Snails not so keen on caffeine

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Synthetic caffeine kills snails however laboratory results are yet to be translated into an effective application method for farmers to use in the paddock.

Snails are a difficult and costly pest to manage and the current practice of "bash 'em, burn 'em and bait 'em" is not altogether consistent with the ideals of sustainable farming.

The crop can't be burnt or bashed between seeding and harvest, when snails are most active, so there is a heavy reliance on baiting during the winter months. Repeated applications of baits can be costly and may not be very effective on small and juvenile snails. Moreover, baiting late in the season is not recommended because grain or legumes contaminated with snail bait residues will be rejected at delivery points.

There are few proven alternatives for snail control, and with each snail being able to lay hundreds of eggs, a relatively small number of escapees can quickly develop into a significant pest population.

With this in mind, SANTFA has been working since 2009 to identify an alternative snail control method that will enable snails particularly juveniles, to be targeted throughout the growing season in farming systems where stubbles are retained and soils are not cultivated.

This work, which is still in the very early exploratory stage, has identified a brew of synthetic caffeine as a potential alternative treatment for snail control.

Without knowing what the final formulation of a caffeine product will be or what mode of application will be needed it is difficult to suggest what a synthetic caffeine treatment for snails might cost.

Caffeine is best known as an addictive stimulant that drags people from bed in the morning. However, some plants produce caffeine as a natural insecticide.

Traditionally, caffeine has been extracted from well-known crops such as coffee and tea. These days, much of it is synthetically manufactured in bulk at industrial facilities, which provides a more reliable supply of lower-priced product than traditional natural product extraction.

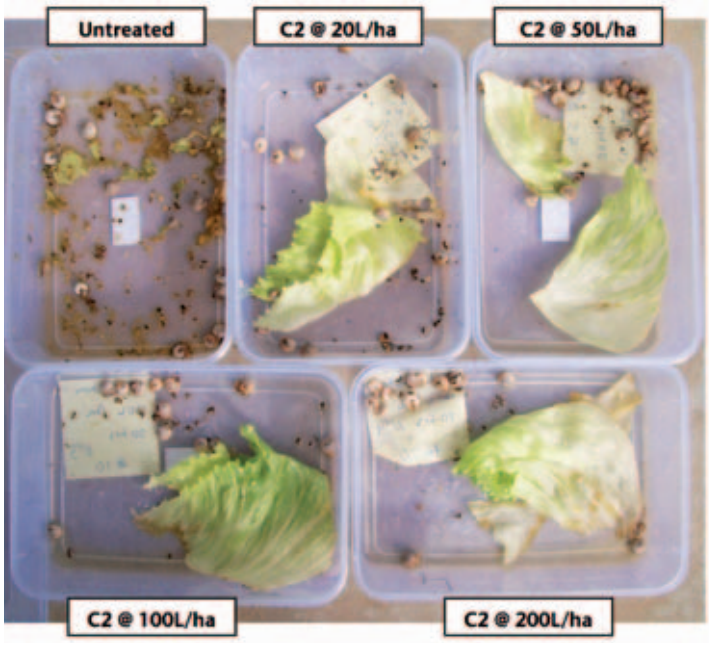
In 2002, Hollingsworth et al1, reported that synthetic caffeine (1mL of a 2% solution) could kill a Hawaiian orchid snail *(Zonitoides arboreus)* and that foliage treated with caffeine solutions could significantly reduce feeding pressure by slugs *(Veronicella cubensis)*. Hollingsworth also proposed that slugs and snails would be more susceptible to contact poisoning from caffeine than beneficial arthropods because caffeine may pass more readily through the mucus produced by the 'foot' of molluscs than through the cuticle of insects.

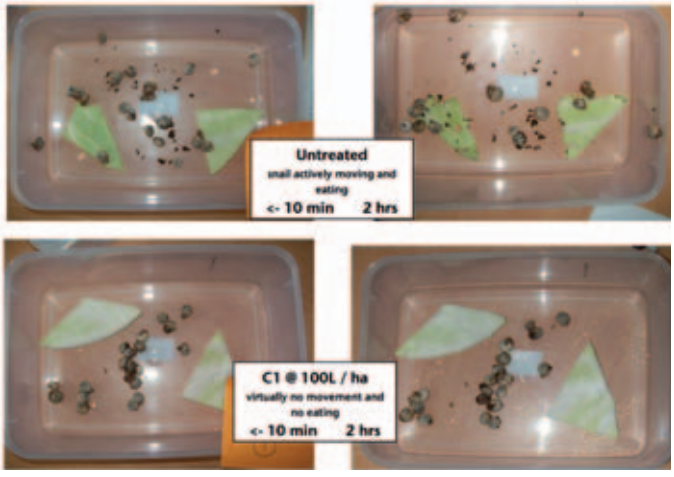
Caffeine is currently classified by the USDA as 'safe' for humans, so Minimum Residue Limits (MRL) for grain from crops sprayed with caffeine late in the season is not expected to be a major issue.

In 2010 SANTFA began to screen the effectiveness of synthetic caffeine as a control agent for the Italian White Snail, the major snail pest in Southern Australia.

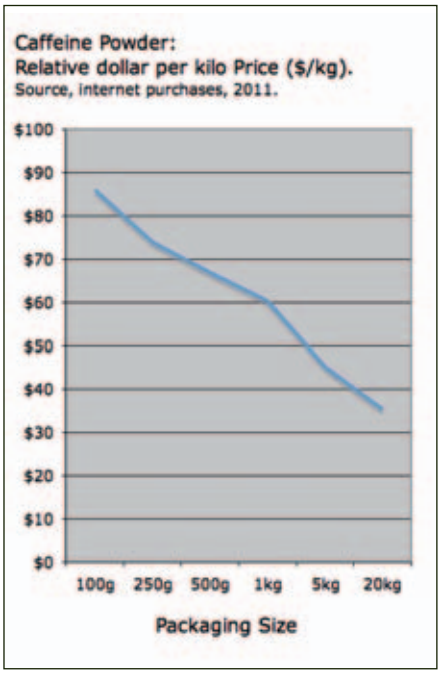
Lab testing

Caffeine screening tests were performed in May 2010 using adult snails captured after opening rains. The synthetic 'food grade' caffeine was sourced as a pure white powder from an internet merchant in the USA that supplies Chinese-made caffeine.





THESE PHOTOGRAPHS, TAKEN DURING LABORATORY TRIALS, CLEARLY ILLUSTRATE THE IMPACT OF CAFFEINE ON SNAILS, WHICH EXHIBIT SYMPTOMS ALMOST IMMEDIATELY ON EXPOSURE AND STOP MOVING AND EATING WITHIN A FEW MINUTES (FIGURE 1 - ABOVE). THE LONGER-TERM EFFECT OF THIS IS SHOWN IN FIGURE 2 (LEFT), TAKEN FOUR DAYS AFTER TREATMENT.



A 2% solution of caffeine (2g in 100mL) was prepared and measured doses placed into five clear plastic containers at rates equivalent to 20, 50, 100 and 200 litres a hectare, with a nil treatment control. The containers were fitted with lids that allowed air flow but would prevent snails escaping. Weighed quantities of lettuce (or cabbage) were placed in each container as a food source, followed by 20 healthy adult snails. The experiment was replicated on several occasions.

The snails exhibited symptoms of caffeine exposure almost immediately (Figure 1).

After four days at room temperature the amount of lettuce consumed and the visual appearance of the snails were used to quantify the impact of the treatments (Figure 2).

The results of this trial showed that synthetic caffeine can kill snail pests found in Southern Australia. Subsequent testing in 2011 has shown that conical snails are also equally susceptible to caffeine applied in a plastic container.

Field trials

Identifying an active ingredient that has relatively good operator, crop and public safety and targets a major pest is an exciting breakthrough. However, there are many challenges to be overcome between identifying a potential new control agent and being able to provide farmers with a reliable and effective product based on the new agent.

One of those is achieving the same level of control in the field as in the laboratory.

In this instance, applied caffeine has so far had little effect on snails in the field. The levels of control achieved in field trials in which snails were sprayed with synthetic caffeine have been inconsistent and too low to warrant growers attempting to use it as a control method at this stage.

One of the logistical challenges to the use of synthetic caffeine as a broad-scale foliar spray relates to water temperature, which has a major impact caffeine solubility. Caffeine is quite soluble in hot water but solubility drops dramatically as water temperature decreases. To maintain a 2% caffeine solution the water temperature needs to be above 25°C, which is not likely in a spray tank during winter.

Preliminary tank testing confirmed that a 2% solution of caffeine precipitated at 10°C, lowering the applied concentration and blocking up the spray nozzles.

Another food and beverage agent, sodium benzoate (E221), also sourced via the internet, was identified as a compatible solubility enhancer for caffeine. Being another food-industry product, it is anticipated that it too should be able to be used on crops without major safety or MRL issues.

Adding sodium benzoate at 1% to caffeine at 2% was enough to maintain caffeine solubility in relatively cold water (-7°C). The mixture of caffeine and sodium benzoate gave the same level of snail control efficacy as caffeine alone in the plastic container tests but addition of the solubiliser may have an effect in the field. Snails are generally more active in wet conditions and the sodium benzoate enhanced solubility of the caffeine may compromise coverage if it allows rain to wash the caffeine off the plants and into the soil.

The field test treatment was a foliar spray of 2% caffeine solution at 100L/ha (2kg caffeine/ha) plus 1% sodium benzoate, with most applications made directly after rainfall or in the early morning following a dew.

Snails at all of the trial sites reacted to the spray by drawing back into their shells or dropping off the foliage but lived through the treatment and were not adequately controlled. A few snails placed in plastic containers on the ground in the path of the boom applying the spray died quickly, indicating that the spray exiting the boom was of lethal concentration.

This indicates there is an issue with field application of synthetic caffeine. Theories about reasons for the lack of efficacy in the field include caffeine tie up in stubble, clay or the living foliage.

No crop damage was observed from the foliar treatment.

Next steps

We know that early formulations of glyphosate used to require almost a day for the herbicide to be taken in by the plant and begin to have an effect, whereas modern glyphosate formulations such as RoundUp PowerMax are taken into the plant within 20 minutes of application. The glyphosate molecule hasn't changed but the formulation that delivers the active into the plant has been significantly improved and we are exploring the potential of different additives to improve the field results of caffeine on snails.

Caffeine is an active ingredient that can kill snails, so the challenge is to formulate something that will get enough of it into the snail in a field environment to do the job.

Does this mean we need a surfactant, a spray oil, a bonder or something else? The short answer is that we don't know, but we are working on finding something that will enable this agent to work and hope to gather some resources and insights from industry partners along the way.

Another question we aim to explore is whether, if the caffeine is being translocated into crop plants, will it repel snails and prevent them feeding on the crop? If so, does this have a fit for susceptible seedlings such as canola?

Solid bait

With very limited data and virtually no other documented trial work to draw on, a decision was taken to also test caffeine as a solid bait, in the form of rabbit pellets sprayed with a 2% caffeine solution. However, feeding these pellets to snails proved less effective than the direct foliar treatment.

It is difficult to know if the anti-feeding effect observed by Hollingsworth on Hawaiian slugs was a factor with the solid

bait, and if so whether or not it can be overcome by using an attractant to mask the caffeine.

We are currently testing an apple juice jelly infused with caffeine. Apple products are known to be very attractive to snails and may help overcome the anti-feeding effect if it is a factor.

Costs

Without knowing what the final formulation of a caffeine product will be or what mode of application will be needed it is difficult to suggest what a synthetic caffeine treatment for snails might cost.

However, based on current costs, we believe a caffeine product will be affordable for growers provided the required level of efficacy can be achieved through improved formulation and application strategies rather than higher application rates.

However, there may be scope for significant cost reduction from buying the quantities required for commercial production of such a product.

We have seen significant savings from buying larger consignments of synthetic caffeine (Figure 3) and it would seem reasonable to expect further significant price reductions when sourcing industrial quantities direct from manufacturers.

REFERENCES:

1) Hollingsworth R., Armstrong J., Campbell E; Caffeine as a repellent for slugs and snails. NATURE, Vol 417, June 2002.

2) Benzoate adjuvant to increase the utility of methyixanthine pesticides: identification of a potential rodenticide formulation for organic food production.

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CAFFEINE HAS A DEVASTATING IMPACT ON SNAILS.

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