UNDERSTANDING TURF MANAGEMENT
The ninth in a series by
R.W. Sheard, Ph.D., P.Ag.

PHOSPHORUS

During the past century more effort in research time and money has been expended on the study of the chemistry of phosphorus in the soil than any other element. The importance assigned to this plant nutrient reflects the generally low concentration that is normally found in the soil solution and the importance of the element in the nutrition of plants.

Why does grass need phosphorus?

Even though the concentration of phosphorus in the grass blade is generally in the range of 0.3 to 0.5 percent, one-eight that of nitrogen or potassium, it is still considered an essential major nutrient. It is essential for the transfer of energy derived from the sun by photosynthesis in the cells in the leaf to all other parts of the plant. The most actively growing portions of the plant, the meristematic region at the base of the leaf and the growing tip of the root, therefore contain the highest levels of phosphorus. Thus one realizes the importance of phosphorus in root development.

Phosphorus also tends to concentrate in seeds and on maturation of a plant the phosphorus will move from other parts of the plant to the seed as it is formed. Nevertheless the amount of phosphorus that can be stored in the small seed of bluegrass never meets the requirement of the rapid growth which occurs immediately following germination of the seed; thus the essential need for a relatively high level of phosphorus in the soil when a new stand is being established.

Phosphorus seldom influences the colour of turf unless there is extreme deficiency when a purplish tinge may be seen. Slow development of a newly seeded sports field or slow growth of a turf receiving adequate nitrogen may be a warning that phosphorus is deficient. Any suspicion of low phosphorus nutrition should be confirmed by soil or plant analysis.

Why the great concern?

Most soils generally contain less than **one ppm** of phosphorus in the soil solution at any time of measurement. If the rate at which this low level in the soil solution is replaced is too slow you have a deficiency problem and it becomes a rate limiting factor in turf growth. The low level is caused by the extremely low solubility of most phosphorus compounds in water - that is - how much phosphorus is dissolved in the soil solution.

The original mineral from which all phosphate fertilizers are manufacture - fluorapatite (tricalcium phosphate or rock phosphate) - is extremely insoluble (Table 1). The insolubility is further increased by a low level of fluoride in the rock phosphate, a similar concept to the use of fluoride to increase the strength of your tooth enamel. When very finely ground, rock phosphate can be considered a slow release phosphate source, but it is only effective in supplying phosphorus to turf on acid soils; soils of less than pH 5.0.

In the 1880's, two soil scientist, Lawes and Gilbert, at the Rothamstead experiment Station in England discovered that treating the rock phosphate with sulphuric acid greatly increased the solubility of the material (Table 1). The increase was due to the formation of monocalcium phosphate, the basic phosphate compound in ordinary (0-20-0) and triple (0-46-0) phosphates. Further manufacturing processes can produce calcium metaphoshate and ammonium phosphates which are essentially water soluble.

Regardless of the form of phosphate fertilizer added to the soil, the phosphate will slowly revert to an insoluble form through a process often referred to as phosphate fixation. The overriding factor controlling the process is the pH of the soil.

In the last article in this series it was mentioned that phosphorus was most soluble between pH 6.5 and pH 7.2. At a pH value more acid than 6.5 the concentration of aluminum, iron and manganese in the soil solution increases, all of which form insoluble compounds with phosphorus. At pH values greater than 7.2 there is an increase in the amount of calcium and magnesium in the soil solution; ions which also form insoluble compounds with phosphorus. Hence phosphorus added as a fertilizer tends to remain in a form which can recharge the soil solution most readily in this relatively narrow pH range between 6.5 and 7.2.

Table 1: The solubility of several phosphorus compounds.

Compound	Formula	Solubility in Water (ppm)
Monocalcium phosphate	$Ca(H_2PO_4)_2$	50,000
Dicalcium phosphate	$Ca H PO_4$	60
Tricalcium phosphate	$Ca_3(PO_4)_2$	1
Fluor-apatite	$[Ca_3(PO_4)_2]_3 CaF_2$	0.003

It should be understood, however, that the reversion to a completely insoluble form such as tricalcium phosphate is a multi-step chemical process which may take years for completion. In the first few months the initial compounds produced may be only slightly less soluble than the material added as a fertilizer. The greater the amount of these initial forms in the soil, the more rapidly the concentration of phosphorus in the soil solution can be recharged and the greater the fertility of the soil for grass.

Researchers have attempted to increase the efficiency of phosphate fertilizer use by cultivated crops by placing the fertilizer in band, proving a localized zone of higher phosphorus concentration. To a degree this practice is copied for turf managers in the suggestion that a high phosphate fertilizer should be surface-applied and worked into the top 2 cm. just prior to seeding a new stand.

Phosphorus and pollution

The chemistry of phosphate in soil, which is based on the formation of compounds of relatively low solubility, results in a very low concentration of phosphorus in the soil solution. Furthermore the formation of these compounds prevents any significant downward movement of phosphorus in the soil. Research at the Univ. of Guelph, using radioactive phosphate fertilizer applied in May, demonstrated that the phosphate had not migrated downward more than one cm by the end of the season (Table 2). Pollution by phosphorus in percolating ground water, therefore, seldom occurs.

Water pollution by phosphorus from land surfaces is primarily from the erosion of phosphorus-enriched soil particles into water systems. The number one system for the prevention of soil erosion is a bluegrass sod. Hence phosphorus pollution by surface flow from turf areas is also as close to zero as is feasibly possible.

Efficient phosphate use

A turf manager should be concerned most about the phosphorus levels in his soils at the time of establishment of a new stand. At that time phosphate applied at least at the rate recommended by a soil test is one of the best insurance moves he can make for the rapid establishment of a vigorous sod. This phosphorus should be worked into the top inch of soil during the final seed bed preparations.

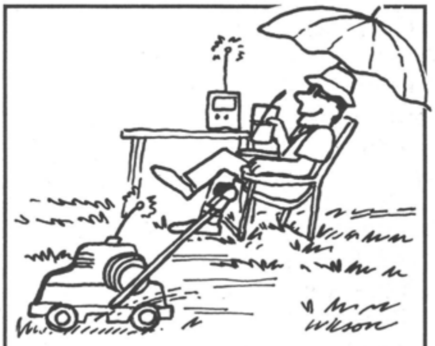
Subsequent phosphorus applications, of necessity, are applied to the soil surface. Furthermore clippings continually returned to the surface tend to concentrate the phosphorus at the surface. This is not a problem. Research using radioactive phosphorus to identify the source of the phosphorus found in the grass has shown that in one growing season up to 30% of a surface application of fertilizer phosphorus may be utilized by the grass plants. This percentage utilization is as high as that recorded for band applications for cultivated crops.

While phosphorus only needs to be applied once each season most turf fertilizers contain some phosphorus. The amount required for a full season may be estimated from a soil test. Since the fertilizer rates used are generally set by the amount of nitrogen required at any one application, a knowledge of the number of nitrogen applications planned for the year and the rate of material application should allow the calculation of the concentration of phosphorus required in the complete fertilizer.

Remember for established turf it is not necessary to include phosphorus every time you make a fertilizer application.

Table 2: The downward movement of fertilizer phosphorus in one season from a surface application on grass.

Depth of sampling (cm)	Concentration of applied fertilizer phosphorus (ppm)
0 - 1.5	275
1.5 - 3.0	41
3.0 - 4.5	11
4.5 - 6.0	3
6.0 - 7.5	1



Space Age Mowing

Thomas Noonan and partners John Fisher and Barry Bryant have won a U.S. patent for an automatic, self-propelled lawn mower that stores a map of terrain and a cutting route in its microprocessor.

"Basically, it can memorize a lawn and then reroute itself," Mr. Noonan, a salesman for Minnesota Mining & Manufacturing Co. in Havertown, PA., said of the mowing robot he and his partners call MOBOT.

The gas-powered mower relies on three navigation systems. First, the computer map tells it where to turn or slow down for a hill. Because mechanical problems, such as wheel slippage, can still knock it off its route, it adjusts its position by using sensors to detect metal markers or guide paths buried at intervals in the lawn.

If the mower cannot find its way, it shuts itself off. Ultrasonic sensors also tell the mower to shut down if there is an obstacle in its path. An alarm would alert the mower's owner to put down the ice tea and check out the problem.

(reprinted from the Globe & Mail June 9, 1993)

University of Guelph
Puts Compost to Use on Turf

by Mike Bladon,
Superintendent of Grounds, U. of G.

The Ontario Agricultural College and the Ontario Veterinary College at the University of Guelph generate large amounts of animal wastes. In the ages past this material was utilized on adjacent farm land but today the University is surrounded by urban development. It became economical to dispose of the wastes in the municipal land fill site but in 1982 the city refused to continue the practice.

Prof. Jack Pos of the Engineering Department designed an 'in vessel' high-speed aerobic composter to process the waste. The unit is 110 feet long and 16 feet wide. A flail mechanism of farm cultivator teeth attached to 3-foot pieces of flat steel slowly moves along parallel railway lines mounted 4 feet above the base. The flail mechanism makes one pass in one direction only over the bed of composting material each day. This propels the material slowly toward the exit which takes approximately 10 days from the time the waste is dropped at the entrance. An elevator system deposits the material on a concrete pad or loads the material directly into a truck. Additional aeration is obtained by forcing air through 6-inch pipes located below the base.

No objectional aroma is noticeable from the facility which is located near several academic buildings. Aroma is also not detected when the material is used in the grounds maintenance on the campus.

Approximately 5,000 tonnes of material are fed into the composter each year, generating 2,500 tonnes of useable material. Chemical analysis is performed every six months. The material has a fairly constant C:N ratio of 30:1, which makes it ideal for our uses.

We use the finished compost as a mulch, as a soil additive and as a topdressing material for our 30 acres of athletic fields. These include space for football, lacrosse, field hockey, soccer, rugger and baseball. There is intramural schedules, inter university schedules and a yearly six-week practice session by the Toronto Argonauts.

The application to our fields is made using a commercial, high capacity top dresser which does a superior job of uniform application and is much preferred to the manure spreader we originally employed. In 1982 we replaced our program of topdressing with a soil mix with the compost.

To date our results have been:

1) We do not have the thatch problems we had prior to the start of this program. We only dethatch about every three years.
2) Each year we core cultivate with removal of the plugs, overseed and then topdress. This procedure gives us a good seedbed.
3) The topdressing and core cultivation program has provided a more resilient surface for the athlete.

4) We do not require as much fertilizer as before. We now only fertilize twice each year.
5) Drainage and infiltration of water has improved since we began the program.
6) Due to the heat generated in the composter weed seeds are killed and have not been a problem on our fields.
7) The compost is very fine and filters down through the leaf blades. We have not had to screen the material before use.

Some other observations we have made in the use of the material may be of interest to the reader.

We have found the material will cause foliar burn of the turf if used fresh from the composter. Thus our topdressing program involves material which has been stored for a few months.

The material is applied at a rate of 1/2 inch, so 146 -160 cubic yards are required for an average field. The material is light and easy to handle, except after heavy rains. There is no problem with the topdresser applying the wet material.

In order to maintain the temperature of 55 C for microbial activity in the winter months we have to insulate the walls of the composter with processed compost to prevent freezing on the inside of the cement walls.

Although the manure bins are clearly marked, plastic garbage bags and other foreign material still find their way into the system and must be removed manually.

In conclusion we are pleased with the material as a topdressing material. In addition we are utilizing a material which a decade ago was treated as a waste.

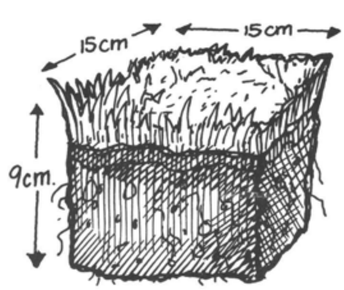
HOW TO Submit A Turf Sample For Disease Identification

by
Pam Charbonneau
OMAF Turf Extension Specialist

Often disease problems are difficult to diagnose in the field and we must rely on specialized equipment and techniques that can only be performed in a diagnostics laboratory. If this is the case for you, then the following guidelines will help you with disease sample collection and sample submission.

Collection of Samples

Samples for disease diagnosis should be taken when the disease is active. Samples should be taken from an area which is representative of the diseased area on the edge between healthy and diseased turf. A sample should be taken before fungicide treatments are made. The sample should be roughly 15 cm square and 9 cm deep, including thatch and soil. It is not necessary to include several cm of soil with the sample. Samples taken with a soil probe are not large enough to diagnose. Another good way to take a sample is with a golf course cup changer.



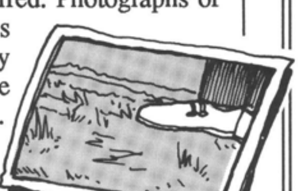
Preparation of the Sample for Shipping

Samples should be wrapped in a newspaper or paper towel to prevent them from drying out. Never add water to a sample as this will encourage rot. **For the same reason samples should not be shipped in a plastic bag.** The wrapped sample should be placed in a sturdy box.

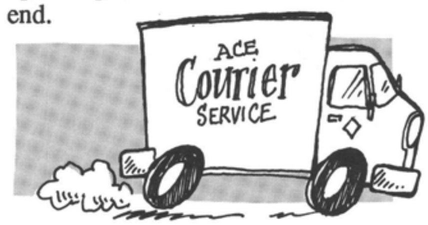
Sample Submission

The person in the diagnostic laboratory has not been lucky enough to observe the disease symptoms in the field. Because of this it is essential that the following information accompany the sample:

1) the grass species affected,
2) the extent of the damage,
3) a complete, accurate description of the symptoms,
4) date the symptoms first appeared,
5) the cultural practices used on the affected area - i.e., fertility, pesticide applications, etc.,and
6) weather conditions before the damage occurred. Photographs of the symptoms can be very useful for the diagnostician.



To insure that the disease sample reaches the clinic in good condition the sample should be couriered or delivered personally. Try to avoid sending samples on Friday as they may end up sitting undelivered over the weekend.



The address to direct the sample to is:

OMAF Pest Diagnostic Clinic,
Agriculture and Food Laboratory Services Centre,
P.O. Box 3650,
95 Stone Road W., Zone 2,
Guelph, ON.
N1H 8J7
(519) 767-6256

Video tapes on Turf Management

by the University of Guelph
& The Sports Turf Association

- Tape 1: Grass Selection
- Tape 2: Cultural Practices
- Tape 3: Weed Control
  (Running time averages approx. 10 minutes per tape)

- available in 8 mm and VHS format (please specify)
- $35.00 each
- STA members receive a 20% discount in price if the tapes are ordered through the Sports Turf Office:

328 Victoria Rd. S. (R.R. 2)
Guelph, Ont. N1H 6H8
Phone (519) 763-9431
FAX (519) 766-1704

For further information regarding these and other tapes in horticulture and agriculture, contact:
Independent Study, University of Guelph, Guelph, Ontario N1G 2W1
(519) 767-5050, Ext. 3375
FAX (519) 824-9813

GTI RESEARCH HILITES

The 1992 GTI Research Report contains some data obtained by Dr. R.E. Pitblado of the Ridgetown College of Agricultural Technology which may be of interest to sports field managers.

The data concerns the rate at which various cultivars of Kentucky bluegrass, turf-type tall fescue and perennial ryegrass establish ground cover. The rate is of particular concern where a turf manager is overseeding or repairing a worn area on a sports field.

Seeding of the plots occurred on August 26, 1992. Rainfall conditions were ideal with a shower within 24 hours and frequent showers throughout the test period. No supplemental irrigation was used. The seeding rate was 4, 8, and 5 lb/1000 ft^2 for the Kentucky bluegrass, tall fescue and perennial ryegrass respectively. Fertilizer was applied at 0.5 lb N/1000 ft^2 as 6-24-24 prior to seeding and again one month after seeding as 1 lb N/1000 ft^2 as SCU-based 25-4-10.

An visual evaluation of the ground cover was made 10, 13, 30 and 60 days after seeding.

Of the three species, Kentucky bluegrass was the slowest to emerge with no visible germination in 10 days (Table 1). Significant differences existed between cultivars with a 3.5 point difference between the best and the poorest cultivars at 60 days.

Tall fescue was intermediate between bluegrass and ryegrass in emergence and also showed significant differences between cultivars in ground cover after 60 days (Table 2). The spread in cover rating between the best and poorest cultivars was similar to bluegrass.

As expected, the most rapid emergence and ground cover completion was obtained with the perennial ryegrass cultivars (Table 3). Essentially complete ground cover was achieved in 30 days with all the ryegrass cultivars. Nevertheless, in the first 13 days there were significant differences between the cultivars.

In many repair situations it is important to rapidly establish a turf cover.

Table 1: Ground coverage by Kentucky blue grass following an August 26, 1992 seeding.

Cultivar	13 days	30 days	60 days
	(Rating: 0 = no growth, 10 = full coverage)		
CYPRESS (Poa trivialis)	4.3	8.9	10.0
EAGLETON 1425	2.8	6.8	7.8
BANFF	2.0	6.8	8.3
LIBERTY	2.3	6.0	7.5
GEORGETOWN	1.1	6.5	7.8
WELCOME	1.1	6.6	7.5
HAGA	1.4	6.0	7.5
PRINCETON	1.1	6.1	7.0
CYNTHIA	1.2	6.0	7.0
NUSTAR	1.0	6.0	6.8
CREST	1.4	5.5	6.5
TOUCHDOWN	1.1	5.3	6.8
BRONCO	1.5	5.3	6.5
LIMOUSINE	1.0	5.5	6.5
BARON	0.7	5.8	6.5
NUBLUE	0.8	5.3	6.5
SUPTRNOVA (Poa supina)	0.9	4.8	7.0
ECLIPSE	0.6	5.3	6.5
OPAL	1.0	5.3	6.0
INDIGO	0.9	5.0	6.3
BARZAN	0.9	4.8	6.3
CHATEAU	0.6	5.5	5.8
NASSAU	0.6	5.0	6.3
GNOME	1.3	4.5	6.0
SYDSPORT	0.7	3.8	6.0
MIDNIGHT	0.6	2.8	4.3

Table 2: Ground coverage by tall fescue following an August 26, 1992 seeding.

Cultivar	10 days	13 days	30 days	60 days
	(Rating: 0 = no growth, 10 = full coverage)			
REBEL II	3.3	6.0	8.8	10.0
JAGUAR II	2.0	5.3	8.3	9.8
DIXIE	2.3	4.5	7.9	8.5
TRIBUTE	1.8	4.8	7.8	9.8
CROSSFIRE	2.0	4.5	8.0	9.5
SHORTSTOP	2.5	4.5	7.8	8.8
SHENANDOAH	1.1	4.5	7.8	9.3
REBEL 3D	1.9	4.3	7.6	8.8
MUSTANG	1.4	4.3	7.4	8.5
MINI MUSTANG	1.5	4.0	7.5	8.3
CREWCUT	0.6	3.0	6.5	7.8
VEGAS	0.4	2.8	6.5	7.8
TWILIGHT	0.4	2.8	6.5	7.3
BONSAI	0.6	2.8	6.3	6.5

Perennial ryegrass is the obvious choice, followed by tall fescue and finally bluegrass. While this fact has been well documented previously, the turf manager should be aware there are also differences between cultivars within each species and use this data in making his selection of which cultivar to purchase.

Table 3: Ground coverage by perennial ryegrass following an August 26, 1992 seeding.

Cultivar	10 days	13 days	30 days	60 days
	(Rating: 0 = no growth, 10 = full coverage)			
EDGE	5.1	8.3	9.5	10.0
SR 4000	4.9	8.0	9.5	10.0
PALMER	4.5	8.0	9.5	10.0
YORKTOWN III	4.5	7.8	9.5	10.0
ENVY	4.8	7.5	9.5	10.0
COMPETITOR	4.3	7.8	9.5	10.0
OMEGA II	4.8	7.0	9.5	10.0
SATURN	4.8	6.8	9.5	10.0
EXPRESS	4.5	7.9	9.5	10.0
LOWGROW	3.8	7.5	9.5	10.0
SR 4100	4.3	7.0	9.5	10.0
SR 4200	3.8	7.3	9.5	10.0
DELAWARE DWARF	4.0	7.0	9.5	10.0
DIMENSION	3.3	5.5	9.5	10.0
PINNICALE	3.0	5.8	9.5	10.0
GATOR	2.5	5.3	9.5	10.0

Revised OMAF Publication 384 Available

The revised OMAF Publication 384, Recommendations for Turfgrass Management is now available. This publication contains valuable information on turfgrass management including weed, insect and disease control as well as fertilizer recommendations. This publication can be obtained at no charge from your local OMAF county office, through the OMAF Information Centre, 801 Bay St., Toronto, ON. M7A 2B2 or through the Guelph Turfgrass Institute.

IN MEMORIAM

Many members will be saddened to learn of the death of Dr. Steve Fushtey at Agassiz, B.C. Steve shared his wealth of knowledge on plant nematology, plant pathology and turfgrass diseases with turf managers across Canada. During his career he was associated with the Faculty of the Univ. of Guelph from 1954 to 1980 and then with Agriculture Canada at Agassiz as a Research Scientist until 1987. Since retirement he worked with the Western Turfgrass Association, acted as Agronomist for the Royal Canadian Golf Association, and served on the Advisory Committee for the Fairview College Turfgrass Management Program. All aspects of the industry will miss this active turf researcher and advisor.

CLIPPINGS

New York State is reported to have 635,000 acres of home lawns, 80,000 acres of park land in turf, and 27,000 acres of cemeteries in addition to an unrecorded acreage in golf courses, highway medians, college and school campuses.

Early records show bluegrass was know in ancient Greece where it was called Poa. The scientific name for Kentucky bluegrass - Poa pratensis - may be translated as "Poa of the meadow".

The first turf experiments were started in the United States by J.B. Olcott at Manchester, Connecticut in 1885. He investigated species suited for turf use and selected bent grasses (Agrostis spp.) and fescues (Festuca spp.). Five years later similar work began at the Univ. of Rhode Island.

Establishing Bowling Green Levels

- A HI-TECH OPTION

Roy Benseman
Greens Superintendent
Tarawhiti Bowling Club
Wellington, N.Z.

The need for level greens is obvious. And the essential first step towards getting a level green is to survey the surface and measure relative heights using a convenient grid. From here on it is just hard work, but at least you know where you are going.

To measure these levels there is a dazzling array of equipment on offer - theodolites, dumpy levels, laser beams, computerized work stations and so on. All are specialized techniques requiring skilled operators. You may be interested in a method we use at our club. It is simple, cheap, almost idiot-proof, and will give results that are at least as accurate as any other.

What you need:

- A small table, a large bucket of water and a brick.
- 30 meters of clear polythene tubing - 9 mm bore is fine.
- A stick about two meters long, and a meter rule.
- 40 meters of fishing line and two pegs.
- A pencil, paper and some masking tape.
- Two club members - one with reasonable eyesight.

You may dispense with the table if you are willing to lie down on the green to make each measurement. And you **may** use a small bucket of water if you are prepared to see it tipped over at some critical moment by some ham-fisted helper.

Preparation:

Take your fishing line and, using the two pegs to anchor it, stretch it across the green from ditch to ditch. Now tear off short strips of masking tape and wrap them around the line at whatever intervals you think appropriate, and pencil on each some identifying mark. In our case (33.5 m green) our first measuring point is 300 mm in from the profile - we don't consider anything nearer the edge of the green to be significant. This bit of tape is marked "0". At the other end, and again 300 mm from the ditch, we mark the last point "20". Nineteen other bits of tape are stuck evenly along the line and are marked 1 to 19 - this works out as just under two meters between grid points.

You're now ready to start.

Step 1: Stretch your line along the North profile and mark your grid intervals with chalk on the woodwork. Now do the same at the South end. Mark them 0 to 20 from West to East.

Step 2: Now stretch the line from North to South with the "0" profile marks at each end. The first 21 points of measurement now await your expert attention.

Step 3: Put the table in the middle of the green with the bucket of water on top - mix in a teaspoon of detergent to cut down on surface tension. Tie the brick to one end of the polythene tube and drop it in the bucket. Take the other end of the tube and walk briskly to the ditch. Suck hard on the tube until water starts to syphon from the bucket, and drop the end in the ditch and leave it syphoning until you are **absolutely sure** there are no air bubbles left in the tube.

Step 4: Pick up your stick, put one end on the green somewhere, hold it upright and tape the tube to it. Unless you have a **very** high table you will find that the water level will settle somewhere around eye level. If it's too low for comfortable reading jack up the table or put more water in the bucket.

Step 5: Tape your meter rule on the stick so that the water level is somewhere about the middle of the rule - for clarity in this description let's put the 0 mm end at the top. It doesn't really matter which way it goes as long as you remember which way is up. But it is **vital** that the rule is firmly fixed on the stick - any slippage will be immediately reflected in your measurements.

Step 6: Find somewhere on the profile which looks solid. It is going to be your "reference mark". It is your insurance against things like a bubble in the system, a leaking bucket, or a table sinking 50 mm into the green. You should check it about every 40 measurements.

Step 7: Place your measuring stick on the reference mark, hold it vertical (it has to be badly off vertical to make a really significant difference to your readings), and note the reading on the meter rule. Let's say you get 746 mm.

Step 8: Go to the grid point (0.0) and repeat the process. You now record 761 mm. You deduce from this that the (0.0) is 15 mm **higher** than your reference point. Think about it.

Step 9: Now do the whole green, shifting the line progressively across the green, and referring regularly to the reference point. Repeated readings should be within 2 mm of the mean.

With a little experience two people can complete the whole process in about three hours. One measures, the other records.

How to Present and Use the Data:

Initially we had a computer program that gobbled the numbers and spat out information like how much soil would be needed to fill the low spots to any selected level, the thickness of packers needed at each grid point for wires, etc., etc., It was all good fun but pretty much a waste of time.

What we do now can be easily done by simple arithmetic. Set up the grid on a piece of paper, find the lowest reading on the green surface, and subtract this number from all the measured points. You now have a pattern showing the height of each grid point relative to the lowest point on the green. This will quickly show you where your high areas are, or you can draw contours if that helps. How you interpret your information , and what you do about it is up to you.

A program of getting our greens level was started three years ago. Initial measurements showed deviations of up to 35 mm on the playing surface, and 50 mm in some corner areas. Now that levels are getting better we currently use a philosophy that goes something like this: "Any grid point that is within 9 mm of the lowest point on the green is near enough - a long screed will look after these minor imperfections. The place to watch and work on are the remaining high areas." So, any level from 0 to 9 is marked as "0". All others are reduced by 9 - these are the high spots on the green and during winter renovations we double-drill these ares and apply a minimum of topdressing. It makes only a small correction, but always in the right direction. Figure 1 shows one of our greens prior to renovation this year. Note the ridge running east/west on grid lines 15 and 16, and another one running north/south on grid line 15. Except in the extreme corners, none of the deviations are too serious. The green played well last season and it will be interesting to see to what extent we have managed to correct these deviations. It will be checked some time in October.

NORTH

0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0	5	6	0	0	1	0	0	1	1	1	1	0	0	1	3	0	0	0	0	1	10
1	2	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	2
2	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	1	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
5	4	2	1	0	0	0	0	0	0	1	1	3	1	0	0	0	0	0	0	0	0
6	4	0	0	0	0	0	0	0	0	1	1	1	2	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	1	2	1	2	1	0	0	1	0	0	0	0	0
8	0	0	0	0	0	0	0	0	2	2	0	1	0	1	0	2	0	0	0	0	0
9	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
10	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
15	0	0	0	0	2	5	1	0	2	2	0	1	4	1	0	0	0	0	0	0	0
16	0	0	0	0	4	7	2	0	1	1	0	1	4	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	1	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	12	3	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	3

SOUTH

Figure 1: The Elevation Grid (mm) on the # 1 Green of the Tarawhiti Bowling Club, Wellington, N.Z., Feb. 1992.

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TURF HEIGHT - "Now You See It — Now You Don't"

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As we travel through the East Coast and Mid-Atlantic States diagnosing problems with athletic fields, we are repeatedly confronted with an age old problem — cool season turf grasses suffering from excessively low cutting heights.

For the purpose of this article we shall construe cool season turfgrass species to be predominately Kentucky bluegrass, improved varieties of turf-type ryegrass, and improved varieties of tall fescue. Our reference to excessively low cutting height would be turf grasses that are cut to a height of one (1) inch or less. The title "Now You See It — Now You Don't" refers to our experience with seeing fields with thick and hearty stands of turfgrass in the spring and summer which turn into badly worn and poorly performing fields after only a few games in the fall.

In an attempt to come to grips with the dilemma, we tried to determine why the phenomenon was so widespread and what, if anything , we could do to combat the problem. Height of mowing was noted to be a common problem associated with this condition.

We spoke to many sports turf managers and grounds keepers covering all levels of competition, i.e., professional, colleges, universities, public schools and municipal facilities. We wanted to know what rationale existed for mowing turfgrass at a height of an inch or lower and if they thought maintaining this height was best for the survival of the turf.

Our assumption was that this low height reduced the impact absorption qualities of the turf, reduced the shear or traction qualities, increased compaction ratios, and vastly decreased the wear tolerance and recovery time after competition. In addition, associated with low mowing was a significant reduction in the turfgrass root system. We are pleased to report that none disagreed with these assumptions. All agreed that they would prefer to have the turf maintained at higher levels, but there was little agreement as to the ideal or proper height.

This controversial situation led us to an attempt to determine if there were any standards imposed by formal sanctioning agencies or leagues as regards turf height or the overall quality of a playing field to be determined acceptable for athletic competition. While we were not surprised by our finding, it is lamentable to report that no such standards exist.

Athletic field maintenance and preparation for games is largely guided by an apprenticeship of folklore with most respondents suggesting that it was the coaches who wanted the grass cut "as low as we can get it" and they indicated that all other levels of administration or governance support the coaches position.

Our interest then turned to the coaches in an attempt to determine their reasoning for seeking the lowest cutting heights achievable.

The overwhelming attitude of the coaches was that a higher cut turf would somehow impede the speed of the athletes, (especially fast backs in football) and thus the outcome of the contest. Soccer and field hockey coaches were inordinately concerned with "ball roll" and this is understandable. It was also clear in our observations of many soccer and hockey fields that they would have been better off with a slightly higher turf height, with a thicker and more uniform stand. Clumpiness tended to occur on low cut fields when the grass dissipated due to inability to recover after play. This condition became more pronounced when fields were used in very wet weather after the recovery ability had already been weakened.

It appeared our task was clear; — study the literature to find research to