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Project Code	
Project Type	

FINAL REPORT 2017

PROJECT CODE	: S214

PROJECT TITLE
Novel cultural control for snails

PROJECT DURATION

Project Start date	1 July 2014					
Project End date	30 June 2017					
SAGIT Funding Request	2014/15		2015/16		2016/17	

*this amount was carried forward to 2016/17 then returned

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PROJECT REPORT

Executive Summary

The key objective of this project was to improve South Australian Grain growers' capacity to effectively control snail infestations using microwave technology. Microwaves are already being developed for control of weed seeds in Australian cropping systems. This project aimed to investigate the feasibility of destroying snails on standing stubble after harvest.

Initial development of dose responses for the four snail pest species in grains provided proof of concept that microwaves can, and are commercially feasible to, control large round snails. However, microwaves in their current capacity will not provide a commercial control of small round (juvenile) snails nor either of the two species of pointed snails. The concentration of microwave dose may be more suited to spot treatments of snail clusters on summer volunteer plants than treatment of larger areas.

This project was terminated after the first stage and no field tests were conducted as proposed in the second stage due to the lack of suitable commercial equipment being available currently. The poor response of pointed snails and juvenile round snails is due to small-sized snails not absorbing enough energy to cause mortality; hence the main obstacle to the further development and application of this technology for snail management is an engineering issue that is being addressed outside the scope of this SAGIT project.

Project Objectives

Project aims

The key objective of this project is to improve South Australian Grain growers' capacity to effectively control snail infestations using microwave technology.

This project aims to investigate the feasibility of destroying snails on standing stubble after harvest in three steps:

1. Development of dose responses of the four snail pest species. (KPI 2015_1.)
2. Bioassays of mortality response of snail eggs, and after revision in 2015, included testing of the dose response of individuals to microwaves after activation by various methods. (KPI 2015_2.)
3. Field test the efficacy of commercial microwave equipment. (KPI 2016_3.)

Key Performance Indicators (KPI)

KPI	*Achieved (Y/N)*	*If not achieved, please state reason.*
2015_1	Y	Assays completed 2015
2015_2	Y	Assays completed 2016
2016_3	N	Commercial equipment was not available
2016_4	Y	Final Report

Technical Information

Methods

An 8 kilowatt field microwave unit has been developed for control of weed seeds (University of Melbourne). One of these units (2 kw) was used to conduct assays to determine snail mortality response to increasing microwave intensity in a laboratory setting. A modified microwave (1.2 kw) was used in the 2016 assays.

Area treated: 55 mm diameter container centred to the highest microwave dose.
Time treated: 0 secs (control), and between 2 to 5 sec intervals (treatments).
Species tested: *Theba pisana* (white Italian snail)
Cernuella virgata (common white snail)
Cochlicella acuta (pointed snail)

Number of snails tested: 10 per replicate, 2-4 replicates per microwave exposure time. After exposure all snails were hydrated by placing into water for 2 sec then placed in plastic containers (55 mm diameter by 100mm), with holes placed in the lids and moistened paper towel at the base, on a laboratory bench at 20-25ºC.

Assessments: The number of dead and live snails was scored 12 hours and 8 days after treatment (DAT), and snail sizes measured at 8 DAT.

The significance of dose response was tested using a Generalised Linear Model (Binomial with logit link) with treatment within species (factor) or size (covariate) included in initial models. If treatment was significant dose response was calculated for that experiment. Size was excluded from final models where not significant.

Results and discussion

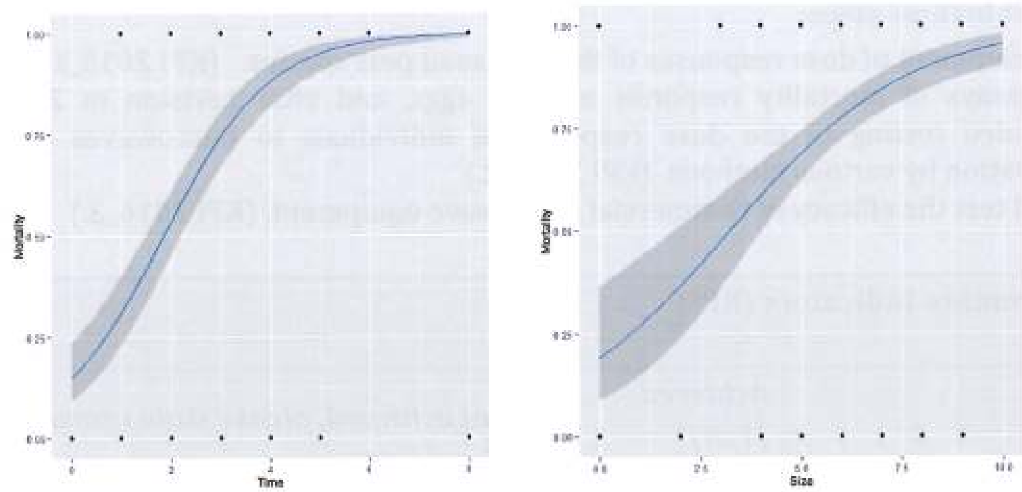

Fig 1 Dose response of white Italian round snails to microwaves.
a/ adults (L) and b/ juveniles (R) where the size of juvenile snails had more influence on probability of mortality than exposure time to microwaves.

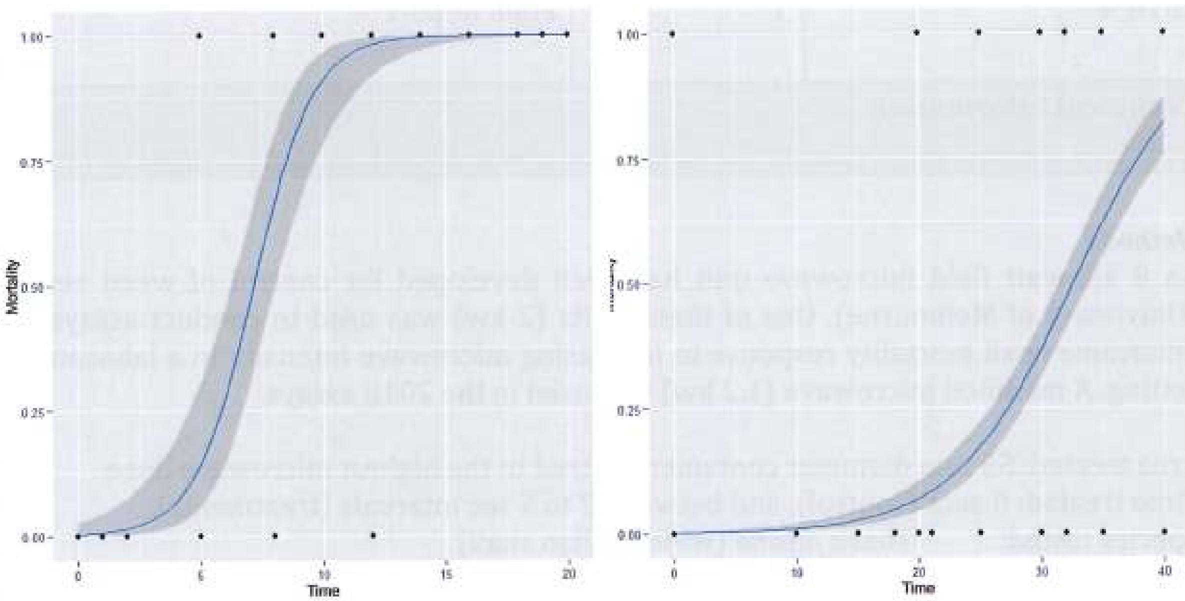

Fig 2 Dose response of common white (L) and pointed snails (R) to microwaves.

Data for pointed snails was not centred to lethal exposure time hence predicted response is cut off.

Note: black dots indicate actual data with the blue line fitted from a logit model with shaded area representing 95% confidence limits, Time is in seconds, mortality is expressed as proportion, and for 1(R) size is in mm.

For adult white Italian snails death was rapid (Fig 1 (L) & 2 (L)), however there was a lack of response by lab reared juvenile snails (data not presented) to microwave exposure at the levels used in this experiment. Where a range of sizes of field collected juveniles were used (Fig 1 (R)), the size of snail exposed was the significant factor, not increased dosage as dosages used were all greater than the LD90 (lethal dose that kills 90% of the tested animals) as determined from adults, with no significant interaction detected ($Z = -0.948$, $P = 0.343$).

Table 1. Dose responses for three species of snails and different life stages as tested using a 2 kilowatt unit. Results displayed from six experiments.

	Expressed as exposure time (s) Energy was 21.5 J cm^{-2} s^{-1}		Model	
	LD_{50}	LD_{90}	Intercept	Slope
vineyard Adult_E1*	14.15 ± 2.26	18.64 ± 3.90	-6.93± 1.66	0.49 ± 0.19**
vineyard Adult_E2*	7.18 ± 0.42	9.85 ± 0.62	-5.92 ± 1.18	0.82 ± 0.15***
white Italian Adult	1.85 ± 0.17	4.20 ± 0.29	-1.73 ± 0.29	0.94 ± 0.11***
white Italian Juvenile lab reared	Not calculated	Not calculated	Not significant	
white Italian Juvenile collected from the field	Not calculated	Not calculated	Not significant	
pointed snails Adult	32.62 ± 0.61	43.29 ± 1.21	-6.71 ± 0.57	0.21 ± 0.018

* E1 and E2 are repeat trials with adult vineyard snails

Different species did respond differently with Italian snails most susceptible, but this was most likely due to their larger size. Water loss was not the cause of death with snails all weighing the same before and after exposure, hence the opposite response to what was expected. That is, size was the most important factor with smaller snails requiring greater doses. We suspect this is due to differing rates of absorption of the microwave energy. The dose required to cause pointed snail mortality (Fig 2 (L)) was large (>40sec), suggesting more modifications are required to the technology before it would be practical to use in the field.

Only dose responses for adults were calculated using a 2 kw unit.

Species (adults)	LD90 Microwave energy (joules)	Delivery time (secs)
White Italian snail	1,770 ± 120	4.2
Common white snail	4,150 ± 260	9.9
Pointed snail	18,265 ± 510	43.0

Results in 2016 using a 1.2 watt unit fitted with a new antenna designed to modify the microwave distribution to make it more effective for smaller-sized snails, support previous findings:

Cochlicella acuta (pointed snails) 90% mortality 527 +/- 116 Joules equated to 50 sec
Prietocella barbara (small pointed snails) 90% mortality 1402 +/- 390 Joules equated to 37 sec

These results indicate that the new antenna reduced the amount of power required to kill conical snails.

Activating individuals with water did not change the time, hence energy, required to kill pointed snails after 50 sec exposure. ($F_{1,9} = 0.347$ $P = 0.572$

Treating individuals with a carbonate fungicide did not change the time, hence energy, required to kill pointed snails after 50 sec exposure ($F_{1,9} = 1.52$ $P > 0.252$)

Feeding individuals prior to treatment did not change the time, hence energy, required to kill pointed snails after 50 sec exposure. ($F_{1,9} = 0.545$ $P > 0.481$)

Conclusions Reached &/or Discoveries Made

Results of inactive individuals of four snail species, including juveniles of white Italian snails indicated current microwaves are viable for the control of adult round snails.

However, smaller juvenile round snails and both species of conical (pointed) snails required dosages, hence exposure times, greater than commercially viable.

Conclusion: The concentration of microwave dose may be more suited to spot treatments of snail clusters on summer volunteer plants than treatment of larger areas. The poor response of pointed snails and juveniles is due to small snails not absorbing enough energy for mortality; hence the main obstacle is an engineering issue at this stage which is being addressed outside the scope of this project.

Intellectual Property

All IP regarding this technology is held by GRDC and the University of Melbourne.

Application / Communication of Results

Key findings

- Current microwave technology is very effective (LD90 4.2 sec) at killing dormant adult white Italian snails.
- Juvenile and pointed snails did not absorb microwave energy as efficiently, hence longer exposure times were needed than practical in the field.
- Engineers are developing new technology that has a more even distribution of energy, which may improve efficacy against smaller snails.

Industry impact

When commercial equipment becomes available this technology has the potential to aid in the integrated management of all pest snails. In particular, round snails that are increasingly causing market access issues into China could be controlled with microwaves mounted on robotic units as being developed by University of Queensland in collaboration with the University of Melbourne. This engineering work will overcome the main obstacle, amount of energy hence time to kill small snails, which at this stage is outside the scope of this project.

Extension activities

1. Moore J, Micic S, Brodie B, **Nash M** (2016) "Control of snails and slugs using microwave radiation." presented at "Australasian Microwave and Radio Frequency Symposium" Melbourne Nov 2016
2. **Nash M**, Brody G (2015) "Can microwaves kill snails?" Hart Field Day Research Guide 2015
3. Hart Field Day 2015 "Establishment insects and snails" at Hart Trial Site SA on Tuesday 15th Sept 2015
4. YP Alkaline Soils Group Inc. spring crop walk "Snail Management Innovations" at Glenburnie Trial Site, Minlaton SA on Wednesday 16th September 2015
5. Crop Protection Society of South Australia "Latest on Snail Research" at Roseworthy SA on Wednesday 15th of April 2015.
6.

POSSIBLE FUTURE WORK

Field testing of commercial units (once developed) by either University of Melbourne and University of Queensland as part of GRDC investments for the control of weed seeds using microwave technologies.

Publication of these findings in a peer reviewed journal.

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