The worm turns: earthworm cast reduction on golf courses

A byproduct of the tea tree may provide an organic solution to a long-standing and vexing problem faced by golf course superintendents.

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(**Top left**) In the 1890s Peter Lees, head greenkeeper at Mid-Surrey GC in England, introduced mowrah meal as a means of controlling earthworms on golf courses. (**Top right**) Watering in the mowrah meal. (**Bottom**) One of three wheelbarrow loads of earthworms removed from a putting green treated with mowrah meal. **Photos published by R. Beale in 1908 (3) and reprinted by J. Beard (4)**

Article continued from last issue.

Lees' method involved applying powdered mowrah meal (made from seeds of *Bassia latifolia*, the butter tree of India, after the edible oil had been pressed out) and watering it in. Natural components in mowrah meal irritated the earthworms, causing them to come to the surface, where they were raked into piles, shoveled into wheelbarrows and hauled off the site.

Lees' method is regarded as among the most important historical innovations in turf management, in part because it allowed expansion of British golf courses on upland soils, areas that previously had been ill-suited for golf because earthworms made the putting greens unplayable (4). USGA bulletins described mowrah meal as an "outstanding efficacious treatment" and a "very effective earthworm eradicator" when applied at the rate of 15 pounds to 1,000 square feet of green and watered liberally afterward (10,11). At one time, at least a dozen proprietary fertilizers and other products containing mowrah meal were marketed for earthworm control on golf courses (11). Use of the method declined in the late 1940s and 1950s with development of chlordane and other earthworm-toxic synthetic pesticides.

Mowrah meal is rich in *saponins*, natural soaps or surfactants found in the leaves and seeds of oats, spinach, alfalfa, chickpeas, soybeans, ginseng, tea and hundreds of other plants (6,15). Saponins have antifungal and antibacterial activity and form part of the plant's natural defenses against disease. Plant saponins are used in manufacture of natural soaps and shampoos, cosmetics, and even

as a component of the foamy "head" of root beer. Although saponins were never confirmed as the earthworm-active component in mowrah meal, it is highly likely that their detergent-like irritation of earthworms' mucus membranes was the basis for its effectiveness. Mowrah meal is no longer marketed for earthworm management, but are there other sources of plant saponins that could be developed for that purpose?

(Top) Earthworms expelled from 1 square meter of a push-up green after tea seed meal was applied. (**Bottom**) This desiccated earthworm was found the morning after the turfgrass was treated with tree-seed meal. **Photos by D. Potter**

Back to the future

In 2007, the first author attended a sports turf conference in Beijing, China, where he learned of a natural substance used in that country to control snails and slugs in vegetable fields and to suppress earthworms and casting on sports fields. The method involves applying a byproduct of tea oil manufacture. Tea seed oil pressed from seeds of the Chinese tea oil plant, *Camellia oleifera*, is used for cooking and in soaps and shampoos, margarine and other products. Tea seeds, fruits and oil are rich in antioxidants and are used in Chinese traditional medicine. After the seeds are crushed to extract the oil, the residue is ground into meal or pressed into "cake" or pellets. Tea seed meal is used as a component of animal feeds, as an organic fertilizer and for other purposes.

Websites of many Chinese tea oil manufacturers (for example, www.camellia-oil.com) claim that tea seed meal can be used to control earthworms on sports turf and lawns. A 2007 search of the worldwide scientific literature, however, found no references or data supporting that claim, and no information concerning rates, timing, effectiveness or other aspects of using tea seed meal to manage earthworms and casts. But like mowrah meal, tea seed meal is high in natural saponins (5,13) and therefore worth evaluating as a possible substitute for Peter Lees' historical remedy for cast reduction.

Testing for cast suppression, 2007-2008

We started researching tea seed meal in autumn 2007 to determine whether it could be used to reduce earthworm casts on playing surfaces. Most of the early trials were done on a large, predominantly Penncross creeping bentgrass push-up green at the University of Kentucky's A.J. Powell Jr. Turfgrass Research Center near Lexington. The site had high numbers of actively casting earthworms (>95% *Apporectodea* species). Other trials were done in fairway-height creeping bentgrass and on a perennial ryegrass fairway. A full account of the experiments was published in a peer-reviewed international scientific journal (13).

Our initial tests were with crude tea seed meal pellets (3.2 millimeters diameter; 5–8 millimeters long) and powder obtained from a source in China. The powder, essentially a dust, proved awkward to apply, so later work focused on the pellets. Application of the pellets at 6 or 12 pounds/1,000 square feet (2.93 or 5.86 kilograms/100 square meters) followed by irrigation, quickly expelled as many as 200 worms/10 square

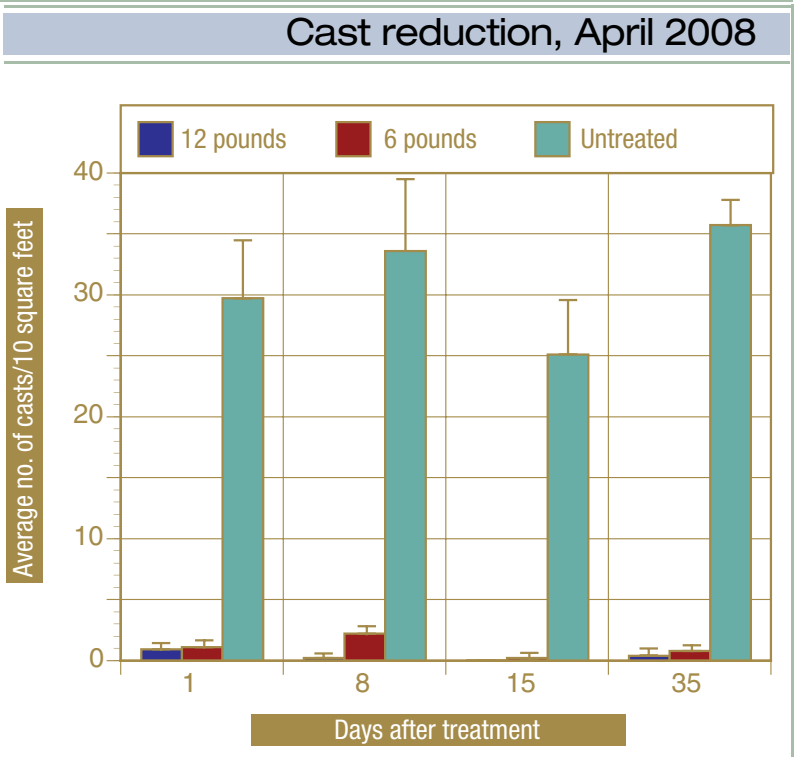

Figure 1. Reduction in earthworm (*Apporectodea* species) casts on a creeping bentgrass push-up green after applying crude tea seed meal (12 or 6 pounds product/1,000 square feet) in April 2008.

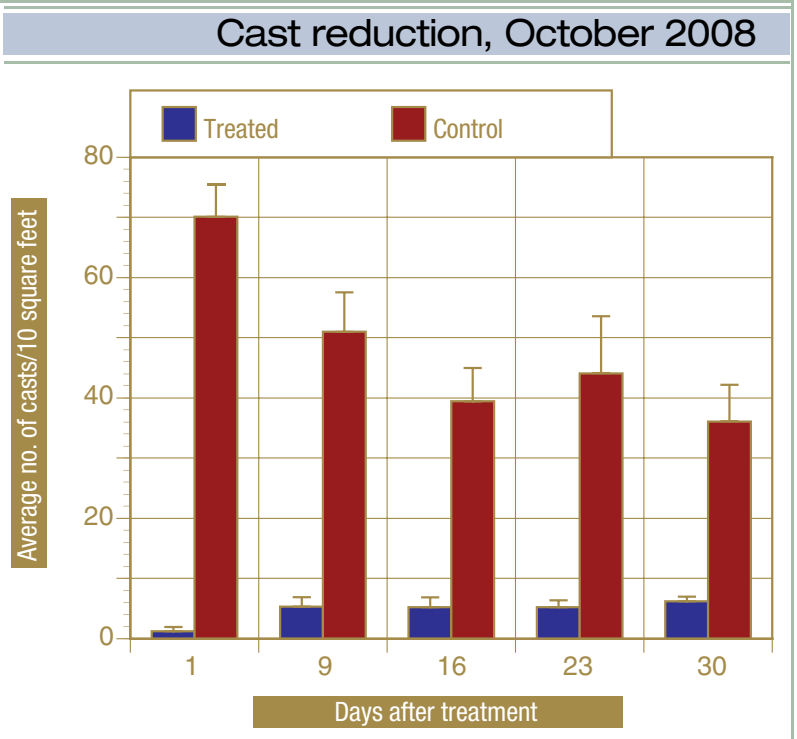

Figure 2. Reduction in earthworm casts following application of crude tea seed meal (6 pounds product/1,000 square feet) on a perennial ryegrass golf fairway in October 2008.

feet (0.93 square meter) on the push-up green. Most of the expelled worms dried up and died on the turf surface; other experiments indicated relatively few worms that burrowed back down survived. Expelled worms appeared flaccid and quickly desiccated, evidently because their mucus coating had been disrupted. A single tea seed meal application in early April 2008 reduced castings in replicated plots on the push-up green by >95% for at least five weeks (Figure 1). In another trial on the push-up green, application of tea seed meal in early October reduced casts by 98% after two days and 83% after 30 days (Figure 2). Finally, a sequence of lab trials, called bioassay-guided fractionation, confirmed that the chemical basis for tea seed meal activity on earthworms is the natural triterpene saponins found in tea seeds.

We tested two methods for removing the expelled worms from putting green surfaces (13). Locations of expelled worms were marked with dabs of orange turf paint. The following morning a single pass with a greens mower removed about 66% and one pass with turf sweeper removed 40% of the cadavers.

In other tests, the tea seed meal pellets did not provide any control of white grubs or cutworms in field plots (13). Unlike earthworms with their mucus-covered skin, insects have an exoskeleton that seems to protect them from being dried out from exposure to saponins. On the plus side, the pellets also did not harm the tiny soil-inhabiting insects and mites that help to decompose thatch and grass clippings.

Non-native (invasive) earthworm species

The first and second authors began a systematic survey of the earthworms on Kentucky golf courses in spring 2011 to clarify which species are associated with surface casts. Several thousand specimens were collected from a total of 18 fairways on six different courses. We also sampled worms on push-up greens. All of the culprits appear to be non-native, invasive species. At least seven species have been identified, the most common by far being *Apporectodea* species. The Kentucky earthworm surveys will continue for at least another year. Nightcrawlers, which also are invasive, seem to be responsible for most of the casting problems in the Pacific Northwest (1).

A natural organic fertilizer

After hearing about our earthworm research at an educational seminar, representatives of a developer and manufacturer of natural fertilizers and biorational materials for turf, ornamental horti-

Top: Crude tea seed pellets. **Photo by D. Potter**
Bottom: Early Bird fertilizer. Note the finer granules of the refined product. **Photo courtesy of Ocean Organics**

culture and specialty agriculture (Ocean Organics Corp., Ann Arbor, Mich./Waldoboro, Maine) expressed interest in developing an organic fertilizer based on tea seed meal. They formulated the raw meal into a finer, proprietary blend of tea seed meal, kelp extract and composted poultry manure, called Early Bird 3-0-1 Natural Organic Fertilizer, suited for golf course use.

Caveats and limitations

The goal of this research was to facilitate development of a natural product that can be used to alleviate the problem of excessive earthworm casting on golf courses and sports fields. Early Bird is not labeled for earthworm control, although registration as a biological pesticide is being pursued. Since tea seed meal is a natural product, it is subject to variation in saponin content related to genotype of the source plants, growing location, and how the raw material was processed, handled and stored (5). Early Bird is, to our knowledge, the only turfgrass fertilizer with tea seed saponins for which quality is monitored.

Saponins are distributed in diverse plant species including many cultivated crops regularly consumed by humans (6,15). The saponins in tea seed meal have low acute oral and dermal toxicity for vertebrates including mammals and birds (15). Biodegradation is rapid, within three to five days in the field.

High concentrations of saponins are toxic to fish, but tea seed meal is considerably less toxic to fish than some other products (for example, pyrethroid insecticides) regularly used on golf courses (13). With sensible guidelines (for example, buffer zones around ponds and streams, and no treatment of saturated soils where runoff could occur), it should be possible to use a tea seed meal-based product without harming aquatic organisms.

An issue with earthworm expellants such as tea seed meal or mowrah meal is the unsightly nuisance and temporary odor when large numbers of worms die on the surface. In our experience, the expelled worms dry up relatively quickly and most of them are removed by mowing. The dried-up worms are less evident on fairways than on greens. Superintendents who tried Early Bird report removing expelled worms by mowing, with a backpack blower, vacuum, water hose or combinations thereof. The ideal remedy would provide economical long-lasting suppression of casting without killing the earthworms, but such a product has not yet been found.

Conclusions

This research indicates that tea seed meal, a

natural byproduct of tea oil manufacture containing natural surfactants called saponins, is effective for expelling earthworms and suppressing casting on playing surfaces. The mode of action is similar to that of mowrah meal, a mainstay for managing earthworms on golf courses a century ago. Tea seed meal has been formulated into an organic fertilizer (Early Bird 3-0-1) suitable for use on fairways and putting greens by Ocean Organics Corp. Early Bird has been available since 2010.

Most of the casting problems on North American golf courses are caused by non-native, invasive earthworm species. Saponin-rich natural products such as tea seed meal have promise as an alternative to off-label use of synthetic pesticides for alleviating the problems caused by excessive earthworm casts on low-cut playing surfaces.

The research says

→ Earthworm casts create a serious management problem in turfgrass on golf courses and sports fields, particularly under cool, moist conditions.

→ Cultural methods do not adequately control the earthworms or their casts, and no chemicals are currently approved for earthworm control in the U.S.

→ In the 1890s, British greenkeeper Peter Lees discovered that when mowrah meal, made from seeds of the butter tree of India, was applied to turf and watered in, it acted as an expellant, forcing the worms to the surface, where they were raked up and removed from the site.

→ Recently, Chinese tea seed meal pellets, made from the seeds of the tea tree, have been shown to be effective in expelling earthworms and suppressing casting on turfgrass playing surfaces. Like mowrah meal, the pellets are made from a plant rich in saponins, which may irritate the earthworms' skin.

→ Tea seed meal is now available in the U.S. as an organic turfgrass fertilizer suitable for fairways and putting greens.

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