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Review

The biology and management of prickly paddy melon (*Cucumis myriocarpus* L.), an important summer annual weed in Australia

Razia S. Shaik [a, d, *], Geoffrey E. Burrows [a, d], Nigel A.R. Urwin [c, d], David Gopurenko [b, d], Brendan J. Lepschi [e], Leslie A. Weston [d]

[a] School of Agricultural and Wine Sciences, Charles Sturt University, Locked Bag 588, Wagga Wagga, NSW 2678, Australia
[b] NSW Department of Primary Industries, Wagga Wagga Agricultural Institute, Pine Gully Rd, Wagga Wagga, NSW 2650, Australia
[c] Faculty of Science, Charles Sturt University, Port Macquarie, NSW 2444, Australia
[d] Graham Centre for Agricultural Innovation, Charles Sturt University, Locked Bag 588, Wagga Wagga, NSW 2678, Australia
[e] Australian National Herbarium, Centre for Australian National Biodiversity Research, GPO Box 1600, Canberra, ACT 2601, Australia

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ABSTRACT

Cucumis myriocarpus is an annual cucurbitaceous summer weed infesting fallow fields and pastures. Infestation results in reduced moisture availability for winter cereal crops as well as reduced crop yields and pasture quality. The need to manage this weed is of paramount importance given its adverse effects on farming systems, biodiversity and grazing livestock and its ranking as the number one weed of importance in Australian summer fallows of grain crops. Land management practices, including movement of grazing animals and over-stocking, are potentially assisting the spread of *Cucumis myriocarpus* fruits and viable seed. The plant is characterized by the presence of small, ellipsoid to spherical melon fruits with spiny appendages. Each plant can produce up to 50 or more melons per plant, with each fruit containing up to 200 viable seeds. Seed is often dormant upon fruit maturity and our results under controlled environmental conditions suggest both physiological and physical factors influence dormancy. Under field conditions, seedlings can form large vines growing upto 3 m in length. Field pollination experiments suggest that this melon is mainly self-pollinated by insects, including bees, flies and wasps. *Cucumis myriocarpus* is generally managed by the use of various broadleaf phenoxy herbicides and systemic post-emergent products. It is found in this study that this weed established through multiple flushes of germination, hence multiple herbicidal applications coinciding with rainfall events one suggested for more efficacious management. However, rotation of infested pastures with cereal crops such as canola and wheat also results in improved control. Additional studies into the impact of soil with and physical properties, disturbance and grazing, are recommended for development of more efficacious control measures. This review discusses taxonomy, genetic variation, biology and ecology and management of this important summer annual weed.

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* Corresponding author. School of Agricultural and Wine Sciences, Charles Sturt University, Locked Bag 588, Wagga Wagga, NSW, 2678, Australia.
E-mail address: rshaik@csu.edu.au (R.S. Shaik).

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1. Introduction

Cucumis myriocarpus is a summer annual invasive vine of natural habitats (Burrows and Shaik, 2014; Martin et al., 2006; Roger et al., 2015). It is also a significant weed in agricultural cropping systems in Australia (Michael et al., 2010b, 2011), especially in fallow crop fields, where it can cause reduction in available moisture for subsequent winter crops resulting in reduced crop yields (Felton et al., 1994; Fromm and Grieger, 2002; Leys et al., 1990). It has been estimated that in southern Australia, summer weeds, if left uncontrolled, can contribute to one tonne/ha of wheat yield losses arising from the loss of up to 50 mm of soil moisture (Van Rees et al., 2011).

C. myriocarpus can also result in loss of native plant biodiversity when it invades natural landscapes (Hallett et al., 2014). The need to manage this weed is of paramount importance given adverse effects on farming systems, biodiversity and grazing livestock and its ranking as the number one weed of importance in Australian summer fallows of grain crops (Llewellyn et al., 2016). The predictions of its increased spread as a result of climate change are a cause for concern (Michael et al., 2011). Here, we present a comprehensive literature review of the biology of this species. Implications of the plant's biology, ecology and life history on its management are described.

2. Taxonomy and identification

Cucumis myriocarpus has many common names including prickly paddy melon, bitter apple, giffappel, gooseberry melon, paddy melon, prickly melon, squash melon, wild cucumber (Parsons and Cuthbertson, 2001; Wagstaff, 2008), gooseberry gourd (DiTomaso and Healy, 2007), prickly paddy cucumber (Grubben and Denton, 2004) and gooseberry cucumber (Bosch, 2005; Wiersema and León, 2013). 'Prickly' refers to the soft spines on the fruit; the origin of the term 'paddy' is uncertain, but has been attributed to 'Paddy,' the archetypal Irishman who grew them believing that they were edible (HerbiGuide, 2014). The generic name '*Cucumis*' is derived from the ancient Latin name for the cucumber, and the epithet '*myriocarpus*' is derived from the Greek '*myrias*' (or Latin '*myrio*'), meaning 'many' and the Greek '*karpos*' (or Latin '*carpa*') meaning 'fruit', which refers to its abundant fruit production (Quattrocchi, 1999).

Populations of naturalised *Cucumis myriocarpus* in Australia and more globally have been referred to *Cucumis myriocarpus, C. myriocarpus* subsp. *myriocarpus* or *C. myriocarpus* subsp. *leptodermis* (Schweick.) C. Jeffrey and P. Halliday (Kirkbride, 1993) [see CHAH (2015)]. However, morphological and molecular data indicate that Australian plants represent *Cucumis myriocarpus* subsp. *myriocarpus* (Shaik et al., 2012).

Cucumis myriocarpus may be confused with two other weedy cucurbit species. These include *Citrullus colocynthis* (colocynth) and *Citrullus lanatus* (camel melon), especially when immature. However, certain key morphological features can be used to differentiate between them (Table 1 and Fig. 1).

3. Genetic variation

To better understand the genetic diversity associated with *Cucumis myriocarpus* populations in Australia, samples from geographically diverse sites across Australia were collected and compared to the native African range and from naturalised populations elsewhere in the world, including USA, India and Europe (Shaik et al., 2015). Limited genetic variation among Australian populations and other invaded locations was apparent with only one main haplotype observed across Australia (Shaik et al., 2015), in contrast to the native African populations where considerable diversity was observed (Shaik et al., 2015).

Limited genetic variation may potentially assist in control of invasive weedy species, allowing development of a single effective method for optimal control. Biological control is known to be more effective in weedy plants exhibiting minimal variation (Burdon and Marshall, 1981; McFadyen, 1998). However, the sourcing of a biocontrol agent for *Cucumis myriocarpus* will probably be difficult due to the close relationship of *Cucumis myriocarpus* to many economically important, cultivated cucurbits e.g. watermelon, (*Citrullus lanatus*), zucchini (*Cucurbita pepo* cv. Zucchini), rockmelon (*Cucumis melo*) and squash (*Cucurbita pepo*).

4. Origin and distribution

Cucumis myriocarpus is native to South Africa (Burrows and Tyrl, 2012; DiTomaso and Healy, 2007), Zambia, Botswana (Phillips, 1992), Mozambique and Lesotho (Grubben and Denton, 2004) and has typically invaded areas with similar Mediterranean