



The biology, phenology and management of Australian weed-camel melon (*Citrullus lanatus* (Thunb.) Matsum. and Nakai)



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ABSTRACT

Citrullus lanatus (camel melon) is an important summer weed of Australian fallows, and can rapidly develop monocultural stands in sandy soils receiving adequate soil moisture. As a general review on the biology of *C. lanatus*, this paper reviewed the current published literature (including our recent published studies) and also summarised extensive field and laboratory studies performed on its biology, phenology and management in the South-West Slopes of New South Wales. Recent population genetics studies conducted in Australia have shown that the species is monotypic, and was introduced as a single colonisation event in the mid 1800's. Our studies showed genetic diversity in *C. lanatus* to be non-existent across Australia and invasive ranges and highest in the native range in Africa. Further genetic analyses have shown the species in Australia is identical to *Citrullus lanatus* var. *citroides*, the citron melon, native to Africa and now naturalised across Africa, Asia and North America, where it is a weedy nuisance or occasionally a food source for livestock and humans. Although limited genotypic diversity may facilitate potential biocontrol strategies for *Citrullus lanatus* in Australia, biocontrol may be difficult due to its close genetic similarity to commercial watermelon, a major horticultural crop in Australia and more globally. In Australia, field germination was observed to occur during a two to three-month period between late spring and summer, when warm soil temperatures occurred and field establishment was typically observed after significant rainfall events and was associated with soil moisture availability. Controlled environment seed dormancy findings indicated that dormancy was significantly reduced by storage at ambient laboratory temperatures over eighteen months. Seed dormancy was transient and appeared to be both physical and physiological in nature, and was dependent on the period of after-ripening during the post-harvest period. Key reproductive attributes, including high seed production, self-compatibility and pollination facilitated by several non-specific pollinators have likely resulted in increased spread of this weed in Australia and more globally. Management of *C. lanatus* is achieved using IWM strategies including pre and post-emergent applications of herbicides as well as limiting fruit production by cultural practices including mowing, grazing and cultivation.

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1. Introduction

Citrullus lanatus is described as a cucurbitaceous weed with a vining growth habit, preferring sandy soils. It is commonly found in irrigated summer croplands and pastures (Leigh and Mulham, 1965). It was originally a native of South Africa, but is currently distributed across Asia, North and South America, New Zealand and much of Australia (Leigh and Mulham, 1965; Parsons and Cuthbertson, 2001). In Australia, *C. lanatus* var. *citroides* is an important summer annual weed (Burrows and Shaik, 2014; Shaik et al., 2016) in natural habitats, pastures and cereal cropping systems causing significant yield losses (Fleming et al., 2013; Michael et al., 2010).

Significant control of *C. lanatus* has been achieved by the application of glyphosate plus metsulfuron, as well as glyphosate plus 2,4-D ester. The use of fluometuron incorporated into pre-emergent or post-emergent soils has also been found to provide good control of this melon. In fallow fields, atrazine and triclopyr yielded adequate control of *C. lanatus* (Johnson and Spora, 2002). Early morning spraying of plants with a mixture of triclopyr, 2,4-D and metsulfuron followed by heavy grazing for five consecutive days has also been recommended (DAAF, 2014; Roulston et al., 2000).

It has been estimated that in southern Australia, summer weeds such as *C. lanatus* can contribute up to 1 MT/ha wheat yield losses if left uncontrolled, as a result of soil moisture depletion (about 30 mm) that would otherwise be available for subsequent winter crops and interfere with crop growth (Van Rees et al., 2011). Wild melons (including *Citrullus lanatus* var. *citroides* and *Cucumis myriocarpus*) are now ranked as the most important weed pest of summer fallows in Australian grain crops (Llewellyn et al., 2016, GRDC Cost of Weeds to Australian Grain Crops Report). Currently, there has been limited information published on the ecology, biology and management of this weed. This review compiles information from the existing global literature and field and laboratory studies performed between 2009 and 2016 in south-eastern Australia to present a thorough review on the biology of *C. lanatus* var. *citroides* in light of implications for improved management.

2. Taxonomy and identification

C. lanatus has many common names including camel melon,

Afghan melon, pie melon, bitter melon, wild melon, bitter apple, mickey melon, paddy melon, citron, preserving melon, watermelon, bastard melon and wild melon (Black, 1943; Charles, 2014; Hartley, 1979; Lazarides et al., 1993). 'Camel melon' is the most common name for this melon in Australia and is related to the presumed mode of its introduction to Australia, via Afghan cameleers in mid 1800's to early 1900's, who purportedly used this species as a feed source for their camels (Parsons and Cuthbertson, 2001; Robertson, 1981). The generic name '*Citrullus*' is derived from the Latin word '*citrus*' for the citron tree (*Citrus medica*), probably in reference to the similarity of fruit size and colour between this species and some *Citrullus* taxa. The epithet '*lanatus*' is derived from the Latin for 'woolly' in reference to the woolly indumentum on most plant parts (HerbiGuide, 2015).

Populations of naturalised *C. lanatus* in Australia have previously been referred to with this name or *C. lanatus* var. *lanatus* (i.e. the commercial watermelon) [see CHAH (2015)]. However, recent morphological and molecular findings indicate that Australian plants are in fact identical to *C. lanatus* var. *citroides* (L.H. Bailey) Mansf., the citron melon (Shaik et al., 2012, 2015). *C. lanatus* is often confused with two other weedy cucurbit species in Australia, *C. colocynthis* and *Cucumis myriocarpus*, particularly when immature. *C. lanatus* and *C. myriocarpus* are morphologically similar, particularly when no fruit can be observed (Shaik et al., 2017). *C. lanatus* seedlings can be identified by their deeply lobed, variegated leaves (lighter in colour around the leaf veins), whereas *C. myriocarpus* seedlings can be recognised by their deeply lobed and paler green leaves. *C. lanatus* resembles *C. myriocarpus* except for the presence of bifid tendrils, single axillary flowers and larger, 10–15-cm-long, spherical-to-oblong-shaped fruits, which can be striped or spotted in appearance (Tables 1, 2, 3 and Fig. 1). However, key morphological features can be effectively used to differentiate these melon species (Tables 1, 2 and 3).

3. Genetic variation

To better understand the genetic diversity associated with *C. lanatus* populations in Australia, samples from geographically diverse sites across Australia, the native African range and from naturalised populations elsewhere in the world were collected and evaluated using molecular markers and DNA sequence analysis

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