THE WITCH HUNT CONTINUES – THE USE OF INTEGRATED RESEARCH AND TREATMENT APPROACHES TO RID AUSTRALIA OF THE PARASITIC PLANT PEST RED WITCHWEED

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ABSTRACT

Red witchweed (RWW) was first detected on a sugarcane property in the Mackay region in July 2013. Extensive delimitation surveillance identified a total of eight infested properties (IPs), six cane properties and two cattle enterprises (formally cane), all within close geographic proximity.
A nationally cost-shared integrated research and treatment eradication program commenced in 2015 to assess and then apply the most effective control treatments for Mackay conditions to destroy plants and accelerate seedbank decline. At the completion of eight years of regular surveillance and treatment activities, there has been a 99% reduction in the number of detections, a demonstrated 94% decline in the soil seedbank, 51% of paddocks have been released from quarantine and the net infested area has decreased by 24.5% to 5.42ha.
This integrated research and collaborative approach (involving industry, State, Territory and Federal governments) provides confidence that the RWW Eradication Program is on track to be the first in the world to eradicate this species.
Keywords: red witchweed, *Striga asiatica*, eradication, surveillance, adaptive treatment.

INTRODUCTION

Red witchweed (*Striga asiatica*) pest details

The genus *Striga* comprises at least 30 species, three of which are amongst the world's worst weeds, with RWW identified as the attacker of the greatest number of plant species of any Striga species (Shaw *et al*. 1962). Red witchweed is a small annual plant that grows attached to the roots of a host plant (Musselman 1980). This obligate parasite (cannot develop without a suitable host plant) draws its nutrients and water from the roots of its host, generally causing the host to wilt, turn yellow and often become stunted (Press *et al*. 1987). Red witchweed plants can produce up to 500,000 dust-like seeds (Shaw *et al*. 1962) which can remain viable for up to 14 years when buried (Bebawi *et al*. 1984).
Hosts include a wide range of tropical and sub-tropical grass species and cereal crops, including sugarcane, sorghum, corn/maize, pearl millet, rice and some pasture species (Parker 2012). Glasshouse trials established by the Queensland Department of Agriculture and Fisheries (DAF) in Brisbane have also identified wheat and barley as hosts for red witchweed, as well as the weedy grasses *Digitaria violascens* (crabgrass), *Eleusine indica* (crowsfoot grass) and native sedge *Fimbristylis dichotoma* (common fringe-rush) (Vitelli *et al*. 2018).
Without effective control, red witchweed can cause significant reductions in yield of susceptible crops. Red witchweed can also affect trade, as a number of Australia's trading partners have import restrictions on seed and grain originating from countries where the species is known to occur, therefore it is considered a serious economic pest.

Infestation in Queensland

An emergency response was declared when red witchweed was detected in July 2013, and an Interim Response Plan developed to direct delimitation surveillance over two years (2013-15) while agreement to fund a national cost sharing eradication plan was negotiated. Risk pathway analysis was conducted to provide tracing and surveillance targets based on the primary dispersal pathway, which was identified as the movement of soil contaminated with red witchweed seeds. Quarantine, movement controls and comprehensive hygiene requirements were implemented to minimise the risk of spread. Extensive surveillance during this period established a high level of delimitation and confidence that red witchweed was restricted to eight IPs in close proximity to each other.

A 10-year eradication program was established in 2015 under a 50:50 cost share arrangement. Partners included Federal and State Governments (Queensland, New South Wales and Northern Territory) and the affected agricultural peak industry bodies of Canegrowers, AgForce (through Grain Producers Australia) and Cattle Council (through Meat & Livestock Australia).

RED WITCHWEED ERADICATION PROGRAM 2015-2025

The aim of the Program is to ensure that red witchweed is extirpated from the eight Infested Properties (IPs) by 2025, with eradication confirmed following no further detections after a ten-year Proof of Freedom surveillance period. Eradication of red witchweed requires two control strategies running in parallel – the prevention of seed production and elimination of the dormant soil seedbank (Eplee 1992).

Extensive research has been conducted to assess the most effective treatment for Mackay conditions to encourage germination and accelerate red witchweed seedbank decline, which was estimated as 1,000,000/m^2 prior to the start of the Program (Williams *et al*. 2022). These treatment options have been implemented in a targeted four-zone approach on the eight IPs:

- **Zone A** – Red witchweed detected between 2015 and 2023. A 30m buffer was established around each detection and if it encroached on a cane crop area, the entire paddock was removed from production and incorporated into Zone A. Extensive surveillance and treatment activities are conducted in Zone A.
- **Zone B** - Extends from the outer perimeter of Zone A for an additional 30m (i.e. 60m from red witchweed detection point). Zone B is regularly monitored by surveillance staff and herbicides applied to reduce the incidence of host plants. Zone B areas containing cane paddocks remained in production.
- **Zone C** – remaining production area, normal business activities apply.
- **Zone R** - Paddocks that are released from Zone A after accumulating sufficient points and are subject to ten-year Proof of Freedom surveillance.

Area of operations (to 30 June 2023)

Of the original eight IPs quarantined under the Program, two have been released from quarantine and treatment. The calculated area of operations (ha) is provided in Table 1 – a total of 66.4ha has been released from quarantine (transitioned to Zone R).

Table 1: Calculated area of operations (ha) for each IP – 31 March 2023

	Zone A (ha)	**Zone B (ha)**	**Zone R (ha)**	**Total (ha)**
Start of Program	108.8	21	0	129.8
30 June 2023	54.4	9	66.4	129.8
Reduction	54.4ha (50%)	12ha (57%)		

Surveillance

Surveillance activities have found that red witchweed is not evenly distributed throughout each IP, with plants generally concentrated on headland areas between the crops. Surveillance is conducted on transects 2-3m apart, on a 5-14 day cycle to enable detection prior to seeding, with over 71,000 km (approximately 258 surveys of each IP) during 2015-23 (Figure 1).

Figure 1: Example of surveillance tracking data

To more accurately reflect spatial distribution, each IP is divided into 10x10m management grids (54,818 grids across the eight properties). Of the 108.8ha initially classified as Zone A, red witchweed detections (July 2013 – June 2023) were only found on 717 management grids (1.3% of total grids – 98.7% of the properties have never had a red witchweed detection), equating to a total net infested area (NIA) of 7.17ha which has been subjected to intensive treatment activities. Due to the Program's successful treatment regime, as of 30 June 2023:

- two entire properties have been released from quarantine and reclassified to Zone R,
- Zone A has been reduced by 50% to 54.4ha, and
- the NIA reduced by 24.5% to 5.42ha.

Detections

The total number of detections are provided in Table 2. At the completion of eight years of treatment (30 June 2023) there has been a 99% reduction in the number of red witchweed detections.

Table 2: Red witchweed detections

2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	TOTAL
3,677	942	710	41	11	5	19	32	5,437

Research

An integrated ten-year control study on one of the sugarcane-growing IPs was established in 2015 to investigate the efficacy of a range of agronomic practices in depleting the red witchweed seedbank and preventing further seed production. Fifteen treatments, comprising of pre- and post-emergent herbicides, catch crops, trap crops and fumigants were evaluated annually through the monitoring of seed viability in 5,800 seed sachets that had been buried at five depths (0, 100, 200, 300 and 500 mm).

- The research findings showed that after five annual applications of either ethylene gas, dazomet, ethephon, sorghum, corn or soybean, the red witchweed soil seedbank viability was reduced to 0%, irrespective of seed burial depth.
- This research indicates that the treatment regime of the Program (which incorporates many of these techniques) is on track to achieve extirpation by 2025.

In 2016, canisters containing red witchweed seeds were also buried at five different depths on paddocks within each IP and exposed to normal treatment activities in the field. A selection of these canisters was removed from Zone A blocks that had reached the 100-point criteria for reclassification to Zone R and seed viability assessed.

- Seed viability was 0% on two of the three properties.
- On the third property, seed viability in field retrieved seeds was 1% (average) compared to 44% viability in laboratory-stored seed from the same seedstock.
- Additional treatments were applied to this third property to increase the likelihood of 0% seed viability when blocks were eventually released.

This research indicates that the treatment activities and 100-point quarantine release system has been effective in developing confidence that land allocated to Zone R has achieved extirpation of red witchweed.

At the completion of eight years of treatment (30 June 2023) there has been a demonstrated 94% decline in the soil seedbank.

Treatment

An integrated control program combining the use of:

- false host (soybean) which stimulates germination of seed but doesn't allow red witchweed to thrive,
- true host (corn) which triggers germination and will support attachment and growth (closely monitored and any detections immediately destroyed),
- pre- and post-emergent herbicides,
- a soil germination stimulant (ethylene gas), and
- soil fumigation

has significantly reduced the number of red witchweed detections and soil seedbank during the eight years of treatment (Figure 2).

Figure 2: Treatment techniques – a) false and true hosts, b) ethylene germination stimulant, c) soil fumigation

Continued use of these techniques will provide justification for transitioning paddocks out of quarantine and into the ten-year Proof of Freedom surveillance phase.

Release from quarantine (transition to Zone R)

The implementation of a scientifically based point system for release of Zone A paddocks from quarantine has been founded on the research conducted since 2015 identifying best-practice management under local Mackay conditions. Paddocks are assigned a number value according to the treatment activities, detections and surveys undertaken, with those treatments that contribute the most towards eradication qualifying for more points than those with lower impacts.

The higher the number of points, the greater the confidence that red witchweed has been extirpated from the paddock. For additional confidence, intensive treatment activities are conducted in the NIA of each of the blocks due for re-classification to Zone R.

Once a paddock achieves a score of 100 it is eligible to be released from quarantine and re-classified as Zone R (released). This arbitrary target of 100 points does not indicate a quantifiable level of risk reduction but reflects the lower probability of red witchweed remaining in the paddock.

If any red witchweed is detected in a paddock, the score reverts to zero and accumulation of points must start again.

Based on the points system, a total of 66.4ha has been released from quarantine and incorporated into Zone R (30 June 2023). These paddocks are subject to periodic surveillance for a ten-year period to demonstrate Proof of Freedom – no red witchweed has been detected in this 66.4ha of Zone R.

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