

Eradication of kochia (*Bassia scoparia* (L.) A.J.Scott, Chenopodiaceae) in Western Australia

Jonathan Dodd¹ and Roderick P. Randall^{1,2}

¹Department of Agriculture, Locked Bag 4, Bentley DC, Western Australia 6983, Australia

²Cooperative Research Centre for Australian Weed Management

Summary The kochia eradication program in Western Australia is an example of an eradication program that is unusual in several ways. The eradication program began within twelve months of the plant's introduction in 1990, by which time it was already widespread due to being sown by farmers and other landholders throughout the WA wheat belt; at most sites the plant had begun to naturalise and spread. Managers of the eradication program had precise information on the location of farms to which kochia seed had been sold as part of a multi-species salt-land rehabilitation seed mix. The sowing sites were usually readily located, since most were salt scalds in low-lying areas. Many introduction sites were fenced, which, fortuitously, prevented long-distance spread, since fences effectively contained seed laden parent plants that had the potential for long-distance seed spread by acting as 'tumbleweeds'. The program was well funded, with State and Commonwealth funds provided through the SCARM Consultative Committee – the first time this process had been applied to a weed incursion. The program incurred a total of \$176,000 in direct costs to the SCARM process, with an estimated additional \$318,000 in labour and monitoring costs for landholders and Government field officers. The detailed local knowledge of Agriculture Protection officers and co-operation of the landholders greatly contributed to the program's success. No kochia plants have been found since 2000, ten years after its introduction.

Keywords Kochia, *Bassia scoparia*, eradication, Western Australia, national funding.

DISCUSSION

Taxonomy and location of vouchers *Bassia scoparia* (L.) A.J.Scott, Family Chenopodiaceae. Synonyms: *Chenopodium scoparia* L. [basonym], *Kochia childsii* hort. ex anon., *Kochia scoparia* (L.) Schrad. Common names: kochia, Mexican firebush, Mexican fireweed, besenkrout, hokigi, mirabela, mirabel.

The taxonomy of the widespread, weedy form of kochia is uncertain, but it appears to be *B. scoparia* ssp. *densiflora*, or *B. densiflora* (P. Wilson, pers. comm. 1992, in Dodd and Moore 1993). An ornamental form of kochia known as burning bush, mock cypress, summer cypress or belvedere (*Kochia scoparia* forma

trichophylla (hort. ex Voss) Schinz & Thell., *Kochia trichophylla* hort. ex Voss) has been recorded as a weed in South Australia and Western Australia, but is not the weed discussed here.

The Western Australian Herbarium (Department of Conservation and Land Management) PERTH holds over 20 voucher specimens of *B. scoparia* collected from infestations in Western Australia (Western Australian Herbarium 1998).

World distribution and weediness elsewhere Kochia is an annual that is native to eastern Europe and western Asia. It is now naturalised in most of Europe, and parts of temperate Asia (China, Japan), Canada, USA, Argentina, Africa and New Zealand (Csurhes and Edwards 1998).

Number of locations in Australia and date of naturalisation All infestations of kochia in Western Australia were derived from the original introduction in May 1990 of seed intended for sowing on salt-affected soils to produce salt-tolerant plants for forage and salt-land rehabilitation. By late 1991, kochia had been sown at 68 sites across the south west of the State (Figure 1).

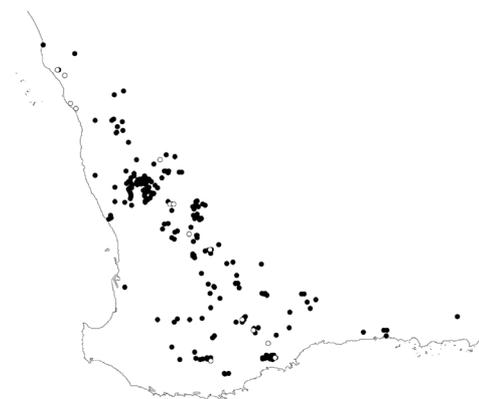


Figure 1. *Bassia scoparia* sites in south-west Western Australia. Black dots are affected properties, as far apart as 850 km, circles are collection sites of specimens listed in Western Australian Herbarium (1998).

Naturalisation of kochia occurred within two years of its introduction. By 1992, it was naturalised and growing actively at 52 of the sites where originally sown. Separate introductions of kochia occurred in Tasmania in 1995 and 1997 and were associated with sowing contaminated carrot seed imported from USA (A. Bishop pers. comm. 1995); the ensuing eradication program is not covered here.

Area of each location and density of plants Most infestations were small, reflecting the limited extent of the original plantings in salt-affected sites. When surveyed in late 1992, before concerted eradication efforts began, 38 of the 52 known infestations were less than 10 ha in extent, although one infestation covered 111–120 ha (Table 1).

Dead, seed-laden kochia plants break off at ground level and may then be spread by wind as ‘tumbleweeds’. Evidence of this was seen at two sites where seedlings and mature plants were found up to 3 km from the introduction sites, with lines of plants marking the paths of tumbling parent plants. Due to this rapid spread, the estimated area infested at the two sites increased from <10 ha each in spring 1992 to 750 ha each in January 1993. At another site, kochia had spread up to 5 km over five years, further illustrating this plant’s capacity for long-distance dispersal. The total area infested by kochia reached a maximum of 3277 ha in 1993.

Within an infested site, seedling distribution was usually uneven, and was highly correlated with the location of the original (parent) plants. Seedling densities were often high, reaching several thousand seedlings m⁻² close (1–2 m) to parent plants, reflecting their large size and fecundity.

Biological and ecological features relevant to the feasibility of eradication

- *Seed dispersal* Apart from deliberate sowing of seed – which was the initial means of introduction of this weed to Western Australia – seed dispersal is primarily by means of wind-blown plants (‘tumbleweeds’). In uncontrolled situations, this enables kochia to achieve rapid, long-distance spread (Forcella 1985). However, the presence of simple wire fences, built to exclude stock from many of the initial sowing sites, contained the plants and prevented their spread. Compare this with the virtual impossibility of containing wind-dispersed seeds such as those of skeleton weed (*Chondrilla juncea* L.) (Dodd 1996).
- *Plant form* Although they are annuals, kochia plants are typically large (up to 1.5 m in height and diameter) and have a vegetative growth period

Table 1. Size distribution of kochia infestations in Western Australia, December 1992 (Dodd and Moore 1993).

| Size class (ha) | Infestations (n) | Size class (ha) | Infestations (n) |
|-----------------|------------------|-----------------|------------------|
| 0.1 – 10 | 38 | 61 – 70 | 0 |
| 11 – 20 | 4 | 71 – 80 | 1 |
| 21 – 30 | 5 | 81 – 90 | 0 |
| 31 – 40 | 0 | 91 – 100 | 1 |
| 41 – 50 | 2 | 101 – 110 | 0 |
| 51 – 60 | 0 | 111 – 120 | 1 |

that lasts several months before flower and seed production begin. The large plants are relatively easy to detect, while the lengthy vegetative period provides extended opportunity to search for plants before they begin reproduction. However, there is concern over the role of small plants that germinate in summer and become reproductive when small (<20 cm high).

- *Seed longevity* Kochia is reported to have short-lived seeds, in the order of one to three years. The seed bank is largely exhausted within 12 months, which improves the prospects for eradication. However, the small proportion of seeds with greater longevity pose a risk, unless follow-up site inspections are conducted.
- *Salt tolerance* Kochia was introduced specifically for sowing on salt-affected soils; this resulted in it being sown in precise locations in the agricultural landscape (i.e. salt scalds and salt-affected paddocks). These areas were easy to locate during the initial surveys and subsequent monitoring visits. Kochia is not an obligate halophyte, however, and flourishes on normal agricultural soils.
- *Palatability* The palatability of kochia was exploited in the eradication program by introducing high densities of sheep onto infestations to provide intense grazing pressure that defoliated larger plants and destroyed smaller plants.

Details of eradication program, including post-eradication monitoring procedures

The eradication of kochia was the first nationally funded program to target a weed incursion. The program received State and Commonwealth funds through a Standing Committee on Agriculture and Resource Management (SCARM) Consultative Committee.

Under the arrangements approved in March 1993, SCARM provided a maximum of \$200,000 for a four-year eradication program. Half the funds came from

the Commonwealth and the rest from the States, with each State's contribution being proportional to the value of its wheat production, which was considered to be the industry sector at greatest risk from kochia. The funds were used for operating and overheads costs such as herbicide, fuel, vehicle expenses, insurance, aircraft hire, contract spraying and travel allowances, with herbicide costs accounting for 40% of the actual budget. All labour costs were absorbed by the Western Australian Department of Agriculture.

Direct expenditure of SCARM funds on the eradication program over four years is as follows:

| | |
|---------|------------------|
| 1992/93 | \$71,546 |
| 1993/94 | \$41,547 |
| 1994/95 | \$36,000 |
| 1995/96 | \$27,000 approx. |
| TOTAL | \$176,093 |

The cost of labour since the start of the eradication program is estimated to be \$318,488; this is based on approximately 15,536 hours work, which involved 1942 property inspections.

The total cost of the four-year SCARM funded eradication program and the labour costs associated with monitoring and control activities during and after the program are approaching \$494,600.

The criterion originally used for eradication in this program was when no plants were found at a site after three successive years of inspections. While no plants have been found since 2000, some plants had previously been found at a few sites after four or five years of clean inspections (M. Clark pers. comm. 2002). In view of this, we recommend that the kochia-free period be increased to five years before eradication is claimed for a particular site. At this stage, total eradication of kochia from Western Australia is not being claimed, but it is close to being achieved.

The progress achieved by the kochia eradication program supports the statement of Dodd and Moore (1993) that kochia was 'a suitable candidate for eradication because of its recent introduction, its limited but well documented distribution... and the limited longevity of its seeds'.

Potential distribution in Australia Climate matching indicated that the potential distribution of kochia covered most of central and southern Australia, including the main cereal-growing regions of all southern mainland states (Figure 2).

Kochia is a C_4 plant that is competitive under hot sunny conditions, and has a high water use efficiency that enables it to thrive in summer; because of this kochia is considered a potentially serious weed of summer-growing crops in parts of south eastern Australia.

Chances of post-entry trade Kochia is unlikely to have had a sufficient period of establishment in Western Australia to allow the development of post-entry trade, because of the early and comprehensive response to the introduction of this plant.

The kochia incursion into Western Australia was a major factor leading to changes in national plant import requirements, which are now based on weed risk assessment of potential imports and the operation of a permitted/prohibited list on plant imports. Because of these changes, legal intentional importation of this weedy form of *B. scoparia* should not recur.

Nevertheless, kochia seed continues to be available from many herb companies and forage seed suppliers that offer kochia seed over the internet *via* national and international mail services. Although it would be illegal to import seed to Australia from these sources, their continued presence represents an on-going risk of re-introduction.

There is still interest in USA in the use of kochia as a forage plant ('a living haystack'), on account of its palatability, rapid growth, high productivity and ease of establishment. Most recommendations for the use of kochia as an alternate forage source apply only when no alternative feed is available, but they highlight the issue of oxalate toxicity with various forms of livestock (Anon. 2002).

Other sources, however, continue to recommend kochia as an alternative field crop for use as a pasture fodder plant, and for revegetation and erosion control. These recommendations are made almost exclusively in the USA and most appear to cite a single reference, Undersander *et al.* (1990).

In addition to its claimed value as an alternative field crop, kochia is promoted as having herbal uses as

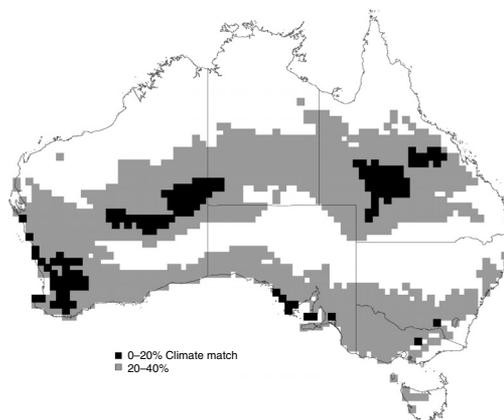


Figure 2. Potential distribution of *Bassia scoparia* in Australia (CLIMATE analysis).

an antibacterial, antifungal, antiphlogistic and astringent agent, a cardiogenic and diuretic, and a treatment for skin infections (Fern 2002).

Much of the popular internet-based information about kochia in the USA promoting the apparent benefits of the plant is based on dated, biased information. The volume of this information exceeds that dealing with the plant's deleterious attributes. Hence the continued use and promotion of kochia in the USA reflects a lack of recognition of the potential impacts of this plant on crops, livestock and rangelands.

Implications of the kochia case history for eradication policy

- *Resources* The eradication program was highly organised and well resourced, due to the availability of dedicated State and Commonwealth funding (the kochia eradication program was the first instance of a weed being tackled nationally by the Consultative Committee process).
- *Rapid response* Official intervention began within twelve months of the introduction of kochia, following the first reports of naturalisation.
- *Knowledge of sites* Comprehensive records were obtained from the seed merchant who sold the kochia seed. This allowed precise tracing of seed lots, identification of landholders and, consequently, rapid and accurate location of introduction sites.
- *Targeted eradication* Because of the comprehensive knowledge of the location of the original introductions, it was possible to target known sites for surveillance, eradication procedures and monitoring. By contrast, many other weed eradication programs are reactive, with eradication measures not being implemented until infestations have been found.
- *Local knowledge and assistance* Field operations during the eradication program involved experienced agriculture protection officers who lived in the affected regions. These officers had good working relationships with local farmers that were valuable for the location and searching of remote sites.
- *Willingness of the farming community to assist* Local farmers were highly cooperative and they provided considerable extra resources to the search and control operations. There could have been significant resistance from farmers if they had not been convinced that eradication was the right thing to do.

- *Effective early engagement with affected farmers* Early in the eradication program, the Department provided all affected farmers with comprehensive information kits on kochia that detailed the weed's biology and outlined the proposed management options.

REFERENCES

- Anon. (2002). 'Feeding Kochia'. Saskatchewan Agriculture and Food website. URL: http://www.agr.gov.sk.ca/docs/crops/forage_pasture/forage_management_production/FeedingKochia.asp.
- Bishop, A. (1995). Personal communication. Department of Primary Industry and Fisheries, Tasmania.
- Clark, M.J. (2002). Personal communication. Senior Agriculture Protection Officer, Department of Agriculture, Lake Grace, WA.
- Csurhes, S. and Edwards, R. (1998). 'Potential environmental weeds in Australia, candidate species for preventative control'. (Biodiversity Group, Environment Australia, Canberra, ACT).
- Dodd, J. (1996). Comparison of the eradication programs for kochia (*Kochia scoparia* (L.) Schrad.) and skeleton weed (*Chondrilla juncea* L.) in Western Australia. Proceedings of the Eleventh Australian Weeds Conference, Melbourne, pp. 82-4.
- Dodd, J. and Moore J. (1993). Introduction and status of *Kochia scoparia* in Western Australia. Proceedings of the Tenth Australian and Fourteenth Asian-Pacific Weeds Conference, pp. 496-500.
- Fern, K. (2002). 'Plants for a future'. (The Field, Penpol, Lostwithiel, Cornwall PL22 0NG, UK). URL: www.pfaf.org.
- Forcella, F. (1985). Spread of kochia in the northwestern United States. *Weeds Today* 16, 4-6.
- Undersander, D.J., Durgan, B.R., Kaminski, A.R., Doll, J.D., Worf, G.L. and Schulte, E.E. (1990). *Kochia*. 'Alternative field crops manual', ed. W.I. Madison, (University of Wisconsin-Extension, Cooperative Extension, USA). URL: <http://www.hort.purdue.edu/newcrop/afcm/kochia.html>.
- Western Australian Herbarium (1998). 'FloraBase - Information on the Western Australian flora'. (Accessed March-April, 2002). (Department of Conservation and Land Management. Perth). URL: www.calm.wa.gov.au/science/florabase.html.
- Wilson, P.G. (1992). Personal communication. Western Australian Herbarium, Perth.