



Worm Casting

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1 Introduction

Some grounds staff love them, some hate them, some occupy a middle ground in between, but whatever your view on the humble earthworm, they certainly are a talking point at the moment. Up until recently, there have always been products available to discourage or even kill worms and hence reducing casting issues. Pesticides historically used to control earthworms included mercuric chloride, lead arsenate, and even sodium cyanide – fortunately all are now banned. During the 1950s and 1960s, a single application of chlordane would kill earthworms and eliminate casting problems for as long as seven years. However because of its build up in the environment, harm to wildlife, and chronic human health risks, it was banned. In recent years Carbendazim had been the go to product for ground staff hoping to keep pitches clear of casts. Carbendazim was originally developed as a fungicide, had a temporary respite as a biocide, but eventually bit the dust for sale earlier in 2017 with a use-by date at the end of August 2017.

Earthworm tunnels lessen soil compaction and provide passageways through which air and water can percolate, enhancing penetration and growth of plants. In addition, earthworm feeding activity stimulates microbial decomposition of grass clippings and thatch and accelerates nutrient recycling, so a moderate level of earthworm activity is beneficial even on sports fields. Not all worms deposit their waste on the surface. Of the many species found in the UK, only three are known to deposit surface casts. The remaining species release their casts underground, so avoiding all of the mess and annoyance caused to the grounds staff teams around the country. The worms that cause our issues fall into the Anecic earthworms category, and they make permanent vertical burrows in soil. They feed on leaves/debris on the soil surface that they drag into their burrows. They also cast on the surface. They also make middens (piles of casts) around the entrance to their burrows. Anecic species are the largest species of earthworms in the UK. They are darkly coloured at the head end (red or brown) and have paler tails. Anecic earthworm species include *Lumbricus terrestris* and *Apporectodea longa*

Earthworms need a moist environment due to their method of respiration, as they diffuse oxygen and carbon dioxide through their skin. Their skin produces a film of mucous for the process to occur, and therefore has to be moist for respiration to take place.

An Earthworm has a long segmented body, which has a mouth at one end and an anus at the other. The mouth is closer to the clitellum, which is commonly called the saddle, found around a third of the way down the body. An earthworm moves via a line of bristles called setae, which can be found in pairs on each segment. Worms need plenty of moisture to move around in the soil profile, so a well drained dry soil will help a little to slow their progress. Earthworms prefer a neutral or slightly alkaline soil so, in some circumstances, we can discourage them by lowering the pH with careful use of acidifiers, but this in itself can cause issues if not done with great care.

In research performed by Dr Daniel Potter (2011), he found that prior to the period when chemicals became the common 'go to' method for controlling worm issues, a method was pioneered by British greenkeeper Peter W. Lees during the 1890s, it was so effective that it had become the mainstay for earthworm suppression on European and United States golf courses by the 1920s. Lees' method involved applying powdered mowrah meal, a meal made from seeds of *Bassia latifolia*, the butter tree of India, after the edible oil had been pressed out. Natural components in mowrah meal irritated the earthworms, causing them to come to the surface, where they could then be disposed of. I tried to source some mowrah meal for this investigation, but was unable to find a UK source for it in any form. Should materials become available, it is a plant that could be investigated in more detail in the future.

2 What we are investigating

We are testing a variety of products that as well as their normal function, have been known to suppress worm casting, some organic supplements that are reported to have a beneficial side-effect that suppresses worm activity and casting, traditional controls to reduce casting issues and cultural controls (brushing, switching, picking off, etc.), to see if casting issues can be managed in other ways.

2.1 What we did

We contacted the manufacturers or UK distributors of several products that whilst not directly designed for worm cast suppressing do seem to have this effect as well. Only Ivisons who sell Castaway liquid declined to take part in the trial. As earthworms are not particularly keen on an acidic soil, we assessed whether acidifying agents and acidifying fertilisers would have a cast reducing effect too.

2.2 West Essex Based Ground

A typical club level cricket ground was selected that operates on a low budget, and has a known issue with worm casting on it's ground that the groundsman there used to try to control to some extent with Carbendazim. The ground is made up of a typical Essex clay loam with no artificial drainage systems in place, and whilst not susceptible to flooding, does reach field capacity (full of water) and remains that way for some time during the wetter winter months. These damp conditions have provided a nice environment for earthworm activity. The groundsman commented that he likes the vast majority of benefits that the worms provide and would love a product that only suppressed casting species.

2.3 Method

Eleven squares were marked out that were mostly 3m x 3m in size making each zone 9m² in size. Zone one was set aside as a control zone, to compare the other zones against. After each assessment, each zone was cleared again using a variety of cultural methods that could also double as an alternative control method if a ground did not wish to use any of the product methods described later. They were also assessed for their effectiveness.

2.3.1 Brushing

Using a stiff conventional wide headed brush was hard work, and only worked well when the casts were fairly dry, when they were damp, they had more of a tendency to smear, probably due to the pressure being applied by the broom head as part of the sweeping process

2.3.2 Switching

Using a 3.5 metre Carbon fibre switch worked well with all but the soggiest worm casts, moderate effort was required, and casts were broken up and dispersed even when damp-wet. Effects were not good when casts were wet and soggy , as they tended to smear slightly. As an alternative to a switch, a cheap flexible fishing rod could be used as a switch. This was tried and worked very well too.

2.3.3 Vacuum

A Billy goat vacuum picked up damp and dry casts, but wet sticky casts were frequently sticky enough to resist being sucked up into the bag. However, even the damp casts clogged up the vacuum pipe so due to the time taken cleaning the pipes, this is not a recommended method.

2.3.4 Drag Mat

A drag mat only worked on dry to slightly damp casts anything more than damp caused smearing.

2.3.5 Chain harrow

This was particularly effective at clearing the casts, even wet ones with very little smearing, as it seemed to lift the wet ones off. It is only suitable for use on outfields, as its primary purpose is in scarifying the turf, which it does very well too.

2.3.6 Rotary mowing

Similarly to the Vacuum, the bag clogged up reducing capacity, but on a low height setting without a bag, it was able to break up dry casts.

2.3.7 Picking off by hand

Tediously slow and boring work, it works well, but was mind numbingly boring, I could only do it once!

2.3.8 Brambles Towing

For those clubs that do not own a chain harrow, a natural alternative that has been successfully used by groundsmen in the past is to tow some cut down (and leafless) winter brambles behind a tractor or mower. They are light particularly strong and resistant to breaking and of course cheap as well as often being in abundance around many grounds in the UK. They were not used as part of this trial, but positive feedback has been received from others, and could be a good technique to try if funds are tight.

3 Investigation Summary

The effectiveness of the products and methodologies varied in their affect on worm casting. With the manufactured products with known casting benefits faring better than the traditional/organic solutions.

Garlic as an old wives tale proved completely ineffective actually producing more casts than the control zone. Of the traditional solutions, only Iron sulphate which is frequently used to harden the turf had a discernible change at 72% of the casts in the control area. From the selection of professionally manufactured products, Squirm, Downcast and Castclear were the cheapest with results in the 65-75% range. Purity was the most expensive product per application at 52p for the granules and £2.40 for the liquid, however it produced the best result in terms of cast count at just 12% of the control area.

With regard to cultural controls on a cricket square, the only reliable way of clearing casts in a time efficient manner is to use a swish tool to disperse casts, this worked on all but the wettest of casts. Off of the square, a chain harrow was particularly effective even on wet casts, and helped lift thatch too.

4 Product types & mode of action

The products available now that are marketed to have some affect on worms, are all classified and assessed as fertilisers on their data sheets, that also happen to deter or irritate worms which is an additional benefit to ground staff as well as their soil and nutrient improving abilities. Some products work by acidifying the soil which worms are not terribly keen on, and others work by irritating the worm so that they move off elsewhere or become desiccated on the surface.

Liquids require dilution in water at the required rate. Some powders and granules are applied direct to the area to be treated, and some powders and granules require dilution in water. These are best strained before placing in knapsack sprayers or other equipment to ensure impurities that can block the equipment are removed.

Clearcast (approx £87/10l) from Rigby Taylor was not available at the start of the trial, but has a similar mode of operation as Squirm, Castclear and downcast.

4.1 Castclear - £23.82/L (Liquid)

CastClear is a non-pesticidal nutrient that increases turf health and deters lawn soil casts. Packaging seems to be targeted more at the home retail market with the largest bottle size being 1 litre.

It suppresses and deters earthworms from being in the upper reaches of the soil where their casts cause so many problems on the lawns surface. Containing more than 5% amino nitrogen with more than 15% bio-organic sulphur, it is a combination of nutrient materials that other trials have shown to reduce worm-cast levels on sports grounds, gardens, etc. Close scientific evaluation by the manufacturer has shown that this new product does not kill worms or reduce populations, but does deter worms from travelling through treated soils.

It incorporates an environmentally friendly surfactant system that moves the nutrient into the upper soil structure and fixes it there; providing good persistence of deterrent effect until breaking down to natural nutrients absorbed by plant roots.

The manufacturer states that it can be used with absolute safety from first tiller formed on new seeds at low rates of application, and year round on established swards.

4.2 Downcast - £44.70/10L (Liquid)

Downcast is a non-pesticidal nutrient based liquid that improves turf health and encourages casting worms away from sward surface, hence reducing surface casts. It is not toxic to worms, being based on Ammonium Sulphate it is known not to be bio-accumulating in the soil. It breaks down over time with bacteria no natural nutrients that can then be taken in by plant roots.

4.3 Squirm - £43.20/10L (Liquid)

A non-pesticidal, nutrient rich product to reduce worm castings on turf. Another Ammonium Sulphate based product with low levels of key nutrients that discourages worm activity near the surface that are supposed to reduce worm castings and offers a quick green up as a bonus. It also is non-bio accumulating. It breaks down over time with bacteria into natural nutrients that can then be taken in by the grass plants.

4.4 Purity - £38.40/20kg sack (Granule & Liquid) £132/10L

This product is based on tea seed meal, a natural by-product of tea oil manufacture, and containing natural surfactants called saponins, is effective for expelling earthworms and suppressing casting on playing surfaces. Xsyagri have performed research on tea seed meal, and found it to be effective as an organic fertiliser due to its high content of protein, which is widely used in the plating of crops and fruit trees with sound efficiency. In China they use tea oil derivatives to clean fish ponds and kill insects in paddy fields. They are also used by the Chinese for preventing and controlling other pests like earthworms, cutworms, nematodes, leeches, etc. So for us in the UK, it would seem likely that it would be detrimental to our nematode products that are designed to attack chafer grubs, and other insects. This may not be the case with this product, but it is a possibility to be aware of and perhaps could be pursued further in future research projects.

The mode of action irritates the earthworms, causing them to come to the surface where they can be picked off and moved to a more desirable area, if left on the surface they often desiccate as they are reluctant to bore back down into the treated area. The product is harmful to the aquatic environment, so should not be used if your ground is close to a water course. It is biodegradable and does not bio-accumulate within the soil profile, and has a PH of 5.7. The product helps promote grass growth improving root mass according to the literature, as well as deterring worms although this is not directly stated on the data sheets.

It is available in both liquid (10litre) and granular form (20kg). A 20kg sack treats 660m², a 10 litre can treats 1250m².

4.5 Acidification by Barley Vinegar - £3.35/5L

Great care has to be taken when using vinegar as an acidifying agent, as over application will kill grass, in fact vinegar has been used in the past as an organic total herbicide.

An initial application was made at 1ml/m in 1 litre of water.

4.6 Iron Sulphate - £1/kg, another acidification agent

Iron Sulphate is an Iron rich and long lasting fertiliser that will encourage strong growth and healthy dark green grass and act as a turf hardener. The recommended rate is 10gm/m². At this rate it must be applied in cool damp conditions.

If you apply it, mix it or spill it on stone surfaces it will produce a rusty stain, particularly on concrete or porous sandstones. You should wear gloves when applying as a powder. For the purposes of this trial, it was applied in solution 100g in 5 litres of water. When putting through a pressure or knapsack sprayer, it is important to pass the dissolved liquid through a very fine mesh sieve first, as it can have some trace impurities that could clog up your nozzles or other fine parts of your equipment if not passed through a fine mesh.

Only two applications of iron sulphate were made to avoid any risks of iron panning.

4.7 Mustard as a raising agent - £9/500g

An alternative method of getting earthworms out of the ground is to pour a mustard solution on the ground. To make the mustard solution, add 25 ml volume of mustard powder to 0.75 litre of tap water and shake well. Keep checking the area where you poured the solution (and surrounding area) for ten minutes to see if any earthworms emerge. Initially this was applied to the whole area, but was then reduced to a per square metre rate following initial failures and feedback from worm researchers. When putting through a pressure or knapsack sprayer, it is important to pass the dissolved liquid through a very fine mesh sieve first, as it can have some trace impurities that could clog up your nozzles or other fine parts of your equipment.

4.8 Acidification by Sulphur - £5/250g

This is a common acidifying material used in horticulture. Soil organisms convert sulphur into sulphuric acid, so acidifying the soil. The more finely ground the sulphur the more quickly the bacteria can convert it. However, acidification by sulphur takes weeks to have an effect, and when the soil is cold in winter, months are likely to be needed. We are going to give it a try anyway even if just to confirm that it is too slow to be of use.

The sulphur was sprinkled evenly in stages over the soil to be treated at the rate (eventually) of 270g/metre as the soil at the test site is a clay loam, soils rich in clay have a buffering capacity so much more sulphur is needed to change their pH than is needed to alter the pH of a sandy soil. Applied to the surface it can take some time for the acidity to be changed at a depth deep enough to affect worm activity, so the assumption is that this experiment will not produce a reduction in worm activity.

4.9 Garlic powder - £6/500g

Garlic has the vital chemical compound allicin, which is a wonderful therapeutic ingredient with many medicinal qualities. The allicin compound contains sulphur, which gives the herb its pungent savoury and peculiar smell. Old groundsmen's tales have mentioned that as well as being good for turf health, it helps promote root growth and helps resist fungal infections, they have seen a reduction in casting too. So we thought we'd give it a try. When putting through a pressure or knapsack sprayer, it is important to pass the dissolved liquid through a very fine mesh sieve first, as

it can have some trace impurities that could clog up your nozzles or other fine parts of your equipment.

4.10 Washing Up Liquid as a raising agent - 60p/500g

Washing up liquid is commonly used in science experiments and research as a raising agent, and was suggested as an option for this trial. The problem/risk with washing up liquids/detergents etc, is they are a mixture of non-ionic and anionic surfactants, softeners, etc., designed to shift food, grease and other debris off of a plate. When used on amenity Grassland, it can result in leaf scorch if not flushed off and if in excess or if concentrated within the soil there is a serious chance that they will lead to dispersion of clay particles (deflocculation) and clogging. There is also the risk of some biological consequences. Some of the leading brands contain preservatives which are known to 'inactivate' bacteria. Therefore washing up liquid was deemed to be unsafe for use and beyond the scope of this investigation.

5 Assessment process

The products were all applied where specified in the exact method and rate defined on the label, and for naturally derived products at rates traditionally used in horticulture and scientific research. All applications would be performed when the soil is moist/damp but not waterlogged. Follow up applications would be performed after 2 weeks where required, and then at approximately 4-6 week intervals as weather permitted where products recommended it, up to 3 applications maximum for the purposes of this trial.

There are regulations that have to be adhered to in this process, so each product was applied with its designed purpose being the reason for application, e.g. fertiliser with side effect that reduces PH, soil conditioning, organic soil conditioners, etc. As a licensed user we cannot use the product as a pesticide and must always follow any on label instruction. Our focus will be on any positive side effects as a result of their primary use.

5.1 Surface preparation

The areas were cleared of any existing debris, leaf litter, animal faeces, etc.. Then neatly mowed with a cylinder mower for to produce a clean healthy sward. This was performed the day prior to product application on the 18th November, with the products being applied the following day that was clear wind free and sunny. The soil condition was damp and firm and not water laden or sodden.

Squares were marked out that were 3m x 3m in size, with one for each product or method being utilised, along with a control area that is being used for reference. Only enough liquid for a 2m x 2m square was available for Purity liquid, so this should be considered when looking at the table figures.

5.2 Assessment table

The initial application and trial start date was performed on 19/11/17, the initial soil PH just prior to application was 6.6-6.7.

Product/method	Zone	Quantity Applied ^(a)	Application cost	Assessment Dates>			
				26/11/17	6/1/18	6/2/18	10/3/18
				1	2	3	Final
Nothing	1	n/a	n/a	141	216	222	256
CastClear	2	(1st) 18 - 250 (2nd) 6.5 - 250 (3rd) 6.5 - 250	1. 43p 2&3. 15p	103	130	135	176
Downcast	3	(1st) 18 - 250 (2nd) 9 - 250 (3rd) 9 - 250	1. 8p 2&3. 4p	114	143	134	172
Squirm	4	(1st) 18 - 250 (2nd) 9 - 250 (3rd) 9 - 250	1. 8p 2&3. 4p	119	169	138	188

Purity Liquid ⁽¹⁾	5	(1st) 80 - 5000	£2.40 ⁽²⁾	9	14	12	11
Purity Granules	6	(1st) 30g/m ⁽³⁾	52p	25	29	20	28
Barley vinegar	7	(1st) 10ml - 1000 (2nd) same (3rd) same	0.6p	147	202	182	260
Iron Sulphate	8	(1st) 100g - 5000 (2nd) same	10p	131	117	165	190
Mustard	9	(1st) 25g - 750 (2nd) 225g -3750 (3rd) 225g -3750	1. 45p 2&3. £4.05	94	205	168	244
Sulphur powder	10	(1st) 135g ⁽⁴⁾ (2nd) same (3rd) same	£2.70	144	169	176	175
Garlic solution	11	(1st) 100g - 5000 (2nd) same (3rd) same	£2.40	136	218	236	253

(a) - Quantities are measured in grams (g) for powders or granules, and millilitres (ml) for liquids in (n) ml of water

(1) - Only a 4 metre square area could be assessed due to lack of liquid availability

(2) - Application cost scaled up for a 9 square metre test area to enable cost comparison

(3) - After spreading, the granules were watered with a rose hose gun for 10 minutes, without inducing surface run off

(4) - Scatter applied as a dry powder over the area, as sulphur not soluble in water, bacteria will break down over time

6 Conclusion

All the professionally made products seemed to perform their primary role well, healthy fertilisation, etc. All of them had some affect on the cast reduction too, some of the organic traditional solutions however were not so successful. Whilst no option seems to be as good as Carbendazim used to be, the trial has shown that there are useful products out there that can help ground staff with their tasks all be it with some cast removal/dispersal still required.

6.1 Casts per metre

Product/method	Total Casts	Casts /metre	% of Control zone
Nothing, control area	835	92.8	100% - n/a
CastClear	544	60.4	65%
Downcast	563	62.5	67%
Squirm	614	68.2	73%
Purity Liquid	46	11.5	12%
Purity Granules	102	11.3	12%
Barley vinegar	791	87.9	94%
Iron Sulphate	603	67	72%
Mustard	711	79	85%
Sulphur powder	664	73.8	80%
Garlic solution	843	93.6	101%

6.2 General Observations, etc.

Where products were expected to have an affect on soil acidity, PH tests were performed at the end of the trial to see if there had been any long term change to the soil PH level. It started out at approximately 6.6-6.7.

6.3 Castclear, Downcast and Squirm

Each of these acidifying fertiliser products worked well, all returning very similar figures in terms of cast counts, and all seemed to help their test squares look healthy as could be expected from turf health products. At the end of the trial, there was no discernible change in soil PH at 6.5, so the acidifying process is fast with early cast counts being lowest. These products are all suitable for repeated use at the recommended intervals, and so could assist in an integrated pest management programme over a Autumn-Spring period. Downcast and Squirm were by far the cheapest of the professionally marketed products that had a noticeable change in the test areas.

6.4 Purity

Within minutes of the initial application, the worms were seen to be rushing out of the surface of the test areas and heading away from them. Clearly they did not like the product, so as has been mentioned on forums, the product appears irritating to them. A couple of days later no dead worm bodies were found, so it is assumed they went off to untreated ground to escape the product. However, this was not proven, and as mentioned earlier, there is some suggestion that the worms and potentially other creatures could be killed. More research would certainly be welcome on this to give ground staff greater clarity on the issue, is this something that the IOG or a university could investigate. Let us hope so as initial findings are optimistic.

6.5 Iron Sulphate

An immediate green up of the grass sward was observed within days of the initial application, only two applications were made as the groundsman did not wish to risk iron toxicity through over application. The soil PH was unaltered at 6.5 by the end of the trial.

6.6 Mustard

After the second application at the higher rate, worms were raised to the surface within a few minutes where they could be picked off and moved to an area where they were not considered a pest. However to the eye, over the course of the trial and the area tested, it did not seem discernibly different in appearance to the control zone.

6.7 Sulphur

Sulphur which in itself is a key plant nutrient, does not dissolve in water, so this was applied directly to the soil surface. By the end of the trial, this was the only test square with a noticeable change in soil PH, with a final reading of 6.0. The slow working nature of sulphur in acidifying the soil probably accounts for the improving nature of the worm cast count towards the end of the trial.

6.8 Garlic

An immediate strong smell of Garlic was apparent, but this soon dispersed from the area if not from my gloves. Whilst the turf looked healthy, there was no discernible difference between this test square and the control square. In fact figures indicate the worms seemed to favour it, but could this be a side effect of garlic's other beneficial properties.

7 Glossary

Field Capacity - A soil at field capacity has been saturated, then allowed to drain freely without evaporation until drainage effectively ceases. This can continue indefinitely on clay soils. At field capacity, the macropores in the soil are air filled and meso and micropores still have water in them.

Carbendazim - Former commonly used worm suppressing product that was originally developed as a fungicide. All stock had to be used up by August 2017

Hectare - 10000 square metres (100m x 100m)

Chain harrow - A device usually towed behind a tractor for scarifying, thatch lifting, etc.

Harrowing removes dead thatch lifts vegetation up and levels any mole hills. It encourages air movement and root aeration and improves water infiltration. It reduces disease in theory by exposing fungi and bacteria to sunlight, although it may be that the healthy growing conditions for the sward is more important.



A chain Harrow

8 Test Areas



The control areas looking from zone 11 back towards 1.



Squirming worms 10 minutes after application in zone 6



Pleasant still conditions on initial application day.

9 References & Sources

- [Source: Pitchcare editorial article] <https://www.pitchcare.com/news-media/the-culture-of-worms.html>
- Controlling Earthworm Casts on Golf Courses By Daniel A. Potter , Carl T. Redmon D, and David W. Williams. (2011)
- RHS Encyclopedia of Gardening by Christopher Brickell
- Earthworm society

10 Acknowledgements

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