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Skeleton weed : how serious a threat in Western Australia?

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■ The ride-along used during paddock searches for skeleton weed.

Skeleton weed: how serious a threat in Western Australia?

Skeleton weed is probably the most serious weed ever to threaten the Australian wheat industry. It interferes with wheat cropping at two stages: through competition with the growing crop, particularly for nitrogen and water during the crop's development; and later through the production of a tall, wiry flowering stem which tangles in harvesting machinery and can make harvesting difficult, if not impossible.

The weed is a major problem in eastern Australia although a combination of cultural, chemical and biological control programmes is helping to reduce its impact.

In Western Australia, skeleton weed is being contained mainly by eradication efforts. Weed Agronomy Research Officers, **F. D. Panetta and J. Dodd**, *are studying the ecology of skeleton weed to determine why it hasn't spread further and how current control methods can be more effectively applied.*

Background

Skeleton weed was introduced to Australia about 1910 and was first identified in 1917 at Wagga Wagga, New South Wales. It subsequently spread very rapidly, up to about 24 kilometres per year, from 1920 to 1960. Early spread was particularly rapid along railway lines. Today, in eastern Australia, skeleton weed can be found from south-eastern Queensland to the Eyre Peninsula in South Australia.

The introduction of selective herbicides, in particular 2,4-D, in the late 1940s provided an economic means of suppressing skeleton weed within wheat crops. Although the use of 2,4-D suppressed the development of flowering stems so that grain could be harvested, this herbicide could not be applied until the early tillering stage, by which time the weed had exerted competitive effects on the crop.

Later, annual legumes were incorporated into a crop-pasture rotation. This prevented seedling establishment of skeleton weed, reduced the vigour of established plants by shading and led to the development of more vigorous crops through increased soil nitrogen levels.

Recently, the release of biological control agents has further reduced the impact of skeleton weed in the eastern States, although this approach has not been entirely successful.

Biological features

Skeleton weed is a herbaceous perennial member of the daisy family (Asteraceae). Its growth cycle starts in autumn with germination and seedling establishment as well as regrowth of rosettes from established root systems. Vegetative growth continues through winter, and during late spring an erect, spindly flowering stem grows from the centre of the rosette.

Small yellow flowers appear from early December until late summer, provided adequate moisture is available. A single mature plant can produce more than 15,000 seeds in a season. The rosette leaves die off in early summer, and the flowering stem dies back by autumn, when new rosette leaves appear from the root crown.

Levels and patterns of moisture availability are critical to successful reproduction by seed. Moisture must be readily available for plants to produce viable seeds. If plants are stressed at flowering, the seeds which are produced either contain no embryo or are shed before the embryo is fully developed.

■ Rosette of narrow-leafed skeleton weed.

Viable seeds demonstrate little or no dormancy. They will germinate quickly over a wide range of temperatures in light or darkness immediately after they are shed. Because of these germination characteristics, buried seeds do not accumulate for a substantial period below established plants and seed populations are frequently depleted during the hot, dry conditions which follow isolated summer showers.

Apart from establishment from seed, the most important means of increase of skeleton weed populations is through regeneration from the root system when it is disturbed by cultivation. The roots contain a sticky, white latex which oozes out when the surface is cut and effectively seals the cut end, slowing moisture loss and allowing severed root pieces to survive for long periods.

Root fragments one centimetre long are capable of forming new plants and regrowth can occur from as much as one metre below the soil surface. Because the regeneration potential of root systems is so great, repeated shallow cultivation has been probably the single most important factor contributing to the build-up of infestations in Australia.

Although the Australian populations of skeleton weed were originally considered to be identical, further research indicated that three distinct and stable forms of the species are found in Australia. These forms were originally distinguished primarily on the basis of the shapes of rosette leaves and were described as narrow-leafed, intermediate-leafed and broad-leafed plants.

Apart from differences in the ability to regenerate from root fragments (broad-leafed plants are the most vigorous), the three forms vary considerably in their susceptibilities to biological control agents (see table).

Distribution

Skeleton weed occurs over a range of soil types, although sandy soils are more often infested than heavier soils. Seedlings establish more readily on lighter soils and plants develop more extensive lateral root systems because of easier penetration.

In Australia skeleton weed has been recorded from regions with average annual rainfall ranging from 225 to 1,500 millimetres. Densest populations occur in the low to medium rainfall zone (300 to 500 mm) where winter rainfall predominates, but with no severe summer drought.

Skeleton weed in Western Australia

The first known outbreak of skeleton weed in Western Australia occurred at Ballidu in 1963. Since then there has been a steadily increasing number of finds, now exceeding 100.

Infestations have been found in the northern, central and eastern regions of the wheatbelt, with by far the greatest number of finds (52) in the Shire of Narembeen (Figure 1). Individual outbreaks have ranged from a few isolated plants to fairly dense infestations spread over several hectares. The largest outbreak at Narembeen, found in December 1973, comprised about six hectares of dense plants with scattered plants spread over an additional 100 hectares.

In the northern wheatbelt, particularly dense and extensive infestations have appeared in the Pithara-Miling area and north of Geraldton. As yet no plants have been found in southern wheatbelt areas.

The weed has not been restricted to the wheatbelt, however, as a number of plants have been found in the Perth metropolitan area and along railway lines.

Skeleton weed is a top priority declared plant in Western Australia. In the 1982-83 financial year more than $400,000 was spent in the eradication campaign organised by the Agriculture Protection Board.

When new plants are found they are sprayed with Tordon 50-D at the rate of 10 litres per hectare. The infested property is placed under quarantine until no further plants are found following searches for three successive crop years. Treatment with Tordon 50-D is impractical for very large areas because of the cost and the disadvantage that only grasses will grow on treated areas for at least 12 months.

Because rolling stock entering Western Australia from the east could introduce skeleton weed seeds through most of its flowering season, the railway line from Koolyanobbing to Kwinana is seached for skeleton weed each summer and all plants found are destroyed.

Current research

A number of different approaches have been taken to gain a fuller understanding of the ecology of skeleton weed in the Western Australian wheatbelt.

Identification of forms

Studies are under way to determine which forms of skeleton weed are present in Western Australia and to map their respective distribution. As new finds are made the plants are identified.

Preliminary studies have indicated that the shapes of leaves from skeleton weed rosettes may vary considerably according to growing conditions, so that identification of forms now is based upon the technique of starch gel electrophoresis. Day-old seedlings are ground up to release enzymes which, when subjected to an electric field, demonstrate distinctive patterns for each form. Plants no longer have to be grown for three to six months for reliable identification and the technique is so fast that up to 60 plants can be identified during a day's work.

To date only the narrow-leafed and broad-leafed forms of skeleton weed have been found in Western Australia (Figure 1); the narrow-leafed form appears to be more widespread (Panetta, 1984).

Seed viability

As moisture stress during flowering and seed set markedly reduces the production of viable seeds, it is essential to assess the peformance of reproductive plants under field conditions.

In December 1982 a limited number of plants from new finds were caged and individual flowering stems were enclosed in nylon mesh bags. At intervals through the summer the accumulated seed was removed from the bags and tested for viability in the Department of Agriculture's laboratory at South Perth. Contrasting types of behaviour of flowering plants are shown in Figure 2.

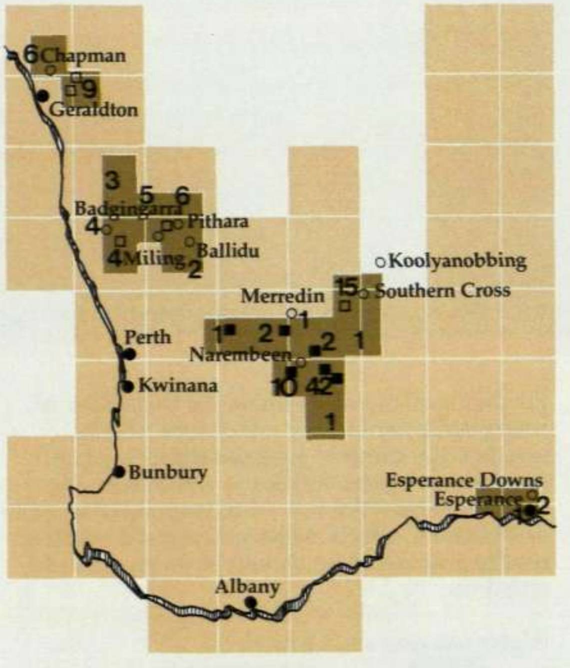

Figure 1. The green area shows the distribution and number of farms infested with skeleton weed at November 1983.
Key: □ = narrow-leafed; ■ = broad-leafed. Skeleton weed has been eradicated from about a quarter of these farms, the remainder are under quarantine.

At Narembeen, plants produced viable seeds until the end of February in the absence of appreciable rainfall, whereas at East Badgingarra the production of viable seeds was interrupted during February, but resumed following further rainfall.

It is not known whether the differences in behaviour between skeleton weed plants at the two sites were due to differences in plant age (length of tap root and total extent of root system), differences in the amount of moisture in the soil profile, or both factors. Tap roots have been traced to depths greater than four metres when attempts have been made to excavate root systems, and this would appear to indicate that plants can make extensive use of moisture stored in the soil profile.

Fate of seeds

As skeleton weed seeds display virtually no dormancy, experiments have been undertaken to determine how many seeds germinate following summer rainfall and of these what proportion survives.

Viable seeds were buried in containers and placed on Research Stations at Chapman Valley, Merredin and Esperance Downs during the last week of February 1983. In June 1983 the seeds were retrieved. Most of the buried seeds germinated even if less than 10 mm of rain fell at any one time, and most seedlings died without emerging.

Effectiveness of biological control agents upon different forms of skeleton weed.			
	FORM		
Control Agent	Narrow-leafed	Intermediate-leafed	Broad-leafed
Rust fungus (*Puccinia chondrillina*)	3	under test	0
Gall midge (*Cystiphora schmidti*)	2	2	2
Gall mite (*Aceria chondrillae*).......	2	1	0
Root moth (*Bradyrrhoa gilveolella*)	1	1	1

3 = substantial control in most areas
2 = high potential for control but cultivation disturbs life cycles
1 = low potential for control
0 = no potential for control

■ Flowering stem starting to grow from broad-leafed skeleton weed rosette at Narembeen.

Further studies will examine the behaviour of seed populations under conditions which simulate the climatic patterns prevailing in a number of regions within the wheatbelt. The results gained from this work may allow areas to be defined in which skeleton weed will establish readily and therefore should be given special attention.

Water use and root growth

Water availability can be critical during periods of seed production and seedling establishment. Methods are being developed to measure water use by skeleton weed and the effects of water shortage. Seasonal patterns of water stress and water use may then be related to the viability of seeds produced at different times during summer and autumn.

Information concerning the water status of field-grown plants will be useful in determining the most effective time to spray infestations, since actively growing plants are more susceptible to the effects of herbicides.

Other important information required includes the rate of growth of root systems and whether development patterns differ between the two forms of skeleton weed found in Western Australia.

In one experiment, narrow-leafed and broad-leafed seedlings grown in a glass house differed in the rate and pattern of root system growth. Broad-leafed seedlings produced a deeper and more branched root system within a few days of germination. It is not yet known whether these differences would also be found amongst seedlings grown in the field.

What if skeleton weed becomes established here?

It seems reasonable to ask what might happen if skeleton weed is particularly well adapted to regions within Western Australia, and to consider what options are available if the eradication programme is not successful.

Where skeleton weed occurs in eastern Australia, the most widely employed forms of control have included cultural, biological and chemical methods. Reductions in the sizes of populations have been most dramatic when two or more forms of control have been implemented simultaneously.

Cultural control

Since skeleton weed's above ground growth consists of a rosette of leaves close to the soil surface for the winter growing season, it is potentially vulnerable to shading by winter annuals.

At Cowra, New South Wales, Moore and Robertson (1964) found that two years after a pasture based on subterranean clover had been established in an area bearing a heavy infestation of skeleton weed, the density of skeleton weed was reduced to less than 40 per cent of its original level. In the absence of grazing a complete foliage cover was obtained each year, and subterranean clover shaded skeleton weed plants for three to five months.

In the Western Australian wheatbelt it is doubtful whether this type of result could be expected because of lower rainfall, poorer subterranean clover pastures and grazing pressures which would reduce the shading potential. Pastures based on medics may not exert a substantially suppressive effect upon infestations of skeleton weed for similar reasons.

Biological control

In 1971 a strain of rust (*Puccinia chondrillina*) specific to the narrow-leafed form of skeleton weed was released in New South Wales. It spread rapidly and had such a great impact in some areas that farmers were able to suspend chemical control measures which previously had been a prerequisite for harvesting crops.

However, the rust's infection of its host as well as its growth and reproduction are strictly seasonal, being greatest during late winter and spring; it has a relatively slight effect upon skeleton weed in the warmer, drier sites which most closely resemble many regions within the Western Australian wheatbelt.

No strains which will attack the broad-leafed form of skeleton weed are currently available, and in recent years wheat farmers in New South Wales and Victoria have again incorporated chemical control measures into their management systems owing to the increased abundance of this form.

The potential within Western Australia of the two insects and the mite which attack one or more forms of skeleton weed in eastern Australia is unknown (see table).

■ Blocked header in heavy skeleton weed infestation in wheat at Wagga Wagga, N.S.W. (Photo: Eric Cuthbertson.)

Chemical control

The chemical 2,4-D is recommended for suppressing skeleton weed in wheat crops. While this is not a costly practice when applied to the crop, plants are not suppressed until after considerable competition for nutrients and moisture has occurred. Furthermore, established plants continue to deplete soil nitrogen during the periods between crops, a situation which may be particularly detrimental on soils which have inherently low levels of nitrogen. It is possible to spray skeleton weed infestations when land is not under crop, but such a practice must be economically justifiable.

Although skeleton weed may be tolerated within cereal crops, its presence reduces crop management flexibility. In areas of the South Australian Murray-Mallee region, competitive effects make it impossible to grow lupins in paddocks which carry substantial populations of skeleton weed. This situation is relevant to crop management in the Western Australian wheatbelt.

Various formulations of picloram are used to control skeleton weed in the eastern States, but the rates at which these need to be applied are not economical for broadacre use. This chemical has strong residual effects, particularly depressing legumes used in the rotation. At present a satisfactory chemical method of controlling skeleton weed is not available to wheat growers.

Conclusion

Because the resources which can be allocated to the eradication campaign are limited (particularly in regard to voluntary labour), it is essential to gain a detailed understanding of how well skeleton weed is adapted to the range of environmental conditions in this State. When areas which are especially prone to infestation can be delineated, the effectiveness and efficiency of the eradication campaign will be increased.

References

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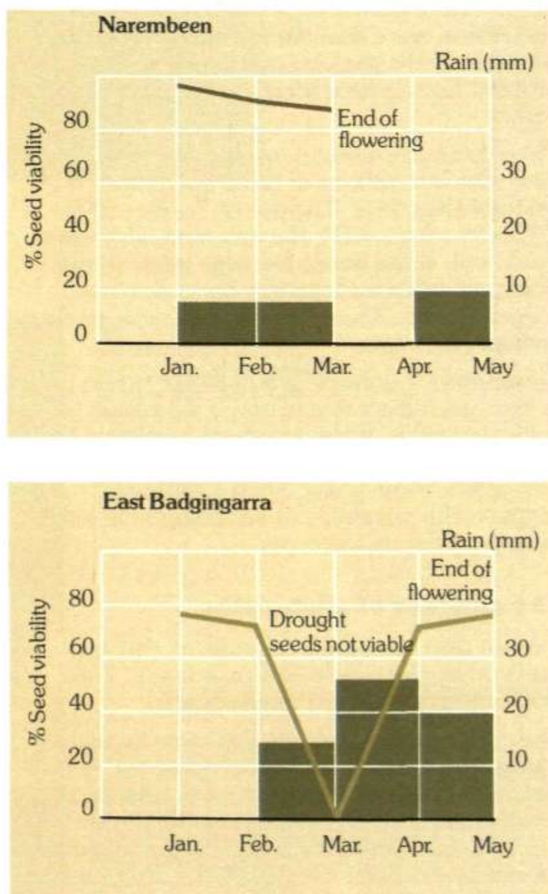

Figure 2. Seed viability and monthly rainfall at Narembeen and East Badgingarra.

■ Flowering stems of broad-leafed skeleton weed in wheat near Narembeen.