Bladder ketmia (*Hibiscus trionum* L.) in Australia – a variable taxa

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Summary Accurate identification is important for the management of weed species for a range of different reasons including the selection of effective herbicides, implementing timely management before seed set and for the selection of appropriate biological control agents. Bladder ketmia (*Hibiscus trionum* L.) is extremely variable in Australia with at least three weedy forms occurring. This study assessed variation within and between these forms in a range of field and glasshouse studies.

The field studies illustrated a number of differences between narrow and wide leaf forms of bladder ketmia, and determined that two phenotypes of the wide leaf form existed, one with a cream or yellow centred flower and the other with a red centred flower.

Glasshouse studies were used to evaluate the biotypic differences between 29 populations of *H. trionum* taxa collected broadly from within the northern grain zone (Emerald in central Queensland to Narromine in central New South Wales). There was significant variation between *H. trionum* taxa in many of the 67 growth parameters measured. There was also significant variation in these parameters within different populations of the same taxon.

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 taxa under the name *H. trionum* is needed to determine if it comprises more than one species.

Keywords Identification, varieties, populations, management.

INTRODUCTION

Hibiscus trionum L. (bladder ketmia) 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 cotton properties were infested (Taylor and Inchbold 2001). While individual plants are not overly competitive, bladder ketmia often occurs in dense stands that may cause yield losses. Bladder ketmia can be 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 is a restricted range of herbicides that can be used in cotton without risking crop injury.

There is currently confusion as to the correct nomenclature associated with *Hibiscus trionum* within Australia and around the world (Johnson 2003). In Australia for example, Mitchell and Norris (1990) recognise the presence of two varieties within New South Wales (NSW) and Queensland (Qld), *H. trionum* var. *trionum* L. and *H. trionum* var. *vesicarius* (Cav.) Hochr., but only some field identification guides recognise species variability (Wilson *et al.* 1995), while other taxonomic (Stanley and Ross 1986) and identification publications (Cunningham *et al.* 1981, Auld and Medd 1987) fail to make any distinctions, despite extensive herbarium collections being available. Additionally, although many weedy populations identified from overseas appear to be of the variety known as *H. trionum* var. *trionum* in Australia, 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 forms of *H. trionum* 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 forms of bladder ketmia, thereby complicating successful control.

This study was undertaken to quantify the biotypic differences within the species *H. trionum*. Initial investigations determined biological differences between the different forms that are 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.

MATERIALS AND METHODS

This study involved the assessment of phenotypic variation between a total of 29 populations collected

from arable fields from Emerald in central Qld to Narromine in central western NSW. This cropping zone represented well over 90% of the total production area of the Australian cotton industry. Seeds of each population were collected from mature seed heads during summer, cleaned and stored in closed brown paper bags at room temperature for at least six months until they were planted. Using the taxonomic treatment of Mitchell and Norris (1990), plants were broadly identified as belonging to one of two varieties, either *H. trionum* var. *trionum* or var. *vesicarius*.

The glasshouse study was undertaken at the Australian Cotton Research Institute (ACRI) at Narrabri, from January–April 2001. Seed dormancy was broken immediately before planting using sandpaper scarification for two minutes for var. *trionum* and acid scarification with concentrated H_2SO_4 for 20 minutes for var. *vesicarius*. Previous laboratory tests had shown that these treatments resulted in 85–100% germination within five days under 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) was measured on plants in four sequential destructive harvests approximately three weeks apart, only the most relevant parameters have been reported here (Table 1).

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

Character	*H. trionum* var. *vesicarius*	*H. trionum* var. *trionum*
Common names	Wide leaf bladder ketmia.	Narrow leaf bladder ketmia.
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 three lobes, not deeply divided.	Leaves have three, sometimes five lobes, deeply divided.
Leaf margins	Margins not toothed (entire).	Margins are toothed.
Leaf size (length × width)	95 × 89 mm (yellow centre flower). 101 × 70 mm (red centre flower).	68 × 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 appearance	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 (glasshouse studies only)	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).

RESULTS

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

In the broadest sense, the distribution of the two varieties is geographically distinct but their distributions overlap. *Hibiscus trionum* var. *trionum* is found in the cooler, more temperate eastern areas, while *H. trionum* var. *vesicarius* occurs in the hotter, more semi-arid western and northern areas of Australia. A line 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 roughly divides the varieties. It appears that *H. trionum* var. *trionum* is spreading whereas the distribution of *H. trionum* var. *vesicarius* is relatively stable.

Field surveys and herbarium investigations also revealed the presence of two phenotypes of *H. trionum* var. *vesicarius*. While both phenotypes appear vegetatively similar, differentiation is a relatively simple matter once flowering occurs (Table 1). Again while these phenotypes were generally geographically separated, there is some commonality in distribution. The phenotype commonly found throughout NSW and southern Qld (the Macintyre valley, Darling Downs, and St. George), has a yellow or pale cream centred flower (similar to the hue of the surrounding petal colour). In contrast, the phenotype commonly found throughout southern, central and western Qld has a rich crimson/red centred flower. It is likely that both phenotypes co-exist in a number of areas although they were only found growing together on the Darling Downs and in the St. George irrigation area.

Biotypic variation within forms and populations The major differences between the two varieties and the two phenotypes within *H. trionum* var. *vesicarius* have been outlined (Table 1). This study also identified a number of other gross morphological and developmental differences between the two varieties that can help with more accurate field identification.

Both phenotypes of *H. trionum* var. *vesicarius* are erect annual plants with waxy, green leaves, shallowly lobed without toothed margins, 95–100 mm long and 70–90 mm wide. Plants flowered within 33–38 days of seedling emergence and seeds reached maturity at 53–61 days (on average), depending on the phenotype (Table 1). Field studies showed that at least 65 seed heads were produced on medium sized plants in the period from December-April, after which the plants were killed by frosts.

In contrast, *H. trionum* var. *trionum* is semi-prostrate to erect with deeply lobed and divided leaves that are about 70 mm long and 90 mm wide. Flowers have cream coloured petals with a deep purple centre. Plants flowered and set seed earlier than in *H. trionum* var. *vesicarius*, within 30 and 46 days of seedling emergence on average respectively. An average of 160 seed heads were 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 seeds were produced from September–April.

In general, the reproductive development and seed production of the yellow flower phenotype of *H. trionum* var. *vesicarius* exceeded the red flower phenotype.

There was also considerable variation in the parameters between the different populations assessed within a variety or phenotype. Such variability is likely to have been inherent.

DISCUSSION

Identification and taxonomy of *H. trionum* This study has highlighted the presence of two distinct forms of *H. trionum*, and the existence of two phenotypes within what is currently known as *H. trionum* var. *vesicarius*. 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 gives considerable support to the concept of a two species split in this taxon 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.

Management of *H. trionum* Research by Wallace (2001) showed that tolerance varied between forms of *H. trionum* to both glyphosate and bromoxynil. Anecdotal evidence also suggests that differential tolerance to trifloxysulfuron may be expected.

Because current herbicide labels make no distinction between the different forms of *H. trionum*, an examination of the action of herbicides on these forms is needed.

It is important to note that different populations within a variety and phenotype also show variation in

key lifecycle parameters, as shown by the range in the data. Monitoring of local populations needs to occur to ensure that timely management is achieved at an individual farm level.

ACKNOWLEDGMENTS

This work was funded by the Cotton Research and Development Corporation as part of a Post Doctoral Research Fellowship at the University of New England. Dr John Hosking offered valuable comments on this paper.

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