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Epinastic Growth and Accordion-Type Leaf Formation of *a Phoenix Canariensis* Following Herbicide Application

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Abstract

Canary Islands date palms (*Phoenix canariensis*) were introduced to Australia in the second half of the nineteenth century as ornamental plants, where they have become naturalised in those urban, peri-urban and agricultural landscapes where hot dry summers and cool winters or mild temperatures prevail. Given their persistence, and proven resilience to low moisture conditions once they have become established, they are often regarded as a hard to eradicate, invasive environmental plant. Palms that are subject to extreme nutrient deficiencies, such as Boron, may experience damaged or impaired shoot apical meristem which can result in malformed leaf and stem growth. This paper describes longitudinal observation of the effects of a poising event on a Canary Islands date palm, when a farmer applied a 'cocktail' of herbicides comprised of an above-strength formulation of both Brush-Off and Ally. The plant's continued persistence, albeit with malformations, demonstrates the resilience of Canary Islands, date palm as an ornamental species.

Keywords: growth malformation, meristem, poisoning, invasive plants, ornamental palms

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Introduction

Canary Islands date palms (*Phoenix canariensis* Chabaud) are considered ornamental trees which have been distributed by the horticultural industry well beyond their endemic range (Zona, 2008; Spennemann, 2018a and Spennemann, 2019a). As garden escapees, they have become naturalized and an invasive environmental tree in a number of countries, even though the exact biomechanical and biochemical processes of dispersal are not yet well understood (Spennemann, 2019b). They were introduced in the second half of the nineteenth century to Australia and soon became ubiquitous as street trees and ornamental feature trees in many communities where hot dry summers and cool winters or mild temperatures prevailed. Garden escapees have long since become naturalized in urban, peri-urban and agricultural landscapes (Spennemann, 2019d and Spennemann, 2020b) and provide food for numerous spaces in novel ecosystems (Spennemann, 2020c; Spennemann, 2019b and Spennemann, 2019c). *Phoenix canariensis* is a dioecious anemophilous tree which typically grows to a height of 18–20 m, with a trunk diameter between 0.6 and 1.2 m. The crown tends to reach a diameter of 10-12m, made up of in excess of 200 arching, pinnate leaves of 5-6m (max 7m) length. The abscission scars of the fronds are rhomboid, giving the stem a characteristic appearance. The Canary Island Date Palm reaches reproductive maturity and first flowers after six to seven years as well as (in some locales between 8 to 10 years). The date palm readily and reliably sets fruit and seeds freely, annually producing between 5,000 and 30,000 obvious drupes (dates) which vary widely in their physical properties (shape, length, diameter, mass, colour) between individual palms (Djouab *et al*., 2016 and Saro *et al*., 2014). The drupes range from 15-30 mm in length, 12-17 mm in thickness and 2–5 g in mass (Djouab *et al*., 2016), of which the seed contributes less than 0.9–1.5 g. The seed requires temperatures between 25ºC and 35ºC (Chatty and Tissaoui, 1999) and germinates under natural conditions after 83-110 days. It shows its first two-leave shoots at about one year of age. Due to their relative isolation in an agricultural production landscape, the Canary Islands date palms growing at various locations at Alma Park (Southern Riverina, New South Wales, Australia) which have been used for a range of studies showing the dispersal success of the species in naturalised settings (Spennemann and Pike, 2019; Spennemann, 2018b; Spennemann *et al*., 2021 and Spennemann, 2020c). Given their persistence, and proven resilience to low moisture conditions once they are established, they are often regarded as a hard to eradicate, invasive environmental plant (Helensburgh Landcare, 2018 and Echuca Landcare Group, 2015). Removal of invasive specimens is frequently carried out mechanically (felling, excavation) or chemically (spraying) by land management agencies and private landholders. During years 2016 or 2017 numerous self-seeded palms on the southern side of Munyaplah Settlement Road, Alma Park were sprayed by the adjacent land holder with a self-designed herbicide ‘cocktail’. While all smaller palms died, one larger specimen survived, albeit with malformations. This plant will be the focus of this brief paper.

Materials and methods

The palm was encountered during survey work examining the dispersal success of self-seeded palms in an agricultural production landscape. The first photographed during fieldwork on 7 May 2018 (Fig.1). It was revisited on occasion of follow-up fieldwork on 23 July 2018, 5 April 2019 and 27 July 2019. At that time the base of the palm was cleared of ground cover and dead leaves were removed on all sides to fully expose the stem, allowing the palm to be examined and systematically photographed. Subsequent visits occurred on 4 March 2020, 30 May 2022 and 26 March 2023.

Fig. (1): The malformed palm seen from the north before the removal of dead leaves. Note the straight rachis of the older leaves. Photo 7 May 2018.

3. Origin of the palm

The palm discussed in this study is a self-seeded male P. *canariensis* palm, located on the southern side of the Munyaplah Settlement Road, Alma Park, NSW (coordinates -35.587435, 146.777432) At the same time of writing (March 2023) the twisted palm measures 4 m in height with a 1.0m tall stem of 3 m girth (measured at 0.5m above ground) and a crown diameter of 4 m. Judging from the remains of the dead leaves encountered in 2018, the palm, prior to poisoning, would have reached a height of about 3.5 m and a crown diameter of about 4–4.5 m. Based on other growth information in south-eastern of Australia (Spennemann, 2020d), a Canary Islands date palm of that size would be between 5 and 8 years old. Limitations in moisture may have retarded the growth, in which case the palm may be up to 12 years old. The plant is a self-seeded male specimen. The closest mature female plants are located along the drive way to the property ‘Glenalvon’, some 680m to the northeast (Fig. 2) (Spennemann, 2020a and Spennemann, 2022). Close to the palm (ca 1.5 m southwest) is the stump of a dead eucalypt tree (most likely Eucalyptus melliodora), which was reputedly cut down well over ten years ago (Lieschke, 2019b). If the dead eucalypt existed as a stag at the same time of seed deposition, the likely vectors are the Australian Raven (*Corvus coronoides*) and in particular the Pied Currawong (Strepera graculina). Both species are well established vectors for *Phoenix canariensis* (Spennemann, 2019b) and are also on record as feeding on the palms at Glenalvon (pers obs. by the author) (Lieschke, 2018). An additional, but less likely, vector would be the Red Fox (Vulpes vulpes) which is known to defecate viable P. *canariensis* seeds (Spennemann and Pike, 2019) and which has been documented (via scats) as feeding on P. canariensis drupes underneath the palms at the ‘Glenalvon’ driveway (Spennemann, 2018b).

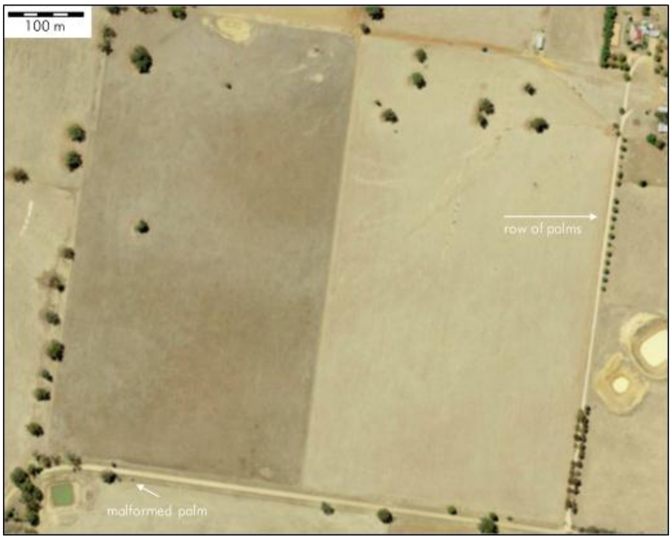


Fig. (2): Location of the affected palm in relation to the probable seed palms lining the driveway of 'Glenalvon,' Alma Park (NSW, Australia). Base image: Land and Property Information (2014).

4. History of management interventions

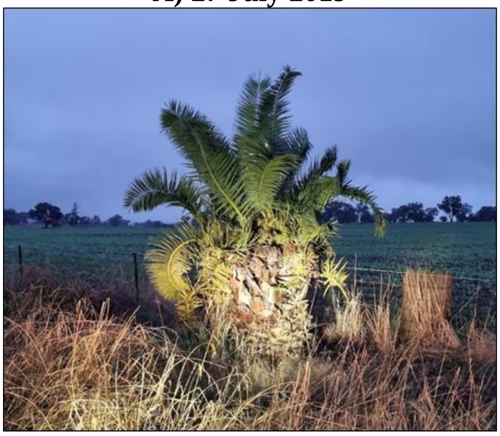
During years 2016 or 2017 all self-seeded palms on the roadside verge of the southern side of Munyaplah Settlement Road were sprayed by the adjacent land holder with herbicide (Lieschke, 2019c). The herbicide used by local farmers to treat such self-seeded palms and other hard-to-eradicate plants is commonly a 'cocktail', such as a mixture of Roundup (Sinochem, 2016) and Ally (Dupont, 2009) or Brush-Off (Bayer, 2015) and Ally, often with a small amount of diesel fuel added to increase adherence of the herbicide to leaf surfaces (Lieschke, 2019c; Lieschke, 2019a and Lieschke, 2019b). Based on prior personal experience that P. *canariensis* are hard to eradicate once they are established, the adjacent land holder sprayed the palm with an herbicide mixture comprised of Brush-Off at approximately twice the recommended strength and Ally at approximately three to four times the recommended concentration. While all other (smaller) palms died, the larger specimen discussed here survived. The active ingredient of Ally is isopropylamine salt of glyphosate (Dupont, 2009), while the active ingredient of Brush-Off is Metsulfuron-Methyl (Bayer, 2015); a systemic compound with foliar activity, that inhibits cell division in shoots (and roots).

5. The current conditions of the palm

At the same time of initial observation, the palm exhibited a number of dead and partially defoliated leaves in all directions, some of which still oriented straight upwards (Fig. 1). At the same time of the first formal documentation in 2019, the palm, once cleared of dead leaves, showed a strong unilateral growth and lean (epinasty) towards the south-east (Fig. 3a). The leaves in the south-eastern sector emerged horizontally, but then exhibited strong twisting of the petioles (Fig. 4a). The majority of the twist appeared to have been in a counter-clockwise direction. The petioles were much thinner than those expected for a palm of its age and also much thinner than the petioles of the older, not malformed but dead leaves. All leaves in the north-western sector exhibited extreme malformation with very stunted growth, shortened and concertinaed petioles as well as accordion-type leaf development (Fig. 4c; Fig. 5a,b). Even though distorted, the leaves were strong and stiff. A number of inflorescences were formed after the malformed petioles emerged, suggesting that the tree continued to push male flowers even immediately after the herbicide application (Fig.5d). The yellowing of some petioles and associated necrotic speckling as well as the yellow spotting observable under transmitted light on some of the leaflets (Fig. 6) resemble symptoms of Potassium (K) deficiencies (Nelson and Patnude, 2012) or those of non-necrotic chlorotic spotting. The malformation of leaves was greatest in the north-western and northern sectors which are facing the road, and the least in the south-eastern sector. This suggest that the herbicide was applied (from the road) in the north-west, with the concave upper surfaces of the petioles funneling the herbicide solution onto the central growth bud. It can be surmised that the apical meristem was differentially affected. A year later (March 2020), little new growth had occurred (Fig. 3b). In May 2022, this changed had invigorated growth in the south-eastern sector of the plant, but little development in the north-western sector (Fig. 3c). At the same time of writing, (March 2023) the plant exhibited very stunted growth with twisted leaves in the north-western sector, but strong vigorous growth with continue lean in the south-east (Fig. 4bd, including evidence of several inflorescences, two of which were open or opening with apparently healthy flowers producing nectar and abundant pollen Fig. 8). P.*canariensis* is known to recruit and exhibit growth responses following strong moisture pulses (Spennemann, 2020b). While local precipitation data are unavailable, given the rural location, it is possible approximate the rainfall conditions by averaging the closest three stations(Bureau of Meteorology, 2023a, Bureau of Meteorology, 2023c, Bureau of Meteorology, 2023b). The rainfall pattern for the period January 2017 to March 2023 shows increased moisture from early 2020 onwards (Fig. 9). The total annual rainfall for 2022 was the highest recorded total in the past 40 years, with the total for 2021 being the six highest. It seems likely that high moisture level facilitated the strong recovery of the palm.

A) 27 July 2019

B) 4 March 2020



C) 30 May 2022

D) 26 March 2023

Fig. (3): The malformed palm tree seen from the north with trunk exposed (dead leaves removed).

27 July 2019 | 26 March 2023

East

(A)

(B)

West

(C)

(D)

Fig. (4): The malformed palm tree seen from east and west, 27 July 2019 and 26 March 2023.

(A)

(B)

(C)

(D)

Fig. (5): Stem and twisted leaves seen from the south.

A) Accordion leaves (23 July 2018); B) Stem and twisted leaves with accordion pattern seen from the south (5 April 2019); C) Lesions on the petiole (5 April 2019); D) remains of male flower (4 March 2020).

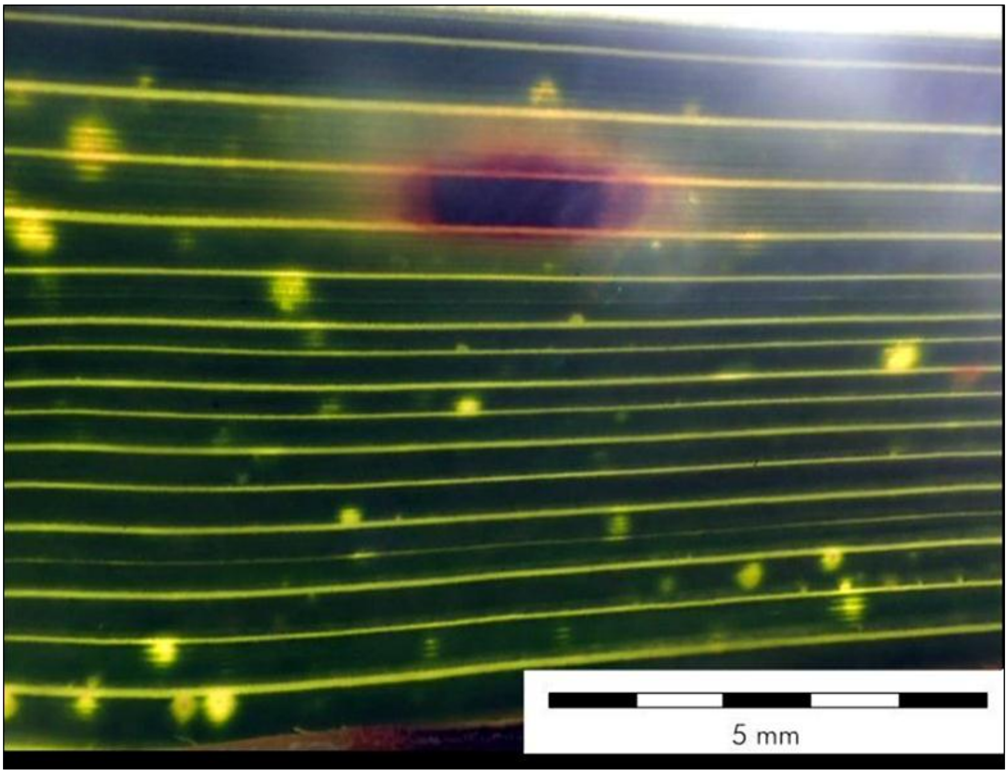


Fig. (6): Lesions on a leaflet. Photo 5 April 2019.

Fig. (7): The growth point seen from the north. Note the vigorous leaves in the back and the twisted leaves in the front. Dead leaves with accordion malformation can be seen at the right. Photo 26 March 2023.

(A) **(B)** **(C)**

Fig. (8): Efflorescences. A) evidence of multiple efflorescences; B) fresh efflorescence; C) Western Honey Bees (Apis mellifera) feeding on nectar and collecting pollen: Photo 26 March 2023.

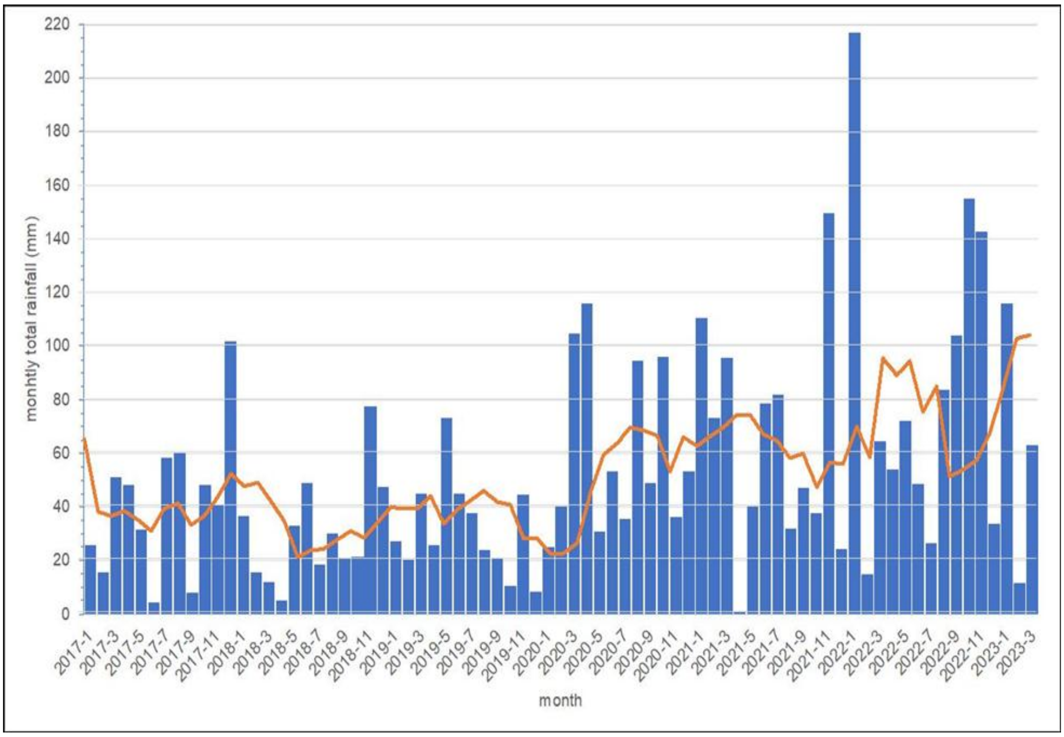


Fig. (9): Average monthly precipitation (and running five-monthly average) in the study area, January 2017–March 2023 (see text).

Discussion

While we know that the palm was poisoned, the effects of the poisoning on the meristem are not well understood. The V-shaped leaves would funnel the herbicide mixture to the petioles and from there directly onto the central growth bud. Given the differential response, it can be surmised that the apical meristem was unevenly affected. Herbicides, in particular phenoxy herbicides, are known to lead to malformations (Broschat, 2007b). While auxins are required in low concentrations for the induction of cell division, cell expansion and also for rooting (Eeuwens, 1978: Abdel-Rahim *et al*., 1998), such auxins become detrimental in higher concentrations. Romney (2007) has shown, phenoxy herbicides, which are potent synthetic auxins, have negative effects on palm growth and appearance, with emerging leaves exhibiting malformation. Palms are sensitive to smaller doses of phenoxy herbicides (2,4-D, 2,4,5-T and MCPB) than are needed to kill weeds (Romney, 2007; Romney, 1964). Numerous studies consider the impact of glyphosate on palms when applied as herbicide to control the weeds surrounding the palms (Ofosu-Budu *et al*., 2014; Baidoo-Addo *et al*., 2000; Hornus, 1990; Traore *et al*., 2010; Mohamad *et al*., 2010; Wibawa *et al*., 2009; Sidik *et al*., 2018). In all cases the impact on the palms was found to be negligible. None of these studies, however, have examined the impact of direct application of the herbicide on the palm itself. Donselman and Broschat (1986, 1987) noted that direct application of glyphosate led to leaf distortion on several species of palms, but that this effect was not long-lasting at the concentrations were tested. Various studies consider the impact of Metsulfuron-Methyl herbicides on the soil of oil palm plantations (Ismail *et al*., 2015; Zain *et al*., 2013), but as in the case of glyphosate herbicides, none of the studies have examined the impact of direct application of the herbicide on the palm itself. Metsulfuron-Methyl inhibits cell division in shoots (Bayer, 2015), which may well manifest itself in the leaf malformation. While the malformation can be attributed to the application of the herbicide cocktail, the exact process at the cell-level is unclear. The poisoning either mimics the effects of boron deficiency, or it influenced the mineral balance of the palm. This cannot be assessed without sectioning the meristem, which would kill the plant. In this context, it is worth noting that at the same time of the first observation during 2018, the appearance of the palm showed all the symptoms of a boron deficiency. This characteristically damages the shoot apical meristem, or impairs its activity, leading to deformed new leaf growth (Shorrocks, 1997). Common malformations are twisted petioles, zigzag leaves and corrugated leaves in cases of moderate boron deficiencies, with extreme deficiencies often manifesting themselves in accordion leaf development. Prolonged periods of boron deficiency lead to epinasty and leaning crowns (Broschat, 2011; Broschat, 2009; Broschat, 2007a; Broschat, 2007b; Patnude and Nelson, 2012 and Elliott *et al*., 2004). All of this has been observed at the specimen under discussion. Given the strong similarity between the symptoms of Boron deficiency and the observed statis of the palm, it can be surmised that the effects of the herbicide cocktail are similar.

7. Long-term prognosis

The long-term prognosis for the palm is positive, although in a deformed state. Based on the experiences of (Donselman and Broschat, 1987), recovery of the palm from glyphosate poising appears possible, but it is unclear what long-term effects the Metsulfuron-Methyl component of the herbicide ‘cocktail’ will have. The fact that numerous new, but still slightly distorted leaves have formed since the poisoning event demonstrate the resilience of the species. Moreover, the fact that the palm continues to produce viable male flowers with an abundance of pollen further underlines the resilience of *Phoenix canariensis* to environmental influences. Discussions were held with the adjacent landholder on the medium-term future of the palm. Given that the distorted growth form does not impact on the adjacent fence, the landholder agreed not to undertake any further actions, in the form of additional poisoning or physical removal/uprooting allowing for prolonged monitoring.

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Conflicts of Interest: The author declares no conflict of interest.

References

Abdel-Rahim, E.; Abdel-Fatah, O.; Kobasse, M.; El-Shemy, H. and El-Samei, M.A. (1998). Growth of date palm callus as affected by growth regulators, sugars as carbon source and amino acids as organic nitrogen source. Arab Journal of Biotechnology, 1: 99-106.

Baidoo-Addo, K.; Nuertey, B. and Asamoah, T. (2000). Use of Round Up (glyphosate) in weed control under oil palm: some cost implications. Journal of the Ghana Science Association, 2: 94-98.

Abdel-Rahim, E.; Abdel-Fatah, O.; Kobasse, M.; El-Shemy, H. and El-Samei, M.A. (1998). Growth of date palm callus as affected by growth regulators, sugars as carbon source and amino acids as organic nitrogen source. Arab Journal of Biotechnology, 1: 99-106.

Baidoo-Addo, K.; Nuertey, B. and Asamoah, T. (2000). Use of Round Up (glyphosate) in weed control under oil palm: some cost implications. Journal of the Ghana Science Association, 2: 94-98.

Baranwal, V.K.; Manikandan, P. and Ray, A.K. (1989). Crown choking disorder of coconut: a case of boron defciency. Journal of Plantation Crops, 17: 114–120.

Bayer (2015). Bayer Brush-Off Brush Controller. Technical Information. Hawthorn East: Bayer CropScience Pty Ltd.

Broeshart, H.; Ferwerda, J. and Kovachich, W. (1957). Mineral deficiency symptoms of the oil palm. Plant Soil, 8: 289-300.

Broschat, T.K. (2007a). Boron deficiency symptoms in palms. Palms, 51: 115-126.

Broschat, T.K. (2007b). Boron deficiency, phenoxy herbicides, stem bending and branching in palms – is there a connection? Palms, 51: 161–163.

Broschat, T.K. (2009). Palm nutrition and fertilization. HortTechnology, 19: 690-694.

Broschat, T.K. (2011). Uptake and distribution of boron in coconut and paurotis palms. Hortscience, 46: 1683-1686.

Broschat, T.K. (2014). Boron Defciency in Palms. Gainesville, FL: Institute of Food and Agricultural Sciences, University of Florida.

Bureau of Meteorology (2023a). Climate statistics for Australian locations. Monthly climate statistics. Albury Airport (station nº 072146). Canberra: Bureau of Meterology.

Bureau of Meteorology (2023b). Climate statistics for Australian locations. Monthly climate statistics. Narrandera Airport (station nº 074148). Canberra: Bureau of Meterology.

Bureau of Meteorology (2023c). Climate statistics for Australian locations. Monthly climate statistics. Wagga Wagga AMO (station nº 072150). Canberra: Bureau of Meterology.

Chatty, Y. and Tissaoui, T. (1999). Effect of Temperature on Germination of Ornamental Palm Trees in Tunisia. In: II International Symposium on Ornamental Palms & other

Monocots from the Tropics. Acta Hort, 486: 165–167. DOI 10.17660/ActaHortic.1999.486.22.

Corrado, F.; Quencez, P. and Tailliez, B. (1992). La déficience en bore chez le palmier à huile: symptômes et corrections. Oléagineux, 47: 719-725.

Da Rocha Pinho, L.G.; Monnerat, P.H.; Pires, A.A.; Freitas, M.S.M. and Marciano, C.R. (2015). Diagnosis of boron deficiency in green dwarf coconut palm. Agricultural Sciences, 6: 164.

Djouab, A.; Benamara, S.; Gougam, H.; Amellal, H. and Hidous, K. (2016). Physical and antioxidant properties of two Algerian date fruit species (*Phoenix dactylifera* L. and *Phoenix canariensis* L.). Emirat J Food Agri, 28: 601-608. DOI 10.9755/ejfa.2015-12-1056.

Donselman, H. and Broschat, T.K. (1986). Phytotoxicity of several pre- and postemergent herbicides on container grown palms. Proc Fla State Hortic Soc, 99: 273-274.

Donselman, H. and Broschat, T.K. (1987). The effects of several pre- and postemergent herbicide on ornamental palms. Principes, 31: 138–141.

Dupont (2009). DuPont Ally Herbicide. Technical Information 31786/0108. Macquarie Park: Dupont Australia.

Echuca Landcare Group (2015). Weeds of Northern Victoria and Southern NSW.

Eeuwens, C. (1978). Effects of organic nutrients and hormones on growth and development of tissue explants from coconut (*Cocos nucifera*) and date (*Phoenix dactylifera*) palms cultured in vitro. Physiol Plant, 42: 173-178.

Elliott, M.L.; Chase, A.R.and Broschat, T.K. (2004). Compendium of ornamental palm diseases and disorders, St. Paul: American Phytopathological Society Press.

Helensburgh Landcare (2018). Be Weed Wise - Cocos palm & Canary Island date palm. Cocos palm (Syagrus romanzoffiana) and Canary Island date palm (*Phoenix canariensis*). Helensburgh, Qld: Helensburgh & District Landcare Group.

Hornus, P. (1990). Désherbage chimique des ronds de palmiers adultes. Technique de bas volume. Oléagineux, 45: 295-304.

Ismail, B.; Eng, O. and Tayeb, M. (2015). Degradation of triazine-2-14C metsulfuron–methyl in soil from an oil palm plantation. PloS one, 10: e0138170.

Jayasekera, K.S. (1988). Boron Deficiency in Coconut. Cocos, 6: 19–20.

Jayasekera, K.S. and Loganathan, P. (1988). Boron Deficiency In Young Coconut (*Cocos nucifera* L.) In Sri Lanka Symptoms and Corrective Measures. Cocos, 36: 31–37.

Kamalakshiamma, P.G. and Shanavas, M. (2002). Boron Deficiency in Coconut. Symptoms and Corrections. Indian Coconut Journal, 32: 1–5.

Land and Property Information (2014). SIX imagery—Walbundrie ADS40_SC 24-02-2014.

Lieschke, A. (2018). The Palms at Glenalvon, Alma Park. Phone conversation with Dirk H.R. Spennemann. IN Communication (Ed.) Alma Park and Albury.

Lieschke, D. (2019a). Eradication of palms at Glenalvon driveway, Alma Park. Phone conversation with Dirk H.R. Spennemann. IN Communication (Ed.) Alma Park and Albury.

Lieschke, G. (2019b). Chemicals used for the eradication of palms on Munyaplah Settlement Road. Phone conversation with Dirk H.R. Spennemann. IN Communication (Ed.) Alma Park and Albury.

Lieschke, G. (2019c). Eradication of palms on Munyaplah Settlement Road. Phone conversation with Dirk H.R. Spennemann. IN Communication (Ed.) Alma Park and Albury.

Mohamad, R.; Mohayidin, M.G.; Wibaya, W.; Juraimi, A.S. and Lassim, M.M. (2010). Management of mixed weeds in young oil-palm plantation with selected broad-spectrum herbicides. Pertanika J Trop Agric Sci, 33: 193-203.

Nelson, S. and Patnude, E. (2012). Potassium Deficiency of Palms in Hawai‘i. Plant Disease April. Honolulu: College of Tropical Agriculture and Human Resources, University of Hawai‘i.

Ofosu-Budu, K.; Avaala, S.; Zutah, V. and Baafi, J. (2014). Effect of glyphosate on weed control and growth of oil palm at immature stage in Ghana. International Journal of Agronomy and Agricultural Research (IJAAR), 4: 1-8.

Patnude, E. and Nelson, S. (2012). Boron Deficiency of Palms in Hawai'i. Plant Disease April. Honolulu: College of Tropical Agriculture and Human Resources, University of Hawai'i.

Purba, A. and Turner, P. (1973). Severe boron deficiency in young oil palms in Sumatra. Planter, 49: 10-13.

Rajaratnam, J. (1972). Hook leaf'and 'fish-tail leaf': boron deficiency symptoms of the oil palm. Planter, 48: 1.

Romney, D.H. (1964). Observations on the effect of herbicides on young coconuts. Weed Research, 4: 24-30.

Romney, D.H. (2007). More on leaning crown syndrome. Palms, 51: 57–58.

Saro, I.; Robledo-Arnuncio, J.J.; González-Pérez, M.A. and Sosa, P.A. (2014). Patterns of pollen dispersal in a small population of the Canarian endemic palm (*Phoenix canariensis*). Heredity, 113: 215-223. DOI 10.1038/hdy.2014.16.

Shorrocks, V.M. (1997). The occurrence and correction of boron deficiency. Plant Soil, 193: 121-148.

Sidik, S.; Purba, E. and Yakub, E. (2018). Population dynamics of weeds in oil palm (Elaeis guineensis Jacq.) circle weeding area affected by herbicide application. IOP Conference Series: Earth and Environmental Science. IOP Publishing.

Sinochem (2016). Roundup Herbicide. Safety Data Sheet. Melbourne: Sinochem International Australia.

Spennemann, D.H.R. (2018a). Canary Islands Palms (*Phoenix canariensis*) in Australia: introduction and early dispersal. Palms, 62: 185–201.

Spennemann, D.H.R. (2018b). *Phoenix canariensis* seed encountered in scats and ejecta collected at Alma Park. Albury, NSW: Institute for Land, Water and Society, Charles Sturt University.

Spennemann DHR. (2018c). *Phoenix canariensis* seed in scats and ejecta collected at Alma Park, and Walla Walla, NSW. A photographic documentation. nº. Albury, NSW.

Spennemann, D.H.R. (2019a). Canary Islands Palms (*Phoenix canariensis*) as ornamental plants. The first thirty years of the horticultural trade. Huntia, 17: 79–102.

Spennemann, D.H.R. (2019b). The connective potential of vertebrate vectors responsible for the dispersal of the Canary Island date palm (*Phoenix canariensis*). Flora, 259: 151468. DOI 10.1016/j.flora.2019.151468.

Spennemann, D.H.R. (2019c). The contribution of the Canary Island date palm (*Phoenix canariensis*) to the winter diet of frugivores in novel ecosystems. Europ J Ecol, 5: 27–37.

Spennemann, D.H.R. (2019d). Epiphytic growth of ornamental palms on suburban street trees in Albury, NSW (Australia). Cunninghamia, 19: 113-119.

Spennemann, D.H.R. (2020a). Background to the Palms at Alma Park (NSW) III: Glenalvon Homestead. Albury, NSW: Institute for Land, Water and Society, Charles Sturt University.

Spennemann, D.H.R. (2020b). Canary Island date palms invading a remnant riverine eucalypt forest in south-eastern Australia: processes and patterns of recruitment. Cunninghamia, 20: 245–257. DOI 10.7751/cunninghamia.2020.20.013.

Spennemann, D.H.R. (2020c). Consumption of Canary Island Date Palm *Phoenix canariensis* drupes by Pied Currawongs Strepera graculina. Australian Field Ornithology, 37: 201–211. DOI dx.10.20938/afo37201211.

Spennemann, D.H.R. (2020d). A grove of 110 Canary Islands date palms at Ebden, NE Victoria. Albury, NSW: Institute for Land, Water and Society, Charles Sturt University.

Spennemann, D.H.R. (2022). Dispersal of the date stone beetle Coccotrypes dactyliperda (Coleoptera, Curculionidae, Scolytinae) in a managed rural landscape in Australia. J Insect Biodiv Syst, 8: 191-205.

Spennemann, D.H.R. and Pike, M. (2019). Rites of Passage: germination of regurgitated and defecated *Phoenix canariensis* seeds. Proc Linn Soc N S W, 141: 49–59.

Spennemann, D.H.R.; Pike, M. and Robinson, W. (2021). Germination rates of old and fresh seeds and their implications on invasiveness of the ornamental Canary Islands date palm (*Phoenix canariensis*). Europ J Ecol, 6: 70-86. DOI 10.17161/eurojecol.v6i2.13474.

Traore, K.; Soro, D.; Camara, B. and Sorho, F. (2010). Effectiveness of glyphosate herbicide in a juvenile oil palm plantation in Côte d'Ivoire. Journal of Animal & Plant Sciences, 6: 559-566.

Von Uexküll, H. and Fairhurst, T. (1999). Some nutritional disorders in oil palm. Better Crops International, 13: 16–21.

Wibawa, W.; Mohamad, R.; Juraimi, A.S.; Omar, D.; Mohayidin, M.G.and Begum, M. (2009). Weed control efficacy and short term weed dynamic impact of three non-selective herbicides in immature oil palm plantation. International Journal of Agriculture and Biology, 11: 145-150.

Zain, N.M.M.; Mohamad, R.B.; Sijam, K.; Morshed, M.M. and Awang, Y. (2013). Effects of selected herbicides on soil microbial populations in oil palm plantation of Malaysia: a microcosm experiment. African Journal of Microbiology Research, 7: 367-374.

Zona, S. (2008). The horticultural history of the Canary Island Date Palm (*Phoenix canariensis*). Garden Hist, 36: 301–308. DOI 10.2307/40649462.