STOPPING THE SPREAD BEST MANAGEMENT OF ANODA WEED AND VELVETLEAF

Stephen B. Johnson
Formerly, School of Rural Science and Agriculture, University of New England, Armidale 2351.
Presently, NSW Department of Primary Industries, Locked Bag 1000, Narrabri 2390.
Australian Cotton Cooperative Research Centre, Locked Bag 59, Narrabri 2390.

Summary

There are a number of minor weeds that occur throughout the Australian cotton industry that have considerable potential to spread and become increasing problems. Two of these are anoda weed (*Anoda cristata)* and velvetleaf (*Abutilon theophrasti*). Research has been focussed on these weeds in an effort to better understand the biology and lifecycle of these weeds to prevent further spread and to lead to increased management success. This paper briefly outlines that best management of these species can be achieved by controlling successive flushes of seedlings, preventing weed seed set and by rigorous farm hygiene practises. While these practises need to be part of an Integrated Weed Management (IWM) package, the limited suite of herbicides that are currently registered to control anoda weed, and lack of any herbicide registrations for velvetleaf is likely to hamper future management. This paper calls for further herbicide screening and registration of herbicides for both weeds in the Australian cotton industry. At present, one of the best means of management is the maintenance of rigorous standards of farm hygiene, akin to the *Come Clean Go Clean* campaign used to prevent the spread of cotton pathogens.

Introduction

Weed management is difficult on Australian cotton farms with a wide range of species to manage (Johnson and Hazlewood 2002) and large costs, often exceeding over $400/ha/yr (Taylor and Walker 2002). Previous research has focussed on a small number of common and problematic weeds encountered on farm, for example nutgrass, (generally *Cyperus rotundus*, Charles 2002b), bladder ketmia (*Hibiscus trionum*, Johnson *et al.* 2004), peach and bell vine (*Ipomoea lonchophylla* and *I. plebeia* respectively, Charles 2002a), polymeria take-all (*Polymeria longifolia*, Johnson *et al.* 2003) and mintweed (*Salvia reflexa*, Roberts and Gibb 1998). Concurrently, research has also focussed on a number of minor weeds that have the potential to become increasing problems, for example a number of other nutgrass species (*Cyperus* spp., Charles 2002b), annual Polymeria (*Polymeria pusilla*, Johnson 2002) and anoda weed and velvetleaf (*Anoda cristata* and *Abutilon theophrasti* respectively, Johnson *et al.* 2002).

Both anoda weed and velvetleaf have considerable potential to spread from areas where they currently occur to throughout the Australian cotton industry (Johnson 2003). An industry survey of consultants during 1996 found that anoda weed was both a widespread and increasing problem in the Macintyre Valley, the Darling Downs/South Burnett and St. George areas in Queensland (Johnson *et al.* 2003). Unfortunately since the survey, small but increasing infestations of the weed have been recorded in the Gwydir (Moree and Collarenebri), lower Namoi (Wee Waa) and Macquarie (Trangie and Warren) valleys, and at Bourke. There is strong evidence to suggest that anoda weed is spreading from these isolated sites, both across already infested farms and onto previously clean farms.

In contrast, while velvetleaf was recorded as early as the 1840's in western New South Wales, its potential to impact cotton crops has not been recognised until quite recently. Only small and somewhat isolated infestations have been recorded in the Gwydir, Namoi and Macquarie valleys, and at Tandou (Johnson 2003). Although the weed has been recorded on around 20 individual farms, it is only a major concern on less than half of these. This situation is surprising given the major problem that this weed is to cotton growers in the United States of America (USA). Since it has the potential to become a similar problem in Australia as it is in the USA, significant management needs to be directed towards its management (Johnson 2003).

Although there is a significant body of world-wide research on velvetleaf, and to a far-lesser extent on anoda weed, specific Australian information on the distribution and spread (Johnson *et al.* 2002), and biology and lifecycle of the weeds (Johnson 2003) has been limited. This has hampered both attempts to stop these weeds spreading and the successful management of these weeds where they occur. This paper outlines a short summary of research information relating to the biology, ecology and lifecycle of anoda weed and velvetleaf before discussing how this knowledge can be used to achieve best management outcomes for each of these weeds.

General information on anoda weed

Anoda weed can emerge and grow throughout spring, summer and autumn. Although mature seed can be produced within 73 days of emergence resulting in very small amounts of seed in late spring, mature seed is rarely produced before late February and this continues throughout autumn. Anoda weed is easily spread on dirty harvest and cultivation machinery, in cotton lint, and probably in water. Because of this, it is desirable to manage this weed in cotton crops, in fallow country, in waste areas beside fields and in irrigation systems. Plants can produce an average of 1200 seeds and limited information from overseas indicates that the weed has strong seed dormancy. This allows seed survival in the soil for a number of years.

There are two main aspects that need to be considered in the management of anoda weed. The first is management of the weed within the cropping system, especially to control successive emergence events after rainfall and irrigation. This will also involve the management of the weed in fallow and off-field locations to ensure that the problem is reduced with time. The second aspect is the practice of good farm hygiene, with special attention given to harvest and cultivation machinery. Because of the very specific conditions that appear to be needed for flowering to occur, the vegetative phase of the weed is relatively long and this presents a number of opportunities for management.

Each of the general management aspects outlined above will be discussed in relation to information derived from the Best Bet Management section in WEEDpak and from other anecdotal evidence from consultants, agronomists and growers. It is important to note that only those herbicides registered have been outlined below, and that the mention of such information does not imply that the action of the herbicide has been substantiated by this research.

How to best manage anoda weed

Management within crop

There are a limited number of pre-plant and in-crop management options to reduce or eliminate both seedling flushes and adult anoda weed plants.

Pre-planting - both broadacre cultivation and herbicide applications need to be considered to reduce seedlings that emerge prior to planting or in summer fallows. Pre-irrigation to initiate a seedling flush

is one management practice that should also be considered. Zoliar® (norflurazon) is registered for the control of anoda weed and should be used at label rates pre-plant.

Post-planting - the use of inter-row cultivations combined with applications of Staple® (pyrithiobac-sodium), registered for over-the-top cotton applications on small anoda weed plants, represents the best option for managing the weed in crop at present. Although the cost of Staple® is high, sequential applications are recommended to manage successive emergence events throughout the season, particularly on heavily infested fields.

Chipping is also recommended to manage this weed, although the difficulty in detecting this weed amongst similarly coloured and shaped foliage in the cotton crop represents a challenge. For this reason it may be important to educate chippers about this weed, explaining the similarities in foliage colour and shape and having pot specimens for them to observe. This practice may also help in achieving better weed management for a range of other weeds as well.

In general, fields should be chipped twice during the season. The first chip should be during November and December to rogue out as many plants as possible missed by cultivation and herbicide applications. The second chip is needed before late February, before mature seed is set. Anoda weed plants are easier to identify at this stage in the season as they tend to break through the cotton canopy. It is necessary to remove adult plants with green seed heads on them from the field after they are chipped because anecdotal evidence suggests that seeds are viable, are able to mature on dead plants and thereby contribute to the soil seed bank. These plants should be carefully collected and burnt, and the burning area inspected regularly to ensure seedlings have not re-emerged from any unburnt seed.

Trial work suggests that there is some evidence that the use of Roundup Ready herbicide® in Roundup Ready crops®, glyphosate through shielded spray units in non-glyphosate resistant crops and salvage applications of glyphosate at defoliation appear to be effective against this weed. Currently no product containing glyphosate is registered for the control of anoda weed and further research is needed to substantiate this information.

It is also important to remember to practice good Integrated Weed Management (IWM), even with the limited number of options available in-crop to delay any possible buildup in herbicide resistance.

Rotation crops - the use of management practices to control anoda weed in alternative crops is very limited. There is some opportunity to manage small anoda weed seedlings in peanut crops using paraquat, and using metribuzin in soybean crops, but these applications should be carried out according to label restrictions.

Summer fallows - there are a limited number of options for managing anoda weed in fallow situations although the use of paraquat, norflurazon and fluroxypyr are all registered options that appear to have some action against anoda weed. It is important to ascertain application restrictions and plant-back periods before herbicide application occurs however. Leaving aside soil structural and moisture conservation concerns, shallow broadacre cultivation is also a very useful tool in managing the weed.

Good farm hygiene

Anoda weed is easily spread on harvest machinery used for grain and cotton crops, cultivation machinery, on dirty vehicles, equipment or clothing, in cotton lint and probably in irrigation water. The key to stopping anoda weed infestations from spreading is likely to occur with good farm hygiene and will include the following:

1. All harvest machinery that may have been working in 'dirty' areas should be cleaned before it enters 'clean' areas. Anecdotal evidence suggests that failure to do this has resulted in the spread of the weed to many new areas. The message "*Come clean Go clean*" needs to be applied at a field level on farm to prevent anoda weed from spreading. In addition, consider cultivating and harvesting fields infested with anoda weed last so that the spread of seeds is minimised and machinery can be cleaned properly afterwards.
2. Anoda weed seed is easily spread in cotton lint because the weed produces mature seed around cotton harvest. Areas where waste lint falls or is left beside fields require special attention to ensure that these populations do not act as weed seed reservoirs. This is especially the case in previous module pad areas.
3. In the same way controlling weeds in other non-crop on-farm areas is critical to stop the spread of anoda weed to cropping areas. These areas include fallow fields, roads and roadside edges, along fence lines and riverbanks, in pasture country and in other disturbed wasteland. Parking cultivation and other machinery on weedy wasteland is a sure way to spread weeds onto fields.
4. As already mentioned, removing dead plants with green seed heads on them for burning will help prevent seeds being added to the seed bank.
5. Plants should be removed in all irrigation system infrastructures, for example around storage walls, and supply and return channels, where practical. This will help prevent weed seed being moved around in irrigation water.

General information on velvetleaf

Velvetleaf can emerge and grow throughout spring, summer and autumn. The weed appears to be easily spread in irrigation and flood water, and probably on dirty machinery. Mature seed can be produced within 62 days throughout summer and autumn with an average of 4900 seeds produced per plant. Again, it is desirable to manage this weed in all situations when and where it occurs, for example in cotton crops, along irrigation systems and floodways, on uncultivated land and in summer fallows. This weed has strong seed dormancy and data from overseas indicate that seed is able to persist for up to 50 years in the soil seed bank. Interference from this weed on cotton is likely to be a combination of plant competition for resources and allelopathy, where velvetleaf produces chemical compounds that inhibit the cotton growth.

There are two key aspects that are important in the management of velvetleaf. The first is the management of the weed in-crop, especially to prevent successive seedling flushes after rainfall and irrigation. The management of the weed in non-crop areas is also an important aspect to help manage this weed. The second aspect is good farm hygiene, in particular in the maintenance of a weed free irrigation system and floodways on farm. Because there is some time before seed production occurs in December there are a number of opportunities in which to manage this weed.

Velvetleaf is recognised as one of the most serious summer cropping weeds in the USA and there are many means to manage the weed, including both herbicides and bio-herbicides in that country. Some of the herbicides registered there that achieve good control in various cropping situations include glyphosate, pyrithiobac-sodium, (Staple®), oxyfluorfen (e.g. Goal®), norflurazon (e.g. Zoliar®), 2,4-D ester, atrazine, flumetsulam (e.g. Broadstrike®), imazethapyr (e.g. Spinnaker®), linuron (e.g. Afalon®), clomazone, lactofen and mixes of MSMA with either lactofen or cyanazine (e.g. Bladex®). Although velvetleaf causes

some serious problems in Australia, the isolated nature of most infestations, and the lack of rapid spread (until quite recently) has meant that no herbicides are currently registered in Australia for the control of the weed. Herbicide evaluation trials need to be considered as a matter of utmost urgency to ensure that relatively cost-effective and legally defensible management can be achieved for this weed.

The following information has been drawn from the Best Bet Management section in WEEDpak and from other anecdotal evidence from consultants, agronomists and growers. An evaluation of herbicide management options for velvetleaf was outside the scope of this research however.

How to best manage velvetleaf

Management within crop

There are relatively few pre-plant and in-crop management options to reduce or eliminate both seedling flushes and adult velvetleaf plants. There are currently no registered herbicides for the control of velvetleaf in Australia. Grower observations can be found in the best bet management guide of WEEDpak (pg. G2.35 in Taylor *et al.* 2002). Broadacre cultivation needs to be considered to kill the number of seedlings that emerge prior to planting, or in summer fallows. Pre-irrigation should also initiate a flush of seedlings that can be controlled by broadacre management. In-crop, the use of inter-row cultivation combined with chipping represents an excellent option for removing small numbers of plants. The use of pot specimens to explain the differences between velvetleaf and cotton may again be a useful tool to increase chipping success. Chipping should be carried out prior to mature seed set in December. A second chip may also be necessary to rogue out later emerging plants and prevent further seed set. Any plants with green seed heads on them should be carefully removed from the field and burnt to prevent further seed spread since anecdotal evidence suggests mature seeds can be set from green heads left to dry in the field.

The use of alternative weed management practices to control velvetleaf in rotation crops is also very limited. There is a need for herbicide evaluation work and registrations for the management of this weed in both rotation and fallow crops (Johnson 2003). Acknowledging this, it is important to remember to practice good IWM, even with the limited number of options available, to delay any buildup in herbicide resistance.

Good farm hygiene

Velvetleaf is easily spread in irrigation and flood water, on dirty machinery, equipment or clothing, in cotton lint and perhaps after being ingested in animals. The key to isolating velvetleaf infestations before they spread to clean fields and farms is good farm hygiene and will include the following:

1. Vigilance is required year round on any velvetleaf plants growing inside and outside storage walls, along supply channels and return ditches and within fields. A good example of how this may be implemented can be found in the farm hygiene section of WEEDpak (pg. F2.5 in Johnson and Spora 2002).
2. Since there is strong anecdotal evidence to suggest that seed heads and seeds are also spread in floodwater, particularly in overland flows, good farm hygiene will include treating all plants in 'melon hole' country (areas where the weed appears to be favoured), and on other land near rivers and waterways. It will also mean liaising with neighbours who may have the problem so that overland water flows do not introduce the weed. All areas where flood trash has settled should be inspected periodically for the weed after flooding events.
3. Since velvetleaf is easily spread in water, the practice of standing pumped river water (including floodwater) in velvetleaf-free storages for up to a week should be considered. This may allow seed to settle out to some extent.

4. All machinery and equipment that has been in infested fields should be cleaned down thoroughly to remove mud, soil and seeds. The message "*Come clean Go clean*" needs to be applied at a field level on farm to prevent velvetleaf from spreading. In addition, consider cultivating and harvesting fields infested with velvetleaf last so that the spread of seeds is minimised and a proper clean down of machinery can be conducted afterwards.

5. There is some evidence that velvetleaf seed can be spread in cotton lint, especially when mature seed is shed when the field is picked. For this reason it is important to inspect areas where waste lint falls, or is left beside fields, to ensure that these populations do not act as weed seed reservoirs. This is especially the case in previous module pad areas.

6. It is important to pay attention to non-crop on-farm areas so that spread does not occur into cropping areas. Non-crop areas include fallow country, roads and roadside edges, along fence lines and riverbanks, in pasture country and in other disturbed wasteland. Parking cultivation and other machinery on weedy wasteland is a sure way to spread weeds onto fields.

7. As already mentioned, removing dead plants with green seed heads on them for burning will help prevent seeds being added to the seed bank.

8. There is some anecdotal evidence from Australia and the USA that animals may also ingest and spread seed in faeces. For this reason it may be necessary to keep boundary fence lines in good condition and to regularly inspect all farm areas for new outbreaks.

Acknowledgements

This work was funded by the Cotton Research and Development Corporation when the author was a Post Doctoral Research Fellow at the University of New England (UNE). The Post Doctoral Research Fellowship was supervised by Assoc. Prof. Brian Sindel at UNE and Mr Graham Charles at the NSW Department of Primary Industries, Narrabri.

References

Charles, G. W. (2002a). Managing cowvine in cotton. *In* 'WEEDpak, A guide for integrated management of weeds in cotton', pp. H2.1-8. (Australian Cotton Cooperative Research Centre, Narrabri).

Charles, G. W. (2002b). Managing nutgrass in cotton. *In* 'WEEDpak, A guide for integrated management of weeds in cotton', pp. H3.1-34. (Australian Cotton Cooperative Research Centre, Narrabri).

Johnson, S. B. (2002). Polymeria and take-all. *The Australian Cottongrower*, Volume 23, no. 5, pp. 54-60.

Johnson, S. B. (2003). 'Ecology and management of bladder ketmia (*Hibiscus trionum*) and other emerging problem Malvaceae weeds, and Technical support for the development of WEEDpak'. Final Report on the Cotton Research and Development Corporation Project UNE32C (Australian Cotton Cooperative Research Centre, Narrabri). pp. 94.

Johnson, S. B. and Hazlewood, S. (2002). Weed species lists. *In* 'WEEDpak, A guide for integrated management of weeds in cotton', pp. J3.1-8. (Australian Cotton Cooperative Research Centre, Narrabri).

Johnson, S. B. and Spora, A. C. (2002). Farm hygiene in integrated weed management. *In* 'WEEDpak, A guide for integrated management of weeds in cotton', pp. F2.1-5. (Australian Cotton Cooperative Research Centre, Narrabri).

Johnson, S. B., Sindel, B. M. and Charles, G. W. (2004). Bladder ketmia (*Hibiscus trionum*). How variable is it? *Proceedings of the 12th Australian Cotton Conference*. (Australian Cotton Growers Research Association, Broadbeach).

Johnson, S. B., Sindel, B. M. and Jones, C. E. (2003). Survey of *Polymeria longifolia* (Lindley) in the Australian cotton industry. *Plant Protection Quarterly*, 18, 120-26.

Johnson, S. B. Taylor, I. N., Sindel, B. M. Charles, G. W. and Mackinnon, L. (2002). The distribution, spread and management of bladder ketmia, anoda weed and velvetleaf in Australian cotton farming systems. *Proceedings of the 11th Australian Cotton Conference.* (Australian Cotton Growers Research Association, Brisbane). pp. 169-76.

Roberts, G. N. and Gibb, D. (1998). Herbicide control of mintweed (*Salvia reflexa*) in cotton production systems. Proceedings of the 9th Australian Agronomy Conference. (Wagga Wagga). pp. 597-598.

Taylor, I. N., Johnson, S. B. and MacKinnon, L. (2002). Best Bet Management Guide. *In* 'WEEDpak, A guide for integrated management of weeds in cotton', pp. G1.1-2.38. (Australian Cotton Cooperative Research Centre, Narrabri).

Taylor, I. N. and Walker, S. R. (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. pp. 16.