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A comprehensive study on noxious weed *Conyza bonariensis*

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Abstract
Conyza bonariensis is the most problematic, noxious, invasive and widespread weeds in modern-day agriculture**.** *Conyza bonariensis* (L.) Cronquist, flaxleaf fleabane, originating from South America, is a major emerging weed threat for dry-land cropping systems in Australia. This species shares a unique set of biological features, which enables them to invade and adapt a wide range of environmental conditions. Distinct reproductive biology and an efficient seed dispersal mechanism help this species to spread rapidly. Ability to interfere strongly and to host crop pests makes it a worst weeds of cropping systems. Cultural practices such as crop rotations, seed rate manipulation, mulching, inter-row tillage and narrow row spacing may provide an effective control of the species. weed management techniques have been discussed in this paper, such options need to be tested and applicated in the field. Ecological influences on all key life stages of *C. bonariensis* were investigated. There is a need to expand the ecological knowledge of *C. bonariensis* in order to better understand its success in minimum tillage systems and to provide principles for the improved management of this weed. The adaptations of weeds to herbicides and herbivores is related to ecological, metabolic, enzymatic, physiological, anatomical and morphological changes.

Keywords: Reproductive biology, environmental conditions, effective control, seed dispersal

Introduction

C. bonariensis is a mainly annual herbaceous weed overwinters as a rosette, and spreads by producing high numbers of wind-dispersed seeds. *Conyza bonariensis* (L.) Cronquist is a species of the Asteraceae family. Common names include hairy fleabane, flax-leaf fleabane, fleabane, wavy-leaved fleabane, asthma weed and Argentiinan-koiransilmä (Roy *et al*. 1998 [31], Randall 2002) [28].

Conyza bonariensis is a cosmopolitan weed. It infests arable land, orchard, vineyard, forest, roadsides, abandoned fields, as well as industrial sites (Burry and Kloot 1982) [6]. It is one of the most difficult weeds to control in minimum tillage farming systems (Somervaille and Mc Lennan 2003) [35].

Annual or biennial herb to 1 m high, robust, erect, grey-hispid; stems usually unbranched below inflorescences, often branched near base, lateral branches regularly overtopping main axis, densely hirsute with spreading septate hairs. Leaves hispid with short antrorse hairs and with longer spreading septate hairs; leaves densely arranged, usually greyish green, basal leaves linear, oblong, or narrow-oblanceolate, 4–9 cm long, 5–15 mm wide, margins toothed, sometimes teeth obscure; leaves becoming progressively smaller, 3–6 cm long and 5–10 mm wide, oblong to linear, entire. Inflorescence a pyramidal or corymbiform panicle; head many, hemispherical, 5–6 mm long, 8–12, *Conyza bonariensis* is a hexaploid species (allopolyploid), with a chromosome number of 2n = 54 (Razaq *et al*.,1994 [32], Urdampilleta *et al*., 2005) [39]. Conyza species have a basic chromosome number of nine: diploid, triploid, tetraploid and hexaploid configurations have been reported (Goldblatt, 1985 [16]; Razaq *et al*.,1994;) [32].

Conyza bonariensis has the narrowest leaves at the rosette stage when compared to other Conyza species. It has a more compact structure, with many short branches and bearing large capitula. *C. bonariensis* produces basal rosettes prior to bolting and flowering (Thebaud and Abbott 1995) [38].

Conyza bonariensis seedling growth is very slow, and the rosette stage relatively prolonged, even under the optimal thermoperiods of 27/22°C (Zinzolker et al. 1985) [46]. Active growth commences in spring or early summer with plants producing, over a long period, a mass of light fluffy seeds which are readily dispersed by the wind (Cunningham *et al*. 1981) [11]. *Conyza bonariensis* has resprouting characteristics. There were about 4–6 buds at the top of the taproot (near the soil surface) of over-winter *C. bonariensis* plants (Wu *et al*. 2007) [43, 44]. This feature enables the plant to regenerate from its basal buds after top removal (Davies,1999) [13]. *Conyza bonariensis* often follows a winter or summer annual life cycle. It predominantly emerges in autumn and early winter, forms a basal rosette stage over winter and produces seeds in the following spring or summer. A small fraction of *C. bonariensis* also germinates in spring and bolts without an over-wintering growth stage. On-farm monitoring of field emergence over time in a light sandy loam soil showed that 99% emergence occurred in late autumn, early and late winter, and 1% emerged in mid spring (Wu *et al*. 2007) [43, 44]. The tap roots of *C. bonariensis* can grow more than 35 cm deep into the soil to absorb available water, thereby surviving the severe drought conditions frequently experienced in the winter in south-eastern Queensland (Regehr and Bazzaz,1976) [30]. The establishment of a strong root system over winter months provides sufficient food reserves for rapid growth during the following spring. It is difficult to control these over-wintered *C. bonariensis* plants, although they are small in appearance. In fact, these plants are well developed, thereby requiring higher management inputs to control them (Wu and Walker 2004) [42]. *Conyza bonariensis* is selfcompatible, and apparently not actively pollinated by insects, suggesting either autogamy or wind-pollination (Thebaud *et al*. 1996 [37], Zelaya *et al*. 2007) [45]. *Conyza bonariensis* produced large and rounded capitula, with capitulum total length of 5.1 mm and base width of 3.6 mm. The number of florets per capitulum was estimated at 211, which is about three times greater than *C. canadensis,* and two times greater than *C. sumatrensis* (Thebaud and Abbott 1995) [38]. Reproductive capacity of *C. bonariensis* is high relative to total plant biomass. Baker (1965:147) [4] defines a plant as a weed "if, in any specified geographical area, its populations grow entirely or predominantly in situations markedly disturbed by man (without, of course, being deliberately cultivated plants)". Furthermore, weeds grow where we either want other plants to grow or no plants to grow (Rao, 2000) [29]. One means by which weeds are grouped is by habitat type, and these include agrestal (agricultural weed), ruderal (waste sites/disturbed sites), grassland, aquatic, forestry and environmental weeds (Holzner, 1982) [18]. Conyza species reproduce autogamously, are self- compatible, and as a result have a reduced pollen-to-ovule ratio compared with xenogamous reproducers (Cruden, 1976) [10]. With no requirement to attract a pollinator, the flower size is small compared with an outbreeder, thus enabling efficient energy use (Ornduff,1969).

Conyza bonariensis plants are capable of producing up to 357 561 wind-dispersed seeds per plant (Kempen and Graf, 1981) [20]. Average seed production was estimated at 290 per head and 266 753 per plant from Kern County, California (Kempen and Graf, 1981). Seed settling velocity is a useful indirect measure of dispersal ability, with low settling velocity corresponding to high dispersal ability (Andersen, 1992) [1]. The seeds of *C. bonariensis* plants are enclosed singly in small hard achenes. The achenes are equipped with a tuft of bristles known as the pappus. *Conyza bonariensis* seedling establishment and survival increased with an increase in Asteraceae species richness (Prieur-Richard *et al*.,2000) [27]. Seed persistence is also affected by soil type. *Conyza bonariensis* seeds buried in a light sodosol soil had significantly higher percentage viability than those buried in the heavy textured vertosol soil. When exhumed after 24 months of burial, 8% viable seeds were detected in the light soil, and 2% in the heavy soil (Wu *et al*., 2007) [43, 44]. Biomass and reproduction of *C. bonariensis* and *C. canadensis* decreased in the presence of higher annual grass species richness but increased in the presence of annual legumes (Lavorel *et al*., 1999) [22]. This reported increase in biomass, when grown in the presence of legumes, is likely due to the increase in nitrogen availability (Palmer and Maurer, 1997) [26].

Seed of this plant that emerged under decreasing temperature and photoperiod conditions show an increase of dry matter production and reduced flowering induction, whereas under increasing temperature and photoperiod conditions there is less accumulation of dry matter and more flowering induction (Soares *et al*., 2017) [36]. Therefore, based on the climatic conditions, it is possible to predict this species development and, then, make recommendations for control at the appropriate time. Chambers and Mac Mahon (1994) [8] described two separate phases of seed dispersal. Phase I, is the transit from parent plant to the soil surface and Phase II involves subsequent horizontal or vertical movements (Chambers and Mac Mahon, 1994) [8]. Phase I, or primary dispersal, for Conyza species is via wind, an abiotic means (Wu, 2007) [43, 44]. Wind dispersal (anemonochory) is one of the most studied seed dispersal vectors. Structural features of a seed which reduces the speed it falls, for example; a pappus of a high surface area to volume ratio, increases the likelihood of lateral transportation by air currents (Chambers and Mac Mahon, 1994; Cousens and Mortimer, 1995) [9].

Hairy fleabane [*Conyza bonariensis* (L.) Cronquist] is a weed of the Asteraceae family whose main characteristics are high competitivity and prolificacy, producing more than 800 thousand seed per plant (Kaspary *et al*., 2017) [19]. Worldwide, hairy fleabane is one of the main weeds in wheat, soybean, and maize cultivations, causing significant drops of grain yield (Vargas *et al*., 2007 [40]; Agostinetto *et al*., 2017) [3]. Conyza *bonariensis* seeds are reported to remain viable for at least 1 to 2 years (Weaver, 2001) [41]. In addition to small seed size aiding dispersal, Conyza species, and many other Asteraceae members, have a pappus attached to the achene (Fenner 1985 [15]; Dauer *et al*. 2007) [12], such structures act as a drag-enhancing parachute (Andersen, 1993) [2]. Pappus lengths for the Conyza species in Australia range from 2 to 5 mm (Everett, 1990) [14]. It is reported in numerous Asteraceae species that the pappus alters its geometry in varying levels of humidity (Sheldon, 1974) [33]. Although exotic plants typically arrive in a new country without their native herbivores, this does not exclude the possibility of generalist herbivores in the new habitat from predating these plants (Case and Crawley, 2000) [7]. In an investigation in south east Queensland, 30 *C. bonariensis* plant density was reportedly increased with cattle grazing, (McIntyre *et al*., 2003) [23]. In addition to the grazing of *C. bonariensis,* vegetative biomass, seeds and flowers, are consumed by birds (Lepschi, 1993) [21].

The abundance of this weed may also be due to a tolerance to many of the herbicides commonly used in crops and fallows. Glyphosate resistant *C. bonariensis* was initially reported in South Africa in 2003 (Heap, 2010) [17].

The majority of weed problems are ecological in nature and therefore sustainable long-term control strategies must be based on an understanding of the biotic and abiotic factors which promote or suppress the establishment, growth and spread of weeds (Sindel, 2000) [34]. There are reports of herbicide resistance biotypes of *C. bonariensis* in eight countries, across a range of mode of action groups, including glyphosate (Heap, 2010) [17]. The importance of ecological and life cycle studies of weeds to underpin effective management strategies has been well documented (Mortensen *et al*. 2000 [25]; Mohler 2001 [24]; Booth *et al*. 2003) [5]. An individual *C. bonariensis* plant flowers sequentially and the flowering period can span 1 to 28 4 months (Thebaud *et al*., 1996) [37].

Conyza bonariensis: Vegetative and Reproductive Structures

Result & Discussion

In this study, ecological aspects of the key life stages of *C. bonariensis* were investigated, comprising of germination, emergence, growth and development, seed dispersal and seed longevity. *Conyza bonariensis* is not able to germinate when buried beneath the soil surface. This paper aim is to expand the ecological knowledge of *Conyza bonariensis* (L.) Cronquist in order to better understand the ecological niche this plant occupies. This knowledge will assist in understanding the ecological reasons for the success of *C. bonariensis* in minimum tillage systems of the northern cropping region of Australia. A series of experiments was conducted targeting each life stage of *C. bonariensis*. This work revisits the findings to highlight ecological reasons for the success of *C. bonariensis*, compare the ecology of the species, provide management principles for effective control and describe future research priorities. Dispersal distance decreases with increases in humidity. Pappus hairs are closed in together at higher humidity. Farm hygiene is another important element in effectively managing this weed. With a very high fecundity and ability for long-distance seed dispersal, control measures need to be extended to non-cropping areas of the property.

Conclusion

Study emphasizes on taxonomy, morphology, distribution, current biological and ecological knowledge and the agronomic impact and control of *Conyza bonariensis* (L.) Cronquist. Conyza species are prolific seed producers. Another opportunity to expand the suite of options for an integrated weed management approach for *C. bonariensis* is biological control. Future research in the use of biological control agents, allelopathy and bioherbicides is important as no one single management option can successfully control *C. bonariensis* in the long-term. The findings of this research can also predict future problematic weeds and species shifts within these cropping systems. A lifecycle summarizes the ecological characteristics of *C. bonariensis* as identified by this research. Several physiological, ecological, morphological adaptations that contribute to its success as a weed should be considered. These include variations in seed physiology and germination, responses to herbicides & herbivores and mechanisms related to stress tolerance and defense such as the production of toxins or the ability to resist herbivory.

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