

On Property Management of Branched Broomrape

A BEST PRACTICE MANUAL FOR BROAD ACRE, HORTICULTURE, GRAZING,
LIFESTYLE AND ORGANIC LAND USES

This manual is based on research undertaken in South Australia. The life cycle, host list, potential distribution and control measures apply to Australian conditions

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growing
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regions



Government
of South Australia

Biosecurity SA

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Designed by Jade Kraus

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USING THIS MANUAL

Branched broomrape is a parasitic weed that grows in many different locations on a property and across the landscape. You may find it in on hosts in your crops, in the scrub or bushland, along laneways, in your pasture or on roadsides. As you need to manage branched broomrape over all your property this best practice manual has been produced to address all the situations you may encounter.

You may not need to read this complete manual. Select the section that is relevant to your farming enterprise.

- If you want to know about the **biology of the weed** - Read the **Introduction and Chapter One**.
- If you are **developing an on-farm biosecurity plan** – Work through the risk assessment in **Chapter Two**.
- Choose those sections that **match your weed control aims** and the **properties' enterprise and landscape mix**.
- If you own a **scrub or bush block** see **Chapter Two**.

The information is up to date as at May 2013. Check with your reseller for the latest in herbicide options.

COMPANION PUBLICATIONS

Farm biosecurity manuals that provide best practices techniques and guidelines to minimise the risk of introduction of pests onto properties are available from the Plant Health Australia website www.planthealthaustralia.com.au or the farm biosecurity website www.farm.biosecurity.com.au that also provides other useful information such as risk assessment templates and checklists.

A Compendium that describes the research undertaken in South Australia from 2000 to 2013 is located on the Primary Industries and Regions SA (PIRSA) website and the Branched Broomrape website - www.branchedbroomrape.net.au

IMPORTANT NOTICE

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KEY MESSAGES

The principles of branched broomrape control apply to all weeds. Think ‘Farm Biosecurity’ and how to manage the cropping undesirables – weeds, insects and fungus diseases. It’s all about managing risks and the level of risk you can accept. Minimise the impact of the undesirables you have and work towards preventing new arrivals.

TO PREVENT THE INTRODUCTION OF BRANCHED BROOMRAPE:-

- Only have clean machinery come onto the property–
 - o Prevent contaminated soil coming onto the farm – in bulk or on ground engaging equipment or contractor’s machinery.
 - o Clean chaff or straw from harvest and haymaking equipment.
- Buy clean hay
- Aim for excellent host weed control in all crops
- Be vigilant when you grow a host crop
- Follow normal good practice for bought in or agisted stock and bring them onto the farm through a dedicated quarantine paddock that you can check for weeds.
- Use your farm utility to inspect stock and crops and carry visitors around the farm.

TO MANAGE BRANCHED BROOMRAPE AIM TO REDUCE THE SEED BANK AND PREVENT SPREAD:-

- Know where the weed is located
- Adopt the principles of prevention for clean parts of the property
- To prevent contamination of produce
 - o Aim for excellent host weed control in all crops
 - o Select host crop varieties where herbicides can strip attached broomrape plants
- Consider continuous cropping to enable long term host control
- Control host weeds in fence lines and scrub
- Herbicides will control hosts in pastures and can improve pasture quality
- Remove host weed sources - How many fences do you need?
- Expensive fumigation will almost destroy the seed bank

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INTRODUCTION

Branched broomrape is an annual root parasite of broad leaved dicotyledonous (two leaves at germination) plants such as vegetables and canola, but not grasses such as cereal crops. It extracts all its nutrient and moisture from host plants and has no leaves or chlorophyll and does not photosynthesise, so needs a healthy host plant to produce high numbers of flowers and seeds.

In common with other pests, landholders are responsible for assessing their own on-farm and property risks in relation to branched broomrape and working out how to grow produce that meets standards set by markets. Branched broomrape joins the range of weeds that require active management decisions.

- The Australian strain of branched broomrape will host on at least 45 crop, ornamental or weed species so may be present on a weed in a crop or attached to the crop plants themselves.
- The weed requires management effort across a wide range of enterprises.
- The number of on farm enterprises varies between properties and so will the best practice options for this weed.
- Best practice management of the weed is based on two simple principles: -
 - o Preventing the incursion of the weed onto your property.
 - o Denying the parasite the opportunity to set seed.

This manual describes how to manage branched broomrape across a range of enterprises and land uses. You may not have to read it all to develop a plan for your property.

Scientific research indicates that branched broomrape will grow in free draining, alkaline soils outside the Murray Mallee, so has the potential to spread across the predicted Australian range (see map on page 12).

Branched broomrape is classified as a noxious weed in the “natural resources management” legislation of most States across Australia, so will be subject to the policy applying under these arrangements. Check with your relevant State/Territory authority on the legal status of broomrape in your area.

THE THREATS FROM BRANCHED BROOMRAPE

The presence of branched broomrape may be both a production and marketing issue. The threats remain but have been put into context through experience gained during the 12 year eradication program and more is now known about how the weed behaves and its control in Australian production systems than in the year 2000.

PRODUCTION ISSUES

The branched broomrapes are parasitic weeds of a wide range of broadleaf crops in the Mediterranean, Europe, Central Asia, the Middle East, South Africa and North, South and Central America. A single form of branched broomrape was discovered in 1992 near Bowhill in the Murray Mallee of South Australia and was the subject of an eradication program for 12 years from 2001 to 2012.

When present in high numbers this weed will reduce yields and quality of host crops. The branched broomrapes are one of several broomrape species that infest 16 million hectares worldwide. They affect around 50% of the world’s sunflower crops, 35% of the world’s faba bean crops and 45% of the world’s lentil crops. In some areas, production of pulses has been abandoned because of broomrape. Dense infestations are reported to cause production losses of up to 75% in tomatoes and 90% in rapeseed (canola), limiting farmers with the weed to growing only non-host crops.

The branched broomrape found in Australia has a wide host range that includes horticultural crops, so there is

potential for yield reduction due to direct parasitism of host crops if the weed is not effectively managed.

MARKET ACCESS ISSUES

Several countries have import regulations prohibiting the presence of branched broomrape seed as a contaminant in produce or its import as seed. These countries include China, Indonesia, Iran, Japan, Malaysia, New Zealand, North Korea, Tunisia, the USA and the South American SENSEA group.

While broomrape is listed as a prohibited import by these countries, certification of freedom for Australian produce has only been required by importers of legume pasture seeds for sowing. The national grains industry standards, set by Grain Trade Australia, recognize that branched broomrape is now established and appropriate technical standards have been established for grain.

At the local and regional level, the presence of broomrape may affect the sale of high risk produce such as host rich hay or seed potatoes.





Chapter 1

Chapter 1

BRANCHED BROOMRAPE - THE PLANT

This chapter provides information on the lifecycle and biology of branched broomrape. understanding the lifecycle – how the plant grows, how seed disperses and spreads – will help target best practice management strategies and get the best results.

IDENTIFICATION OF BRANCHED BROOMRAPE

Branched broomrape is an annual root parasitic plant that extracts all its nutrients and water from host plants. It has no leaves or chlorophyll and does not photosynthesise, so needs a healthy host plant to produce high numbers of flowers and seeds.

Underground, branched broomrape's attachment to the root of the host plant is usually through a thickened stem or tubercle up to 8 mm in diameter. The tubercle develops numerous root-like structures spreading into the soil.

Branched broomrape flowering stems emerge from as deep as 150 mm below the soil surface and carry small, purplish scales instead of leaves. Stem colours range from straw coloured through light brown to almost black on dead, weathered plants.

The flowering stems of branched broomrape branch from near ground level. Plants can have 10 or more branches but single-stemmed plants are quite common, particularly in lower rainfall years.

Flowering stems typically grow to 10 cm high above the soil surface.

The flowers are tubular, about 15 mm long and are usually light blue to violet in colour.

Up to 1,000 minute, dust-like seeds, about 0.2 mm long, are contained in each dry, oval capsule about 5mm long.

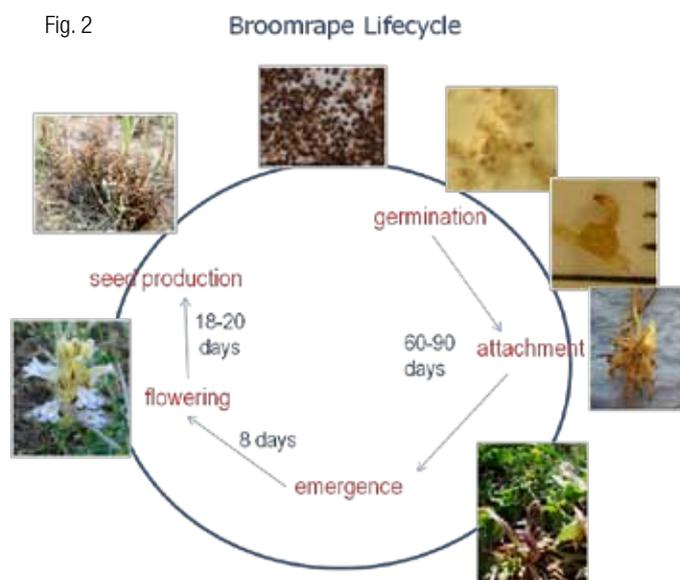
BRANCHED BROOMRAPE AND ITS BOTANICAL NAME

The branched broomrape found in Australia is now given the botanical name *Phelipanche mutelii* but many publications still refer to it as *Orobanche ramosa*.

P. mutelii is found in free draining, alkaline soils in its home environment in the Mediterranean basin. This may explain why our branched broomrape is regularly discovered in Mallee soils but not heavy river flats.

This manual is based on research undertaken in Australia so the host list, life cycle, potential distribution and control measures apply to Australian conditions.

Fig. 2



BROOMRAPE LIFECYCLE

Broomrapes spend most of their growing period below ground, with only the flowering stem emerging from the soil at plant maturity.

Broomrapes are a parasite and cannot survive without a host plant.

Branched broomrape seeds, which are extremely small and have few reserves, have two mechanisms that maximise their chances of attaching to host roots.

They will germinate: -

- Only in response to a chemical signal from the roots of host plants, and
- Preferentially but not necessarily after wetting up in the soil for a few days.

The optimum temperature for broomrape seed germination in the laboratory is 18 - 22°C but germination can occur at temperatures between 10 and 25 °C.

Germinating seeds have a root-like germ tube that can grow only a few millimetres before seed reserves are exhausted. If it has not attached to a host root it dies.

When the germ tube reaches a host root, it forms an attachment called a haustorium, see Figure 2. Broomrape accumulates nutrients and water from its host through the haustorium, developing a bulb-like structure called a tubercle.



Figure 2: A newly germinated broomrape seed attaches to a host root via a structure called the haustorium.

A shoot bud forms at the top of the tubercle that eventually becomes the flowering stem.

Additional root-like structures also grow from the tubercle, giving it a star or spider-like appearance.



Figure 3: Tubercles (commonly known as 'spiders')



Figure 4: A single spider (tubercle)

Soil temperature is the main factor that determines the period between host root attachment and emergence of the flowering stem. Development occurs faster at higher temperatures. In host-testing studies of the South Australian strain of broomrape, emergence of the parasite has been seen from 90 to 120 days after sowing crops.

Flowering begins within six to nine days after the stem emerges above the ground (see Figures 5 and 6) and seed production takes place within a further 18-20 days.



Figure 5: A newly emerged flowering head.



Figure 6: A young flowering plant.

Hosts that are slow to develop root systems will result in later emergence of branched broomrape because they will trigger germination of the parasite later in the season.



Figure 7: Attachment on Cretan weed roots.



Figure 8: Attachment to a carrot just before emergence. Note the potential for nutrient 'drag'.

OBSERVATIONS IN THE FIELD

Branched broomrape emergence has been observed from July to December under rain-fed conditions in South Australia but peak flowering has consistently occurred in November.

Ripe seed is likely to be present from the first week of October.

Dry branched broomrape plants can remain recognisable for at least 12 months after flowering, provided they are not grazed or otherwise physically damaged, see Figures 9 and 10.

Within its range in South Australia, branched broomrape is found in alkaline, well-drained, sandy soils.

SUMMARY OF HOW BRANCHED BROOMRAPE GROWS

- Branched broomrape is an annual parasitic weed that establishes from seed each year
- Plants start growing in autumn with the start of the season
- The weed attaches to host roots through the growing season
- Branched broomrape can host successfully on summer weeds
- Plants flower and set seed in spring
- Under irrigation
- Branched broomrape can grow any time a host grows
- Host crops with a short growing season of less than 90 days can 'beat' branched broomrape as they are harvested before the parasite completes its life cycle.

Figure 9: Dry branched broomrape post flowering.

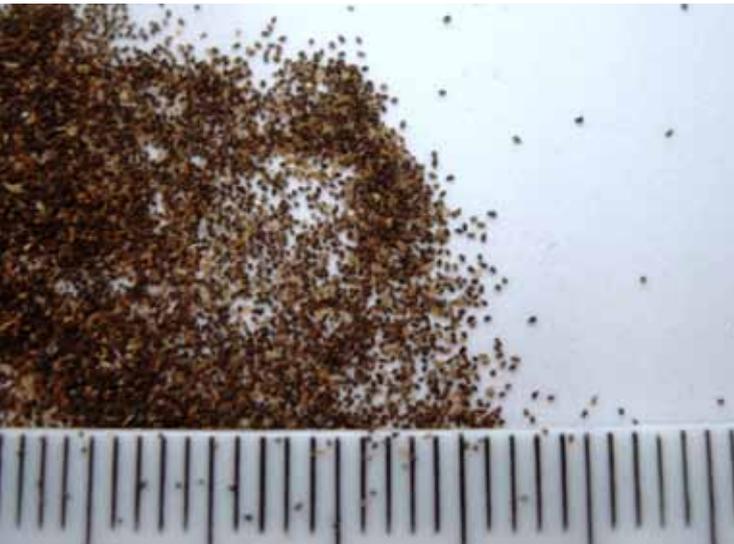


Figure 10: Dry branched broomrape appearing as "dead sticks" when viewed in the paddock.



SEED AND PLANT CHARACTERISTICS

Branched broomrape seeds (about 0.2 mm long) are about the size of a particle of ground pepper and need to be magnified at least 10 times to clearly see physical details, see Figure 11 below.



Branched broomrape plants have seed capsules that each contains up to 1,000 viable seeds, so a plant with 20 capsules could produce 20,000 seeds. Consequently, there is often a huge bank of branched broomrape seed in the soil where plants are found.

Ripe seeds may remain in the capsule and be spread with the plant remains but most seeds eventually fall to the ground, landing within half a metre of the parent plant.

Broomrape seeds can be dislodged from capsules by wind and are capable of blowing in the breeze.

Broomrape seeds have wrinkled surfaces, which can help them cling to a range of materials, and they also readily become electrostatically charged and cling to plastics and metals.

Seed survival is variable. Some seeds decay quite quickly but research shows a proportion of seed can survive for more than 13 years, particularly in water repellent soils. It is estimated that seed will take between 17 to 30 years to decay at these sites depending on the depth of burial in the soil.

Branched broomrape seeds are:

- **size of ground pepper**
- **have a wrinkled surface – can cling to a range of materials**
- **survive more than 13 years in the soil**

HOW BRANCHED BROOMRAPE IS SPREAD

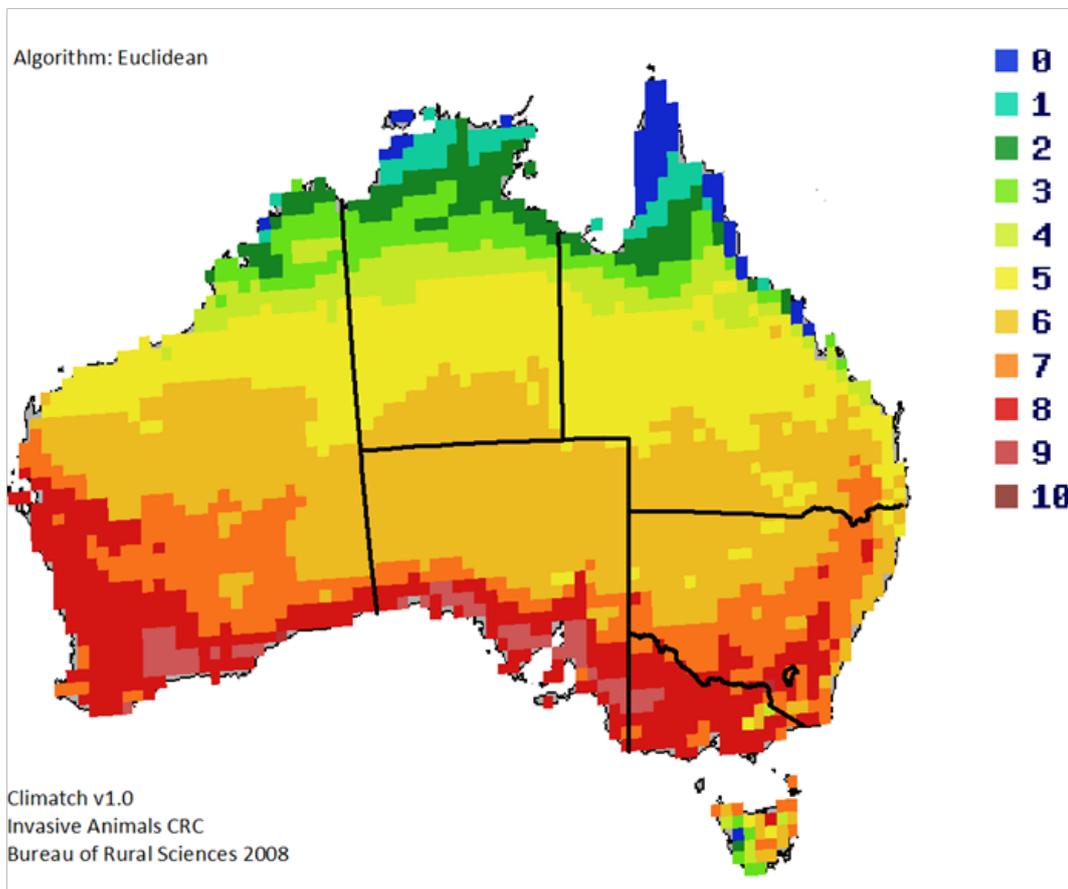
- Farm machinery - particularly in attached soil during wet periods.
- Contaminated soil and animal manures.
- Contaminated fodder and seed.
- Livestock, through the gut but also in wool, hair and fur and in soil and manure that may adhere to the animal.
- Wind Erosion - Broomrape seeds can be spread in soil that is drifting. However, the distance viable seeds can travel is difficult to measure. Factors that will increase the spread further than 5 metres include ground that has little protective cover and so is prone to drift and wind speeds above 11 km/hr.

POTENTIAL DISTRIBUTION

This distribution is based on the Climatch v1.0 model released in 2008 by the Bureau of Rural Sciences, Canberra. It uses the known distribution of the *P. mutellii* form of branched broomrape, in the Mediterranean basin and the Murray Mallee to produce this climate based map of where the weed may spread in Australia.

The number 10 on the colour scale indicates the best match.

Broomrapes are not weeds of the tropics but this model predicts branched broomrape has the potential to grow in all Australian States.



HOST PLANTS OF BRANCHED BROOMRAPE

Branched broomrape parasitises a wide range of broadleaved agricultural and horticultural crops and weeds and has one of the widest host ranges of all this group of parasites. The main hosts observed in the field are native herbs and weeds (e.g. capeweed) in the daisy family. Confirmed hosts of the South Australian strain of branched broomrape are listed below.

Crops that have been host-tested using the South Australian strain of branched broomrape without attachment being observed are onions and various cucurbits (zucchini, pumpkin, cucumber, squash, rockmelon and watermelon).

Potatoes are a significant host of branched broomrape overseas. In Australia only the potato variety 'Shine' has had attachments observed in host testing with the SA branched broomrape strain.

Lucerne has not been observed as a host in the Mallee. However, growers should be wary during stand establishment because potted seedlings of 'Hunterfield', 'Sceptre' and 'Eureka' have hosted broomrape emergence.

HOST RISK FOR THE SA STRAIN OF BRANCHED BROOMRAPE

The following categorisation of host risk for the SA strain of branched broomrape is based on research and field observations. The data obtained from the various experiments and field observations has been used to categorise hosts of the SA strain of branched broomrape as either:

- D = definite host (emerged broomrape observed).
- L = likely host (many attachments observed).
- P = possible host (occasional attachment observed).
- N = likely non-host (no viable attachments observed).

BROADACRE CROPS			
PLANT	SPECIES	FAMILY	HOST RISK
safflower	<i>Carthamus tinctorius</i>	Asteraceae	D
safflower	<i>Helianthus annuus</i>	Asteraceae	D
canola	<i>Brassica napus</i>	Brassicaceae	D
white mustard	<i>Sinapis alba</i>	Brassicaceae	D
chick pea	<i>Cicer arietinum</i>	Fabaceae	D
faba bean	<i>Vicia faba</i>	Fabaceae	D
vetch	<i>Vicia sativa</i>	Fabaceae	D
coriander	<i>Coriandrum sativum</i>	Apiaceae	D
indian mustard	<i>Brassica juncea</i>	Brassicaceae	D
lupin	<i>Lupinus angustifolius</i>	Fabaceae	L
lentil	<i>Lens culinaris</i>	Fabaceae	P
linola	<i>Linum usitatissimum</i>	Linaceae	P
field pea	<i>Pisum sativum</i>	Fabaceae	N
lathyrus	<i>Lathyrus cicera</i>	Fabaceae	N
purple vetch	<i>Vicia benghalensis</i> cv. 'Popany'	Fabaceae	N

VEGETABLES			
PLANT	SPECIES	FAMILY	HOST RISK
carrot	<i>Daucus carota</i>	Apiaceae	D
broccoli	<i>Brassica oleracea var. italica</i>	Brassicaceae	D
cabbage	<i>Brassica oleracea var. capitata</i>	Brassicaceae	D
cauliflower	<i>Brassica oleracea var. botrytis</i>	Brassicaceae	D
tomato	<i>Lycopersicon esculentum</i>	Solanaceae	D
lettuce	<i>Lactuca sativa</i>	Asteraceae	D
eggplant	<i>Solanum melongena</i>	Solanaceae	D
potato	<i>Solanum tuberosum</i>	Solanaceae	N (excluding 'Shine' L)
capsicum	<i>Capsicum annuum var. annuum</i>	Solanaceae	N
cucumber	<i>Cucumis sativus</i>	Cucurbitaceae	N
pumpkin	<i>Cucurbita maxima</i>	Cucurbitaceae	N
rockmelon	<i>Cucumis melo subsp melo</i>	Cucurbitaceae	N
squash	<i>Cucurbita pepo</i>	Cucurbitaceae	N
watermelon	<i>Citrullus lanatus</i>	Cucurbitaceae	N
zucchini	<i>Cucurbita pepo</i>	Cucurbitaceae	N
onion	<i>Allium cepa</i>	Liliaceae	N

PASTURES			
PLANT	SPECIES	FAMILY	HOST RISK
clover - white	<i>Trifolium repens</i>	Fabaceae	D
medic - disc	<i>Medicago tornata</i>	Fabaceae	D
medic - small burr	<i>Medicago minima</i>	Fabaceae	D
lucerne	<i>Medicago sativa</i>	Fabaceae	D (but not observed in field)
clover - balansa	<i>Trifolium michelianum</i>	Fabaceae	D
clover - Persian	<i>Trifolium resupinatum</i>	Fabaceae	L
medic - annual burr	<i>Medicago polymorpha</i>	Fabaceae	L
medic - strand	<i>Medicago littoralis</i>	Fabaceae	L
clover - sub	<i>Trifolium subterraneum</i>	Fabaceae	P

NATIVE PLANTS			
PLANT	SPECIES	FAMILY	HOST RISK
common everlasting	<i>Chrysocephalum apiculatum</i>	Asteraceae	D
golden everlasting	<i>Xerochrysum bracteatum</i>	Asteraceae	D
poached egg daisy	<i>Polycalymma stuartii</i>	Asteraceae	D
variable daisy	<i>Brachycome ciliaris</i>	Asteraceae	D
variable groundsel	<i>Senecio pinnatifolius</i>	Asteraceae	D
Sturt's desert pea	<i>Swainsona formosa</i>	Fabaceae	D
cut-leaf daisy	<i>Brachyscome multifida</i>	Asteraceae	L
sticky goodenia	<i>Goodenia varia</i>	Goodeniaceae	L
scarlet mintbush	<i>Prostanthera aspalathoides</i>	Lamiaceae	L
creeping boobialla	<i>Myoporum parvifolium</i>	Myoporaceae	L
sweet apple berry	<i>Billardiera cymosa</i>	Pittosporaceae	L
showy daisy bush	<i>Olearia pimeleoides</i>	Asteraceae	N
creeping saltbush	<i>Atriplex semibaccata</i>	Chenopodiaceae	N
ruby saltbush	<i>Enchylaena tomentosa</i>	Chenopodiaceae	N
spiny saltbush	<i>Rhagodia spinescens</i>	Chenopodiaceae	N
desert cassia	<i>Senna artemisioides</i>	Fabaceae	N
golden wattle	<i>Acacia pycnantha</i>	Fabaceae	N
native lilac	<i>Hardenbergia violacea</i>	Fabaceae	N
running postman	<i>Kennedia prostrata</i>	Fabaceae	N
wild rosemary	<i>Dampiera rosmarinifolia</i>	Goodeniaceae	N
austral bugle	<i>Ajuga australis</i>	Lamiaceae	N
black anther flax lily	<i>Dianella revoluta</i>	Liliaceae	N
spreading emu bush	<i>Eremophila divaricata</i>	Myoporaceae	N
dryland tea tree	<i>Melaleuca lanceolata</i>	Myrtaceae	N
muntries	<i>Kunzea pomifera</i>	Myrtaceae	N
scarlet bottlebrush	<i>Callistemon rugulosus</i>	Myrtaceae	N
summer red mallee	<i>Eucalyptus socialis</i>	Myrtaceae	N
yorrell	<i>Eucalyptus gracilis</i>	Myrtaceae	N
lavender grevillea	<i>Grevillea lavandulacea</i>	Proteaceae	N
rock correa	<i>Correa glabra</i>	Rutaceae	N

ORNAMENTALS			
PLANT	SPECIES	FAMILY	HOST RISK
nasturtium	<i>Tropaeolum majus</i>	Trapaeolaceae	D
sweet pea	<i>Lathyrus odoratus</i>	Fabaceae	L
gazania	<i>Gazania sp.</i>	Asteraceae	N
alyssum	<i>Lobularia maritima</i>	Brassicaceae	N
sweet william	<i>Dianthus barbatus</i>	Carophyllaceae	N
garden geranium	<i>Pelargonium x domesticum</i>	Geraniaceae	N
italian lavender	<i>Lavandula stoechas</i>	Lamiaceae	N
petunia	<i>Petunia x hybrida</i>	Solanaceae	N
pansy	<i>Viola arvensis</i>	Violaceae	N

WEEDS			
PLANT	SPECIES	FAMILY	HOST RISK
bathurst burr	<i>Xanthium spinosum</i>	Asteraceae	D
capeweed	<i>Arctotheca calendula</i>	Asteraceae	D
Cretan weed	<i>Hedypnois rhagadioloides</i>	Asteraceae	D
false sowthistle	<i>Reichardia tingitana</i>	Asteraceae	D
flatweed	<i>Hypochoeris glabra</i>	Asteraceae	D
skeleton weed	<i>Chondrilla juncea</i>	Asteraceae	D
sowthistle	<i>Sonchus oleraceus</i>	Asteraceae	D
stemless thistle	<i>Onopordum acaulon</i>	Asteraceae	D
tolpis	<i>Tolpis barbata</i>	Asteraceae	D
common heliotrope	<i>Heliotropium europaeum</i>	Brassicaceae	D
corn gromwell	<i>Buglossoides arvensis</i>	Brassicaceae	D
salvation Jane	<i>Echium plantagineum</i>	Brassicaceae	D
indian mustard	<i>Brassica juncea</i>	Brassicaceae	D
white mustard	<i>Sinapis alba</i>	Brassicaceae	D
wild turnip	<i>Brassica tournefortii</i>	Brassicaceae	D
rough poppy	<i>Papaver hybridum</i>	Papaveraceae	L
black nightshade	<i>Solanum nigrum</i>	Solanaceae	P
paddy melon	<i>Cucumis myriocarpus</i>	Curcubitaceae	P

GROWING DEGREE DAYS (GDD) TO TRACK WEED EMERGENCE

Preventing emergence is the best way to control broomrape. This is achieved by early control to remove host plants in your paddock. The best time to spray hosts is when all broomrape plants have attached to host roots but well before it emerges such that the pasture or crop recovers and production losses are minimised.

Predicting the growth of the weed and the best time to spray is not easy as it all happens underground. By using soil temperatures to estimate the rate of plant development, it is possible to calculate the timing of broomrape attachment and emergence. A running total of average soil temperatures or Growing Degree Days (GDD) can also be used to guide the optimal timing for application of herbicides by predicting when broomrape has reached critical growth stages.

WHAT ARE GROWING DEGREE DAYS?

For branched broomrape development, GDD are calculated using average daily soil temperatures. Every day after the start of the season the daily maximum and minimum temperatures are recorded for the top 10cm of soil, added together and then halved. These averages are then accumulated into a running total.



Branched Broomrape in a Mallee paddock

THE IMPORTANCE OF DATE OF SEASONAL BREAK

The GDD for branched broomrape development are accumulated from the date of the break of season rain that prompts the germination of hosts in the paddock. Research in South Australia has indicated that this date corresponds to the day when: -

- 25mm of rain has fallen over a fortnight period after 1st April.

Subsequent rain and germination events prolong the germination of hosts and also broomrape attachments.

Farm practices and broomrape control strategies influence the timing of branched broomrape germination and hence GDD accumulation. For example, planting a crop delays the start date for accumulating GDD from the time of the break of season rain until the day of sowing (i.e. last soil disturbance). Similarly, early season host control delays the start date until the next rainfall event that stimulates a new flush of hosts.

HOW GDD HELPS WITH BROOMRAPE MANAGEMENT

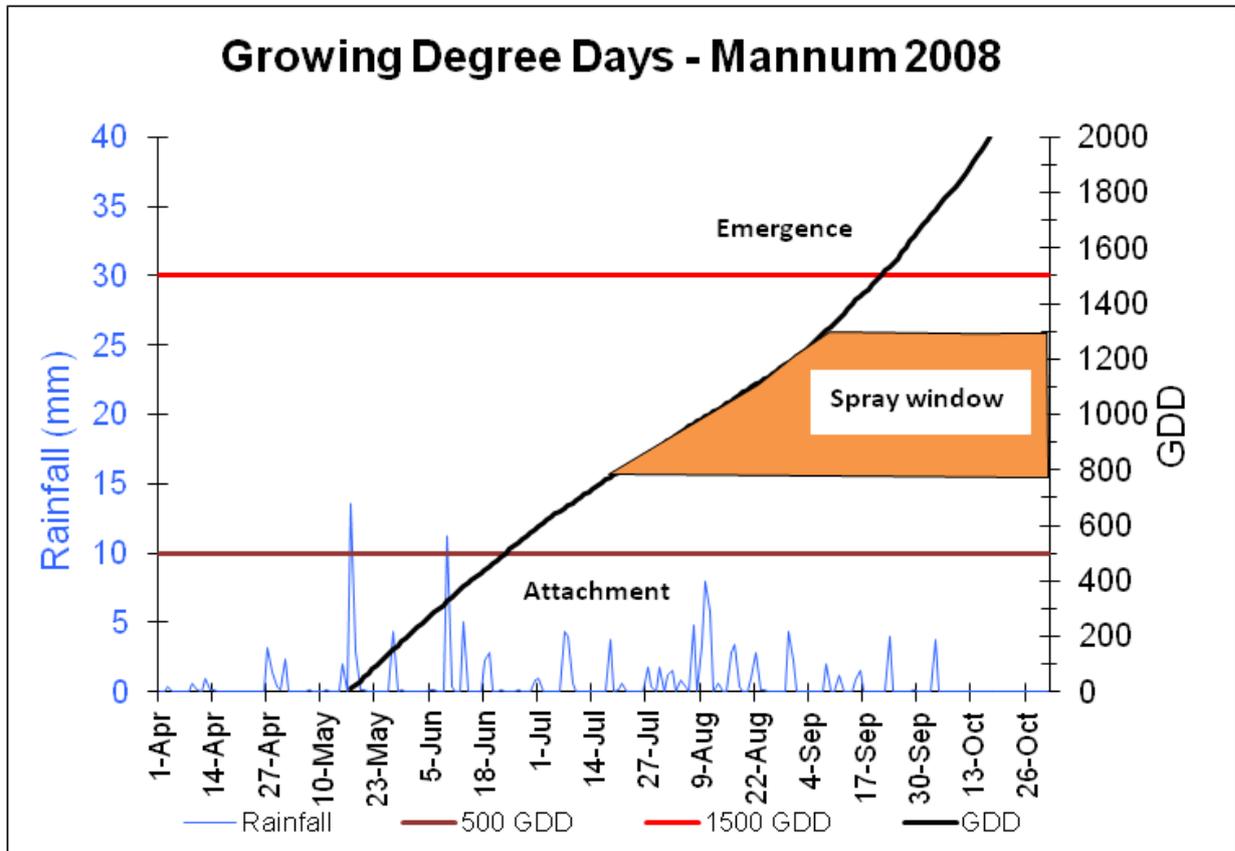
Laboratory research has shown that broomrape attachments to host roots are first seen after 500 GDD. New attachments continue to form until stems start to emerge. By 1000 GDD there are few new broomrape attachments on host plants. Observations in the field confirm these predictions. Herbicides to kill broomrapes attached to hosts can be applied from 700 GDD onwards. Branched broomrape is likely to commence emerging from the soil at 1500 GDD.

AN EXAMPLE OF GDD APPLICATION

Looking at the chart displaying data for Mannum in 2008, the break of season occurred on 17 May and GDD are accumulated from that date. Following the black GDD line, the chart indicates that branched broomrape attachments occurred from 24 June (i.e. where the black line crosses the brown line). Emergence of branched broomrape in 2008

occurred after 1500 Growing Degree Days from the 21 September i.e. where the black line crosses the red line. These data were consistent with field observations in 2008.

The best time to spray varies each year and is discussed in Chapter 5.



Use Growing Degree Days to:-

- Track weed emergence
- Predict when broomrape has reached critical growth stages
- Determine the best time to spray host plants

Chapter 2



Chapter 2

ASSESSING THE RISKS - MANAGEMENT STRATEGIES AND CONSIDERATIONS

This short chapter helps you plan how to manage branched broomrape.

SETTING OBJECTIVES

RATIONAL BEHAVIOUR

Branched broomrape is another of the many weeds you have to manage and is now accepted as naturalised in Australia.

As for other weeds, branched broomrape prevention is the best option. If an infestation is present landholders must weigh up potential threats.

The application of legislation pertaining to this weed may also influence your plan.

Decide on your starting position: -

1. I do not have branched broomrape and want to stay clean

If the weed is not present on your property and your aim is to prevent its incursion go to Chapter 3 Farm Biosecurity & Prevention below.

2. Branched broomrape is on my property

How you manage branched broomrape on all the property is a multi-factored issue and you need to assess your options.

Step 1 – Decide if the market signals or potential production losses are strong enough to warrant action. Are there environmental issues or other factors that you consider important?

Step 2 - List the land uses by crop type, including pastures, non-arable areas, fence lines and scrub/bushland. Match the land uses against the list in the following Chapters. Read the notes for each of your land uses.

Step 3 - Follow through on your management options. These focus on herbicide use and range from maximum control treatments aimed at total host control and preventing any emergence to good agronomy that minimises hosts and opportunity for the parasite.



EFFECTS OF CONTROL STRATEGIES

Branched broomrape

Will build up on: -

- Cretan weed
- Weedy pastures
- Host crops

Will be maintained in: -

- Native vegetation (scrub/bushland)
- Unimproved rangeland type pasture
- Roadside vegetation

Will be reduced

- By continual host denial in all seasons and land uses, both crop and pasture
- Continuous broad leaf weed, host control, in fence lines and scrub
- Sowing host crops that can be sprayed with Group B herbicides to kill attachments
- Growing short season host crops with in ground time of less than 90 days so any attached broomrape does not complete its life cycle.

Broomrape control is centred on preventing emergence of plants. No emergence means no contamination of above ground crops, no seed set and a reduction of the seed bank.

Preventing emergence is achieved by host denial –

- Early control to remove unwanted host weeds in your paddock. The best time to spray hosts is when all the broomrape has attached but before it emerges such that the pasture or crop recovers and production losses are minimised.
- Using a herbicide that is tolerated by a host crop, but kills attached broomrape (e.g. the Clearfield® canola system).

Control is really difficult if a spray option isn't available for a host crop.

Go to Chapter 4 - Management Options



Chapter 3

FARM BIOSECURITY & PREVENTION

This chapter provides you with management strategies, to prevent incursion and spread of branched broomrape on your property.

FARM BIOSECURITY

Farm biosecurity refers to a series of measures to minimise the risk of introducing and spreading pests -weeds, diseases and invertebrates - within a farm, between farms and further afield. The risk of introducing and spreading plant pests occurs when soil, seed, produce, vehicles, machinery, equipment, animals and people move from farm to farm and region to region. While a farm cannot be isolated, managing and reducing the risks posed by unwanted pests can be achieved by adopting routine best practice principles and procedures.

Biosecurity risk mitigation strategies aimed at preventing the incursion of weeds and diseases in general will be effective for branched broomrape.

Branched Broomrape seed with a length of 0.2 mm, is so tiny it won't be seen on inspection. So, it is possible high seed numbers can be present and not be discovered. In some ways branched broomrape is more like a disease than a weed.

Farm biosecurity manuals that provide best practices techniques and guidelines to minimise the risk of introduction pests onto properties are available from the Plant Health Australia website www.planthealthaustralia.com.au or the farm biosecurity website www.farm.biosecurity.com.au that also provides other useful information such as risk assessment templates and checklists.

Examples of industry manuals are:

- Grains Industry Farm Biosecurity Manual: - [Grains-Farm-Biosecurity-Manual.pdf](#)

Northern Adelaide Plains Vegetable Growers Farm Biosecurity Manual for the [NAP Vegetable Growers farm biosecurity Manual.pdf](#)

- Grazing livestock farm biosecurity manual. [National-Farm-Biosecurity-Reference-Manual-Grazing-Livestock-Production.pdf](#)

Farm biosecurity should start with a self assessment and a farm biosecurity plan that identifies risks and outlines their management.

IMPORTANT RISKS TO MANAGE

PLANT PRODUCTION RISKS

Infested soil and any commodity that is harvested at broomrape plant height, during broomrape emergence, are the highest risk agents of seed dispersal.

Hay, ground engaging and hay making machinery, unwashed root vegetables such as seed potatoes are also high risk.

Cereal grains are low risk as they are harvested above broomrape height after the main flowering and seeding period.

Treating infested produce with high temperature and moisture during processing, such as feed pelleting, will destroy broomrape seed.

LIVESTOCK RISKS

Studies show that seeds can travel through the gut of sheep and remain viable, so relying on grazing to control branched broomrape on its own is not a useful management tool.

It is possible that if sheep ingest branched broomrape seeds they can cause further spread across a paddock. An experiment undertaken at Mannum in the South Australian Mallee found that most ingested seed is excreted within four days and by seven days no seed is found. However, it is thought unlikely that sheep eat mature broomrape seed. They will eat emerged plants but the seed is not mature until the plant begins to dry out and becomes less palatable. For the same reason, vermin such as rabbits may not be responsible for spreading broomrape via the gut.

Experiments indicate that branched broomrape seeds remain attached to the fleece and feet of sheep for more than seven days. This mode of spread is possible but in this experiment the seeds were applied by hand to the fleeces and feet. The risk reduces when there is a low probability of seed becoming attached in the paddock due to a small initial seed load.

After 10 years of surveys, there was no trend of increasing density of branched broomrape found

around stock yards. This is evidence that livestock are not high risk vectors of seed dispersal.

Although the likelihood of livestock carrying broomrape seed is low, they do travel long distances and could create new infestations in another region, so the consequences are high.

For this reason isolating animals that are new to a property in special purpose paddocks for seven days is good biosecurity practise in terms of broomrape prevention.

WIND AND WATER

Branched broomrape seed will be carried in breezes of sufficient velocity but is not well adapted to spread by this means. Soil movement by water and wind is a risk. Minimising soil erosion prevents paddock and property to property risk of spread. Low, sparse stubble is sufficient to hinder seed movement by wind.

PROXIMITY

Surveys showed that the most likely place to find another infestation is within a kilometre of a known site. Control your roadsides and work with neighbours for effective mitigation.



PREVENTION

Prevention is better than Cure. Preventing the introduction and spread of branched broomrape involves long term management of key risk factors associated with your production. You have a reasonable level of control over these risks so prevention is achievable.

The table shows some specific examples of preventative measures that can be employed.

ENTERPRISE	POSSIBLE SOURCES OF CONTAMINATION	BIOSECURITY MEASURE
Grain	In the grain	Sow certified or paddock inspected seed.
Fodder	In the hay bale or soil on the outside of the bale	Use containment feed pad and/or regularly inspect feed out paddocks.
Livestock	In the gut or carried on the extremities of an animal	Contain for a minimum of 7 days before paddock release.
Horticulture	Soil contaminated matter or unwashed produce	Wash/process produce after harvest.
Machinery	Soil and other detritus attached to machinery	Remove soil and decontaminate machinery with NiproQuat®.

FARM HYGIENE - DECONTAMINATION

Good hygiene practice is the key to effective farm biosecurity. Employ a 'keep it clean' policy and apply this to vehicles, machinery, equipment, tools and product.

Keeping machinery clean by removing soil and plant debris reduces the risk of transfer of seed amongst paddocks or properties and the risk can be further reduced through decontamination with seed destroying agents.

Broomrape seed is destroyed by a special disinfectant found in the products NiproQuat®, Path-X® and Sporekill®. Washing down in a designated wash down area on farm with a 1% solution of these products reduces the risk of transporting live seed. High pressure wash down saves time in removing soil and debris. Seed readily absorbs moisture and is killed after 12 minutes of exposure to the disinfectant. Rinsing or drying may reduce efficacy. The disinfectant is mildly corrosive of reactive metals and high pressure cleaning has its own risks to operators and machinery.

Broomrape seed is not destroyed by formalin or bleach. A range of other disinfectants have been tested and are not effective enough to be useful.

Designated wash down sites will become at risk locations for new infestations and should be monitored and host weeds controlled as a precaution.

MANAGING ACCESS AND MOVEMENT ON AND OFF FARM

People, vehicles, farm inputs and anything coming onto farm are unintentional sources of risks. Limit entry points to access the property and production zones. Keeping a record of all farm visits and inputs etc. allows trace forward and trace back in the case of an incursion.



Farm-gate signage can be used to inform visitors of your biosecurity status and what you require from them in terms of biosecurity measures. Farm gate signage (such as the one on p. 21) can be placed at critical control/access points.

DISCOVERING BROOMRAPE AND DESTROYING IT

FUMIGATION

Soil fumigation is expensive but effective. A small proportion of viable seed remains and hence a small risk of re-emergence of the weed.

Fumigation with methyl iodide and chloropicrin 50:50 mixes is as effective as methyl bromide in removing 97% of broomrape seed in moist soil.

South Australian research has shown that dazomet, as Basamid® and other products, is effective in removing 95% of broomrape seed when 360 kg/ha is incorporated into soil at 8% soil moisture or greater. At this application rate, clearance times, the time before re-sowing into treated soil, is 30 to 35 days in the Mallee.

A new branched broomrape discovery may be from a new introduction or seed bank that has been present for many years. If no suitable host is present, a seed bank may remain undetected for many years as no broomrape plants will emerge. If paddock or property freedom is your aim, keep checking the paddock or management area for several years.

Chapter 4

MANAGEMENT OPTIONS

This chapter provides you with management options when deciding what to grow in paddocks infested with branched broomrape or when planning to prevent possible future incursions.

It introduces the first step, of a three step planning process, that should be considered when selecting rotations to control broomrape.

A range of production situations are discussed, from cereal and break cropping to annual pastures and general weed management.

STEP 1 – DECIDE ON LAND USE

This is the most important step in the process of planning to control branched broomrape because what you choose to grow in a paddock with broomrape will affect the success of your control measures. This is because chemical control of broomrape will be easier in some situations than others. A smaller, localised infestation can often be treated separately to the remainder of the paddock.

The following chapter will discuss the pros and cons of different land uses with reference to specific broomrape management considerations.

CROPPING ROTATIONS

You can continue broad acre farming profitably and sustainably while controlling branched broomrape, as best practice control and best practice farming methods complement each other.

Effective control will be achieved with a combination of approaches that incorporate the best use of rotations and herbicides.

Broomrape is a parasite that requires a host plant on which to grow. Rotations that concentrate on host denial involve ensuring there is no weed or crop that will host the parasitic plant.

CEREALS

Growing a cereal crop and adopting a zero tolerance approach to broadleaved weeds is by far the most effective way to prevent branched broomrape from emerging. The more cereals in a rotation the more effective it will be in preventing the emergence of branched broomrape.

A long sequence of successive cereal crops can be sustained provided:

- Grass weed control is good.
- Root and leaf diseases are kept in check through choice of crop and variety.



- Higher levels of crop nutrition (especially nitrogen, phosphorous and zinc) are applied to intensively cropped paddocks.

Cereals should be viewed as a flexible rotation option, as they can also be sown for grazing to produce early feed, where pastures were intended but where a broomrape infestation is large or widespread.

BREAK CROPS

Most non-cereal “break” crops can host broomrape, although they are often poor hosts. These include legumes, canola and pastures. Growing a “break” crop in an infested paddock can be a riskier option, but is quite often essential to maintain sustainable cropping systems.

A build up of grass weeds or disease that make it necessary to grow a “break” crop or pasture presents an opportunity to run down the broomrape seed bank.

Timing and chemical choice is critical for success with seed bank reduction so branched broomrape needs to be a priority in management of “break” crops in infested paddocks.

Roots of broad-leaved “break” crops and broadleaf weeds can stimulate germination and attachment of broomrape. This provides an opportunity to destroy broomrape before emergence by spraying the crop with a suitable herbicide.

The options are a selective herbicide that will destroy the broomrape but not the crop, OR a knockdown that will kill the crop and the weed. Suitable herbicide options and timing are listed in Chapter 5.

CLEARFIELD CANOLA

Canola is now a useful break crop option in low rainfall areas with the release of good early maturing varieties and good returns for oilseeds.

Canola can host branched broomrape, but the Clearfield canola variety can be sprayed with Intervix® or OnDuty®, both Group B herbicides, that provide effective broomrape control.

Intervix provides effective control of branched broomrape and many of the weeds that host it. Trial work in 2009 has shown that Intervix can prevent broomrape emergence at rates as low as 300ml/ha.

Consequently, Clearfield canola can provide a disease or weed control break in a cereal rotation in broomrape-infested paddocks. It can also be a profitable crop given a season with good stored soil moisture and early opening rains.

Correct establishment is the key to success, which involves timely seeding, correct seed placement, fertiliser application and pest management.

Canola will grow in most soil types but will perform better in more fertile soils suited to wheat. Sandy soils will require greater inputs, particularly sulphur.

Canola is best sown into standing stubble because seedlings are very susceptible to sandblasting. Worked paddocks increase the risk of seedlings being damaged by drifting soil.

Intervix or OnDuty herbicide should be applied in-crop as early as provided for in the label recommendations. Both are group B herbicides (imidazolinones) and have some residual activity in the soil but, unlike Glean® and Logran® (sulfonyl ureas), break down faster in high pH soils provided there is sufficient moisture.

Non Clearfield cereals and pasture legumes can be sown eight months after spraying Intervix provided at least 250 mm of rainfall has been received between spraying and sowing.

If dry conditions makes it necessary to delay sowing for two seasons following Intervix application, a range of Clearfield cereals are now available and can be sown safely. Using lower rates of Intervix for broomrape control will help to reduce the incidence of herbicide carryover in subsequent years. OnDuty should be used at 40g/ha only.

Glyphosate resistant canola has not been grown in the region where branched broomrape is established in South Australia. However, glyphosate is known to be translocated to attached broomrapes when applied to hosts and in theory, glyphosate resistant canola should be a potential method of branched broomrape control.

PASTURES

The type and quality of the pasture plays a big role as to whether broomrape emergence is likely.

Weedy pastures are common and are a big problem for branched broomrape management due to the number of host weeds they carry. On the other hand, growing good pastures with few broadleaf weeds maximises the benefits from the pasture phase and can help prevent broomrape emergence.

In every year that the branched broomrape quarantine area was surveyed, between 40% and 70% of branched broomrape infestations were found in pasture. Improved pasture management is important if whole farm control is the aim.

MANAGEMENT THE KEY

Field observations indicate branched broomrape doesn't attach to the newer barrel medics when they are in dense, strongly growing stands.

However, broomrape does attach to host weeds growing in medic stands, so it is important to control weeds and encourage good medic growth to maximize the benefits of the pasture and minimise the risk of broomrape emergence.

Practical experience is that pasture medic composition improves in the years following the removal of weedy hosts.

TREAT YOUR PASTURE LIKE A CROP

To get maximum benefit from a pasture, treat it like a crop. A well-managed pasture given the same care and attention as a crop will provide all the benefits claimed for pastures: weed control, disease control, nitrogen contribution, organic matter input and more livestock feed.

It will also minimise the potential for branched broomrape emergence.

BEST-PRACTICE MANAGEMENT

The following guidelines are good pasture management practice regardless of broomrape being an issue:

- Ensure good pasture plant density.
- Ensure adequate phosphorus.
- Medics need phosphorus and sulphur for nodulation and growth.
- Soil test pasture paddocks to determine phosphorus availability and apply fertiliser where levels are low. As with cropping systems adequate nutrition is the key to production.
- Ensure zinc levels are adequate.
- Control weeds and insects.

Controlling broadleaf and grass weeds is essential for productive pastures.

Weedy pastures cause problems. In addition to competing with the pasture:

- Grass weeds carry-over root disease to the following cereal crop.
- Grass seed set in the pasture phase increases competition in the following crop.
- Broadleaf weeds compete with the pasture and, in the broomrape area, introduce the risk of broomrape attachment and emergence.

Spray-graze or hayfreezing techniques are valuable tools to control broadleaf weeds. Spray grazing is cost-effective and will sweeten up weeds so livestock preferentially graze them, increasing the chance of reducing seed set. Long fruited turnip, a preferred host of broomrape, is easily removed with spray grazing.

GRAZING MANAGEMENT

Correct grazing management will maximise pasture production and control weeds. Start grazing as soon as the medic has six leaves (plants 2.5 to 3 cm in height) and the ground is covered.

Maintain consistent grazing pressure during winter and spring. Don't let the pasture get away and don't "crash graze" (graze heavily after a long spell).

Keep pasture height at three to six centimetres during winter. During spring, increase grazing pressure so the pasture doesn't become rank. Aim to keep pasture height to 6 to 10 cm.

Consistent, relatively hard grazing pressure while the soil is still moist will promote leaf and runner production and produce more medic flowers. Crash grazing will remove flowers.

To ensure good seed set reduce the grazing pressure or remove the stock as soon as the season dries off. Livestock can be transferred to spray-topped grass pastures or used to put extra pressure on weedy paddocks.

When seed set is complete and the medic burrs have hardened, livestock can be re-introduced but should be removed once they start eating medic burr.

Grazing benchmarks for medic pastures

- Early winter – start grazing at 6-leaf stage, when pasture height reaches 2.5-3 cm [approx 1,000 kg/ha of dry matter].
- Winter – maintain at 3 to 6 cm [1,200 – 1,700 kg/ha].
- Spring – maintain at 6 to 10 cm [2,000 – 3,000 kg/ha].
- Reduce stock pressure (or remove stock) during seed set.
- Monitor burr removal in late summer/autumn.
- Aim for 100 burrs per 25 cm x 25 cm quadrat in late March.

MANAGING BRANCHED BROOMRAPE-INFESTED PASTURE PADDOCKS

Lay the foundations with good pasture management as outlined above.

Build on that with appropriate herbicide applications. It is important to note that most medic species are

sensitive to herbicides and it pays to check what varieties are in the paddock prior to spraying. Also check label rates of products and look for disclaimers. In some situations medic damage may occur to ensure broomrape is controlled.

There are two herbicide options for infested paddocks carrying medic pasture:

SELECTIVE.

Use Raptor or Broadstrike* at label rates to take most broadleaf weeds out of medic.

* Broadstrike alone is not effective against Cretan weed

NON-SELECTIVE.

Use glyphosate to spray out the pasture stand and any weeds in it. Always spray-top with glyphosate after spray-graze to ensure maximum broomrape control.

Growers taking the non-selective option need to:

- Ensure they have enough feed for their stock once the pasture is no longer available.
- Make sure spray-grazed paddocks are not exposed to soil erosion.

HORTICULTURE

In horticultural situations branched broomrape is a serious threat for the following reasons:

- Irrigation provides ideal moisture conditions and potential hosts all year round.
- Broomrape can dramatically reduce yield in some horticultural crops.
- There are few chemicals that can be used safely to control broomrape in horticultural crops.

Effective control of broomrape will be achieved with a combination of approaches that incorporate the best use of crop rotations, herbicides and in some instances fumigation.

Controlling host plants is best done early in the planning stage as options are generally limited through

the growing period. This involves good paddock preparation and site selection with a preference for areas that have had consecutive years of good weed control prior to planting a horticultural crop.

Rotating crops from one year to the next offers the opportunity to use different herbicides and reduces the potential for host plants to build up.

In preparation of the seed bed there is an opportunity to germinate and kill weeds prior to planting. Irrigation, cultivation and knockdown herbicides can be used strategically to remove an initial flush of weeds. However, cultivation needs to be used with care to avoid soil drift and the potential spread of weed seeds.

In permanent crop situations such as orchards and vineyards, there is minimal disturbance of soil leaving vast areas for germinating weeds. These weeds should be controlled as early as possible to limit the possibility of branched broomrape attachment and germination. More than one application a season may be required due to irrigation, farm practices and seasonal conditions.

Control of weeds will also need to take place in uncropped areas adjacent to horticultural crops, along fence lines or any other area that can act as a source of re-infestation.

Good farm hygiene will be key to preventing broomrape from taking hold on a property. Soil contaminated seed and machinery can be a source of weed seeds, therefore it is important to clean all soil from cultivation and harvesting equipment. This also includes bins and pallets that may hold unwashed produce.



GENERAL WEED MANAGEMENT

BROADLEAF WEEDS

Effective broadleaf weed control is an essential part of a program to control branched broomrape because broadleaf weeds are the most common host.

Wheat, barley, oats and other cereals do not host the parasite but it is often found attached to broadleaf weeds growing in cereal crops.

Effective broadleaf weed management starts in the spring prior to sowing a crop with inspection of the paddock to see what broadleaf hosts and other weeds are present.

The weed profile will influence what crop you choose to grow in the coming year and successive seasons.

The following principles are useful to remember:

- Clean seed is a good starting point.
- Kill existing plants prior to seeding to ensure the crop has no competition from weeds.
- This will also delay the onset of Growing Degree Days and give more time for in-crop control of broomrape later in the season.
- Small young weeds are easiest and cheapest to kill and early control ensures weeds don't become so large they can't be killed once the crop emerges.
- Effective early control requires a "no survivors" approach.

CRETAN WEED

Cretan weed (*Hedypnois rhagadioloides*), a favoured host of branched broomrape, is commonly found growing in the Murray Mallee. Before you can choose broomrape management strategies you will need to know whether Cretan weed is present on your property and more importantly in any broomrape infested paddocks.

Refer to Chapter 7 on Broadleaf Weed Identification for pictures of Cretan weed. If you are unsure whether you have this weed growing in your infested paddocks seek further advice.

The presence of Cretan weed has implications for your choice of strategy as many of the herbicides that will successfully control broomrape will fail in the presence of Cretan weed.

Cretan weed management needs to be effective and on-going from year to year because plant numbers can increase rapidly if even a few plants are allowed to set seed.

CRETAN WEED IN PASTURES

No herbicide gives effective Cretan weed control without damaging medic plants.

Broadstrike® and Raptor®, both Group B herbicides, can offer some protection against broomrape in pastures but may fail in the presence of Cretan weed and cannot be relied on to prevent broomrape emergence.

If Broadstrike® and Raptor® are the only options for broomrape management they should be used early when the weeds are small. They will reduce the risk of broomrape emergence by eliminating some other hosts commonly found in pastures.

Jaguar® (group C + F) and Bromicide 200® (group C) are herbicides that contain the active ingredient bromoxynil and these herbicides have given good control of Cretan weed.

Unfortunately they can be very damaging to medics and are not recommended for use where medics are present. Trials have shown that using them at low rates will result in lesser medic damage but also less Cretan weed control. In pastures that have a low existing medic population but lots of Cretan weed, the use of bromoxynil herbicides should be considered. The only reliable method of controlling broomrape in pastures containing Cretan weed is to spray-top with glyphosate. Spray topping should not be used if there is a high chance of causing soil drift.

There are more herbicide options available for Cretan weed control in cereal crops and control of Cretan weed during the cropping phase is the best option to eliminate or reduce the population of this problem weed. If Cretan weed is dense in a paddock at high risk for broomrape emergence, it will be best to grow a cereal crop and apply a group B herbicide such as Ally®.

SUMMER WEEDS

Some summer weeds such as heliotrope and Bathurst burr can host broomrape and it is possible that under the right conditions broomrape can emerge on summer weeds outside of the typical July-November timing. Summer weeds that are left untreated in a season with wet summers and mild temperatures enable broomrape to germinate and emerge early, prior to July.

The main benefits of summer weed control for cropping are trash management and the conservation of valuable soil moisture and nutrients. Experience is showing that in a low rainfall environment the benefits outweigh the cost of control.

Good summer weed control prevents potential broomrape emergence.

Summer weeds can be controlled by cultivation or herbicides; however control with herbicides is the preferred option:-

- Spraying is faster than cultivating, making timely control easier to achieve especially over a large acreage.
- Cultivation over the summer exposes paddocks to a lengthy period of erosion which can potentially spread soil and weed seeds.
- Cultivation can no longer be viewed as a “cheap” option since fuel costs have increased.

CRITICAL ISSUES FOR SUMMER SPRAYING:

- Keep water volumes high and use adjuvants where possible.
- Avoid spraying stressed plants when possible.
- Smaller, younger weeds are easiest to control.
- Avoid off-target damage.

PREVENTING SOIL EROSION

There is a high probability of branched broomrape seeds being moved in drifting soil, so drift needs to be prevented.

Managing erosion risks:

- Monitor sandy soils closely to prevent over grazing.
- Aim for between 30-50% of anchored vegetative cover to prevent drift.
- Consider moving to a no-till seeding system that retains stubble cover.
- Growing cereals can provide more residues and robust vegetative cover than “break” crops.
- Feed lotting at high-risk times of the year can reduce the incidence of drift caused by stock. Feed lotting Sheep and Drought Feeding Sheep books are available.
- Some broomrape control options can cause drift because they involve spraying out vegetative cover in paddocks or along fence lines over an extended period of time. Each broomrape situation needs to be assessed individually. The risk of drift needs to be taken into account when deciding what broomrape control strategies to adopt.



Chapter 5

HERBICIDE STRATEGIES & INFORMATION

Step 2 – Decide on what to spray

Step 3 – Decide on when to spray

This chapter provides herbicide options for particular situations and addresses steps 2 and 3 in the planning process.

The advice concentrates on branched broomrape control and makes note of some special cases such as Cretan weed control.

Effective host control is effective branched broomrape control. There are many herbicides and combinations that will be effective.

However, this manual is not designed to cover all aspects relevant to herbicides mentioned and it is expected that you, as a herbicide user, will read the label and check with the reseller about the ramifications of using a particular product.

STEP 2 – DECIDE ON WHAT TO SPRAY

Once land use has been chosen it is then possible to choose a suitable herbicide or mix of herbicides for broomrape control.

The available herbicides options can be divided into two broad categories: -

1. Maximum Control
2. Host Denial Control.

MAXIMUM CONTROL – BROOMRAPE HERBICIDE STRATEGIES INCLUDE:

- Herbicides that directly kill branched broomrape through the host.
- Highly reliable, high impact solutions, maximum control, usually 100% effective.
- Depending on the herbicide the host may or may not survive the herbicide application.
- Apply maximum control strategies in paddocks that carry widespread branched broomrape infestations or where the situation demands.

HOST DENIAL CONTROL – BROADLEAF HERBICIDE STRATEGIES INCLUDE:

- These herbicides only affect the host plant and do not kill broomrape attachments, therefore advanced attachments may survive to still emerge.
- Host denial is a sound option that works in most instances but may not always guarantee total prevention of branched broomrape emergence.
- Accurate timing and application of herbicide is critical for success.

The remainder of this chapter will provide situation specific herbicide options in the two categories outlined above. Suggested rates per ha and timings are also provided.

NB. Always check the product label before applying any of the herbicides listed in this manual for critical comments on variety, application and timing for crop safety.

CHECKLIST OF CONSIDERATIONS WHEN

QUESTION	ANSWER
How many broomrape paddocks do I have?	One or two Many I may struggle to manage timely spraying
How big is the recorded infestation?	Small Widespread
Do I have Cretan weed?	Yes No Maximum Control – For large infestations, Host Denial Control - for small infestations
Is the area prone to drift?	Yes No Maximum Control – glyphosate can be used safely and will be most effective.
Do I need to grow pasture in my broomrape paddock?	Yes No
Is maintaining adequate feed for livestock important? Host Denial Control with cereals sown for grazing.	Yes No

CHOOSING A STRATEGY

FACTOR TO CONSIDER

POSSIBLE SOLUTION

I can manage timely spraying

Host Denial Control - Broadleaf herbicides only in cereals; host crops/pasture with appropriate selective herbicide.

Maximum Control - Grow cereals in as many paddocks as possible. Use group Bs early where it may not be possible to spray later on time.

I am confident of an isolated infestation

Maximum Control + Host Denial Control - Treat the isolated infested area with a proven broomrape herbicide and apply a broadleaf herbicide strategy to the rest of the paddock.

Broomrape is spread throughout the paddock

Maximum Control – Use the most practical strategy across the entire paddock; usually a crop that can tolerate a reliable group B herbicide.

Cretan weed will affect how well herbicides control broomrape

Maximum Control – Group B and glyphosate products will be most effective. Herbicides that contain bromoxynil (group C) may also be considered where there is a small broomrape infestation.

I have a good chance of preventing broomrape with a range of herbicides

Strategies must prevent drift

Host Denial Control – Use selective herbicides to keep some cover.

Removing vegetative will not cause drift

Paddock is not suitable to crop

Maximum control – spray topping with glyphosate is recommended., Broadstrike® can be used where there is no Cretan weed.

I can grow alternative crops

Host Denial Control in cereals, Maximum Control in break crops

I need maximum feed in the paddock

Maximum Control – Broadstrike® if no Cretan Weed

I do not need this paddock for feed

Maximum Control – Raptor® or early spray topping with glyphosate

STEP 3 - DECIDE ON WHEN TO SPRAY

Timing of herbicide application is often set with crop and herbicide selection, however when focusing on broomrape control this can be less clear.

USING GROWING DEGREE DAYS FOR TIMELY SPRAYING OF BRANCHED BROOMRAPE

Growing Degree Days (GDD) are used to determine the growth stage of branched broomrape and the optimal spray timing to prevent subsequent emergence. GDD begin from the opening rain that prompts a germination of host weeds in pastures, scrub and fence-lines. In a crop situation GDD begin from the date of sowing. So, the in-crop GDD count will be different to the fence line and scrub count.

Research has found that at 500 GDD the first broomrape attachments can be found on host roots. Once 1000 GDD are reached there are few new attachments on host roots and at 1500 GDD broomrape is likely to begin emergence above ground.

GDD are used to determine the best spray timing for broomrape control depending on each situation and the nature of the herbicide that is to be used.

Generally, spraying herbicide between 700 GDD when most broomrape attachments are present on host roots and before 1300 GDD are reached will give optimal control of broomrape.

This is especially important when using herbicides with a short residual or no residual activity e.g. Broadstrike® and glyphosate. The timing of the herbicide application becomes less important for group B herbicides with a long residual activity (e.g. Logran® and Glean®), as their activity is maintained over the entire season.

Therefore it is necessary to consider the type of herbicide to be used to determine whether additional spray applications may be necessary in a given year:-

- Does it have residual activity, the host situation?
- Are hosts healthy or stressed and seasonal factors?
- Is the season long or short?



TREAT EACH YEAR ON ITS MERITS

The blue dots on Figure 12 show the “break” of the season and the green slides the time of the spray window from 700 GDD to 1300 GDD.

As GDD accumulate between 10-12 degrees per day over winter there is a spray window of around 50 days. An early start to the season and warmth in the soil promotes earlier host and broomrape development so spray early. Later starts mean spray later. The conclusion, treat each year on its merits.

Spraying during the middle of August will be within the window in 80% of years. GDD is used in the following control strategy tables as a constant reminder to treat each season on its merits.



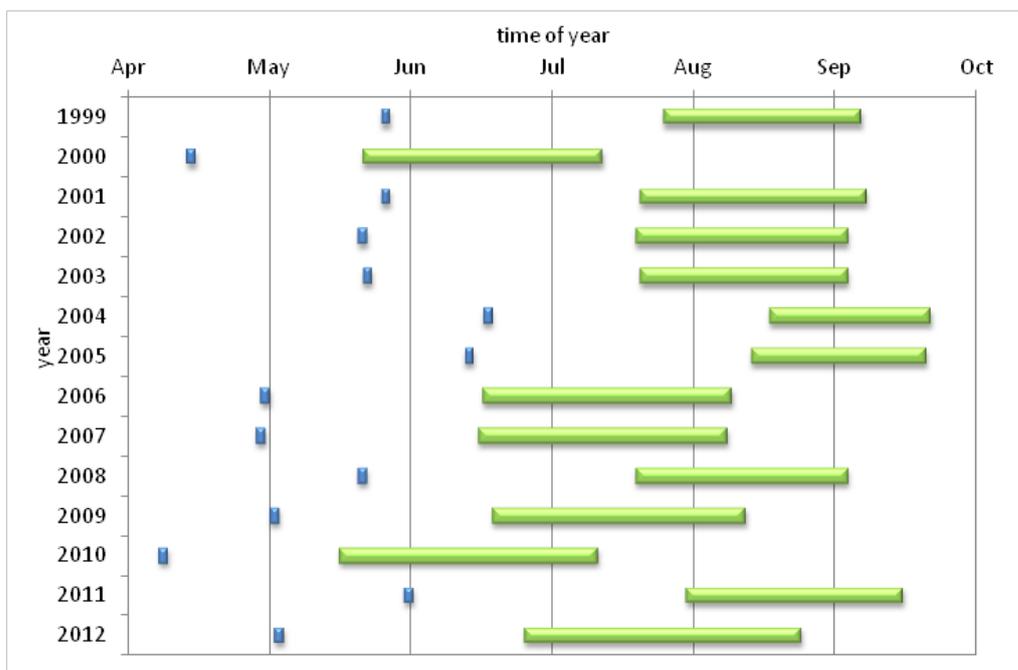


Figure 12 – Spray window variation. (Source: Jane Prider, Biosecurity SA)

SPRAYING IN WET YEARS

Wet seasons can affect accurate GDD spray recommendations because broomrape seeds can continue to germinate over a longer period in the presence of good soil moisture. This is similar to what can happen in wet summers with prolonged summer weed germinations. The following advice will help decide if additional herbicide applications are required in wetter seasons.

PASTURES & SCRUB/BUSHLAND

In pastures and scrub/bushland, it appears that there is an almost continuous germination of branched broomrape through a season. In a normal year, one spray at the right time provides protection for the season, as seasonal conditions prevent late germinating branched broomrape from reaching maturation. However, in long growing seasons such as 2010 a second spray is needed.

If an early opening to the season before 30 April (specifically in SA mallee) is followed up with rain to sustain growth until the end of October, then broomrape plants will germinate up until late July. These late germinating attachments can miss the first herbicide application and grow to maturity before the end of the growing season.

To reduce the risk of emergence in late spring, a second spray will be required to kill the later growing broomrape attachments.

Analysis of rainfall records across the SA Mallee show this will occur two to three times in a ten year period. With an early season break the first spray could occur in June and the second spray in late August.

For pastures and scrub the optimum second spray is to use glyphosate (450g/L) at 600 ml/ha, in August, on known infested sites; not whole paddocks.

CROPPING PADDOCKS

Experience indicates that broomrape hosts can be adequately controlled in crops in all seasonal conditions and hence will generally not require a second spray.

SUMMARY OF SPRAY MANAGEMENT OPTIONS

In all situations it is necessary to identify the nature of the previous branched broomrape infestation(s) to ensure the best plan is put into place.

SPRAY MANAGEMENT OPTIONS			
SITUATION	MANAGEMENT & TIMING	HERBICIDES & RATES	CONSIDERATIONS
Pasture - Cretan weed absent * Pasture paddocks may require 2 spray treatments in some years	Apply Broadstrike between 700 GDD -1300 GDD. *	Broadstrike (flumetsulam) 25 g/ha + Uptake (500 ml/100L)	Recommended for small, isolated infestations only. Consider a follow up glyphosate treatment on the isolated area as a precaution.
	Spray-top pastures with glyphosate before 1300 GDD.	Glyphosate (450 g/L) 600 ml -1.5 L/ha	Recommended for widespread infestations.
	Apply Ally before 1300 GDD.	Ally (metsulfuron methyl) 5-7 g/ha	Recommended for non-arable permanent pastures with no medic.
Pasture - Cretan weed present	Broadstrike can be applied early, however a follow up spray-top is also required to ensure success.	Broadstrike 25 g/ha + Uptake 500 ml/100L and Glyphosate (450 g/L) 600 ml -1.5 L/ha	Broadstrike applied early (700 GDD) is still useful as any broomrape emergence is likely to be delayed. This may provide a longer spray window for spray-topping.
	Spray-top pastures with glyphosate before 1300 GDD.	Glyphosate (450 g/L) 600 ml -1.5 L/ha	One spray only, but must be applied over the entire paddock.
	Apply Ally before 1300 GDD.	Ally (metsulfuron methyl) 5-7 g/ha	Recommended for non-arable permanent pastures with no medic.
Cereal Crop & Cereal Pasture - Cretan weed absent	Apply a knockdown prior to sowing to remove early weed germinations.	Glyphosate (450 g/L) up to 1.5 L/ha	GDD will begin to accumulate from the time of sowing.
	Apply a non-group B broadleaf herbicide on its own or in a mix to target 100% control of broadleaf weeds.	Commonly used herbicides: Diuron Lontrel (clopyralid) MCPA & 2,4-D products	These herbicides are best used in a mix to target several common weed species. Higher rates are required when weeds are large/ mature.
	Apply a residual group B herbicide pre -sowing or post emergent.	Glean (chlorsulfuron) 10-20 g/ha Logran (triasulfuron)15-35 g/ha Ally (metsulfuron methyl) 5-7 g/ha Midas 900 ml (Clearfield Wheat only)	Group B herbicides usually reserved for widespread, high risk broomrape infestations. Some residues may persist in following crops.

SITUATION	MANAGEMENT & TIMING	HERBICIDES & RATES	CONSIDERATIONS
Cereal Crop & Cereal Pasture Cretan weed present	Apply a knockdown prior to sowing to remove early weed germinations.	Glyphosate (450 g/L) up to 1.5 L/ha	GDD will begin to accumulate from the time of sowing.
	Apply a residual group B herbicide pre -sowing or post emergent.	Glean (chlorsulfuron) 10-20 g/ha Logran (triasulfuron) 15-35 g/ha Ally (metsulfuron methyl) 5-7g/ha Midas 900 ml (Clearfield Wheat only)	Group B herbicides usually reserved for widespread, high risk broomrape infestations. Some residues may persist in following crops.
	Use Jaguar in crop for maximum control of Cretan weed.	Jaguar (bromoxynil + diflufenican) 1 L/ha. Check crop safety first.	Consider this option if pastures are frequent in your rotation, as this will help to reduce the Cretan weed seed bank.
Clearfield Canola	Apply a glyphosate knockdown prior to sowing to remove early weed germinations. Apply Intervix or OnDuty in crop for broomrape control and Lontrel where wild turnip is a problem.	Glyphosate knockdown (450 g/L) up to 1.5 L/ha Intervix (imazamox, imazapyr) up to 750 ml/ha + Kwickin or Hasten (500 ml/100L) or 40 g/ha OnDuty + Kwickin or Hasten (500 ml/100L) Lontrel (clopyralid 750 g/kg) 60 -120 g/ha	Clearfield canola is still a host and requires Intervix or OnDuty (group B) to kill broomrape attachments. May be a risky option in a paddock with a widespread or large broomrape infestation.
Fence lines & Non-arable	Apply glyphosate prior to 1300 GDD. Residual group B herbicides can be applied early in the season or prior to 1300 GDD.	Glyphosate (450 g/L) 600 ml-1.5 L/ha 5-7 g/ha Ally(metsulfuron methyl) Logran (triasulfuron) Glean (chlorsulfuron) MCPA or 2,4-D + Ally mix	Consider erosion risk in these areas. Late control with glyphosate will ensure enough vegetative growth to stabilise areas. Group B herbicides and glyphosate can be used on their own or in a mix. Higher rates of group B will give longer residual activity. It is strongly recommended to spray known infested areas with a Group B.
Scrub	Apply Brush Off before 1300 GDD.	Brush Off (metsulfuron methyl) 3-5 g/ha	Spot spraying with a ute boom or hand line.
Horticulture	Apply knockdown, broadleaf herbicides in between rows to prevent weed host growth. Use Jaguar if possible where Cretan weed is a problem.	Glyphosate (450 g/L) 600ml-1.5 L/ha Spray.Seed 1-2 L/ha Jaguar (bromoxynil + diflufenican) 500 ml -1 L/ha	Timings will depend on herbicide and dormancy of horticultural crop.

CONTROL STRATEGIES

CEREALS AND CEREAL HAY			
MAXIMUM CONTROL STRATEGIES	BROOMRAPE HERBICIDES	HOST DENIAL CONTROL STRATEGIES	BROADLEAF HERBICIDES
<p>Continuous cereals with non Clearfield group B herbicides</p> <p>Clearfield Wheat and Barley varieties with Clearfield herbicides</p>	<p>Glean 10-20 g/ha</p> <p>Logran 15-35 g/ha</p> <p>Ally 5 g/ha</p> <p>Eclipse 7 g/ha + MCPA</p> <p>Midas 900 mL/ha (Clearfield varieties only)</p> <p>Intervix 375-750 ml/ha (Clearfield Plus varieties only)</p>	<p>Single or double knockdown herbicides prior to sowing</p> <p>Use of non-Group B broadleaf herbicides only</p> <p>Early weed control is essential to stop large uncontrollable weeds in crop</p>	<p>Lontrel</p> <p>Diuron 900WG</p> <p>Bromicide 200*</p> <p>Jaguar*</p> <p>MCPA products</p> <p>2,4-D products</p> <p>*For Cretan weed control</p>

CLEARFIELD (CF) CANOLA			
MAXIMUM CONTROL STRATEGIES	BROOMRAPE HERBICIDES	HOST DENIAL CONTROL STRATEGIES	BROADLEAF HERBICIDES
<p>Grow CF canola or mustard varieties and use Intervix or OnDuty herbicide</p>	<p>Intervix 300-750 mL/ha</p> <p>OnDuty 40 g/ha</p>	<p>Knockdown herbicides prior to sowing</p>	<p>Use knockdown herbicides prior to sowing.</p> <p>Lontrel post-emergent</p>

CLEARFIELD (CF) CANOLA			
MAXIMUM CONTROL STRATEGIES	BROOMRAPE HERBICIDES	HOST DENIAL CONTROL STRATEGIES	BROADLEAF HERBICIDES
<p>Use a Group B herbicide (check variety safety)</p>	<p>*Spinnaker 70 g/ha</p> <p>*Raptor 45 g/ha</p> <p>*Herbicide may fail to control broomrape in the presence of Cretan weed</p>	<p>Control broadleaf weeds prior to sowing with knockdown herbicides</p> <p>Use non group B broadleaf herbicides</p>	<p>Brodal Options – early post-emergence</p> <p>Bladex – pre-sow, post-sow/ pre-em and post-em applications (not recommended on sands)</p>

VETCH			
MAXIMUM CONTROL STRATEGIES	BROOMRAPE HERBICIDES	HOST DENIAL CONTROL STRATEGIES	BROADLEAF HERBICIDES
<p>Brown manure vetch in early September in normal years with a high rate of glyphosate.</p> <p>Spray vetch with glyphosate and Ally and green manure or graze heavily in early September.</p>	<p>Glyphosate (450 g/L) 1.2 L/ha</p> <p>Glyphosate (450 g/L) 600 ml/ha + Ally 5 g/ha</p>	<p>Control broadleaf weeds prior to sowing with knockdown herbicides</p> <p>Use non-Group B broadleaf herbicides</p>	<p>Sencor – check label for situation specific information</p> <p>Bladex – post sow/ pre-em only (not recommended on sandy soils)</p>

LUPINS			
MAXIMUM CONTROL STRATEGIES	BROOMRAPE HERBICIDES	HOST DENIAL CONTROL STRATEGIES	BROADLEAF HERBICIDES
<p>Apply Eclipse Group B herbicide with no adjuvants or mixes</p>	<p>Eclipse 7 g/ha</p> <p>Eclipse 7 g/ha + Brodal Options 100 ml/ha</p> <p>(refer to label for safe varieties)</p>	<p>Use knockdown herbicides</p> <p>Use non-Group B broadleaf herbicides</p>	<p>Gesatop (Simazine) – apply pre sow or post sow/ pre-emergence</p> <p>Brodal Options – early post-emergence</p>

ANNUAL PASTURES			
MAXIMUM CONTROL STRATEGIES	BROOMRAPE HERBICIDES	HOST DENIAL CONTROL STRATEGIES	BROADLEAF HERBICIDES
<p>Apply Broadstrike from July to August in normal seasons</p> <p>A second application of Broadstrike may be required in an above average or extended growing season</p> <p>Spray top with glyphosate from 700 to 1300 GDD</p> <p>Sow cereals for feed and apply broadleaf herbicides or hay freeze with glyphosate</p>	<p>*Broadstrike 25 g/ha</p> <p>*Raptor 45 g/ha</p> <p>(some medic damage may occur with certain species)</p> <p>Glyphosate (450 g/L) 600 ml-1.2 L/ha</p> <p>*Herbicide may fail to control broomrape in the presence of Cretan weed</p> <p>Spray selective broadleaf herbicide + Ally 5 g/ha</p>	<p>Improve medic density to min 30%</p> <p>Sow new barrel medic & SU tolerant varieties</p> <p>Spray graze early (good medic pasture only) and follow up with spray- top</p> <p>Spray-topping before September</p>	<p>Broadstrike 25 g/ha</p> <p>Spray grazing with MCPA 500 300-500 ml/ha</p> <p>Glyphosate (450 g/L) 600 ml-1.2 L/ha</p>

MAXIMIZING THE EFFECTIVENESS OF BROADSTRIKE®

Broadstrike® is a Group B herbicide commonly used in medic and self-regenerating weedy pastures in the broomrape quarantine area. The reason it is used widely is that it does not have an effect on medic and has limited control of broadleaf weeds, particularly once they are larger in size. This maintains adequate feed for livestock in a medic or self regenerating weedy pasture.

Broadstrike has been used over many years with varying results on broomrape emergence. In many pasture situations Broadstrike has been successful in preventing emergence and where it has failed to prevent broomrape emergence, Broadstrike has in many cases reduced the size of the infestation. It is important to note that Broadstrike does struggle to prevent broomrape emergence in the presence of Cretan weed. Additional strategies will need to be employed in paddocks with Cretan weed.

Broadstrike is a sulfonamide Group B herbicide so has some residual activity but much shorter than the sulfonyleurea Group B herbicides such as metsulfuron methyl (e.g. Ally®) and triasulfuron (e.g. Logran®). For this reason it is necessary to use Broadstrike strategically in pastures, and ensure spray timing is optimal for preventing broomrape emergence.

SPRAY BROADSTRIKE EARLY FOR WEED CONTROL

In pasture paddocks that have a good density of medic (over 50%) it is possible to spray Broadstrike early to remove all broadleaf weeds when they are small.

Applying Broadstrike early in July in most seasons will give better control of broomrape and better weed control on smaller weeds. Later applications in August increase the chance of emergence.

Early applications of Broadstrike are also unlikely to coincide with medic flowering that affects seed set.

CONDITIONS AT SPRAYING

To achieve the best possible results when using Broadstrike there are a number of factors to consider:

- Warm conditions greatly improve the activity of Broadstrike, therefore aim to spray later in the day. Best results will be achieved either early or late in the season when temperatures are milder.
- Spraying in sunny conditions is better than spraying in overcast conditions. It is also advisable to finish spraying by mid afternoon in winter to allow time for Broadstrike to be absorbed into host weeds.
- Avoid frosty conditions – delay spraying if necessary.
- Use higher water rates where possible (up to 100 L/ha).
- Ensure the quality of spray water.
- Use Uptake spraying oil or wetter depending on crop type.

PERENNIAL LUCERNE PASTURES

Lucerne is not a favoured host and established stands are unlikely to host attachments. Broomrape is at highest risk of attaching to lucerne when the roots are young and not woody. Broadleaf weeds remain the biggest risk factor to broomrape emergence.



PERENNIAL LUCERNE PASTURES			
MAXIMUM CONTROL STRATEGIES	BROOMRAPE HERBICIDES	HOST DENIAL CONTROL STRATEGIES	BROADLEAF HERBICIDES
Apply a Group B herbicide.	*Spinnaker 70 g/ha Raptor 45 g/ha *Broadstrike 25-50 g/ha (higher rate for grazing lucerne only) *Herbicide may fail to control broomrape in the presence of Cretan weed	Use selective non Group B herbicides to remove weeds. A bromoxynil herbicide can be used to control Cretan weed in lucerne.	Barracuda 900 ml/ha Diuron on established lucerne Jaguar 500 ml/ha -1 L/ha or Bromicide 200 1.4-2 L/ha where Cretan weed is present.

PERENNIAL GRASSES - VELDT & NATIVE GRASSES*			
MAXIMUM CONTROL STRATEGIES	BROOMRAPE HERBICIDES	HOST DENIAL CONTROL STRATEGIES	BROADLEAF HERBICIDES
Apply Brush-Off from 700 to 1300 GDD.	Brush-Off 5 g/ha on its own or in a mix with a phenoxy herbicide	Use a broadleaf selective phenoxy herbicide at cereal label rates	Phenoxy e.g. Amicide 625 or MCPA 500, (when grasses < 15cm in height and not in head)

* Limited trial data suggests these rates should be safe on perennial veldt grass and native grasses.

SCRUB AND BUSHLAND

In areas with native vegetation spot-spray with 3 – 5 gm of Brush-Off (metsulfuron-methyl) or low rates of other effective chemicals that are not lethal to native vegetation.

SCRUB AND BUSHLAND			
MAXIMUM CONTROL STRATEGIES	BROOMRAPE HERBICIDES	HOST DENIAL CONTROL STRATEGIES	BROADLEAF HERBICIDES
Apply a sub-lethal dose of Brush Off - 600 g/L (metsulfuron-methyl) to areas of known infestation	Brush Off – 600 g/L (metsulfuron-methyl) at 3 g/ha	Apply Interceptor Concentrate Weed Control (Pine Oil) to known infested areas.	Interceptor Concentrate Weed Control (Pine Oil)

HORTICULTURE

Controlling broomrape in horticultural crops will rely mainly on good host denial strategies. The options outlined in the following tables for horticultural crops focus on the management of broadleaf weeds for the prevention of broomrape. These tables give herbicide options for host control at various times of the growing season.



POTATOES		
TIME OF YEAR	HERBICIDE AND RATE	TIMING OF APPLICATION/ COMMENTS
Pre-emergence	Linuron - 2.2 kg-4.5 kg/ha	Apply after planting but before emergence of crop. Incorporate by irrigation or rainfall as soon as possible after application. DO NOT cultivate after application. Use higher rate during summer months.
	SpraySeed 250 3.2 L/ha (boom), (if volume of water exceeds 200 L/ha add 200 ml Agral or 120 ml TITAN wetter 1000 Wetting Agent/ 100 L of additional water)	After planting and hilling up, wait until 10-25% of potato shoots are emerged then blanket spray with SpraySeed 250. Emerged potato shoots will suffer marginal leaf burn but will quickly recover. Weed destruction prior to digging. Spray 3-7 days before digging after all the tops have died down. NB. DO NOT use SpraySeed 250 for potato haulm desiccation.
Post emergence	Metribuzin 470 g/ha (Some varieties such as Atlantic and red skin varieties are especially sensitive to Sencor).	Spray when potatoes are emerging with the largest shoots not more than 10 cm tall. Use higher rate for emerging summer grasses. In summer crops on soils which dry rapidly on the surface, young actively growing weeds will be killed but the residual effect may be reduced. Damage may occur even at the lowest label rate. DO NOT use on Kurell or Bison potatoes.

ONIONS		
TIME OF YEAR	HERBICIDE AND RATE	TIMING OF APPLICATION/ COMMENTS
Ground preparation	Glyphosate (540 g/L) 500 ml-1.2 L/ha SpraySeed 1-2 L/ha	Apply knockdown herbicides prior to sowing.
Pre-emergence	Dacthal 900WG 9-12.5 kg/ha	Spray at planting and use lower rate on lighter soils.
Post emergence	Linuron 500 – 300 g/ha light soils, 500 g/ha heavy soils Juggler 700 - 2-4 or more leaves, 1-3 kg/ha. See label for winter/ spring sown rates.	Post emergence only. Apply when onions are 15 cm or more in height. Retreat when necessary. DO NOT add any pesticide or wetting agent to JUGGLER 700 for use on onions. DO NOT use more than 2 kg/ha on onions when temperatures are over 27°C. Odourless and white onions are more sensitive than other varieties. Repeat spraying may be necessary to maintain weed free crops. Injury caused by sand blasting, water stress or other causes may render onions sensitive to JUGGLER 700 and crop damage may follow.

CARROTS		
TIME OF YEAR	HERBICIDE AND RATE	TIMING OF APPLICATION/ COMMENTS
Ground preparation	Glyphosate (540 g/L) 500 ml-1.2 L/ha SpraySeed 1-2 L/ha	Apply knockdown herbicides prior to sowing.
Pre-emergence	Prometryn 610 g/ha	Apply onto bare moist soil within 2 -3 days of planting. Use the lower rate on sandy soils.
	Dacthal 900WG 9-12.5 kg/ha	Spray at planting and use lower rate on lighter soils.
	Linuron 500 2.2 kg/ha light soils 4.5 kg/ha heavy soils	Apply immediately after planting but before the crop emerges.
Post emergence	Prometryn 944 g-1.2 kg/ha Linuron 500 1.1 kg/ha light soils 2.2 kg/ha heavy soils	Spray when weeds are young and actively growing. Use the higher rate on heavy soils. Post-emergence – DO NOT apply before carrots have reached the 4 true leaf stage, weeds no more than 7 cm tall, or within 5 days of any application of any emulsifiable pesticide or wetting agent as damage to crop may result. On soils high in organic matter use post-emergence rather than pre-emergence. Heavy rains after application may cause crop damage. DO NOT replant treated areas to other crops within 3 months of applications.

ALMONDS		
TIME OF YEAR	HERBICIDE AND RATE	TIMING OF APPLICATION/ COMMENTS
Pre-emergence	Oxyflurofen 3-4 L/ha	<p>DO NOT apply TITAN Oxyfluorfen 240EC Herbicide once bud swell has occurred.</p> <p>Apply to freshly cultivated weed free soil.</p> <p>Use the higher rate when longer residual control is required (up to 4 months).</p> <p>Where grass weeds are expected to be a major problem, or when control of a wider weed spectrum is required, mix the lower rate with 4-5 L Surflan 500 per treated hectare.</p> <p>Read and follow all label directions.</p>
	Zoliar 2.5 kg/ha	<p>Apply using a boom spray to bare ground prior to weed emergence. Apply as a directed spray in 300 to 500 L water/ ha. Avoid contact with foliage or fruit.</p> <p>An application in early autumn will give winter weed control or in early to mid spring will give full summer weed control.</p>
Post emergence	Glyphosate (540 g/L) Boom: 1.6-2.4 L/ha	Citrus, Nuts, Olives, Pome fruit, Vineyards: DO NOT allow spray/spray drift to contact green bark, stems, canes, laterals, suckers, fresh wounds, foliage or fruit.
	SpraySeed 250 2.4-3.2 L/ha	<p>Thoroughly wet plant foliage. Use the high rate for dense more established weed growth.</p> <p>Repeat treatment on regenerated green perennial weeds (such as paspalum and docks) while plants are weakened from previous treatment.</p>

ORGANIC FARMING

Organic farmers face extra challenges in controlling branched broomrape because of limited herbicide options. It is extremely important to know where infestations are located on the property so that you can focus on post-emergent control for branched broomrape escapes.

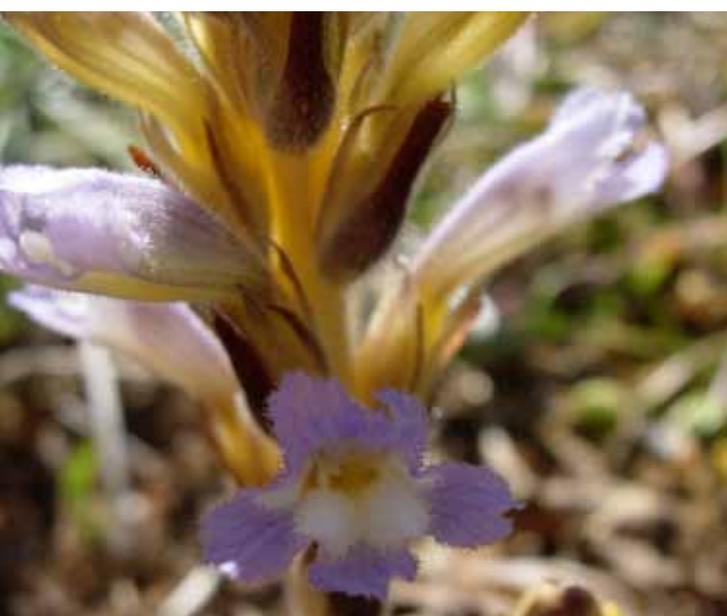
Interceptor Concentrate Weed Control, a pine-oil based herbicide certified for use in organic systems in Australia, kills some broomrape seed in the soil when used as a soil drench.

The key to control is to prevent seed set and the best way to do that is to eliminate all potential hosts including broadleaf weeds.



ORGANIC FARMING			
MAXIMUM CONTROL STRATEGIES	BROOMRAPE HERBICIDES	HOST DENIAL CONTROL STRATEGIES	BROADLEAF HERBICIDES
<p>Heavily graze infested areas</p> <p>Spray infested areas with Interceptor</p> <p>Concentrate Weed Control prior to broomrape emergence</p> <p>Hoe/ pull host plants from known infested areas.</p>	<p>Interceptor Concentrate Weed Control</p>	<p>Hoe/ pull host plants from known infested areas.</p> <p>Wait for emergence and control with Interceptor Concentrate Weed Control by drenching one metre around each plant</p> <p>Wait for emergence then remove broomrape in plastic bag and burn</p> <p>Burn plants in situ</p>	<p>Interceptor Concentrate Weed Control</p> <p>Use molasses to sweeten weeds for grazing in infested areas</p>

FUMIGATED AREAS	
MAXIMUM CONTROL STRATEGIES	HOST DENIAL CONTROL STRATEGIES
<p>Strategies for broomrape management are not required in the fumigated area</p> <p>Treat the entire paddock as recommended for the relevant paddock situation and status prior to fumigation.</p> <p>Group B herbicides will work best.</p>	<p>Sow a cereal crop in the fumigated area and a buffer zone around it to avoid erosion.</p> <p>Broomrape can still emerge outside of the fumigated area so minimise the risk of re-emergence by controlling host plants with a selective herbicide.</p> <p>Apply Group B herbicides or non-Group B broadleaf herbicides.</p>



LIFESTYLE/SMALL ENTERPRISES

Choose a crop or pasture type that will allow you to easily control weeds and learn to accurately identify the common weeds on your property. Many of the common broadleaf weeds are broomrape hosts, therefore sowing grasses or cereals will allow for the selective control of broadleaf host weeds.

For more information on hosts and weed identification pictures refer to Chapters 1 and 7 respectively.

LIFESTYLE/SMALL ENTERPRISES			
MAXIMUM CONTROL STRATEGIES	BROOMRAPE HERBICIDES	HOST DENIAL CONTROL STRATEGIES	BROADLEAF HERBICIDES
Continuous cereals Permanent veldt or grass pastures Group B herbicides	Seek further advice for your individual situation	Use knockdown herbicides prior to sowing crops/ pasture Make sure you can use non-Group B broadleaf herbicides safely Early weed control is essential to stop large uncontrollable weeds in-crop	Seek further advice for your individual situation

FENCE LINES AND NON-ARABLE AREAS

It is important to control host plants along fence lines and in other non-arable areas, particularly around infested paddocks, because they can be a haven for weeds and a source of re-infestation of hosts or branched broomrape.

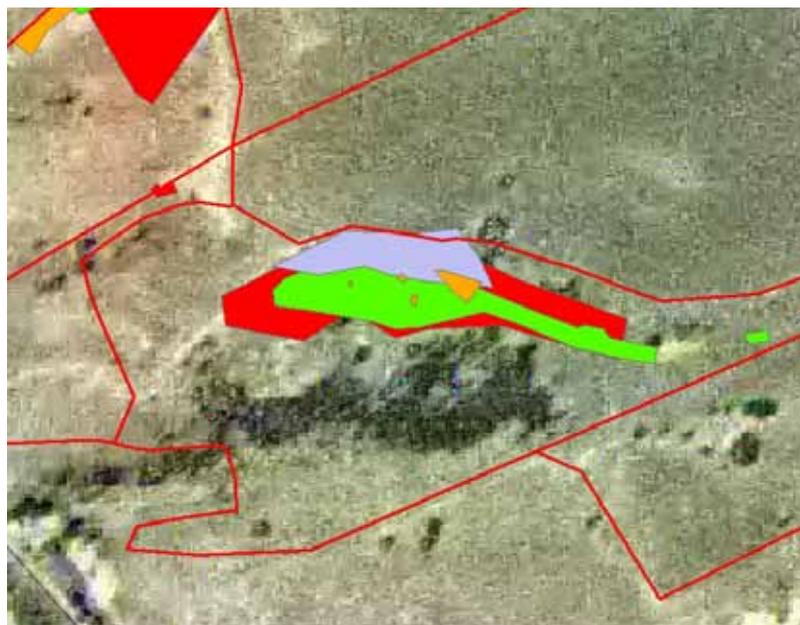


FENCE LINES AND NON-ARABLE AREAS			
MAXIMUM CONTROL STRATEGIES	BROOMRAPE HERBICIDES	HOST DENIAL CONTROL STRATEGIES	BROADLEAF HERBICIDES
Apply glyphosate before 1300 GDD Use Ally 7 g/ha or Glean or Logran to control growth of most weeds Ally 5 g/ha plus phenoxy herbicide will selectively take out broadleaf weeds and leave some growth to stabilise the soil	Glyphosate Ally Glean Logran	Glyphosate and Group B herbicides should be used in a mix where possible and rotated with paraquat to prevent herbicide resistance developing in fence lines. Paraquat will need to be sprayed early to prevent host weed development ~700 GDD, and may require a second application later in the season before 1300 GDD. Heavy grazing is an alternative control option for areas that can't be easily accessed with spray equipment but is not recommended as a stand-alone treatment.	Paraquat Phenoxy herbicides at high rates to control large broadleaf weeds.

HERBICIDE RESISTANCE AND BRANCHED BROOMRAPE CONTROL

Control strategies for branched broomrape rely mainly on herbicide use over many years, which raises the issue of herbicide resistance in susceptible weed species.

Herbicides are grouped on their mode of action (how the chemical kills weeds) and resistance is more likely to occur with some herbicide groups than others. Resistance also appears more often in some weed species than in others. Weeds that can tolerate a normally lethal dose of herbicide are said to be herbicide resistant. Herbicide resistance is caused by repeated use of products from the same herbicide group.



RISK RATING	HERBICIDE GROUP	EXAMPLE
High risk	A, B	Grass selectives, sulphonylureas, imidazolinones
Medium risk	C, D, E, F, G, H	Triazines, trifluralin, diflufenican, bromoxynil
Low risk	I, J, K, L, M, N	Phenoxy (2,4-D & MCPA), paraquat, glyphosate



GUIDELINES

The risk of weeds developing resistance can be minimised by building the following guidelines into your farming systems and management.

The key is to 'keep the weeds confused' and ensure they have no opportunity to adapt to any one management strategy or herbicide group. To achieve this:

- Keep weed numbers low
- Rotate herbicide modes of action
- Where possible use Group Bs in mixes with herbicides from other groups, particularly in cereals. This ensures the weeds are subjected to multiple modes of action at the same time, which reduces the likelihood of any weed plant surviving the sprays.
- There are two basic approaches to branched broomrape control:

- Kill all the hosts and deny broomrape the opportunity to germinate (host denial).
- Use herbicides that kill broomrape as it is germinating or growing.

Host denial is an effective and cheap strategy in cereal crops or grass pastures and gives greater options for using non-group B herbicides.

In crops that are hosts or in crops where weedy hosts are difficult to remove, using a Group B to kill broomrape or glyphosate to kill the crop and broomrape is the only option.

Repeated use of only Group B herbicides in cereals creates a high risk of getting herbicide resistance. Use of MCPA or 2,4-D, however, is low risk, whether they are applied as separate sprays or in mixtures with other herbicides.

OnDuty and Intervix (Group Bs) are the only choice for killing broomrape in Clearfield Canola as Triazines (Group C) have no effect on broomrape and will not kill the parasite when it is attached to canola, so TT (triazine tolerant) canola is not recommended for high-risk broomrape areas.

In peas, vetch, lupins, lucerne or medic, the softer Group B herbicides such as Raptor, Broadstrike, Eclipse and Spinnaker can be effective against broomrape. Correct timing – which varies with the season – and rate are critical for success with these herbicides.

Glyphosate (Group M) is also effective on broomrape and carries a low risk of resistance.

SUMMARY

- The safest strategy for broomrape control in cereals is to use good rates of the Group I herbicides MCPA, 2,4-D or Lontrel in mixtures with other herbicides to kill all the hosts so there is no host source for broomrape.
- Consider using sulphonylurea Group Bs in a mix with other herbicides. The local practice of 2,4-D + Lontrel (Group I) + Ally (Group B)

is a very good mix for stopping hosts, stopping broomrape and minimising the risk of getting resistance.

- Use of glyphosate to spray-top pastures also reduces the risk of resistance.
- Reserve Group B herbicides for use where they are the only practical option and use chemicals from other groups in cereals.
- If you don't grow host crops, rotating the use of a Group B on its own in a cereal is acceptable.

Resistance is a paddock-by-paddock issue. Weeds are most likely to develop resistance in any paddock where only Group B herbicides are used all the time.



Chapter 6



Chapter 6

BROOMRAPE EMERGENCE

This chapter contains information on managing emerged broomrape.

DESTROYING EMERGED PLANTS

The key to containing and eradicating branched broomrape is to prevent it setting seed and adding to the seed bank so emerged plants need to be found and destroyed immediately.

The best control strategy will depend on the scale of the infestation, the stage and vigour of the host plant and the branched broomrape.

It is possible to kill broomrape plants once they have emerged by spraying the host plants, but timing is important to prevent seed set and difficult to get right when the window for control is so small. In most circumstances, emerged plants need to be picked and placed in sealed plastic bags for destruction by burning or burnt where they are discovered.

EARLY DISCOVERY

Branched broomrape plants found before they flower can be killed by spraying the host plants with glyphosate herbicide, but this depends on being able to identify which plant is hosting the broomrape and the host still being fresh enough to take up herbicide.

Use 150 mL of glyphosate per 10 L of water, plus recommended wetters and spray dye so you can see what has been sprayed.

LATER DISCOVERY

Branched broomrape plants emerge and flower very quickly and it must be assumed any flowering plant has already set viable seed.

Consequently, no flowering plant should be moved except in a sealed plastic bag.

Plants can be burned on site using a mixture of one part petrol and four parts diesel. This mixture helps maintain a hot fire for longer than using petrol alone or attempting to burn plants without an accelerant. The mixture will also spread over the soil, which increases the chance of killing seed lying on the surface. It is important not to use a flame thrower to burn the emerged plants as the force of the gas may further distribute the seed before burning can occur.

Isolated individual plants can be picked and placed immediately into a sealed plastic bag to ensure seeds are not spread during transportation and for later incineration. Burn the entire bag in an incinerator with an actively burning hot fire.

DRENCHING

If burning is not an option, saturation of young or mostly dry plants and the soil around them with pure diesel will desiccate the plants and kill partly-developed seeds.

Almost all of the seeds produced by a branched broomrape plant fall within one metre of the emerged plant and 90% within half a metre. It is therefore recommended drenching around emerged plants cover an area with radius of one metre around each plant.

MARK IT ON A MAP

Using a GPS or other paddock landmarks to mark a known infestation will help with control measures in future years. Smaller known areas can be treated separately with Maximum Control strategies in certain situations. It will also be advantageous to come back and monitor the same area every spring to deal with any re-emergence.





Chapter 7

Chapter 7

BROADLEAF WEED IDENTIFICATION

This chapter contains photographs to assist in the identification of plants that commonly host branched broomrape.

Capeweed

Arctotheca calendula



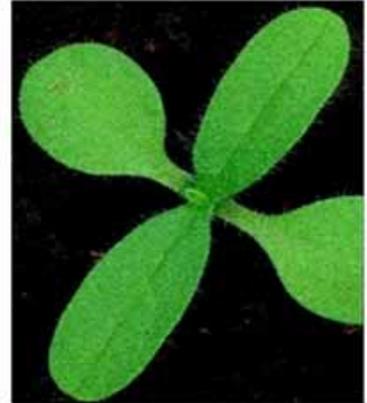
Sheep weed

Lithospermum arvensis



Salvation Jane

Echium plantagineum



Skeleton weed

Chondrilla juncea



Sow thistle

Sonchus oleraceus



Wild turnip

Brassica tournefortii



MORE DETAILED INFORMATION ON CRETAN WEED

CRETAN WEED (*HEDYPNOIS RHAGADIOLIDES*)

Cretan weed emerged as a favoured host of branched broomrape in the Mallee. The presence of Cretan weed will affect our broomrape management strategies as many of the herbicides that will successfully control broomrape will fail in the presence of Cretan weed.

Cretan weed management needs to be effective and on-going from year to year because plant numbers increase rapidly in the Mallee environment.

FAMILY:

Asteraceae (same family as skeleton weed, capeweed, variable groundsel)

CHARACTERISTICS

- Usually occurs as scattered plants in mixed pastures, or in areas that have been disturbed.
- Can form extensive mats of plants 20cm high that can smother crop seedlings.
- Is readily eaten by stock.
- Usually germinates early, generally in autumn.
- Early maturing, so may set seed prior to the normal spray-topping window for grasses.
- A favoured and common host of branched broomrape.

DISTINGUISHING FEATURES

- Leaves are broadly toothed, rough, hairy and up to 7cm long.
- Flower heads are yellow on leafless erect hollow stalks.
- Stems are branched and have hairs.
- Seeds are cylindrical to 6mm long.
- Seed head globular with crescent shaped seeds.



Cretan weed seed head



Cretan weed plant



Flowering Cretan weed plant



A mat of Cretan weed

Appendices

APPENDIX 1 - CONTACTS

GENERAL BROOMRAPE ENQUIRY

The South Australian Murray Darling Basin
Natural Resources Management Board

110A Mannum Rd

Murray Bridge SA

PO Box 2343

Murray Bridge SA 5253

Phone: 08 8532 9100

www.samdbnrm.sa.gov.au

HERBICIDES

Contact your reseller for alternative formulations

MARKETING

Biosecurity SA

33 Flemington St

Glenside SA

GPO Box 1671

Adelaide SA 5001

Phone: 08 8207 7900

APPENDIX 2 - MAXIMUM CONTROL AND HOST DENIAL HERBICIDES LIST

The following list contains products that are useful (but not limited to) in controlling broomrape and hosts. Those marked in bold are known as maximum control herbicides as they kill broomrape through the host.

NB – An * indicates these herbicides can fail in some situations.

Active ingredients are listed so equivalent products can be substituted.

Ally® /Brush-Off (Herbicide Group B) – 600 g/kg metsulfuron-methyl

Amicide 625 (Herbicide Group I) – 625 g/L 2,4-D amine

Bladex 500SC® (Herbicide Group C) – 500 g/L cyanazine

* **Broadstrike®** (Herbicide Group B) – 800 g/kg flumetsulam

Brodal Options® (Herbicide Group F) – 500 g/L diflufenican

Bromicide 200® (Herbicide Group C) – 200 g/L bromoxynil (present as n-octanoyl ester)

Buctril MA® (Herbicide Groups C+I) – 200 g/L Bromoxynil + 200 g/L MCPA

Credit® (Herbicide Group M) – 540 g/L glyphosate

Dacthal® 900 WG (Herbicide Group D) – 900 g/kg Chlorthal-dimethyl

Diuron 500 SC (Herbicide Group C) – 500 g/L diuron

Diuron 900 DF (Herbicide Group C) – 900 g/kg diuron

***Eclipse®** (Herbicide Group B) – 714 g/kg metosulam

Ester 680 (Herbicide Group I) – 680 g/L 2,4-D (present as 2-ethylhexyl ester)

Gesatop 900 WG® (Herbicide Group C) – 900 g/kg simazine

Glean® (Herbicide Group B) – 750 g/kg chlorsulfuron

Intervix® (Herbicide Group B) – 33 g/L imazamox + 15 g/L imazapyr

Jaguar® (Herbicide Groups C+F) – 250 g/L bromoxynil + 25 g/L diflufenican

Juggler 700 (Herbicide Group C) – 700 g/ka methabenzthiazuron

Lexone DF® (Herbicide Group C) – 750 g/kg metribuzin

Linuron (herbicide group C) – 500 g/kg linuron

Logran 750 WG® (Herbicide Group B) – 750 g/kg triasulfuron

Lontrel 750 SG® (Herbicide Group I) – 750 g/kg clopyralid

LVE MCPA® (Herbicide Group I) – 500 g/L low volatile ester

MCPA 500® (Herbicide Group I) – 500 g/L MCPA (present as dimethylamine salt)

Midas® (Herbicide Groups B+I) - 288.5 g/L MCPA (present as ethyl hexyl ester) + 22 g/Limazapic + 7.3 g/L imazapyr

OnDuty® (Herbicide Group B) – 525 g/kg imazapic + 175 g/kg imazapyr

Prometryn 500 SC (Herbicide Group C) – 500 g/L prometryn

***Raptor®** (Herbicide Group B) – 700 g/kg imazamox

Roundup CT® (Herbicide Group M) – 450 g/L glyphosate (present as isopropylamine salt)

Roundup Attack® (Herbicide Group M) – 570 g/L glyphosate (present as potassium salt)

***Spinnaker 700 WDG®** (Herbicide Group B) – 700 g/kg imazethapyr

Sencor 750 WG® (herbicide Group C) – 750 g/kg metribuzin

Spray.Seed 250® (Herbicide Group L) – 135 g/L paraquat (present as paraquat dichloride) + 115 g/L diquat (present as diquat dibromide monohydrate) **for control of Potato weed or use in horticulture where glyphosate cannot be used**

Tigrex® (Herbicide Groups F+I) – 250 g/L MCPA (present as ethyl hexyl ester) + 25 g/L diflufenican

Zoliar 800 DF (Herbicide Group F) – 800 g/kg norflurazon

SPRAY ADJUVANTS

Agral® - 600 g/L nonyl phenol ethylene oxide

condensate non-ionic organic surfactant.

BS1000® - 1000 g/L alcohol alkoxylate

Bonza™ - 450 g/L paraffinic oil + 259 g/L fatty acid and fatty acid derivatives + 91 g/L nonoxynol

Cropshield® - 838 g/L petroleum oil

DC Trate® - 763 g/L petroleum oil

Hasten™ - 704 g/L fatty acid esters of canola oil + surfactant >15%

Kwickin™ - 704 g/L fatty acid esters of canola oil

Uptake™ Spraying Oil – 582 g/L paraffinic oil + 240 g/L non-ionic surfactants

PARTNER HERBICIDES

Goal® (Herbicide Group G) - 240 g/L oxyfluorfen

Hammer® (Herbicide Group G) - 240 g/L carfentrazone-ethyl

CONVERSION FORMULA

Conversion to alternative herbicide

$$\text{Rate/ha of alternative herbicide} = \frac{\text{Recommended rate/ha of listed herbicide} \times \text{Active constituent concentration in listed herbicide}}{\text{Active constituent concentration in Alternative herbicide}}$$

Active constituent concentration in Alternative herbicide