Emex spp. in South Australia

Graham Fromm, Primary Industries South Australia, Murray Bridge, South Australia 5253, Australia.

Abstract

***Emex australis* (three-cornered jack) is found throughout the agricultural areas of South Australia, although it is of greater importance in the cropping and Riverland horticultural areas than in the high rainfall zones of the state. *E. spinosa* (lesser jack) is not as widespread. In the cropping areas *Emex* spp. can contaminate grain, in particular pulse crops. However, current herbicide strategies have kept the number of declined or contaminated loads to a minimum. In the horticultural areas *E. australis* has caused problems as a contaminant of dried fruit. *Emex* spp., if not managed effectively by urban councils, can reduce the amenity value of sports fields and parklands.**

Introduction

Emex australis is commonly known in South Australia as three-cornered jack and is found throughout the agricultural areas of the State. *E. australis* was first recorded in South Australia in 1848 and has since been proclaimed under various Acts of Parliament including Noxious Weeds Act 1931–39, Weeds Act 1956–69, Pest Plant Act 1975 and the Animal and Plant Control (Agricultural Protection and Other Purposes) Act 1986. It causes most problems as a weed of annual crops and pastures in the cereal zone and as a contaminant of dried vine fruit in the Riverland horticultural areas. In addition, if not controlled, it can reduce the amenity value of public lands.

Distribution in South Australia

Emex australis is more commonly found in the lower rainfall cereal zone of the state (250–500 mm annual rainfall) (Figure 1). Within these areas it tends to be more common on the lighter soil types although it can grow successfully on the heavier soils. In the high rainfall zone where grazing is the dominant land use *E. australis* is not a common weed although movement of achenes to these areas in fodder does occur. However, it does occur where cereal and pulse crops are grown in preference to pastures for grazing in the upper part of the South-East region and in the high rainfall zone of the Central region north of Adelaide (Figure 2).

Weiss and Simmons (1977) found that under either high or low temperature regimes (day / night temperatures of 30 / 25°C or 10 / 5°C respectively) flowering was delayed and seed production reduced when compared to optimum day / night temperatures for growth of 15 / 10°C to 20 / 15°C. Panetta and Randall (1993) reported that *E. australis* was a weak competitor in a grazed annual pasture where *Trifolium* and *Hordeum* spp. were present.

Gilby and Weiss (1990) reported that unburied *E. australis* seed has a low germinability and that cultivation and subsequent seed burial increased plant emergence. These results were supported by Panetta and Randall (1994) who also reported that the amount of natural seed burial in a grazed pasture was relatively low.

These factors could explain why *E. australis* is less common in those parts of the high rainfall zone which have a large proportion of agricultural land devoted to pasture production and grazing and have a relatively cool climate. In the lower rainfall areas pastures tend to be less vigorous and have lower pasture plant densities than pastures in high rainfall areas and this may allow *E. australis* to set more seed and thus increase the amount of seed in the soil seed bank. Frequency of cultivation is less in areas under permanent pasture than where annual grain crops are grown as part of the rotation.

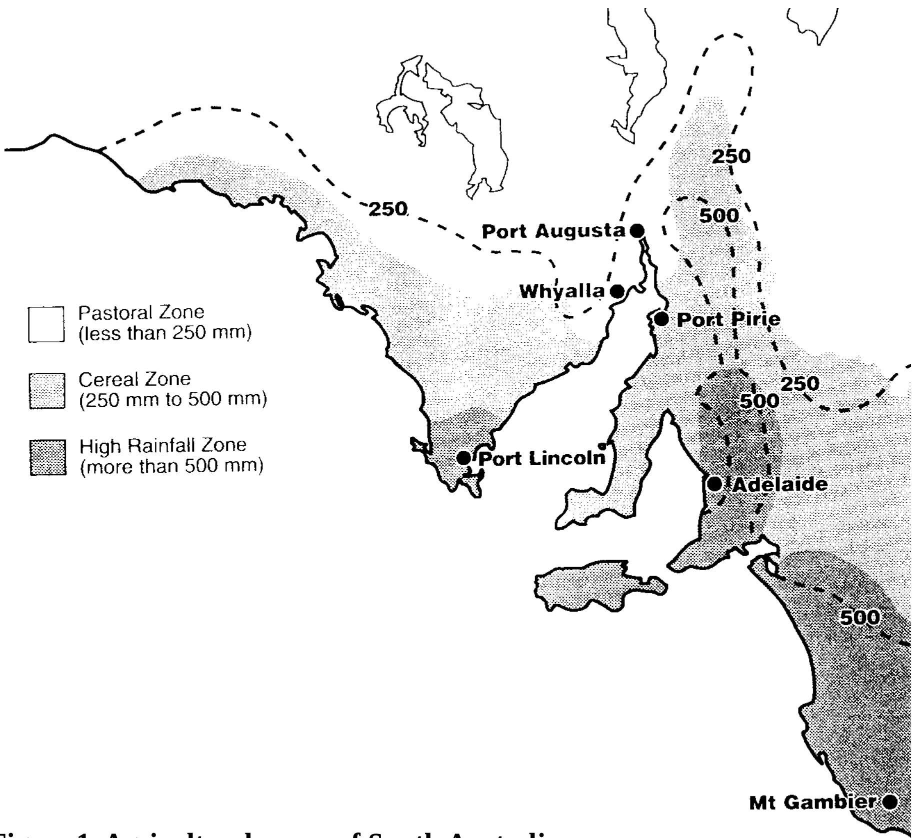

Figure 1. Agricultural zones of South Australia.

Emex spinosa (lesser jack) is less widespread and, at this stage, is most commonly found in the western portion of the mid and upper north of the Central Region and in the eastern portion of Eyre Peninsula Region of South Australia (Figure 2).

Importance as a weed

Emex australis, if not controlled, can compete with cereal and pulse crops and reduce grain production. Black and Dyson (1993) collated trial data from many herbicide evaluation trials in the major cereal growing areas of South Australia to produce a model which can predict the likely yield benefits in cereal crops if a weed or combination of weeds at various weed densities is controlled with herbicides at several different growth stages of the crop. Information is presented in this model for 38 weeds including *E. australis*. If, for example, 33 plants m^{-2} of *E. australis* are controlled at the early post-emergence stage (one to four leaves) in a cereal crop with a weed-free yield potential of 2000 kg ha^{-1}, the predicted yield benefit from controlling the weed is 122 kg ha^{-1}.

In addition to competing with the crop and affecting grain yields *Emex* spp. can contaminate grain samples. The plant has the ability, when supported by a grain crop, to develop a more erect growth habit and as a result *Emex* spp. achenes can be harvested with the grain. The majority of the achenes can be removed if the seed is graded and cleaned. However, the removal becomes more difficult if the spines

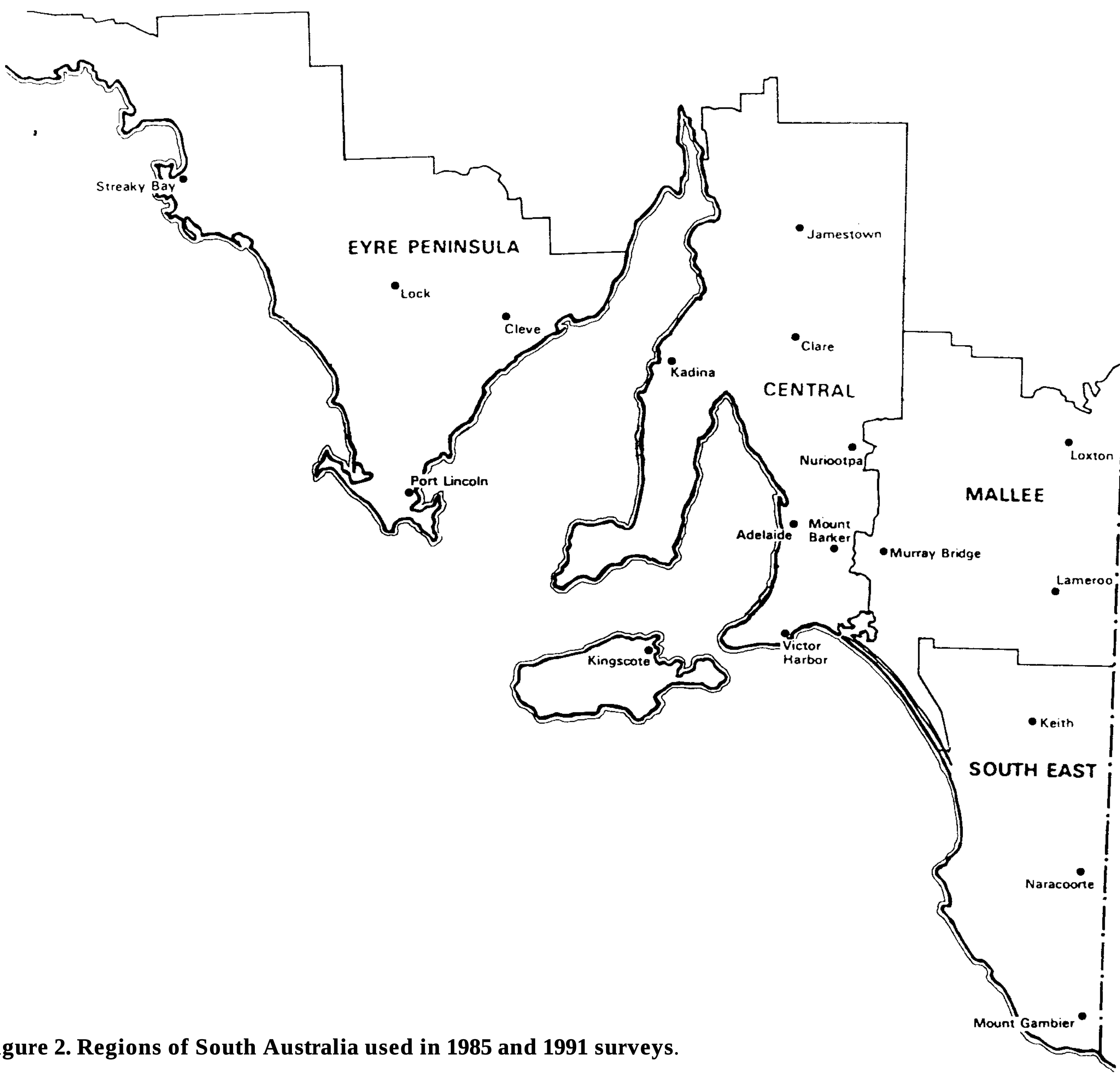

Figure 2. Regions of South Australia used in 1985 and 1991 surveys.

are broken off during the threshing process or the seeds are present in a pulse grain sample such as vetch (*Vicia* spp.) or peas (*Pisum sativum*).

Tolerance levels for *Emex* spp. as a contaminant range from nil achenes in a sample for malting and F1 (feed) barley and milling oats to five achenes 200 g^{-1} for pulse grains (Table 1).

Although the receival standards are clearly defined for *Emex* spp. the number of barley samples contaminated (Table 2) and detections in wheat and pulse grain silo samples (Table 3) is relatively low compared to the number of samples tested. The approximate number of barley samples tested annually ranges from 13 000 to 18 000 depending on seasonal conditions. The number of wheat and pulse grain silos tested is approximately 120 and 30–40 respectively.

In addition to the contaminated samples accepted by the Australian Wheat Board and Australian Barley Board the South Australian Co-operative Bulk Handling Ltd. (SACBH), which operates the silo system in rural areas, can decline to accept loads due to many clearly defined causes including high moisture content, live insects, specific seed contaminants, unmillable material and unspecified foreign material. Table 4 gives details of the number of declined loads due to *Emex* spp. contamination and also gives an annual total of loads declined from all causes. The number of declined loads due to *Emex* spp. contamination is very low given that the number of loads checked by SACBH is any one year can range between 150 000 and 300 000 depending on seasonal conditions. However, these figures may under-estimate the amount of grain contamination as farmers can deliver contaminated grain direct to stock feed processors instead of through SACBH to the Australian Wheat or Barley Boards.

Table 1. South Australian cereal and pulse grain receival standards for *Emex* spp. contamination (1994/95).

Grain	Category, grade or commodity	Tolerance levels for *Emex* spp. achenes
Wheat[A]	All grades	8/half litre
Triticale[A]	All grades	4/half litre
Pulse crops[A]	peas, lupins, chickpeas, faba beans	5/200 grams
Barley[B]	Malting, F1 (feed), F2 (feed)	nil, nil, 1/100 grams
Oats[B]	Milling, feed	nil, 5/litre

[A] Source: Australian Wheat Board.
[B] Source: Australian Barley Board.

Whilst *Emex* spp. contamination of grain does cause some concern it is more of a potential problem if management practices currently used to control the plant fail and the control obtained in grain crops, particularly grain legumes, becomes less effective.

In 1980 a review panel investigated the status and needs of weed research in South Australia (D.W. Stephenson unpublished data) and a list of the ten worst weeds of pastures was proposed (Table 5). *Emex* spp. was not listed. This proposed list did not consider weeds of crops.

As information on the distribution, abundance and relative importance of crop and pasture weeds in South Australia was limited, a farmer survey was conducted in 1985 (J.A. Crocker and G.J. Mitchell unpublished data). The information obtained from this survey was to be used as a guide for determining future research and extension priorities. Subsequent to this a follow-up survey was conducted in 1991 (A.H. Mayfield and R. Edwards unpublished GRDC report) to provide a basis for prioritizing weed research in South Australia.

The 1991 survey also included agronomists, resellers and pest plant officers. The number and regional origin of replies obtained in each of the surveys is presented in Table 6.

In the 1985 survey *E. australis* ranked as the sixth most important weed (Table 7). Rankings were based on the relative severity rating which was calculated from the rating given to the weed and the number of times the rating was assigned to a particular weed by the respondents. D.W. Stephenson (unpublished data) extracted data from the 1985 survey which related specifically to pastures and the ranking obtained by *E. australis* in pastures was eight (Table 7).

However, in the 1991 survey *E. australis* was ranked fourteen (Table 8) which suggested that farmer perceptions of the importance of it as a weed of crops and pastures had declined since 1985. Agronomists, resellers and pest plant officers ranked it thirteen (Table 8) indicating that all people involved in the surveys held similar opinions on *E. australis*. However, it is of interest that farmers tended to rank perennial weeds much lower than the other survey respondents. This may be because they are not as aware of the difficulty in managing these weeds once they become established.

Table 2. *Emex* spp. contamination in barley samples in South Australia.

Year	Site	Number of contaminated samples	Annual total number of contaminated samples
1993/94	Apamurra	1	
	Cowell	1	
	Lameroo	1	
	Port Pirie	2	
	Wudinna	1	
	Arno Bay	2	
	Port Adelaide	2	
	Kyancutta	1	11
1994/95	Bordertown	1	
	Wharminda	1	2

Source: Australian Barley Board.

Table 3. *Emex* spp. detections in silo samples of wheat and pulse grains in South Australia.

Year	Silo Site	Grain	Level detected seeds kg^{-1}
1992/93	Mallala	wheat	5
	Monarto South	wheat	4
1993/94	Hamley Bridge	pea	4
	Hamley Bridge	faba beans	1
	Mallala	pea	3
	Strathalbyn	pea	2
	Wilmington	wheat	1
1994/95	–	–	–

Source: Australian Wheat Board.

Table 4. Number of declined loads due to *Emex* spp. contamination and the number of declined loads from all causes.

Year	Number of declined loads				
	Emex spp.				Annual total from all causes
	Site	Grain	Loads at each site	Annual total (all sites)	
90/91	–	–	–	Nil	274
91/92	Crystal Brook	peas	1		566
	Wallaroo	peas	1		
	Balaklava	barley	1		
	Mallala	peas	1		
	Nantawarra	barley	1		
	Paskeville	barley	1		
	Two Wells	peas	1	7	
92/93	Ardrossan	peas	2		1110
	Balaklava	barley	3		
	Port Giles	barley	7		
	Port Pirie	barley	2		
		lupins	1		
	Wallaroo	barley	1		
		chickpeas	1		
		peas	3		
		wheat	1	21	
93/94	Port Adelaide	peas	1		423
	Tumby Bay	barley	1		
	Port Pirie	lupins	1	3	
94/95	Wallaroo	peas	1	1	306

Source: South Australian Co-operative Bulk Handling Limited.

Table 5. 1980 Review Panel proposal of the worst weeds of pastures in South Australia.

Rank	Weed
1.	Capeweed (*Arctotheca calendula*)
2.	Soursob (*Oxalis pes-caprae*)
3.	Thistles (various)
4.	Barley grass (*Hordeum leporinum*)
5.	Dock and sorrel (*Rumex* spp.)
6.	Horehound (*Marrubium vulgare*)
7.	Brome grass (*Bromus* spp.)
8.	Cape tulip (*Homeria* spp.)
9.	Storksbill (*Erodium* spp.)
10.	Bracken (*Pteridium* spp.)

Table 6. Number and origin of survey replies.

Region[A]	1985 Survey		1991 Survey	
	Number of replies	%	Number of replies	%
Eyre Peninsula	86	38	64	26
Central	92	40	109	45
Mallee	23	10	35	15
South-East	26	12	34	14
Total	227	100	242	100

[A] See Figure 2.

Table 7. The 1985 survey results showing overall rank (and relative severity rating) for weeds in crops and pasture (Crocker and Mitchell, unpublished data) and pasture only (Stephenson, unpublished data).

Weed	Crop and pasture		Pasture only	
	Rank	(relative severity rating)	Rank	(relative severity ranking)
Brome grass (*Bromus* spp.)	1	(46.9)	3	(20.9)
Rye grass (*Lolium rigidum*)	2	(46.0)	4	(19.8)
Barley grass (*Hordeum* spp.)	3	(36.9)	2	(23.0)
Wild oats (*Avena* spp.)	4	(34.0)	14	(7.5)
Soursob (*Oxalis pes-caprae*)	5	(25.8)	5	(16.6)
Three cornered jack (*Emex australis*)	6	(23.1)	8	(11.6)
Salvation Jane (*Echium plantagineum*)	7	(21.8)	1	(23.1)
Horehound (*Marrubium vulgare*)	8	(20.9)	7	(14.1)
Turnip (*Brassica tournefortii*)	9	(19.2)	13	(7.7)
Capeweed (*Arctotheca calendula*)	10	(16.3)	6	(15.0)
Cut leaf mignonette (*Reseda lutea*)	11	(15.2)	12	(8.7)
Ice plant (*Gasoul crystallinum*)	12	(12.3)	19	(5.3)
Radish (*Raphanus raphanistrum*)	13	(11.8)	–	–
Mustard (*Sisymbrium orientale*)	14	(11.4)	16	(7.0)
Silver grass (*Vulpia* spp.)	15	(11.3)	9	(10.0)
Saffron thistle (*Carthamus lanatus*)	16	(11.1)	17	(6.8)
Yellow burr weed (*Amsinckia* spp.)	17	(10.7)	18	(6.2)
Skeleton weed (*Chondrilla juncea*)	18	(10.4)	15	(7.2)
Onion weed (*Asphodelus fistulosus*)	19	(10.2)	20	(5.1)
Dock (*Rumex* spp.)	20	(9.5)	10	(9.0)

Table 8. A comparison of farmer and agronomist, reseller and pest plant officer rankings of weeds in the 1991 survey with the overall ranking of the same weeds in 1985.

Weed	1991 Survey results		Overall rank in 1985 survey
	Farmer rankings	Agronomist, reseller and pest plant officer rankings	
Rye grass (*Lolium rigidum*)	1	1	2
Capeweed (*Arctotheca calendula*)	2	6	10
Wild oats (*Avena* spp.)	3	18	4
Brome grass (*Bromus* spp.)	4	5	1
Barley grass (*Hordeum* spp.)	5	11	3
Soursob (*Oxalis pes-caprae*)	6	>20	5
Skeleton weed (*Chondrilla juncea*)	7	2	18
Bedstraw (*Galium tricornutum*)	8	4	40
Silver grass (*Vulpia* spp.)	9	3	15
Mustard (*Sisymbrium orientale*)	10	>20	14
Radish (*Raphanus raphanistrum*)	11	=13	13
Turnip (*Brassica tournefortii*)	12	>20	9
Sheepweed (*Buglossoides arvensis*)	13	15	20
Three cornered jack (*Emex australis*)	14	=13	6
Stemless thistle (*Onopordum acaulon*)	15	19	22
Saffron thistle (*Carthamus lanatus*)	16	>20	16
Cut leaf mignonette (*Reseda lutea*)	17	8	11
Silver leaf nightshade (*Solanum elaeagnifolium*)	18	9	31
Wireweed (*Polygonum* spp.)	19	>20	29
Yellow burr weed (*Amsinckia* spp.)	20	>20	17

In addition to its importance in grain crops and dryland pastures *E. australis* is a major weed in the horticultural areas of the Riverland area of South Australia. The main problem is contamination of dried fruit and fresh table grapes with the spiny achenes which affects both local and export markets (W. Panagiotopoulos personal communication). Horticultural crops, in general, have less tolerance to many of the herbicides which can be used to control *E. australis* than dryland cereal and pulse crops and this increases the severity of the problem. The problem of *E. australis* in dried vine fruit production is covered in greater detail elsewhere in the proceedings and the issues raised in that paper are relevant to the South Australian situation.

Emex spp. are not a major problem in the small seeds industry as it can either be controlled with selective herbicides or graded out of seed after harvest (P. Smith personal communication).

In irrigated pastures *E. australis* can be controlled effectively. However, poor and run-down pastures with low numbers of desirable species are unable to compete strongly and in this situation it can cause problems if the pasture is cut for hay as the achenes make handling of the hay difficult, especially with small square bales, and reduce the palatability of the product.

In non-agricultural situations *Emex* spp. are a problem in amenity areas such as sports fields and parklands where the spiny achenes can affect the enjoyment of these facilities. In reserves and parks where cultivation does not occur and soil disturbance from other causes is minimal *Emex* spp. are not a major problem and their spread and growth tends to be restricted to car park areas and tracks (R. Carter personal communication).

Discussion

Emex spp. are widespread in South Australia although only causing serious problems in cropping and horticultural areas. In permanent or long term pasture areas problems generally occur when the pasture becomes run-down and non-competitive.

In the cropping areas the use of selective herbicides, in particular trifluralin, when incorporated thoroughly, in both the cereal and pulse phases of rotations and the sulfonylureas in the cereal phase, has reduced the farmer perception of *Emex* spp. as a problem weed. This is reflected in the survey results of 1985 and 1991. The farmer perception appears to be supported by information from grain handling authorities relating to the number of declined loads and contaminated samples as a result of the presence of *Emex* spp. achenes.

One of the issues of *Emex* spp. management is the life of the soil seed bank and seed dormancy. It is of interest that where a nematicide, Nemadi® (a.i. 1950g L^{-1} EDB) was used to control cereal cyst nematodes (*Heterodera avenae*) in cereals during the early to mid 1980s the emergence of *E. australis* was visually far greater than in adjacent untreated areas (T. Dillon personal communication and personal observations). This tended to suggest that the active ingredient (EDB) may have had some effect on seed dormancy.

Emex spp. are a proclaimed weeds under the Animal and Plant Control Act, 1986 and the objectives of the *Emex* spp. policy are to eradicate small isolated infestations of *Emex* spp., to minimize spread from generally infested areas and to prevent introduction of *Emex* spp. to clean areas. Landowners are required to destroy the plant and inhibit its propagation as far as is reasonably possible (R. Carter personal communication).

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Emex australis and dried vine fruit production in Sunraysia

Deidre Pohlner, Sunraysia Horticultural Centre, PO Box 905, Mildura, Victoria 3502, Australia.

Abstract

Australia is renowned for the production of quality dried sultanas free of contaminants. However, one contaminant which poses a threat to Australia's reputation is *Emex australis*. Because of the spined nature of the seed, it readily contaminates fruit during the harvest and drying processes conducted on growers properties. Once in the fruit they are difficult to remove despite rigorous cleaning at packing sheds. Controlling *E. australis* in the vineyard is difficult and costly with growers seeking an alternative control strategy which is cheaper and more effective than cultivation, mulch, cover crops or weedicide.

Introduction

The thought of biting into a piece of cake or muesli bar and ending up with a mouthful of prickles is enough to put anyone off buying products containing dried sultanas! People bearing witness to such experiences to family members and friends, rapidly develop concerns about buying products from the same company or even buying sultanas full stop. This is a very real problem for companies such as Kellogg's and Uncle Tobys who buy thousands of tonnes of Australian dried sultanas each year and it only takes one seed to cost these companies thousands in lost sales.

In 1990 a workshop was held in Mildura initiated by the Dried Fruits Research and Development Council, to investigate a group of weeds called Spiked Weed Seeds (which included *Emex australis*) and their control in vineyards (Buchanan 1990). As a result of this workshop the project 'Spiked Weed Seed Management and Elimination' was developed to try and prevent spiked weed seed contamination of dried vine fruit by identifying the points during production that are at risk of contamination, evaluating cleaning methods used in packing sheds and developing vineyard management practices to prevent growth and seed production from these weeds (Pohlner 1994).

How do the seeds of *E. australis* get into the fruit in the first place?

In order to minimize the amount of contamination which occurs on growers properties, the points during production which are at risk of contamination were identified during the two main steps conducted on growers properties; picking and drying.

During picking plastic buckets are used to collect the fresh grapes from the vineyard. These are the main source of contamination. When these buckets are thrown into the vineyard or dragged between vines during picking, the *E. australis* seeds on the ground stick into the sides or bottom of the soft plastic. This was observed to occur mainly in the undervine area where the buckets are left until they are collected. When the buckets are stacked on a trailer to take them to the drying racks, the seeds dislodge and fall onto the full bucket of fruit beneath it resulting in direct contamination.

Drying of grapes starts on drying racks where fruit is spread evenly over different levels of wire netting and left for a couple of weeks to reduce the moisture levels in the berries. When they have reached a certain moisture level they are shaken down through the levels of wire netting and spread over a plastic ground-sheet to 'finish' dry in the sun. During finish drying, seeds may flick into the fruit when people walk past the plastic, when corners of the plastic flap in the wind or when the edges of the plastic are folded in to prevent the fruit from taking up moisture overnight and when it rains. During this process seeds are scraped off from the underside of the plastic and fall directly into the fruit. Fruit is then collected into bulk bins (½ tonne) and delivered to central packing sheds for cleaning.

Measures employed to remove *E. australis* from dried vine fruit

It is difficult to remove seeds from dried vine fruit as they are similar in terms of size and colour to dried sultana berries. Many seeds actually embed into the dried berries camouflaging themselves. Packing sheds employ extensive cleaning processes whereby the fruit is washed, put through vibrating sieves, passed through blowers, vacuum extractors, an infra-red laser sorter and hand sorted in an attempt to remove all contaminants before the fruit is packed.

Trials conducted in the packing shed, which involved sorting through trash to recover *E. australis* seed removed at each extraction point during cleaning, indicated that the majority of seeds were extracted by 'blowers' because loose seeds are lighter in weight than the fruit. Infrared laser sorters are a relatively recent addition to packing sheds. A lot of emphasis