BLADDER KETMIA (*Hibiscus trionum*) HOW VARIABLE IS IT?

Stephen B. Johnson[1,2,3], Brian M. Sindel[1,3] and Graham W. Charles[2,3]
[1]School of Rural Science and Agriculture, University of New England, Armidale 2351.
[2]NSW Department of Primary Industries, Locked Bag 1000, Narrabri 2390.
[3]Australian Cotton Cooperative Research Centre, Locked Bag 59, Narrabri 2390.

Summary

Accurate identification is important for the management of all weed species for a range of different reasons including the selection of effective herbicides and implementing timely management before seed set so that problems are not increased in future years. The species known as bladder ketmia (*Hibiscus trionum*) is extremely variable in Australia with at least three weedy types occurring. This study assessed the variation within and between these types in a range of field and glasshouse studies.

The field studies illustrated a number of differences between narrow and wide leaf varieties of bladder ketmia, (*H. trionum* var. *trionum* and *H. trionum* var. *vesicarius* respectively), and determined that two phenotypes of *H. trionum* var. *vesicarius* existed, one with a cream or yellow centred flower and the other with a red centred flower.

Glasshouse studies then evaluated the biotypic differences between 29 populations of these varieties and types collected broadly from within the eastern Australian cotton cropping area (Emerald in central Queensland, Qld to Warren in central New South Wales, NSW). There was significant variation between the varieties and types in many of the 67 growth parameters measured. There was also significant variation in these parameters within different populations of the same variety or phenotype.

These studies indicate two important areas for further investigation. Firstly, management recommendations including the timing and choice of herbicides need to be re-evaluated since important differences exist within this species. Secondly, a taxonomic review of the species known as bladder ketmia is needed to clarify if it is comprised of more than one species.

Introduction

Bladder ketmia (*Hibiscus trionum*) is a common cropping weed in Australia and around the world (Holm *et al.* 1997). The weed is both troublesome and widespread in the Australian cotton industry, with field surveys indicating nearly 85% of the cotton properties were infested (Taylor and Inchbold 2001). While individual plants are not overly competitive, bladder ketmia plants often occur in dense stands that can cause considerable localised yield losses. Bladder ketmia can be extremely difficult to control for three reasons. There are many seedling flushes throughout the season after irrigation and rainfall. The weed has prolific seed production and there are a restrictive range of herbicides that can be used without the risk of cotton crop injury.

There is currently confusion as to the correct taxonomic status associated with bladder ketmia within Australia and around the world (Johnson 2003). In Australia for example, Mitchell and Norris (1990)

recognise the presence of two varieties within NSW and Qld (*H. trionum* var. *trionum* and *H. trionum* var. *vesicarius*), but only some field identification guides recognise species variability (Wilson *et al.* 1995), while other taxonomic (Stanley and Ross 1986) and identification (Cunningham *et al.* 1981; Auld and Medd 1987) publications fail to make any distinctions, despite extensive herbarium collections being available. Additionally, although many weedy populations identified from overseas appear to be of the narrow leaf variety (*H. trionum* var. *trionum*), significant variation has been recorded between populations present within and between different countries (Holm *et al.* 1997; L. Craven pers. comm.).

The most important issue that this confusion raises is the ability to manage the weed since recent research has illustrated that varieties of bladder ketmia appear to have differential tolerance to some important cotton and broadacre herbicides (Wallace 2001; D. Harvey pers. comm.). Despite this, herbicide label recommendations make no distinction between the different varieties of bladder ketmia thereby complicating successful control.

This study was undertaken to quantify the biotypic differences within bladder ketmia. Initial investigations determined the taxonomic differences between the two different varieties that were weeds of cotton farming systems. More specific studies were then conducted both to elucidate the gross morphological differences between the varieties and between different populations sourced from within eastern Australia.

Methods

This study involved the assessment of phenotypic variation between a total of 29 populations collected from cultivated fields from Emerald in central Qld to Warren in central western NSW. Seeds of each population were collected from mature seed heads during summer, cleaned to remove seed heads and any damaged seed and stored in closed brown paper bags at room temperature for at least six months until they were planted. The plants were broadly identified as belonging to one of two varieties, narrow or wide leaf bladder ketmia at collection.

The glasshouse study was undertaken at the Australian Cotton Research Institute (ACRI) at Narrabri, during the period January–April 2001. Dormancy breaking treatments were applied to the seed immediately before planting (sandpaper scarification for two minutes for narrow leaf bladder ketmia and acid scarification using concentrated H_2SO_4 for 20 minutes for wide leaf bladder ketmia). Previous laboratory tests had shown that these treatments resulted in 85-100% germination within five days at 30°C constant dark conditions (Johnson 2003). All seeds were planted in 15 cm diameter pots filled with a 2:1 volumetric mix of sand and peat moss respectively. Although a wide variety of vegetative and reproductive parameters (up to 67) were measured on plants in four sequential destructive harvests approximately three weeks apart, only the most relevant parameters have been reported here (Table 1).

Results

Varieties and phenotypes of *H. trionum*

The studies confirmed the existence of two varieties of *H. trionum* throughout the Australian cotton industry (Table 1). Using the taxonomic classification of Mitchell and Norris (1990), the variety commonly known as narrow leaf bladder ketmia is *H. trionum* var. *trionum*, widely thought to have been introduced. In contrast, the variety known as wide leaf bladder ketmia, *Hibiscus trionum* var. *vesicarius* is thought to be native.

In the broadest sense, the distribution of the two varieties is geographically distinct but their distributions do overlap. For example, if a line was drawn through NSW following the division between the north and central west slopes, and north and central west plains, and then into Qld following the division between the slopes and plains in the Darling Downs and Burnett districts then narrow leaf bladder ketmia would be found in the cooler, temperate and more eastern areas, while wide leaf bladder ketmia would be found in the hotter, semi-arid and more western and northern areas of Australia. It appears that narrow leaf bladder ketmia is spreading outside its current area of distribution whereas wide leaf bladder ketmia is relatively stable.

Field surveys and herbaria investigations also revealed the presence of two distinct phenotypes of wide leaf bladder ketmia, and again, while these phenotypes were geographically separated, there is some commonality in distribution (Table 1). While both wide leaf phenotypes appear vegetatively similar, differentiation is a relatively simple matter once flowering occurs. The phenotype that is commonly found throughout NSW and southern Qld, for example in the Macintyre valley, on the Darling Downs, and at St. George, has a flower with a yellow or pale cream centre (similar to the hue of the surrounding petal colour). In contrast, the phenotype commonly found throughout southern, central and western Qld has a flower with a rich crimson/red centre. It is likely that both phenotypes co-exist in a number of areas although they have only been found growing together on the Darling Downs and in the St. George irrigation area.

Biotypic variation within bladder ketmia populations

While the major differences between the two varieties and the two phenotypes within wide leaf bladder ketmia have been outlined (Table 1), this study also revealed a number of other gross morphological and developmental differences between the two varieties that can help with more accurate field identification.

Both phenotypes of wide leaf bladder ketmia are erect annual plants with waxy, largely unlobed green leaves without toothed margins, 95-100 mm long and 70-90 mm wide. Plants flower within 33-38 days of plant emergence and mature seed set within 53-61 days, depending on the phenotype (Table 1). Field studies showed that at least 65 seed heads are produced on medium sized plants in the period December-April, after which frost kills them.

In contrast, narrow leaf bladder ketmia is semi-prostrate to erect with leaves that are about 70 mm long and 90 mm wide. The flowers have cream coloured petals with a deep purple centre. Flowering and seed set occurs more rapidly than in wide leaf bladder ketmia with flowering generally occurring within 30 days of plant emergence and mature seed set within 46 days. An average of at least 160 seed heads are produced annually on medium sized field plants and although seed can be produced throughout the year, especially when plants are sheltered from frost, the bulk of seed production occurs from September–April.

Table 1. A summary of morphological differences between varieties and phenotypes of *Hibiscus trionum* from field and glasshouse studies. Mean data have been presented with ranges in brackets.

Character	Wide leaf bladder ketmia	Narrow leaf bladder ketmia
Common names	*H. trionum* var. *vesicarius*	*H. trionum* var. *trionum*
Introduced/native	Native.	Probably introduced.
Approx. distribution	Warmer, western and northern areas.	Cooler and eastern areas.
Plant height and habit	Always erect and up to 1.5 m high.	Semi-prostrate to erect, to 1.3 m.
Leaf appearance	Waxy and mid to dark green.	Leaves less waxy often with purple tinged edges.
Leaf lobes	Leaves with 3 lobes, not deeply divided.	Leaves have 3, sometimes 5 lobes, deeply divided.
Leaf margins	Margins not toothed (entire).	Margins are toothed.
Leaf size (length x width)	95 x 89 mm (yellow centre flower). 101 x 70 mm (red centre flower).	68 x 90 mm.
Flower appearance	Cream with yellow (+/- distinct) or crimson/red centres.	Yellow/cream petals with deep purple centres.
Time to flowering (average)	33 days (28-39 days) yellow. 38 days (35-41 days) red.	30 days (26-32 days).
Time to mature seed heads (average)	53 days (49-61 days) yellow. 61 days (59-64 days) red.	46 days (42-49 days).
Reproductive plant	Seed heads are conspicuous on the main and larger plant stems.	Seed heads less conspicuous and scattered on most branches.
Seed head appearance	Straw coloured and rough in texture with raised ribs. Not see-through upon maturity.	Light grey and papery with soft, raised ridges that are purple. Nearly see-through upon maturity.
Seed head attachment	Firmly attached to plant.	Easily broken/detached from plant.
Seed head number per plant	33 (16-43) yellow. 25 (22-29) red.	67 (38-120).
Seed size (20 seed wt.)	0.17 g	0.09 g
Seed colour	Black.	Mid grey.
Seed number per seed head	36 (32-39) yellow. 34 (28-41) red.	35 (30-41).

Further investigations revealed that although vegetative development was slower in phenotypes of narrow leaf than in wide leaf bladder ketmia (data not presented), reproductive development was faster. In general, the reproductive development and seed production of the yellow flower phenotype of wide leaf bladder ketmia exceeded the red flower phenotype.

In addition to these difference in the parameters outlined above, there was considerable variation in the parameters between the different populations assessed within a variety or phenotype. Such variability is likely to have been inherent between populations.

Discussion

These studies revealed considerable variation between varieties, phenotypes and even populations of bladder ketmia. These differences are important for a number of reasons.

Management of bladder ketmia

Research by Wallace (2001) revealed the different tolerance of varieties of bladder ketmia to both glyphosate and bromoxynil. Anecdotal evidence also suggests that differential tolerance to trifloxysulfuron can be expected. Because current herbicide labels make no distinction between the different varieties of bladder ketmia, a thorough examination of the action of various herbicides on these varieties needs to be conducted once the taxonomy of the species is accurately determined (see below). It should be noted that of these herbicides only glyphosate is registered for the control of bladder ketmia, as per label recommendations.

Timeliness of management of bladder ketmia

Varieties and phenotypes of bladder ketmia need to be correctly identified so that timely management can occur. For example, to prevent seed set and crop yield loss from narrow leaf bladder ketmia, year round management is needed in both crops and fallows. In contrast, particular attention needs to be directed to both phenotypes of wide leaf bladder ketmia during summer and early autumn only, with yellow flower centre phenotypes producing seed before red flower centre phenotypes. Because of the relatively short vegetative period of both varieties and the successive seedling flushes that occur, constant vigilance in management is required whenever weed growth occurs. This is best implemented through an integrated weed management strategy (Johnson 2003). More information on the management of bladder ketmia can be found in the paper *Best management of bladder ketmia. What you can do to make a difference* in these proceedings (Johnson 2004).

It is also important to note that different populations within a variety and phenotype also show some variation in key lifecycle parameters, as shown by the range in the data. Because of this, monitoring of local populations needs to occur to ensure that timely management is achieved at an individual farm level.

Identification and taxonomy of bladder ketmia

This study has highlighted the presence of two distinct varieties of bladder ketmia, and the existence of two phenotypes within wide leaf bladder ketmia. Seed (2003) found several mechanisms that prevented cross pollination between these two varieties and that all viable seed produced arose from self pollination. The study by Seed (2003) and our own work give considerable support to the concept of a two species split in this taxa in Australia along current varietal lines. This concept is being investigated in a taxonomic review conducted by Dr Lyn Craven from the National Herbarium at CSIRO Plant Industry in Canberra. Once the taxonomy of the species is clarified then identification literature can be updated. These studies also highlight the importance of authors of weed identification literature consulting fully with state and national herbaria to ensure that more accurate guides are produced.

Acknowledgements

This work was funded by the Cotton Research and Development Corporation when the senior author was a Post Doctoral Research Fellow at the University of New England.

References

Auld, B. A. and Medd, R. W. (1987). *Weeds. An Illustrated Botanical Guide to the Weeds of Australia.* (Inkata Press, Melbourne). pp. 255.

Cunningham, G. M., Mulham, W. E., Milthorpe, P. L. and Leigh, J. H. (1981). *Plants of Western New South Wales.* (Inkata Press, Melbourne). pp. 776.

Holm, L., Doll, J., Holm, E., Pancho, J. and Herberger, J. (1997). *World Weeds. Natural Histories and Distribution.* (John Wiley and Sons, New York). pp. 381-386.

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. (2004). Best management of bladder ketmia. What you can do to make a difference. *Proceedings of the 12th Australian Cotton Conference.* (Australian Cotton Growers Research Association, Broadbeach).

Mitchell, A. S. and Norris, E. H. (1990). Malvaceae. In, *Flora of New South Wales, Volume 1*, (ed. G. J. Harden, University of NSW Press, Kensington). pp. 320-340.

Seed, L. U. (2003). Reproductive Biology and Hybridisation of Broad- and Narrow-Leafed Forms of *Hibiscus trionum* (Malvaceae). Bachelor of Science Honours Thesis (University of New England, Armidale). pp. 109.

Stanley, T. D. and Ross, E. M. (1986). *Flora of South-Eastern Queensland, Volume 2* (Queensland Department of Primary Industries, Brisbane). pp. 545.

Taylor, I. and Inchbold, B. (2001). Sustainable Weed Management Systems for Cotton, Project 3.1.5AC'. Australian Cotton Cooperative Research Centre Annual Review 2000-2001 (Australian Cotton Cooperative Research Centre, Narrabri). pp. 54-55.

Wallace, S. R. (2001). The Effects of Bromoxynil and Glyphosate on Two Biotypes of Bladder Ketmia (*Hibiscus trionum*). Bachelor of Rural Science Honours Thesis (University of New England, Armidale). pp. 70.

Wilson, B. J., Hawton, D. and Duff, A. A. (1995). *Crop Weeds of Northern Australia*, (Queensland Department of Primary Industries, Brisbane). pp. 160.