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Biological control of doublegee

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Doublegee (Emex australis) is one of the worst agricultural weeds in Western Australia. To date, however, biological control of this weed has proved elusive.

Multiple releases of two weevils which attack doublegee have not led to insect establishment. For one of these species, further research has shown that doublegee control would probably not be achieved in the wheatbelt even if insect establishment were enhanced by growing its host during the summer months.

A joint Western Australian Department of Agriculture/CSIRO project is investigating the virulence and host specificity of an undescribed South African species of Phomopsis fungus. Should this pathogen prove suitable for importation and release, it may contribute to doublegee control in pastures, especially in conjunction with competition from other plants.

The doublegee problem

Doublegee is a broad-leaved weed that is found over large areas of the central and northern wheatbelt. It causes losses in crop yield and pasture production and the spiny fruits produced in heavy infestations can virtually cripple young stock. Although effective control of doublegee can be achieved with the use of selective herbicides in wheat crops, and reasonable control is possible in grain lupin crops, it has proven difficult to control consistently in pastures. Often doublegee is controlled only at considerable cost to the legume component of pastures.

One of the major barriers to managing doublegee is that its seeds are long-lived, whether buried or resting on the soil surface. This contrasts with many grass weeds, where the prevention of seed production in one season may substantially reduce the weed population in the next.

The doublegee problem must be considered in the context of the crop/pasture rotation; indeed it is likely that doublegee would become insignificant in either a continuous cropping system or a permanent pasture.
It is in the transition from crop to pasture that doublegee is able to 'set itself up' by producing massive numbers of seeds in typically sparse first-year pastures. Work at Wongan Hills by Des Gilbey of the Department's Weed Science Branch has shown that seed densities can increase almost ten-fold when no control is attempted in first-year pastures (Figure 1). Because effective control is so difficult to achieve by conventional methods in pastures, biological control would be most valuable in this stage of the rotation.

Release of biological control agents in Western Australia

The first natural enemy of doublegee to be released in Western Australia was the weevil *Perapion antiquum*. This insect was collected by CSIRO from South African doublegee populations and had successfully controlled doublegee in Hawaii following its release there in 1957. *Perapion* was released throughout the Western Australian wheatbelt during 1974 and 1975. The subsequent lack of establishment was attributed to the wheatbelt's harsh summer climate. However, further collections of *Perapion* from drier sites in South Africa have failed to yield populations which could persist anywhere in the wheatbelt.

Research into possible methods to enhance the survival of *Perapion* will be described later.

In 1981, another weevil, *Lixus cribricollis*, collected in Morocco by CSIRO, was released. It was hoped that *Lixus* would exert a degree of control over docks (*Rumex* spp.) as well as doublegee, but again this weevil failed to establish at any of the sites where it was introduced.

### Table 1. The estimated number of generations of *Perapion* which could develop during the growing season for doublegee at various sites in eastern Australia (from data of M.H. Julien and A.S. Bourne)

<table>
<thead>
<tr>
<th>Site</th>
<th>Doublegee growing period</th>
<th>Estimated no. of generations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merbein, Vic.</td>
<td>March-November</td>
<td>3.0</td>
</tr>
<tr>
<td>Loxton, S.A.</td>
<td>March-November</td>
<td>2.9</td>
</tr>
<tr>
<td>Flinders Island, S.A.</td>
<td>March-November</td>
<td>1.7</td>
</tr>
<tr>
<td>Ma Ma Creek, Qld.</td>
<td>March-October</td>
<td>4.0</td>
</tr>
<tr>
<td>Roseworthy, S.A.</td>
<td>Mid March-October</td>
<td>2.1</td>
</tr>
<tr>
<td>West Wyalong, N.S.W.</td>
<td>Mid March-October</td>
<td>1.9</td>
</tr>
<tr>
<td>Narrabri, N.S.W.</td>
<td>Mid March-October</td>
<td>2.8</td>
</tr>
</tbody>
</table>

![Figure 1. The effect of chemical control upon the size of doublegee seed populations in cropped land which was rotated to pasture (P) either directly or following another year of crop (C).](image)

Biological control of annual weeds

It is fundamentally more difficult to achieve biological control of an annual, as opposed to perennial, weed. In contrast to a perennial, where the target is more or less always available for attack, an annual weed presents a biocontrol agent with a 'feast or famine' situation.

In a strongly seasonal environment, annual weeds are present only as seeds for a large part of the year. Hence, a highly specific agent needs to have some means of persisting (such as a resting stage) in the absence of its host. Then, at the beginning of the growing season, weeds appear quickly and extensively. If the agent does not have the ability to increase its numbers rapidly, a large proportion of the weed population will effectively escape attack. However, this scenario does suggest that such an agent might be relatively successful if weed densities were not too great, a situation which could possibly be achieved by a programme of integrated weed control.

Since *Perapion* does not exhibit a resting stage, a considerable amount of effort has gone into devising methods for increasing its survival over summer. Fortunately, doublegee grows well outside its normal growing season, given adequate moisture.
Work at Wongan Hills Research Station showed that plants emerged and grew most rapidly when irrigation started in early February. More rapid growth resulted from higher temperatures, but the relative absence of competition with other species was also important. Plants which germinated in April emerged with dense populations of subterranean clover and capeweed and were overtopped, slowing their growth considerably.

Using the same approach at Avondale Research Station, Kingsley Fisher of the Department’s Entomology Branch, showed that irrigated doublegee stands could support Perapion populations, which then dispersed to doublegee plants in the surrounding paddock following the break of season. However, this work pointed out another deficiency in the weevil’s biology.

Although Perapion’s life cycle takes four to five weeks at 22 to 25°C, the rate of development drops at lower temperatures, with development ceasing at 10°C. Thus low field temperatures during winter limit the number of generations that can be achieved by Perapion during the growing season.

Researchers in the eastern States estimated the potential number of generations in relation to heat sums calculated for various localities and growing season lengths (Table 1). Although considerable variation existed in generation numbers, the point most pertinent to the Western Australian environment is that the growing periods listed were up to two months longer than those for our wheatbelt localities. This suggests that Perapion might not achieve two generations in some sites. Kingsley Fisher’s work at Avondale has confirmed that Perapion numbers are unlikely to increase sufficiently to achieve control of doublegee.

Future agents

Insect control

After a more detailed study of the insect fauna of doublegee in both winter and summer-rainfall areas of South Africa confirmed there were limited opportunities for obtaining successful insect control of this weed, the search turned to insects associated with the closely related Emex spinosa.

A survey conducted by John Scott of the CSIRO Division of Entomology identified three apionid weevils as potentially suitable candidates. These comprised two further Perapion species, one each from Morocco and Portugal, and a species of Erythrapion from Israel. However, to date there has been no further research into the potential suitability of any of the insects as bio-control agents for doublegee.

Fungal control

Recently, the focus of biological control research has shifted to the possibility of using fungal pathogens as control agents.

Earlier work in South Africa suggested that Uromyces rumicis and an undescribed species of Phomopsis might be suitable agents. The Phomopsis fungus occurs naturally in parts of the south-western Cape Province in South Africa, a region which has a mediterranean-type climate similar to that found over much of south-western Australia. Following infection of doublegee plants, the Phomopsis causes a severe leaf spot and stem blight; seedlings inoculated with the Phomopsis die within seven days and older plants are killed within three to four weeks after inoculation. Researchers have applied for permission to import the Phomopsis for testing in Canberra.

The fungus is seed-borne and causes reductions in germination. Thus the characteristics of the Phomopsis which suggest good potential as a biological control agent include the debilitating nature of the disease it causes, prolific production of spores, high levels of seed infection, apparent high host specificity and its climatic adaptation.
Roger Shivas of the Department’s Plant Pathology Branch is now in Cape Town, carrying out basic research on the *Phomopsis*, including the assessment of virulence of different isolates and the determination of their degree of host specificity.

Although insect bio-control agents may be relatively insensitive to the presence of genetic variability in their target plants (*Perapion* attacks the related *E. spinosa* just as vigorously as it attacks doublegee), the relationship between a fungal pathogen and its host may be much more specialized. For example, the rust *Puccinia chondrillina* attacks only one of the three forms of skeleton weed which are present in Australia.

A recent survey of Australian doublegee populations, using the technique of starch gel electrophoresis, encountered little genetic variability. Of the 15 enzyme systems which were examined, only one showed any variation, and this was detected among populations from south-eastern Australia. For the most part, South African doublegee material was uniform as well.

Although the genes which are detected by electrophoresis are not those which control the resistance or susceptibility to pathogenic attack, it is encouraging that doublegee presents little readily detectable variation. By comparison, the two forms of skeleton weed which are resistant to the first-imported strain of *Puccinia* exhibit differences in a number of enzyme systems in relation to the susceptible form.

**Integrated control of doublegee**

If a biological control agent for doublegee is ever found and established, it is probable that satisfactory control will be achieved only in conjunction with other control tactics. As was mentioned earlier, certain types of agent might be relatively ineffective at high weed densities. For such agents, the control of doublegee achieved through practices associated with cropping may play a significant role in the reduction of weed populations.

Past experience has shown that the overall impact of the damage inflicted by biological control agents may be amplified when a weed is under stress arising from competition. For example, dry weight gain of skeleton weed plants infected with *Puccinia* is considerably less when they are growing in competition with subterranean clover.

A recent experiment conducted at Wongan Hills Research Station indicated that doublegee is a weak competitor, relative to either barley grass or subterranean clover (Figure 2). This augurs well for the potential of a pathogen such as *Phomopsis* to contribute to doublegee suppression in pastures, should it meet the strict requirements for importation and release. However, it also indicates that benefits could be obtained from more active management of first-year pastures.

In the continued absence of either biological control or an economical, selective herbicide for doublegee, re-sowing pastures with competitively superior species may contribute greatly to reducing the impact of doublegee in crop-pasture rotational systems.

**Figure 2. Doublegee competes poorly when growing amongst a) barley grass and b) subterranean clover.**

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![Graph](image-url)