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green world

AN INDUSTRYWIDE PUBLICATION OF THE NEW JERSEY TURFGRASS ASSOCIATION

NJTA

~~Vol. 15 No. 4~~ Vol. 16 No. 1 June 1986

Earthworms and Turf Culture

Sue A. Baldwin-Way and Ralph E. Engel

It is not uncommon for turf growers to speak disparagingly of the poor earthworms and indifferently eliminate them from turf areas. With consideration of the work that earthworms accomplish and their contributions to soil nutrient content and soil porosity, should turf growers let them thrive in some turf areas? The comparative newness of turf science may be the reason these common creatures have been given little attention or research.

Nature of the Earthworm. In the Northeast there are primarily two kinds of earthworms, the common earthworm (lumbricids) and the oriental earthworm *(Pheretima)*. The latter is most likely to produce heavy casts on the soil surface and pose the greatest nuisance. It is the more difficult of the two to control and is probably primarily responsible for the objections to earthworms in turf.

At a glance, the two kinds look very similar. Closer inspection shows a continuous ring of minute bristles on each body segment in *Pheretima;* lumbricids lack those bristles. The amount and rate of casting is a fairly reliable indication of which type of earthworm is present, as the oriental earthworm far exceeds his common cousin in that regard.

Habits of both species seem similar. They are most active and commonly observed in the top layers of the soil during spring and fall, their breeding seasons. Their activity in the upper layers of soil is encouraged by warm, damp weather and overcast days. In drought and in winter, earthworms are likely to burrow 9-10 inches below the soil surface.

Ironically, many of the cultural conditions required for turf are also favorable to earthworms. Small, digestible grass clippings from frequent mowings provide a salad for the earthworms, who pull organic matter off of the soil surface and into their channels. Liming to attain optimum pH for plant growth also provides the more akaline soils that worms prefer. Watering to keep soils uniformly moist is as beneficial to worms as it is to turf. The best soils for turf are also preferred by earthworms: light-to-medium sand loams and loams, as opposed to gravelly or sandy soils.

Earthworms can be very numerous where conditions are favorable — as many as 200-400 can be present in a square yard of soil, which could be as many as a million or more per acre. There are many species within the two types of earthworms. The various species have different tolerances to pH (although few are found where pH is below 4.5) and they select different living conditions in the vertical soil horizon. Distribution at different depths also varies according to temperature and soil moisture.

Effects on Nutrient Relationships. Among the most macroscopic of the soil fauna, earthworms might be credited with doing either more harm or good than they actually accomplish. Little is known about the total amounts of organic matter that can be digested by the earthworm, however, there is evidence of surprisingly efficient digestion of proteins in the leaf litter.

Earthworms influence decomposition by other organisms and encourage some soil organisms. Their contribution to decay of organic matter appears to be associated with a plentiful presence of digestive enzymes, including cellulase and chitinase, in their gut walls.[1]

As they ingest, earthworms mix organic matter, fertilizer, lime, and inorganic particles in their gut, possibly exposing more fresh surfaces to beneficial microbial action.

Perhaps the most significant contribution of the earthworm to the nutrient content of soil involves nitrogen. Earthworm bodies are 12 percent nitrogen (dry weight). Large populations, along with other soil microorganisms, may help provide a more even supply of nitrogen for grass growth. A study by Russel (1910) that used dead earthworms in the check and live earthworms in the test treatment showed a nitrogen content of 47 ppm of inorganic nitrogen in the check and 77 ppm in the test, suggesting that live earthworms contribute more than their body content of inorganic nitrogen to the soil.[2]

Calcium ions above body requirements in solution in earthworms are excreted from the gut as calcium carbonate. Other plant nutrients from whatever is digested from thatch residue by earthworms and accompanying microorganisms surely becomes available, but amounts have not been determined.

Modification of Soil Physical Properties. Numerous studies, especially in Europe, New Zealand, and Australia have determined the amounts of soil earthworms may cast on the surface. These studies show that an active earthworm population can deposit an inch of soil on the surface over a time period of 3-8 years. This is significant when considered as "top dressing" to the surface. Fresh casts have been found to be water stable for 15 days after casting and still twice as stable as control aggregates after 30 days of incubation.[3] It is of interest that not all worms cast on the surface.

Earthworm effects on soil porosity is of obvious interest. Studies have shown that 100-300 channels per square meter of soil are not uncommon. Measurements have shown 8-30 percent increases in pore space, a boon to efficient drainage and irrigation. Less evaporation has been observed in pots containing live earthworms.[4]

The effect of the grinding action of the earthworm has shown slight decreases in silt and increased clay. Although the total change may be small, very little change in these fractions could affect the threshold level of texture that controls the water percolation rate.

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Comments and Opinions

Answering a 1985 Request for Comments on Bentgrass Green Cultivation

With regard to your question on cultivation of greens, you might consider the following summarized points:

1. Topdressing is an important aspect of cultivation programs. Dress as much soil from the cultivation plugs into the turf as feasible, unless the existing soil is grossly incorrect.
2. Cultivation and topdressing shortly before the start of warm weather stress or during the summer is more effective for overcoming slow water penetration, uneven growth and turf failure than fall or early spring treatments.
3. While cultivation in late-spring and early summer is preferred, it is risky unless cool, dry days are selected and the turf is not in serious stress. However, we are in a climate where cultivation and topdressing at this season pay dividends.
4. Avoid early spring treatments because:
   - the turf heals slowly;
   - sometimes bentgrass seems reluctant to grow until May, which invites annual bluegrass to fill the voids;
   - the turf surface is usually quite porous at this season without cultivation.
5. Late summer to fall treatment may be necessary for rejuvenating turf. Be sure there is a real need for cultivation and topdressing greens during fall because:
   - treatment in this period appears to enhance annual bluegrass;
   - it is less effective as an aid to next season's watering;
   - Overseeding with bentgrass is often required.

My opinions on this subject are based on both observations and research. Possibly, the reasons for my choice of May, June, and July center on encouragement of vigorous new growth, minimizing encroachment of annual bluegrass and improvement of surface permeability when greens often take water slowly and unevenly.

REE

The Exciting World of Turf

Like everyone who has worked with turfgrass research and education, I feel richly rewarded for my privileged years of experience. Yet people who have asked me to tell them my line of work often react with pity that I was confined to a life, on my nose, looking at grass. My pleasure and satisfactions have been great. I have found turf growers an exhilarating group.

Like others on this phase of turf work, I carry a disappointment that I did not have time to study many ideas and concerns that have come to mind. One of my early beliefs has been that we need more sophistication in the use of 2, 4-D for dandelions. In addition, we develop exciting ideas from our daily experiences and our reading publications. Several of these from recent weeks have come to our attention as follows: 1. a worker claims to have isolated a toxin from a fungus that appears specifically toxic to one of our weedy turfgrasses, 2. scientists are finding organisms that produce proteins that can cause a plant to produce other protective proteins against disease, and 3. the increased attention to endophytes of turf surely has some biochemists scurrying to isolate the chemical that controls insects. Such discoveries as these will lead to interesting new uses and procedures in turf growing. Be alert to the changes that might be valuable to you and enjoy contemplating all the change that lies ahead!

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Green World is published three times a year by the New Jersey Turfgrass Association, P.O. Box 231, New Brunswick, NJ 08903. Consulting editors: Ralph Engel and Rich White, production editor: Sue Baldwin-Way. Please address inquiries concerning advertising to William Nist, Lebanon Chemical Co., Dayton, NJ 08810. (201) 329-4011.

Earthworms

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It has been noted that earthworms spread soil organisms. Generally, this might be expected to be beneficial. This factor could influence both the nutrient and physical nature of the soil.

Effects of Earthworms on Plant Production. Earthworms are not known to attack healthy plants. Soil cultivation as practiced with some crops is not necessarily conducive to large earthworm populations, however, large concentrations of live worms increased yields of oats or peas 70 percent, while the addition of dead worms made little difference.

In soybean research, yields were returned to normal on puddled soil with the presence of live earthworms, but not with the addition of dead worms.

In another study, earthworms introduced into a soil with dung added were removed at 8 weeks and were found to have gained weight. The dung soil mix was crushed, mixed, and planted to ryegrass. Plant growth was doubled with the soil that had been treated by the earthworms, as contrasted to the growth on the same soil preparation without earthworms.[5]

Fig. 1. Tropical earthworm casts repeated during the day. (Courtesy of the Connecticut Agricultural Experiment Station.)

Effects of Earthworms on Turf. Little formal study of earthworm effects on turf has been conducted. Complaints about this creature have come from England more commonly, where turf growers dislike the muddy casts and also may wish an accumulation of fiber at the surface. The most severe objection to earthworm interference on greens in the United States occurred in the 1950s. Several groups associated with golf raised funds for research and to find a control method. With the species involved at that time, greens brushed free of earthworm casts before noon would have a problem with casts again, after lunch.

The coauthor has been increasingly impressed over the years by the lack of earthworms on the thatch-troubled areas. Earthworm-destroying pesticides have been associated with thatch problems. In England, during the 1969 International Turfgrass meeting, thatch accumulation and turf deterioration was shown where calcium arsenate was used repeatedly for earthworm control.

A series of chlordane plots applied in a 1959 test in New Jersey for crabgrass control has given earthworm control for 27 years. This has caused turf deterioration that appears to be associated, in part, with a lack of earthworm activity at the surface. (figure 2).

Where earthworms appear highly active some remarkably thatch-free areas have been observed. The untreated areas of the 1959 chlordane test has had an active earthworm population and no apparent surface residue problem. A low section of 18 fairway at Hollywood Golf Course in New Jersey had a section with a very active earthworm population in a soil with high organic matter content, which had no thatch problem compared with the rest of the fairway. In February 1986 an older golf course was observed along the central California coast that had a surprisingly small amount of thatch on the fairways. While information on the maintenance program was unobtainable, earthworms were common on the course site.

A recent study on Kentucky bluegrass (Kenblue) showed increased rate of nitrogen fertilization for 7 years with ammonium nitrate, increased soil acidification, and was accompanied by a decrease in Collembola type earthworms and certain other possible decomposers. This decrease was associated with and was considered a major cause of increase in thatch.[6] While there is not enough documentation to show the types and ranges of benefits from earthworms, we might use their help in minimizing thatch and the problem of opening sealed turf surfaces. Again, it seems logical to conclude earthworms do more good and a better job than most cultivating machines.

Favorable and Unfavorable Effects of Earthworms on Turf. The primary objection of most turf growers to earthworms seems to be the worms' practice of casting soil and digested material onto the surface of the turf. While significant casting on fine turf areas such as greens could interfere with play, the casts on lawns and fairways may be less troublesome and annoying than the use of machines to slice or score the turf.

Casting is seasonal and is greater during the active breeding seasons in spring and fall. Not all casting comes to the surface and not all earthworms produce significant casts, so evidence of earthworms may not signify a potential casting problem.

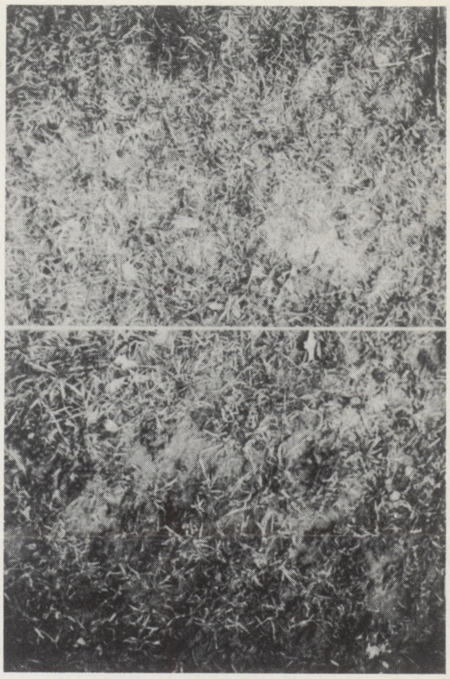

Fig. 2. *Top:* no earthworm activity 28 years after herbicidal rate of chlordane. *Bottom:* more growth and less residue on earthworm-disturbed surface of low-maintenance lawn turf, without chlordane.

Earthworms may contribute to the attraction of moles to an area. When surfacing, earthworms might play a minor part in opening up the soil surface to the germination of weed seeds, however it is unlikely that the number is significant. The decomposition of the thatch is a favorable action that probably outweighs the disadvantage of contribution to weed germination.

Despite some objections to earthworms, it appears that they should be encouraged on turf except fine turf areas, such as putting greens. Regardless of their effects on plant growth and yield, their work is superior to and can reduce the need for mechanical cultivation.

Conclusion. In light of the benefits that earthworms provide vs. the disadvantages of their presence in some turf areas, it seems advisable to let them populate where they can be tolerated. Prior to finalizing the turf management programs, consider the effects of these practices on their survival. By reducing conditions of the habitat where earthworms are to be discouraged, perhaps populations could be reduced to accep-

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Earthworms

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table levels rather than completely eliminated. Worms prefer more alkaline soils, so reducing pH to slight acidity may be some deterrent. Also, if worms are to be discouraged, avoid feeding them — avoid letting clippings fly and, on some occasions, consider inorganic fertilizers or synthetic organics, which may give a reduction in food supply at the soil surface.

Research is needed to determine pesticides that are fatal to earthworms, to find pesticides that kill the target insect rather than the earthworm, to establish the best time of pesticide application, and to develop selective pesticides that will eliminate the unwanted types of earthworms while leaving the helpful types alone. Studying the introduction of earthworms into controlled areas and examining the potential benefits would also be helpful information to those turf growers willing to consider earthworms a valuable natural resource for appropriate areas.

For those willing to encourage earthworms on some areas of turf, it is good to remember that the same cultural practices favorable to turf are generally favorable to earthworms. Heathy turf insulates soil against rapid changes in temperature, adds organic matter, and mellows hard soils. Frequent mowing which leaves small digestible clippings, liming to attain optimum pH for turf growth, watering to keep soils uniformly moist, and practices that keep light-to-medium sand loams open and porous are all as favorable to earthworms as they are to turf.

[1]K.P. Barley, The Abundance of Earthworms in Agricultural Land and Their Possible Significance in Agriculture. *Journal of Advances in Agronomy*. pp. 257-258.
[2]Ibid., p. 259.
[3]Ibid., p. 261.
[4]Ibid., p. 260-263.
[5]Ibid., p. 263
[6]Potter, D.A., B.L. Bridges and F. Carter Gordon. 1985. Effect of N Fertilization on Earthworm and Microarthropod Populations in Kentucky Bluegrass Turf. *Agron. J.* 77:367-372.

"To laugh often and love much, to win the respect of intelligent persons and the affection of children; to earn the approbation of honest critics; to appreciate beauty; to give one's self; to leave the world a bit better whether by a healthy child, a garden patch, or a redeemed social condition; to have looked for the best in others and given them the best he had; to know even one life has breathed easier because you have lived — that is to have succeeded."

Ralph Waldo Emerson

Does "Thirsty" Turf Make Noise?

Plants have been exposed to music in jest and in research. Not too many years ago the University of Illinois exposed corn to sound for 18 hours per day without changing growth. Maybe it is time for man to listen to plants. Dr. E. L. Fiscus, USDA, has listened to noises made by drying plants. These sounds are in the 100 kilohertz range. Since the human ear hears in the 10 hertz to 20 kilohertz range, special equipment is needed to hear the sounds plants make as they become drier. The cells of the vascular system conducting water and nutrients from roots to leaves make minute, high-frequency noise when a deficiency of water causes fracturing in this pathway. Discoveries of this type stimulate many interesting questions for research and theoretical uses. Perhaps this could be used to activate a watering system at a precise time to the advantage of the preferred turfgrass species and to save water. Does this eliminate the need for an on-site agronomist? Scarcely! Things other than a shortage of available soil moisture can cause deficiency of water in the water conducting tissue. An agronomist would seem more important than ever to assure correct interpretation and treatments.

REE

Turfgrass Irrigation Requirements

The late-spring, early-summer season of 1986 is providing turf managers with many sleepless nights and hopes that conditions experienced thus far are not a foreshadowing of more extreme conditions to come during July and August. With water or lack of rainfall on turf professionals' minds, research presented within the last few months regarding turfgrass water use rates may be of interest.

Irrigation of cool-season grasses to replenish 100 percent of maximum evapotranspirational losses resulted in tall fescue using more water than Kentucky bluegrass and perennial ryegrass, with red fescue using the least water.[1] Red fescue remained green longer than the other grasses under deficit irrigation at 75 percent of water lost through evapotranspiration (ET). This occurred because of red fescue's lower water use rate. Deficit irrigation at 50 percent of maximum ET resulted in unacceptable quality of all four grasses.

Water use rates of two Kentucky bluegrasses, a perennial ryegrass, and red fescue were similar when measured during June through September of two growing seasons.[2] Water used by these grasses averaged from 0.13 to 0.14 inch per day. A sheep's fescue had the lowest water use rate of the grasses tested, averaging about 0.09 inch of water per day.

Turf managers may want to compare these findings with their everyday experiences and keep the water consumption rates of turfgrass species in mind when considering establishment of turf on areas with limited water supply. Also, use of grasses with low water consumption rates on certain areas may be useful in conserving limited water resources.

[1]Minner, D.D., and J.D. Butler. 1985. Cool-season turfgrass quality as related to evaporation. Agron. Abstr., American Society of Agronomy, Madison, WI. p. 119.

[2]Aronson, L.J., A.J. Gold, J.L. Cisar, and R.J. Hull. 1985. Water use and drought responses of cool-season turfgrasses. Agron. Abstr., American Society of Agronomy, Madison, WI. p. 113.

RW

Soil — that from which farmers and laundries make a living.

Potassium Release Probed

When soil dries out, changes in surface tension literally pull sheets of minerals apart to release more potassium, according to research by two University of Wisconsin soil scientists.

In their report, H. M. Kunishi and R. B. Corey explain some of the factors that determine how much potassium is released when soil is dried.

Soil seldom gets dry enough in the field to release potassium, but is important to soils men because it interferes with the testing of soil for available potassium. Drying, which is a normal part of soil testing procedures, makes it appear that certain soils have more available potassium than they actually contain in the field. Much of the soil potassium is held tightly in minerals such as mica, and is not available to plants until the mineral weathers and exposes the potassium ions.

Kunishi and Corey are seeking explanation as to why certain soils release potassium as they are dried. This might lead to methods of testing which would not overestimate the amount of this important plant food.

They reported how they used a wetting agent to decrease the surface tension in drying soil samples, and thus reduced the amount of potassium released into exchangeable form. While this is not practical for use in testing procedures, it definitely indicated the reason for the potassium being released by drying.

Their tests also showed several other factors which influence the amount of potassium released. The type of potassium-carrying mineral in the soil, and the size of these mineral particles is important, for example.

Small particles release proportionally more potassium because they have proportionally more edge area where the surface tension can exert splitting pressure. Micas and illites release much potassium, while vermiculite actually tends to tie up potassium which is already available in the soil solution.

The type of chemicals and their concentration in the mineral particles and soil solution also affect the amount of this nutrient released and so does the amount of drying which takes place, the research men concluded.

Reprinted: Wisconsin News

A Major Reason for Liming and Why We Use Nitrate Nitrogen for Early Growth

Reviewing this simple table for a moment impresses us with the reasons for liming acid soils for fertilizer efficiency. Also, it shows us why application of nitrate nitrogen gives early growth in late winter and early spring.

Effect on Soil PH and Temperature on Nitrification of Anhydrous Ammonia[1]

Temperature	Nitrate nitrogen produced in 2 weeks		
	Soil Reaction		
	pH 5.0	pH 6.2	pH 7.4
°F	lb.	lb.	lb.
45	0	0	0
60	4	25	70
70	80	110	450
80	90	230	480
90	60	110	380

[1] From data of L.R. Frederick as quoted by Andrews in Volume 8 of *Advances in Agronomy.*

Bumpy Greens

At several recent meetings, there were comments that annual bluegrass wrecked putting on an assortment of golf courses this spring. Greens with modest amounts of this weed "turfgrass" were as serious offenders as those with greater amounts. Scattered individual plants with a tuft of seedheads seemed to stand higher than bentgrass. The latter often grew very slowly because of low nitrogen availability and/or cold, dry weather. Recall that research publications and comments on nitrogen stimulation of greens suggest that starting fertilization about the end of April or May 1 deters seedheads and gives more even growth of the two species. Fertilization with largely quick-acting nitrogen at 1/2 to 3/4 lb. actual nitrogen per 1000 ft² is suggested to ease the condition.

REE

Improving Your Lies

The few imperfect lies a player may find provide the challenge that makes golf a fascinating game.

When a player starts a round, he is guaranteed 54 perfect lies. He can tee up on 18 tees, and presumably he will have 36 perfect lies on the greens. On only a minority of his shots, therefore, does he even run the risk of an imperfect lie.

The excuse that preferred lies spare the golf course is hardly valid. After all, when a player moves his ball from an imperfect piece of turf to a perfect piece, he will, in most cases, only dig up one more good piece of turf.

Gene Andersen
Autumn 1948 Issue of *USGA Journal*

A New Concept in Disease Control

The systemic fungicide fosetyl Al has no apparent effect on the healthy plant. When the plant is infected with a fungus, the fungicide triggers defense reactions of the plant. If this unique mechanism of fosetyl Al "Aliette" is successful in the field, it will be an added tool in the arsenal of fungicides. Also, this type of action might cause fewer resistant strains of disease organisms.

Bruce B. Clarke