

# CAN YOU GET GOOD WEED MANAGEMENT BY GROUPING WEED SPECIES BY LIFECYCLE?

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## Summary

Knowledge of the lifecycle of troublesome weeds is crucial for devising successful Integrated Weed Management (IWM) strategies. This is particularly useful when potential lifecycle weaknesses are identified and exploited by management. Grouping weed management by lifecycle similarity is intrinsically attractive, particularly when a large numbers of weeds are encountered. This idea was examined for the botanically diverse weed flora in the Australian cotton industry.

The lifecycle of 32 weeds was examined. This information was drawn from the literature, unpublished field observations and from field studies on the lifecycle of problematic species. The literature revealed four weed groups, those with emergence and reproduction: - year round, in all but winter, between mid-spring and mid-autumn, and those with defined warm season periods. These generalised groupings allowed major gaps in management to be identified, in particular in fallow, pre-plant and post-harvest situations.

Individual weed species have different lifecycle characteristics, despite apparent similarities. Failure to recognise these are a key reason why problematic weeds sometimes arise. The lifecycle (field) studies revealed different defined periods of growth and reproduction which could be exploited. These studies indicate that while IWM strategy generalisations can be made based on lifecycle similarity, that specific studies and management of problematic weeds will often be needed.

## Introduction

Weeds are a significant problem in the Australian cotton industry with yield losses and associated control costs reducing overall returns by up to \$400/ha (Taylor and Walker 2002). Significant effort has been made in recent years to develop and implement integrated weed management (IWM) systems that will result in improved weed control, reduced production costs and lead to more environmentally sustainable production systems (Taylor and Charles 2002). To further improve these strategies, it is essential that the biology and ecology of troublesome weeds be well understood. To date, few studies have been undertaken on the biology and ecology of the 200+ weeds that are known to be present on Australian cotton farms (Johnson and Hazlewood 2002). For those species where the biology and ecology is known, for example, the Nutgrass (*Cyperus*) species, (Charles 2002b), Polymeria take-all (*Polymeria longifolia*), (Johnson 2000), Peachvine (Covvine, *Ipomoea lonchophylla*), (Charles 2002a) and Malvaceae species such as Bladder ketmia (*Hibiscus*

*trionum*), (Johnson 2003), better management practices are being implemented thus reducing the impact of these weeds on the farming system.

There are currently a suite of mainly annual weeds that are proving difficult to manage in cotton farming systems. Many of these weeds have been troublesome for some time and have been consistently rated as the most problematic in grower, consultant and field surveys (e.g. Charles 1991, Johnson *et al.* 2003, Charles *et al.* 2004). This research sought to generate lifecycle information on this suite of weeds to determine if lifecycle weaknesses could be identified and exploited for improved management.

## **What we did**

### **Literature and observations**

Information on two key lifecycle stages, seedling establishment and reproduction (both flowering and mature seed set) was sourced for 32 weeds that were troublesome in the Australian cotton industry. This information was drawn from field observations, general sources including Cunningham *et al.* (1981), Auld and Medd (1987), Wilson *et al.* (1995), Parsons and Cuthbertson (2001), various floras including the Flora of New South Wales and Flora of South-Eastern Queensland series, and specific species literature e.g. Hocking and Liddle (1995).

### **Field studies**

Naturally occurring populations of Sesbania (Sesbania pea, *Sesbania cannabina*), Blackberry nightshade (*Solanum nigrum*), Caltrop (*Tribulus terrestris*), Chinese lantern (Wild gooseberry, *Physalis angulata*, also known as *P. minima*) and Australian bindweed (*Convolvulus graminetinus*, formerly known as *C. erubescens*) were evaluated in off-field locations adjacent to cotton fields near Narrabri and Narromine to collect lifecycle data in the absence of weed management. The trials were conducted over two seasons, at one or two locations and were replicated six times. The data obtained represent minimum figures for most lifecycle parameters. Only information that is different from that derived from the literature will be discussed.

## **Results and Discussion**

### **Seedling establishment**

Seedlings of the 32 weeds established in successive flushes after rainfall or irrigation events. These weeds can be split into four basic groups based on the timing of seedling establishment (Table 1). Weeds in the first group are able to establish all year round e.g. Australian bindweed, Narrow leaf bladder ketmia (*H. trionum* var. *trionum*), Peachvine and Bathurst burr (*Xanthium spinosum*). In other cases, year round emergence is strongly suspected e.g. Blackberry nightshade, Cobbler's pegs (*Bidens* spp.) and Yellow seed head dwarf amaranth (*Amaranthus macrocarpus* var. *pallidus*). These



weeds need to be managed all year, whether in crop or fallow situations to reduce crop competition and seed set.

Taxa in the second grouping establish in all but the coolest months of the year, e.g. winter and late autumn. Management is slightly easier for these taxa as year long vigilance is not required, but a focus on pre-plant, in-crop and post-harvest weed management needs to occur. The third grouping is similar to the second in that emergence does not occur in the coolest months of the year, but generally ceases in mid autumn (earlier than group 2) and then restarts in spring e.g. Mintweed (*Salvia reflexa*), Noogoora burr (*Xanthium occidentale*), Italian cockleburr (*X. italicum*), and David's spurge (*Euphorbia davidii*, which requires more research). Less emphasis is required for these species post-cotton harvest, but increased emphasis is required pre-planting, as well as continued emphasis in-crop.

The fourth grouping covers those species which only emerge in the warmer 6–7 months of the year generally in mid-late spring and then cease establishment during mid-late autumn. These species include Chinese lantern, Black pigweed (Giant pigweed, *Trianthema portulacastrum*), Annual polymerica (*Polymerica pusilla*) and Brown beetle grass (*Leptochloa fusca* ssp. *fusca*). The existing program of pre-plant and in-crop weed management may be adequate, but attention needs to be directed towards post-harvest management so that weed escapes do not set seed.

Seedling emergence was recorded in all species during the period November–March, and additionally in most species in the cooler cotton growing months of September, October and April. Around half the species also emerge in the 'shoulder' months of August and May while very few species emerge in the coldest months of June and July. This information indicates that to achieve successful IWM strategies against these weeds, focus should be directed at seedling emergence pre-plant, and to some degree post-harvest

## **Reproduction**

Although the periodicity of flowering and seed set is more restricted than that of establishment (Table 1), the taxa can also be split into four groups. The first group is able to set seed year round and includes Australian bindweed, Blackberry nightshade, Narrow leaf bladder ketmia and Bathurst burr whilst reproduction is suspected year round in Cobbler's pegs and Yellow seed head dwarf amaranth. Again, year round management is needed in crop or fallow situations to ensure the seed bank is not increased.

The second grouping of weeds are reproductive in all but the coolest 2–4 months, generally winter and early spring. Management to prevent seed set needs to occur pre-planting, in-crop, and also post-harvest. The third grouping of weeds only produce seeds during the warmest 6–7 months of the year, generally in summer and autumn e.g. Chinese lantern, Brown beetle grass, Wide leaf bladder

ketmia (*Hibiscus trionum* var. *vesicarius*), or from mid-late spring e.g. Sesbania, Black pigweed, Annual polymeria, Paddy melon (Wild melon, *Citrullus lanatus* var. *lanatus*) and Velvetleaf (Swamp Chinese lantern, *Abutilon theophrasti*). Aside from good seedling control, weed management should be focussed in-crop and post-harvest to prevent seed set.

The fourth grouping, a subset of the third, includes species with defined reproductive periods. For example, floral initiation occurs under minimum night length conditions of 10.5 hours for Noogoora burr and 10 hours for Italian cockleburr (Hocking and Liddle 1995). This means that Italian cockleburr will flower earlier than Noogoora burr where both species co-occur in New South Wales and possibly southern Queensland. There is evidence for specific floral initiation requirements in Anoda weed where growth cabinet plants growing under 10 hour night length conditions did not become reproductive until switched to 12 hour night length conditions, and where field and glasshouse observations indicate that flowering occurs either very early in spring or from late January onwards (Johnson 2003). Observations indicate that both Bellvine (*I. plebeia*) and David's spurge may have similar floral initiation requirements (G. Charles pers. comm.) but research is needed to confirm the actual mechanism of floral initiation in these three species and whether management can be tailored to prevent flowering and seed set as a result.

Flowering and/or seed set was recorded in all species during March and April, and in most species during summer and late Autumn (December–February and May). The majority of species are also reproductive throughout spring, although the number of species increases as temperatures rise. Very few species are reproductive in the coolest month July and only marginally more in June and August. This information indicates that to prevent seed set, to run down the seed bank and to achieve successful IWM strategies against these weeds focus again needs to be directed not only at pre-plant, but especially at post-harvest controls.

### **Field studies**

Although seedlings of two species, Australian bindweed and Blackberry nightshade establish in winter crops and stubble, both species reshoot from tap root material if defoliation, whether by cultivation, chipping or herbicide, has occurred prior to cotton planting. Caltrop plants are able to reshoot from tap root material during warmer months. Plants arising from such material rapidly produce flowers and seed heads in spring and summer and compete with cotton seedlings. Seedlings of Blackberry nightshade grow slowly emerging from under thick cotton crop canopies while those of Sesbania favour periodically flooded areas such as irrigation infrastructure and cotton fields. Moderate seedling numbers (10-50 plants/m<sup>2</sup>) combined with rapid vegetative growth rates e.g. 14-28 mm/day (Chinese lantern), 40+ mm/day (Sesbania) and 45–65 mm/day (Caltrop) aid early season competition with cotton.

Mature seed heads are produced within six weeks of emergence in Caltrop and within eight weeks of late emergence flushes in Chinese lantern, although seedling emergence in Chinese lantern is rarely observed before mid November near Narrabri, with seed head production during February. A similarly long vegetative period has been observed in Sesbania, with seed set from mid summer on. In contrast, Australian bindweed commences seed production in mid spring, around cotton planting.

Extended periods of seed production throughout summer and autumn (Table 1) result in moderate to large seed production per plant e.g. 900+ seeds in Australian bindweed, 12,000-24,000 seeds in Sesbania, 20,000+ seeds in Caltrop and 50,000+ seeds in Chinese lantern. Additional means of seed dispersal include frost-killed but standing plants of Sesbania shedding seeds into waterways, or the spines of Caltrop seed heads puncturing tyres, shoes and animal flesh with attendant dispersal.

These results indicate that large windows of opportunity exist to manage both Chinese lantern and Sesbania before seed set. In contrast, attention needs to be directed at Australian bindweed both before and at planting, and to Blackberry nightshade and Caltrop plants arising from tap root material. Strategic use of chipping with the application of Roundup Ready® herbicide in tolerant crops should also be employed to reduce the rapid seed production of Caltrop and to prevent successive flushes of many weeds from producing seeds. Although generalised weed management based on weed lifecycle similarity is possible, it is important to target management of individual weed species based on key lifecycle weaknesses.

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## References

- B. A. Auld and R. W. Medd (1987). *Weeds. An illustrated botanical guide to the weeds of Australia*. Inkata Press, Melbourne.
- G. W. Charles (1991). A grower survey of weeds and herbicide use in the New South Wales cotton industry. *Australian Journal of Experimental Agriculture* 31, 387–92.
- G. W. Charles (2002a). Managing cowine in cotton, In *WEEDpak, A guide for integrated management of weeds in cotton*, eds. S. B. Johnson, G. W. Charles, G. N. Roberts and I. N. Taylor, pp. H2.1-8. Australian Cotton CRC, Narrabri.
- G. W. Charles (2002b). Managing nutgrass in cotton, In *WEEDpak, A guide for integrated management of weeds in cotton*, eds. S. B. Johnson, G. W. Charles, G. N. Roberts and I. N. Taylor, pp. H3.1-33. Australian Cotton CRC, Narrabri.
- G. Charles, I. Taylor and G. Roberts, G. (2004). The impact of the cotton farming system on weed succession: implications for herbicide resistance and adoption of an integrated weed management approach. *Proceedings of the 14<sup>th</sup> Australian Weeds Conference*, eds. B. M. Sindel and S. B. Johnson, pp. 410–3. Weed Society of New South Wales, Wagga Wagga.

- G. M. Cunningham, W. E. Mulham, P. L. Milthorpe and J. H. Leigh (1981). *Plants of Western New South Wales*. Inkata Press, Melbourne.
- P. J. Hocking and M. J. Liddle (1995). *Xanthium occidentale* Bertol. complex and *X. spinosum*. In *The Biology of Australian Weeds. Volume 1*, eds. R. H. Groves, R. C. H. Shepherd and R. G. Richardson. R. G. and F. J. Richardson, Melbourne.
- S. B. Johnson (2000). Biology and management of the 'take-all' weed, *Polymeria longifolia* (Peak Downs curse), in cotton. Ph. D. Thesis, University of New England, Armidale.
- S. B. Johnson (2003). Ecology and management of bladder ketmia (*Hibiscus trionum*) and other emerging problem Malvaceae weeds. Final report for the Cotton Research and Development Corporation. NSW DPI, Narrabri.
- S. B. Johnson and S. Hazlewood (2002). Weed species lists. In *WEEDpak, A guide for integrated management of weeds in cotton*, eds. S. B. Johnson, G. W. Charles, G. N. Roberts and I. N. Taylor, pp. J3.1–8. Australian Cotton CRC, Narrabri.
- S. B. Johnson, B. M. Sindel, and C. E. Jones (2003). Survey of *Polymeria longifolia* Lindley in the Australian cotton industry. *Plant Protection Quarterly* 18, 120–6.
- W. T. Parsons and E. G. Cuthbertson. (2001). *Noxious weeds of Australia, 2<sup>nd</sup> edition*. CSIRO publishing, Collingwood.
- I. Taylor, and G. Charles, (2002). Integrated weed management for Australian cotton production systems. *Proceedings 11<sup>th</sup> Australian Cotton Conference*, pp. 133-45. Australian Cotton Growers Research Organisation, Brisbane.
- I. Taylor, and S. R. Walker, (2002). A scoping study on weed issues and their economic impact in dryland systems with cotton. Final Report for the Cotton Research and Development Corporation. NSW DPI, Narrabri.
- B. J. Wilson, D. Hawton, and A. A. Duff, (1995). *Crop Weeds of Northern Australia*. Queensland DPI, Brisbane.