6 across 14 known glyphosate-resistant populations collected from roadsides across Australia (Minati et al., 2020). That is, the glyphosate rate needed to be increased 4.7 to 23.6 times to achieve the same level of crop injury (LD50) as the susceptible control.

This compares to earlier work on a range of national populations collected from agricultural and non-agricultural fields over the summer of 2005-06, which reported R/S factors between 1.2 and 6.1 (Walker et al., 2011), suggesting glyphosate resistance factors are increasing with time.

Where paraquat resistance is present, this has been shown to be stronger in older plants, relative to the same plant if treated at the early rosette growth stage (Wu, 2007).

Table 5: Summary of historical resistance-testing of randomly collected flaxleaf fleabane populations

Year	Location	Number populations tested	Sulfonylureas (Gr 2)	Imidazolinones (Gr 2)	2,4-D (Gr 4)	Clopyralid (Gr 4)	Glyphosate (Gr 9)	Paraquat (Gr 22)
2007	SE WA[A]	68					0%	
2014	NE Vic[B]	89	100%			0%	40%	0%
2015-16	Qld/NSW – Cotton[C]						97%	
2016-17	Qld/NSW – Cotton[C]						75%	
2016–18	NSW/Qld[D]	61			0%		100%	
2017-18	WA[E]	94			0%		11%	
2019-20	Sunraysia Riverina[F]	50 64					42% 64%	
2020-21	Sunraysia Riverina[F]	55 57					5% 37%	
2020-21	National[G]				0%		100%	0%
2023	North Coast NSW[H]	10		40%	0%		30%	

A Owen et al., 2009 B Aves et al., 2020 C Koetz et al., 2022
D Jalaludin et al., 2020 E Owen and Beckie, 2020 F Preston et al., 2022
G Widderick et al., 2024 (2 populations of Spray.Seed® – paraquat + diquat – resistant tall fleabane were also detected in this survey)
H ICAN, 2023

4. Monitoring and early detection

Effective control of *Conyza* depends on early detection and continuous monitoring.

Once fleabane is present in the district, there is likely to be a continual source of untreated plants along roadsides and other non-cultivated areas as a source of seed production that will continue to infest minimum-till farming paddocks.

Where winter cropping paddocks contain flaxleaf fleabane seedbanks, the application of an effective pre-emergent herbicide is beneficial in reducing populations throughout winter and possibly into spring, with the length of residual control depending upon both the persistence of the herbicide and the environmental conditions encountered during spring.

Winter crops should be monitored for fleabane germinations and steps should be taken, where possible, to remove these during the cropping phase. There are a range of effective post-emergent herbicide options for use in cereal crops.

Effective post-emergent herbicide options are more limited in pulse crops, often limiting herbicide control options to pre-emergent herbicides applied at planting.

Where fleabane is present in crops at harvest, these paddocks should be prioritised for immediate control post-harvest.

Figure 16: Fleabane will colonise non-crop area sprayed with knockdown herbicides

Glyphosate-resistant fleabane will dominate roadways and non-cropping areas around the farm if glyphosate-based knockdown herbicides are used to keep these areas weed free. Photo: Mark Congreve

5. Integrated control strategies

An integrated control strategy combines multiple management tactics to control fleabane effectively. Stacking different control strategies can rapidly drive down seed production and deplete the seedbank over time. However, as fleabane is well adapted to wind dispersal, it is likely that reinfestation from outside the paddock will be an ongoing problem. Continued vigilance and management is required once fleabane is present in the district.

Growers successfully dealing with fleabane are typically taking a proactive approach to management. Typically, this involves the application of residual herbicide(s) ahead of key expected germination timing, along with a commitment to remove subsequent germinations before stem elongation has commenced.

5.1. Cultural control

There are important cultural management practices that can reduce the impact of fleabane on cropping operations.

Farm hygiene

Fleabane will establish on areas devoid of competition and can be an ongoing source of seed introduction into adjacent cropping paddocks. Where possible, maintain good ground cover on non-crop areas to reduce fleabane establishment.

Spraying fencelines and roadways with non-residual knockdown herbicides will typically result in an environment favouring fleabane establishment, especially if glyphosate is the herbicide of choice and the fleabane population is glyphosate resistant.

Where non-crop areas are to be kept free of all vegetation, it is important to apply residual herbicides prior to the key fleabane germination period – typically this will require residual herbicide application from early autumn.

Paddock selection

Once fleabane is present in the district, wind-dispersed seed may continually infest crop paddocks. Be especially conscious to monitor paddocks downwind of uncontrolled fleabane areas.

Typically, crop competition will be greater in winter cereal crops than in broadleaf crops, so consider crop choice in paddocks deemed to be of higher risk of fleabane incursion or those paddocks that had fleabane seed-set in the previous year.

When choosing the crop to be grown, also consider what knockdown and pre-emergent herbicides are available to manage any subsequent germinations. Typically, there are a lot more herbicide options available for the grass crops (for example, winter cereals), especially if targeting the fleabane when young. There are generally fewer options for post-emergent control in broadleaf crops, especially pulses.

Crop competition

Establishing a competitive crop that achieves rapid row closure will often reduce the ability of fleabane seedlings to establish. Where seedlings have established, vigorous crop competition is likely to also result in a large reduction in plant biomass and associated seed production.

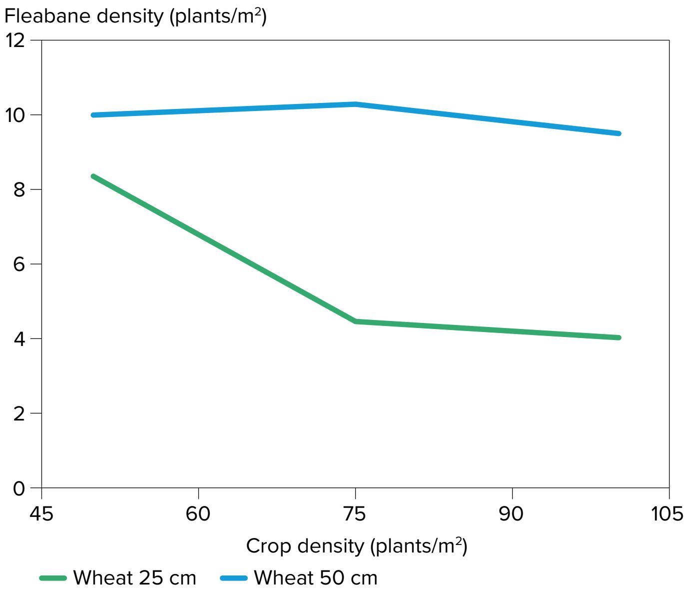
Ensure that there are no missed planting areas within the paddock. Even small areas lacking crop competition are a haven for weeds such as fleabane to set high numbers of seed.

Narrower row spacing will typically increase the crop competition against all weeds, including fleabane (Figure 18).

Figure 17: A missed planting strip allows fleabane to establish

Note, the fleabane has established in the old crop row from the previous year, most likely due to greater soil moisture retention in the stubble line. Photo: Andrew McFadyen

Figure 18: Fleabane plants per square metre were reduced as wheat row spacing was reduced from 50 cm to 25 cm. There was only a minor benefit to increasing plant populations within the row



LSD for row spacing = 4.038 (P = 0.038). Source: Widderick et.al. 2011

5.2. Chemical control

Herbicide control of fleabane species in fallow has always been difficult, even prior to the widespread emergence of glyphosate resistance in recent years. While chemical control alone is not sufficient, it continues to be an important part of an integrated strategy.

5.2.1. Knockdown control in fallow

Achieving consistent knockdown control of established plants is particularly difficult, even with a fully translocated herbicide such as glyphosate or 2,4-D.

Several factors affect performance of knockdown herbicides.

- Flaxleaf fleabane leaves are covered with an extensive network of trichomes (hairs) on the leaf surface, which can make droplet retention and leaf surface coverage extremely difficult. For herbicide leaf uptake to occur, the droplet must contact the leaf surface and not be suspended on the network of trichomes. Adding a spreading adjuvant (typically containing a non-ionic surfactant) may increase droplet penetration of the trichomes. However, this adjuvant system designed to enhance leaf spread by reducing droplet surface tension will also often result in faster droplet evaporation during summer conditions.

- Under spring/summer conditions with rapid droplet drying conditions (high Delta T), there will be less time on the leaf surface for herbicide uptake before the herbicide has become crystalline on the leaf surface and no further uptake will occur. Glyphosate and glufosinate are particularly sensitive, as they require more time in a moist state on the leaf surface as uptake is slower. Higher humidity slows the rate of droplet dehydration and is critical for optimal performance of glufosinate in particular.

- The above-ground appearance of flaxleaf fleabane may not be a true indication of the age of the plant or reflect the extent of underground root development. It is common for uncontrolled fleabane germinating in autumn to sit under a winter crop canopy and only slowly develop above-ground size, while continuing to develop a large root system. Where this occurs, it can be difficult to get enough herbicide into the plant for control due to the extent of the below-ground root system. **Once stem elongation has commenced, fleabane plants will be at least 2 to 3 months old and have a very large root system.**

The net effect is that often knockdown herbicide results can be extremely variable.

A list of the key registered knockdown herbicides has been included at the beginning of this manual. **A key feature is that almost all registrations for knockdown herbicides are particularly sensitive to plant size in order to achieve effective and consistent results.**

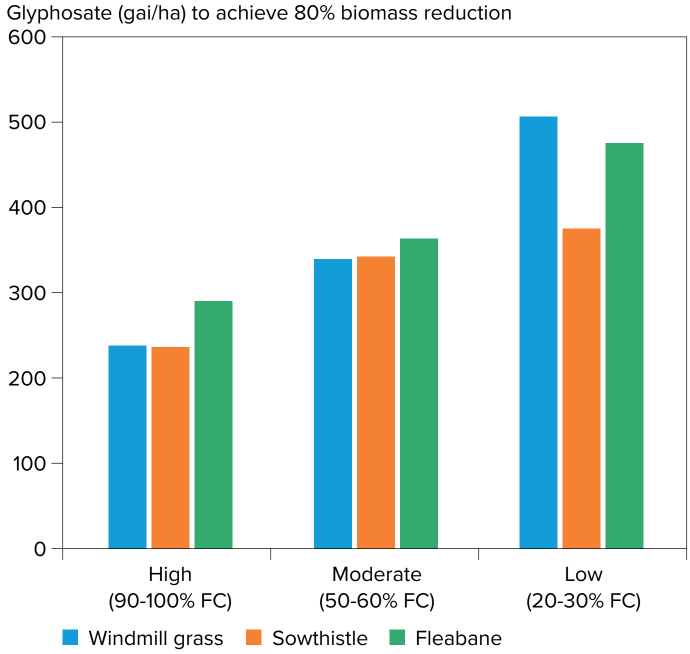
Many GRDC-supported research trials have been conducted over several years to evaluate herbicide response against flaxleaf fleabane farmtrials.com.au/trial_data_explorer.php?action=search&query=fleabane&crop_type_name=&trial_type_cat_id=

Research trials show that to increase the consistency of performance of knockdown herbicides in fallow, consider the following:

- **Always target small weeds, and well before stem elongation has commenced.** Ensure weeds are 'young' and do not have an extensive root system. Weeds should be small (ideally less than one month old and rosettes less than 5 cm diameter).
- Always plan on a double-knock program when targeting fleabane in fallow. Typically, this will be a fully translocated herbicide in the first pass (usually a robust rate of a Group 4 herbicide, or glyphosate plus a Group 4) and followed by a contact herbicide (typically a Group 10, 14 or 22 either alone or in combination).
- Commonly, 2,4-D is often used as the Group 4 product of choice in the first-pass application. This is often a financially driven decision, as 2,4-D is usually the 'cheapest' Group 4 herbicide at the rates required. Other Group 4 herbicides may work equally well when adequate application rates are used (see Figures 20 and 21).
- Often, the addition of a Group 14 herbicide (at labelled 'spike' rates that have minimal residual activity) provides little benefit to a first-pass glyphosate application, especially on larger fleabane, and these mixtures may be antagonistic where summer grasses are also present. It is generally better to use Group 14 herbicides for the second pass of a double-knock application, either alone or in a mix with either paraquat or glufosinate.
- For best results, avoid applying hydrophilic formulations (for example, glyphosate, glufosinate, paraquat) when application conditions are hot and dry (that is, Delta T above 10), both during application and for the hours post-application. Under these hot and dry conditions, droplets will dehydrate extremely fast, and the leaf cuticle will be less receptive for herbicide uptake. As a result, less of the applied herbicide will be able to enter the plant.
- Increase water volume for larger plants or heavy stubble situations.
- Use medium or medium-coarse spray quality to ensure good spray coverage (unless applying 2,4-D based products, which require at least VC spray quality).
- Good soil moisture is also important. Figure 19 shows that a higher rate of glyphosate will be required as soil moisture levels decrease. Target the first pass of a double-knock program as soon as possible after rainfall.

A trial summary, conducted by Grain Orana Alliance in central NSW, represents typical outcomes that are seen across many trials when investigating knockdown control of young fleabane plants prior to planting winter crops (Figure 20). Across these trials, fleabane was small (approximately 5 cm rosette) but already had multiple leaves present. Each treatment was applied alone and also followed by a double-knock of 2 L/ha paraquat 250.

Figure 19: Rate of glyphosate required to achieve 80% biomass reduction under low (20 to 30% field capacity), moderate (50 to 60% field capacity) and high (90 to 100% field capacity) soil moisture regimes



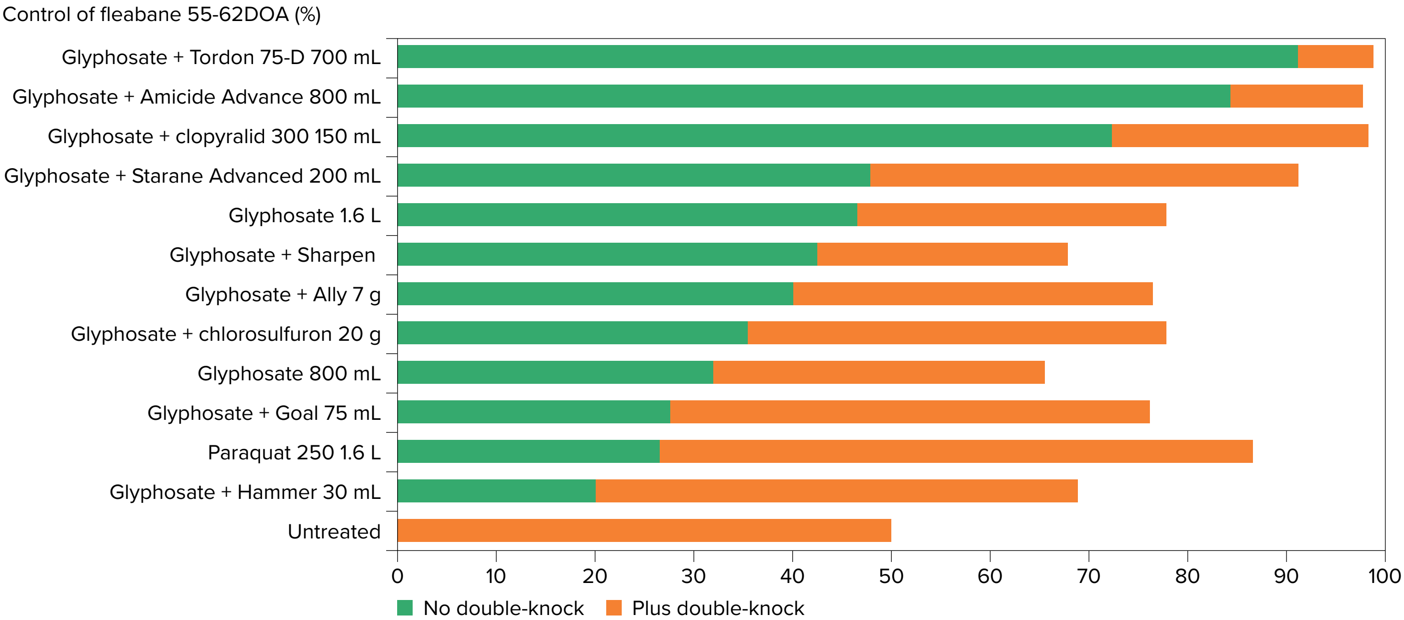
Glasshouse pot trial conducted at University of Queensland, Gatton, on glyphosate-sensitive populations of windmill grass, common sowthistle and flaxleaf fleabane collected from south-east Queensland.

Source: Peerzada et al., 2021

As can be seen from the results, the only treatments able to deliver commercially acceptable, robust levels of control across the 3 trials required a robust Group 4 herbicide in the first pass, followed by a paraquat double-knock. The addition of Group 14 herbicides (for example, Sharpen, Goal, Hammer), metsulfuron (Ally) or chlorsulfuron (Glean) to glyphosate in the first pass provided almost no benefit over glyphosate alone, and typically less benefit than just increasing the rate of glyphosate.

A different trial conducted by Northern Grains Alliance (LB2106 St Ruth, Qld) also targeted knockdown application of an autumn germination of approximately 75% flaxleaf and 25% tall fleabane that was mostly 4 to 6 leaf (4 cm rosettes) at application (approximately 260/m^2) prior to planting wheat. This trial found similar trends. Glyphosate alone, at high application rates, was poor as a single pass. Adding 34 g/ha of Sharpen to glyphosate improved speed of brownout but did not improve the final control over glyphosate alone. Double-knocking these treatments provided only minor improvement in final control. Adding of a range of Group 4 herbicides (at different rates and with different adjuvants) to glyphosate provided significant improvement in final control as a single application, and almost complete control when these treatments were double-knocked. Glufosinate, at optical sprayer application rates, provided high-level control as a single pass or where double-knocked (Northern Grower Alliance, 2021).

Figure 20: Control of young flaxleaf fleabane (5 cm rosettes) from a single application or where the application is followed by a double-knock of paraquat 250 at 2 L/ha



Glyphosate was as Glyphosate 450 at 800 mL/ha unless otherwise stated. Wetter 1000 added to all glyphosate treatments, except Sharpen where Bonza was added, and Hammer where Supercharge was added.
Average of three trials: GOA1230, GOA1231, GOA1232.

Source: GOA, 2012

Note: Herbicide treatments evaluated in this trial series are commonly used pre-plant knockdown mixtures targeting a wide range of weed species; however, several are not specifically registered for control of fleabane. Herbicides not specifically registered for fleabane control have been included in this dataset to demonstrate their performance against fleabane should this weed be present in the paddock at application where they are being applied for other weeds. The results from this series of trials typically reflect why these commonly used pre-plant knockdown mixtures are not registered for fleabane control.

Controlling large plants, post-stem elongation

Northern Grower Alliance conducted a series of 16 field trials targeting advanced fleabane from 2010 to 2013. Across these trials in southern Queensland and northern New South Wales there were in excess of 60 different treatments evaluated, including 19 different active ingredients, 10 different adjuvants and 6 different 2,4-D formulations.

The only treatments that were able to achieve greater than 95% control or biomass reduction in any trial (which would generally be considered commercially acceptable) were some glyphosate + 2,4-D combinations (+/- adjuvants). However, even with glyphosate + 2,4-D, this level of control was only achieved 22% of the time (20 of 92 evaluations).

Table 6: Summary of 19 trials targeting elongating or larger flaxleaf fleabane (Northern Grower Alliance, 2010–13)

Summary of selected herbicide treatments (not all treatments shown)	Rate/ha	No. datasets	Average % biomass reduction	Range
Glyphosate 450	1.5 L	5	11%	0–53%
2,4-D amine + Hasten	Min. of 750 gai	10	54%	4–98%
Glyphosate 450 + 2,4-D	1.5 L + min. of 750 gai	79	76%	26–100%
Glyphosate 450 + Starane Advanced + oil	1.5 + 0.6 or 0.9 L	7	73%	55–94%
Basta +/- Glyphosate 450	3.75 L +/- 1.5 L	7	22%	0–94%
Paraquat 250	2 L	6	41%	7–76%
Glyphosate 450 + Sharpen + oil	1.5 L + 34 g	4	37%	2–81%
Glyphosate 450 + Garlon	1.5 L + 160 mL	4	21%	0–60%

Source: Data compiled from Northern Grower Alliance field trial reports (nga.org.au/trial-summaries)

Note: As can be seen, all treatments are highly variable in final control from a single pass of herbicides applied at these 'broadacre' rates. Fleabane in these trials was considerably larger than the maximum growth stage supported on product labels. Many of these trials were double-knocked with 2 L/ha of paraquat 250 (data not shown), which generally improved control of all treatments; however, even with the double-knock, no treatment was able to consistently control these large plants. Product rates and combinations are included for experimental purposes. Always use registered products and read and follow registered product labels.

Double-knock approach – What is it? How does it work? How to do it?

Users should not expect herbicides to provide consistent and complete control of large, elongating or flowering fleabane plants that will be several months old. Many herbicides can provide significant defoliation; however, large plants often regrow following rainfall, especially if not double-knocked.

The double-knock approach consists of applying 2 different control strategies in sequence. Tactics can be anything that is effective against the weed population – they do not need to be herbicides to achieve the benefits of the double-knock approach. For example, cultivation may be a useful second-pass treatment.

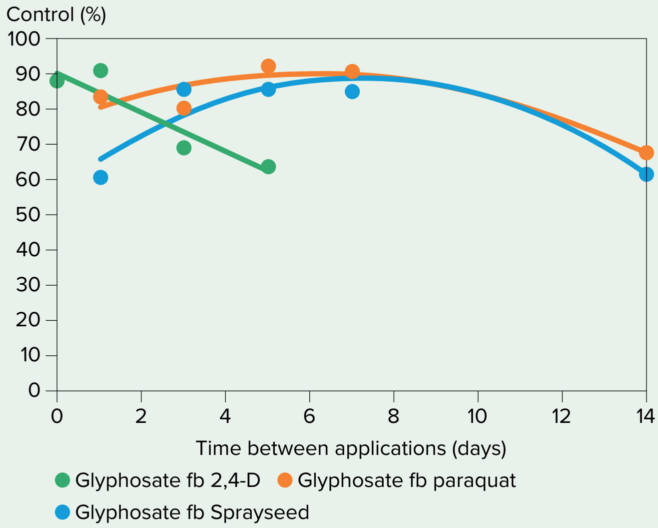
Where resistance is not yet present, the application of a second different management strategy has been shown to substantially increase the time before resistance is selected within the population. It is much harder for an individual plant to develop strategies that can overcome 2 different management tactics and survive the double-knock approach. For this to be effective as a resistance management tool, the double-knock strategy must be implemented before resistance is selected for either tactic.

When a double-knock is used for resistance management, the predominant weed control is being done by the first application, with the role of the second tactic being to control any escapes from the first application. While this approach can be an extremely useful tool for delaying herbicide resistance, it is seldom used in this way in commercial farming as most growers are reluctant to invest the time, effort and expense into applying the second tactic while the first tactic is still achieving very high levels of commercial control by itself.

A more common application of a double-knock approach is where a single herbicide treatment is not providing consistent, effective control of the weed population. In this situation, the objective of this 2-pass program is primarily to achieve satisfactory weed control. In this scenario, there is limited resistance management benefit where the first application is not able to achieve very high levels of weed control by itself. Commonly, this 2-spray strategy will be a systemic herbicide as the first pass (often herbicides from Group 4 and/or Group 9 for fleabane) followed by a contact herbicide as the second pass (often herbicides from Group 10, 14 or 22). If applied in the reverse order, the contact herbicide will typically cause too much physical damage to the leaf structure and reduce optimal translocation of the systemic herbicide(s).

The timing of the second pass needs to allow enough time for the first systemic herbicide to enter the weed and translocate through the plant, yet be applied before the weed can start to recover from the first herbicide. Often traditional double-knocks of a systemic herbicide followed by a contact herbicide are applied from 3 to 14 days apart, depending on weed species, weed size and environmental conditions. Often 5 to 7 days is seen as 'the sweet spot' for targeting grass weeds, and 5 to 10 days for broadleaf weeds such as fleabane.

Figure 21: The effect of double-knock timing on control of 6 to 10 leaf flaxleaf fleabane



Source: Walker et al., 2012

Note that when a contact herbicide is used as the second knock, application is best delayed until approximately 5 days after the systemic herbicide, whereas when 2 systemic herbicides are used in sequence (glyphosate followed by 2,4-D in this case), a short interval between applications will generally result in the highest levels of control.

What to use for the double-knock?

Historically, paraquat or paraquat plus diquat products (Group 22) have been used for the second pass of a double-knock program across many weed species, including fleabane. Provided the first-pass application is reasonably effective, weeds are at the appropriate growth stage, there is no resistance to the Group 22 mode of action, and the Group 22 herbicide is applied correctly (excellent coverage is essential – typically water rates of >100 L/ha will be required), then consistent and high levels of final control can usually be expected when applying the double-knock against many grass and broadleaf species.

However, as can be seen in Figure 22, should the first-pass application not achieve a useful level of activity if applied alone (that is, above 70 to 80%), then the subsequent Group 22 double-knock cannot be relied on to always achieve a high level of final control.

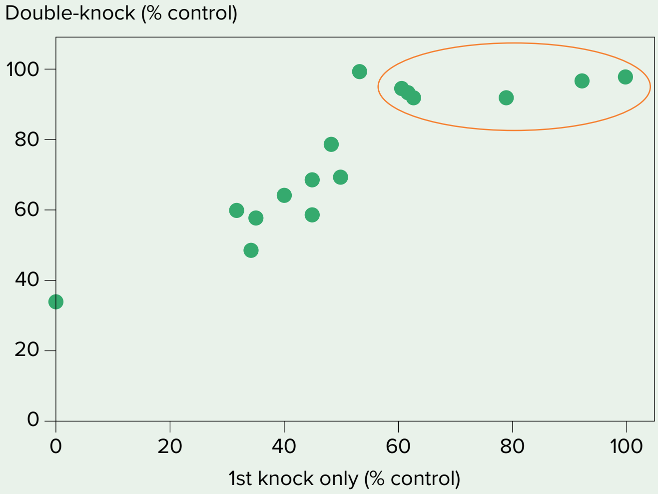
In recent years, substantial trial work has identified alternative double-knock options for the second pass.

The addition of a Group 14 herbicide (at knockdown spike application rates) may often increase the efficacy of a paraquat-based double-knock application, especially on broadleaf weeds such as fleabane (Daniel et al., 2018).

More recently, the use of Group 14 herbicides applied alone (at higher application rates) has shown utility as a double-knock, without the requirement for paraquat as a mixing partner. Terrad'or (tiafenacil) has a label claim for standalone use as a double-knock for fleabane when applied at the highest label rate of 40 g/ha (plus a high-quality methylated seed oil adjuvant).

Additionally, there has been recent interest in exploring applications of glufosinate as an alternative to a paraquat-based double-knock, especially where there are only scattered plants and an optical spot sprayer is available, allowing for cost-effective application of robust application rates.

Figure 22: Data from a range of herbicide treatments across 2 trials in Bute and Pinnaroo (SA) showing the final control of flaxleaf fleabane after the double-knock (vertical axis), relative to the level of control achieved from the herbicide treatment if applied as a first pass only (horizontal axis)



Source: Fleet et al., 2015

This demonstrates that if the first pass application is only likely to provide poor or moderate control, then a successful double-knock result is unlikely to be achieved.

Where herbicides are registered to provide control of larger fleabane plants, much higher application rates will be required, with application generally limited to optical spot sprayer application. Typically, this is only practical where scattered plants are present.

Figure 23 shows the summary of 3 trials conducted on large fleabane (ranging from budding to flowering across the trials) to evaluate 'non-2,4-D' options for use around cotton-growing areas. Data shows the number of glyphosate-resistant flaxleaf fleabane plants surviving/regrowing at 35 to 46 days after application, following application of a range of typical fallow herbicide treatments, mostly applied at optical spot rate application rates.

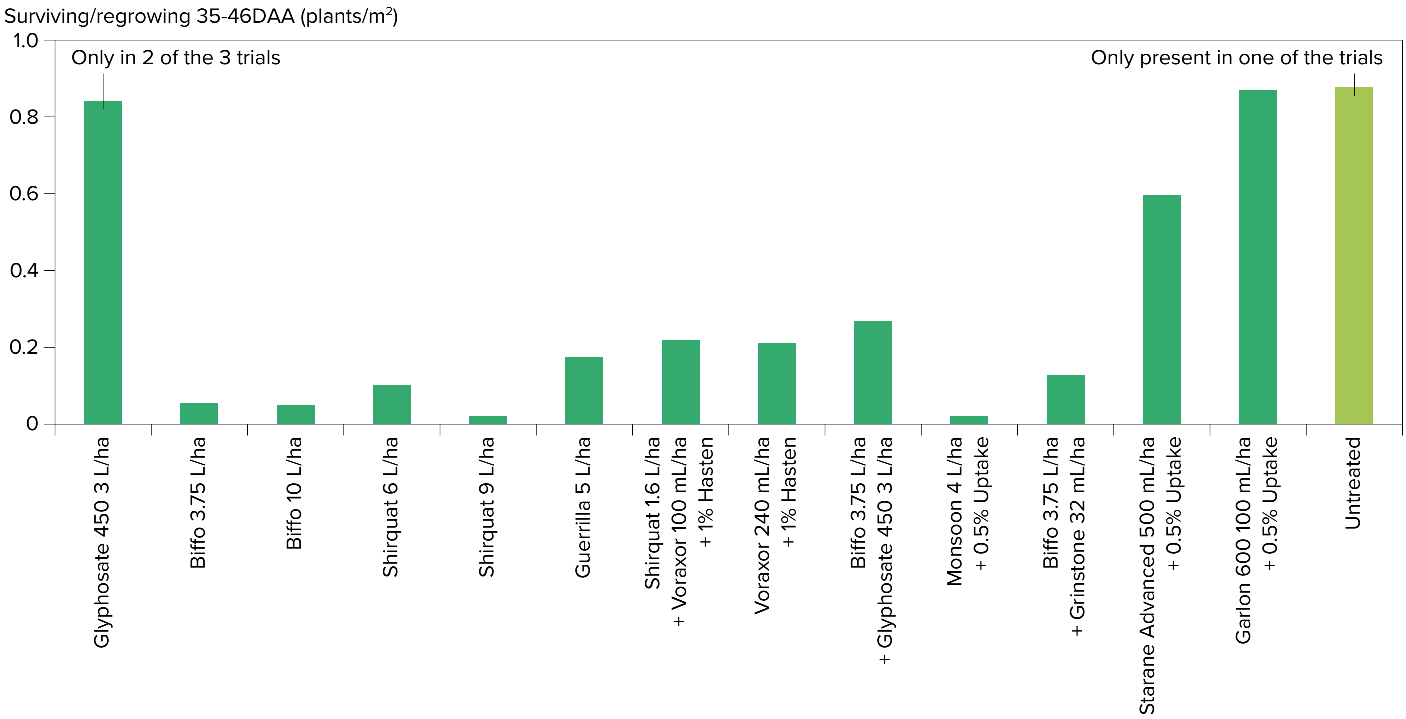
As can be seen, no treatments achieved 100% control across all trials as a single pass, even at these very high 'optical sprayer' application rates.

With the extensive selection of glyphosate resistance in several flaxleaf fleabane populations, many operators have been evaluating glufosinate as an alternative knockdown herbicide option. As of 2025, control in fallow is claimed on some labels of glufosinate products targeting 4 to 6 leaf fleabane when applied as a broadcast application of 3.75 L/ha of a 200 g/L formulation. The Biffo label also claims control of flaxleaf fleabane at up to 40 cm tall when applied as an optical spray application (at up to 30% paddock area treated).

In 2024, 2 field trials evaluated control of glufosinate +/- a range of mixing partners on fleabane (Northern Grower Alliance, 2024). These trials targeted fleabane between the 6 to 8 leaf stage and beginning stem elongation (that is, larger than the registered weed size for the broadcast 3.75 L/ha rate of glufosinate, but smaller than the maximum growth size permitted when using optical spot spraying rates of Biffo). Applications were made at 24° C and 60% relative humidity (NGA2401) and 26° C and 55% relative humidity (NGA2402), which is expected to be ideal conditions for glufosinate uptake.

Across these trials, the 3.75 L/ha of Biffo averaged 89% control, while the 10 L/ha OSST rate delivered an average of 99% control. While these results typically support the weed size and application requirements as per the Biffo product label, it should be noted that this difference in final control between application rates for Biffo alone was not statistically significant at the P=0.05 level for either trial.

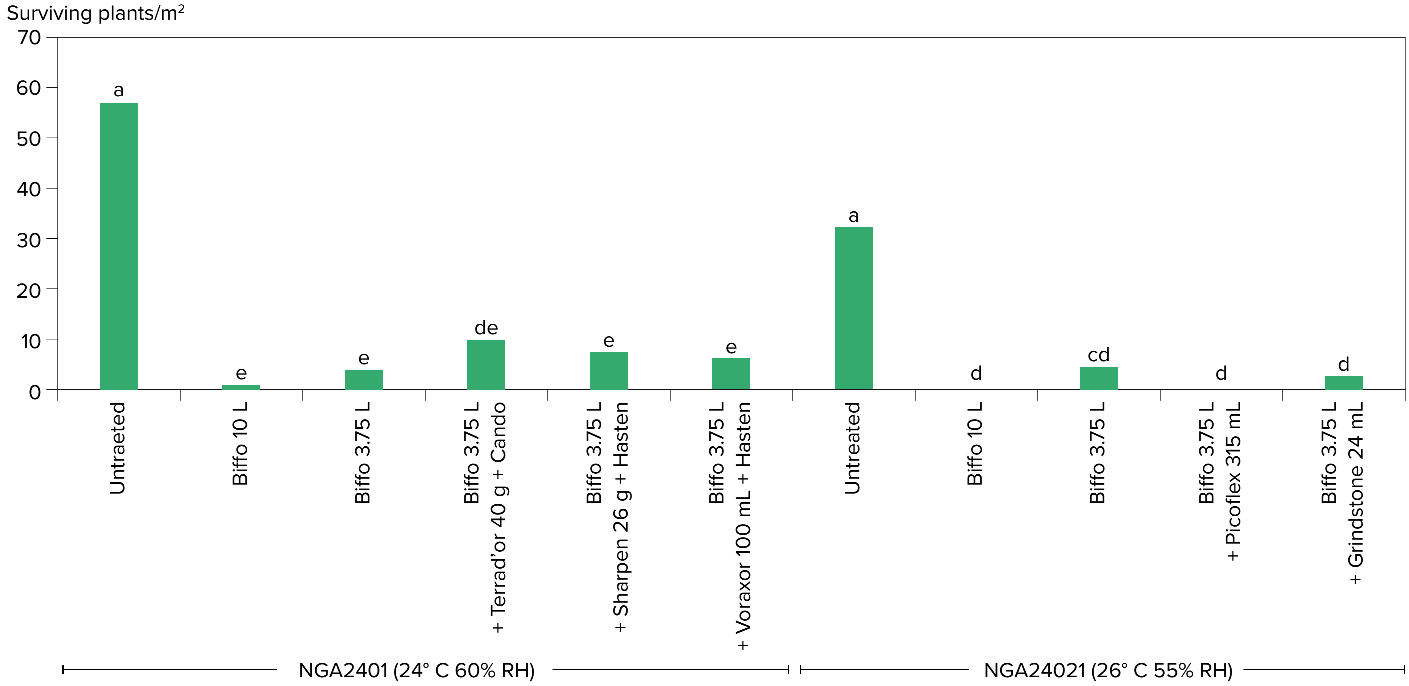
Figure 23: Surviving/regrowing glyphosate-resistant flaxleaf fleabane following a single application of herbicides applied at common optical spot sprayer use rates



Average of 3 trials applied at budding/flowering/maturity NGA2403 (Narrabri), LB2319 (St Ruth), LB2318 (Millmerran).
Data compiled from Northern Grower Alliance field trial reports (nga.org.au/trial-summaries). Some products used here are no longer registered. Product rates and combinations are included for experimental purposes.
Always use registered products and read and follow registered product labels.

In trial NGA2401, a range of Group 14 herbicides were added to the 3.75 L/ha rate of Biffo, while in trial NGA2402, the Group 4 herbicides Picoflex and Grindstone were also tested in a mix with the 3.75 L/ha rate of Biffo. Neither trial recorded a significant improvement in control with the addition of mixing partners over Biffo alone at the same rate.

Figure 24: Efficacy of Biffo (glufosinate) +/- potential mixing partners on 8-leaf to early stem elongating flaxleaf fleabane



Product rates and combinations are included for experimental purposes.
Always use registered products and read and follow registered product labels.

Source: Nothern Grower Alliance, 2024

5.2.2. Residual control in fallow

Where subsequent germinations are expected in the fallow, it is common in northern farming systems to include an effective residual herbicide early in the fallow spray program. The residual herbicide is typically included with the second pass of a double-knock program for best results. However, if the second pass is planned to be applied by an optical spot sprayer, then the residual herbicide may need to be applied as a blanket application to the whole field via the first spray pass.

Picloram (Group 4), terbuthylazine (Group 5), flumioxazin (Group 14) (at residual rates) and isoxaflutole (Group 27) based herbicides will all provide extended residual control of fleabane in the fallow. The choice of which herbicide to use largely comes down to the rotational crop to be grown in that paddock. Check individual product labels for rates, application instructions and plant-back periods to rotational crops.

Typically, these residual herbicides at their registered application rates will consistently provide approximately 60 to 80 days of residual control in most situations. Longer periods of residual control are sometimes seen – typically where there are extended periods of dry soil post-application and therefore reduced rates of herbicide degradation. Residual control past approximately 100 days after application is generally highly variable and should not be relied on.

Figure 25: Fleabane plants will establish where no residual herbicide has been applied

In this winter fallow in preparation for cotton, residual herbicides have been applied to the furrow only, with scattered fleabane plants establishing primarily along the tops of the formed beds where no residual herbicide was applied.
Photo: Mark Congreve

5.2.3. Winter cereals

Controlling flaxleaf fleabane during the winter cereal phase is important for integrated management. Typically winter cereals make up a large percentage of cropped area on most Australian broadacre farms. Coupled with this, there is a range of effective fleabane management strategies that can be implemented in the winter cereal phase. Therefore, a successful integrated fleabane management program will centre around having winter cereal paddocks exit the cropping phase clean of fleabane. This will then make it easier to manage the fleabane problem over the rest of the crop sequence.

Where fleabane seedbank is present, it is common in northern farming systems for fleabane to germinate in late autumn/early winter if conditions are suitable. If not controlled, these individuals will continue to develop an extensive root system throughout winter. After harvest of the winter crop and the removal of crop competition, these established fleabane plants will rapidly commence stem elongation as day length increases. Once stem elongation has commenced, herbicide control becomes extremely difficult and variable.

Therefore, it is important to know the seedbank status of the paddock. Where this is considered high, a residual herbicide applied at planting may be considered. Callisto (mesotrione Group 27) and residual rates of Voraxor (saflufenacil + trifludimoxazin Group 14) are registered for pre-emergent control of autumn-germinating fleabane in winter cereals; however, it is unlikely these herbicides applied at planting would be expected to continue to control spring-germinating populations. Mateno Complete (aclonifen + pyroxasulfone + diflufenican Group 32 + 15 + 12) can also be applied after wheat or triticale have emerged but prior to fleabane emergence.

After crop emergence, continue to monitor winter crops for fleabane germinations and ensure these are removed prior to harvest with a suitable post-emergent herbicide application. There are a range of post-emergent herbicides available that will control young fleabane in the crop (see the table at the start of this manual).

Typically, post-emergent herbicide application rates that can be applied in the winter cereal crops are rate limited due to crop tolerance, so it is important to ensure knockdown applications are **targeted to young weeds soon after emergence**.

Should environmental conditions be suitable, it is also possible for fleabane to germinate and establish in spring in the winter cereal crop, especially where there are gaps in the canopy. There are very few herbicides registered for late application in cereals that are effective on fleabane, and coverage of these small, germinating weeds in a dense crop canopy will be difficult.

- Some saflufenacil products (for example, Sharpen) support application from 'watery ripe' growth stage (BBCH 71) to 'early dough' growth stage (BBCH 83).
- Some 2,4-D amine products (for example, Amicide Advance) support application after the 'firm dough' crop growth stage for desiccation of broadleaf weeds in general.

These use patterns may assist in suppressing fleabane late in the crop, depending on the size and age of the fleabane seedlings and spray coverage achieved.

Knockdown + extended residual control with pyridine-based herbicides

Picloram, clopyralid and aminopyralid-based herbicides provide both knockdown and some level of extended residual control of fleabane.

For extended control, high label rates of picloram-based products can be applied prior to planting winter cereals. Where registered pyridine herbicides are applied in-crop and residual control is desired, it is important to time applications at the early post-emergent crop stage, and well prior to canopy closure. To achieve extended residual control, these herbicides must reach the soil, so best residual control will be achieved where crop foliage interception is low and higher levels of herbicide reach the soil. Often these herbicides will be applied when weeds are small, often around early tillering, or proactively before any fleabane has germinated.

Growers using pyridine-based herbicides for extended residual control of fleabane need to be aware that if this chemistry group is applied late post-emergent with full canopy cover, the increasing level of crop interception of spray droplets leads to increased potential for herbicide to remain in cereal stubble following harvest. This stubble-bound herbicide can subsequently be returned to soil as the stubble decomposes. If a sensitive pulse crop is growing at the time of stubble decomposition, then this may contribute to pulse-crop damage. (For more information refer to the GRDC fact sheet Rotational constraints for pulse crops following the use of aminopyralid, clopyralid and picloram herbicides.)

Applying pyridine herbicides late post-emergent generally results in poorer knockdown (greater weed seedling shading), reduced length of residual control (less herbicide reaching the soil) and potential for greater herbicide residues in cereal stubble (more crop interception and less time for degradation in the crop). Best results will generally be achieved by timing application to early post-emergent, which improves efficacy and residual control, and also reduces the potential for herbicide carryover in the stubble.

Preventing fleabane blowouts after harvest

A common scenario when encountering fleabane for the first time is for growers to be unaware of the problem in the winter cereal crop until harvest, as small weeds will be sitting below the canopy. Often farm operations are too busy to prioritise fallow spraying until after harvest, with growers then seeking a reliable herbicide strategy to control plants now in an advanced growth stage.

Without access to an optical spot sprayer, which may allow the application of very high rates to scattered plants, there are no consistent and effective herbicide solutions available for elongated or flowering fleabane. Allowing fleabane to reach this growth stage typically results in either poor control, leading to a massive increase in seedbank replenishment, or the grower needing to resort to full tillage for effective control.

Significant research over many years seeking consistent and effective knockdown of elongated or flowering fleabane at typical 'broadacre' application rates has not had great success. Herbicide labels accurately reflect maximum growth stages for consistent fleabane control.

Sometimes a strategy of a high-rate Group 4 herbicide (typically a 2,4-D based option) plus glyphosate followed by a double-knock of either paraquat or glufosinate (either applied alone or with a Group 14) may achieve acceptable control of plants that have started stem elongation; however, results are often inconsistent and generally cannot be relied on. Further, this high-rate phenoxy-based strategy will often need to be applied at a time of year when there may be sensitive broadleaf crops (for example, cotton and grapes) in close proximity.

In the northern region, where growers have been dealing with this scenario for several years, fleabane has forced growers to change their management strategy. Almost all northern growers will now have a proactive strategy to manage fleabane in the winter cereal cycle. Typically this consists of at least 2 or 3 of the following tactics:

- Start the winter crop clean of fleabane by the application of an effective double knockdown program and/or a residual herbicide applied prior to sowing.
- Ensure all autumn/early winter germinating fleabane are controlled in the winter cereal with a post-emergent knockdown herbicide. There are several effective herbicides now registered to achieve this.
- If spring germinations are predicted in the paddock, then a Group 4 pyridine herbicide with extended residual activity is likely to be chosen for the early post-emergent application.
- 2,4-D or Sharpen applications may provide some biomass reduction of escapes. Ensure appropriate crop growth stage when making these applications.
- Commence spraying of the fallow immediately post-harvest, which is likely to require a 2-pass (double-knock) strategy.

  Generally, if an optical sprayer is available to apply the second pass, better results can be achieved and costs reduced.

  It is becoming increasingly popular for operations that have limited manpower available during the busy harvest period to have access to an autonomous optical spot sprayer. Where this system is available, the autonomous sprayer can be completing 'on-time' herbicide applications in the recently harvested crops, while farm labour is directed to completing the remaining harvest.
- **Inclusion of an effective residual herbicide with efficacy on fleabane at the commencement of the fallow is a critical component.**

Selection of which tactics to employ will be an individual farm decision. However, **the key is to ensure that fleabane does not commence stem elongation before it is controlled.**

5.2.4. Broadleaf crops

Fleabane management in broadleaf crops is often limited to paddock selection (choosing a paddock with expected low seedbank pressure), an effective knockdown pre-planting, and application of a robust residual herbicide at planting.

If the paddock is known to contain a high population of fleabane seed, then choosing a winter cereal crop is likely to provide a wider suite of management options for that paddock.

In pulse crops, there are no effective early post-emergent herbicides registered for control of fleabane. Management tactics will require at-planting residual herbicides in combination with crop competition once row-closure is achieved.

Figure 26: Ensure a robust pre-emergent strategy is applied at sowing of broadleaf crops to prevent fleabane

There are no effective registered post-emergent herbicide options for knockdown control of fleabane in pulse crops. Ensure a robust pre-emergent strategy is applied at sowing. Photo: Mark Congreve

Sharpen (saflufenacil) can be applied late in some pulse crops as a dessicant prior to harvest (see label for application timing for individual pulse crops). This may provide some biomass reduction of any fleabane present at the time of application.

There are no herbicide registrations for post-emergent fleabane control in canola. However, Lontrel (clopyralid) can be used in canola for a range of other broadleaf weeds at application rates that are the same as those rates used for control of fleabane when applied in cereal crops.

Harvest broadleaf crops as early as possible in the spring (before any surviving fleabane plants have had a chance to set seed) and be prepared to apply a double-knock herbicide treatment immediately after harvest.

In cotton systems, the recent commercialisation of XtendFlex® herbicide tolerance technology (cotton varieties with tolerance to glyphosate, glufosinate and dicamba) can provide a robust integrated solution in this crop, including management of glyphosate-resistant flaxleaf fleabane populations. Shadehouse trials conducted from 2014 to 2017 at Toowoomba by Queensland Department of Primary Industries on both glyphosate-susceptible and glyphosate-resistant fleabane populations showed that glyphosate + dicamba; dicamba followed by glufosinate; or glyphosate + dicamba followed by glyphosate (at rates applicable in XtendFlex cotton varieties) all achieved 100% control of 8 to 10 cm diameter fleabane. In these same trials, dicamba alone achieved 80 to 100% control and glufosinate alone achieved 79 to 99% control (Werth et al., 2021).

5.3. Biological control

Considerable research has been conducted in Australia to evaluate biological control (biocontrol) agents that may target flaxleaf fleabane.

For possible commercial release of biocontrol agents, the following steps must be undertaken:

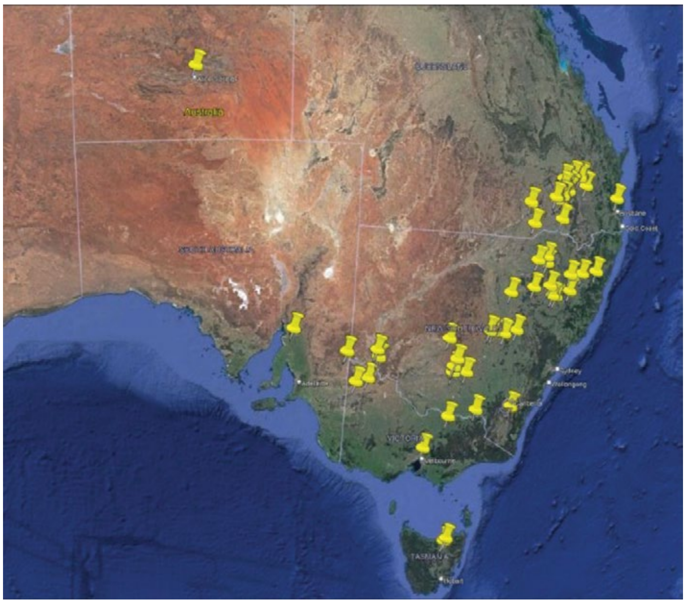
- identification of potential agents (typically from outside Australia)
- screening of candidate agents for efficacy against Australian fleabane populations
- evaluation of the potential for impact on other species (typically a biocontrol agent should be specific to the target pest only)
- evaluation of the ability of the biocontrol agent to persist in the environment after release.

The fleabane biocontrol project is being led by CSIRO. From this research, a primary lead candidate organism has been identified – the microcyclic rust fungus *Puccinia cnici-oleracei* from Colombia (South America). A stem-boring weevil, *Lixus caudiger*, from Brazil is also under evaluation (Gooden, 2023).

The rust fungus demonstrated good efficacy under glasshouse conditions (Figure 27) and was specific to fleabane, so was advanced to outdoor trials in 2021.

Field-scale release trials commenced in 2022-23 (Figure 28), with further work ongoing. It is possible that initial spread of infection is likely to be slow, as it can often be difficult to maintain biocontrol agents on populations of annual weeds, especially on species that are not present year-round. Without the host weed or another suitable vegetative source, the biocontrol agent typically declines as it cannot complete its life cycle. Other biocontrol programs have shown that it can take several years for biocontrol agents in annual weeds to establish successfully in the native environment.

Figure 28: Distribution of field-scale release sites of the rust commenced in 2022-23



Source: Gooden, 2023

Figure 27: Symptomology of the rust fungus *Puccinia cnici-oleracei* affecting fleabane leaves, stems and flowers

Source: Gooden, 2023

5.4. Mechanical control

As fleabane is a small-seeded species adapted to surface germination, strategic cultivation can be a very effective tool in integrated fleabane management programs.

Effective cultivation can remove elongating fleabane that are otherwise difficult to control with herbicides. However, the cultivation machinery selected must be able to deal with the large root system of mature plants, so a blade plough, sweeps or aggressive offset discs are likely to be required for effective control of elongated plants.

Burial of seed greater than 2 cm places seed in a location from which it is unlikely to establish (see Figure 9). In farming systems where some level of cultivation is routinely used, fleabane is often seen heavily infesting adjacent roadways and paddock perimeters with minimal fleabane establishing within the paddock itself.

While cultivation can be used as a tactic to bury a high portion of the seedbank to a depth from which it is unlikely to emerge, it is unlikely that any cultivation technique other than full inversion tillage will bury every seed to the required depth. Therefore, follow-up control of any subsequent germinating plants should always be planned after a cultivation event, either by the application of a residual herbicide post-cultivation or a robust knockdown herbicide application after the next rainfall event post-cultivation.

Figure 29: Tactical cultivation as a management strategy

Cultivating paddock edges can be a tactic to reduce the prevalence of surface-germinating weeds such as fleabane that may be coming in from adjacent areas. Photo: Mark Congreve

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Notes

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