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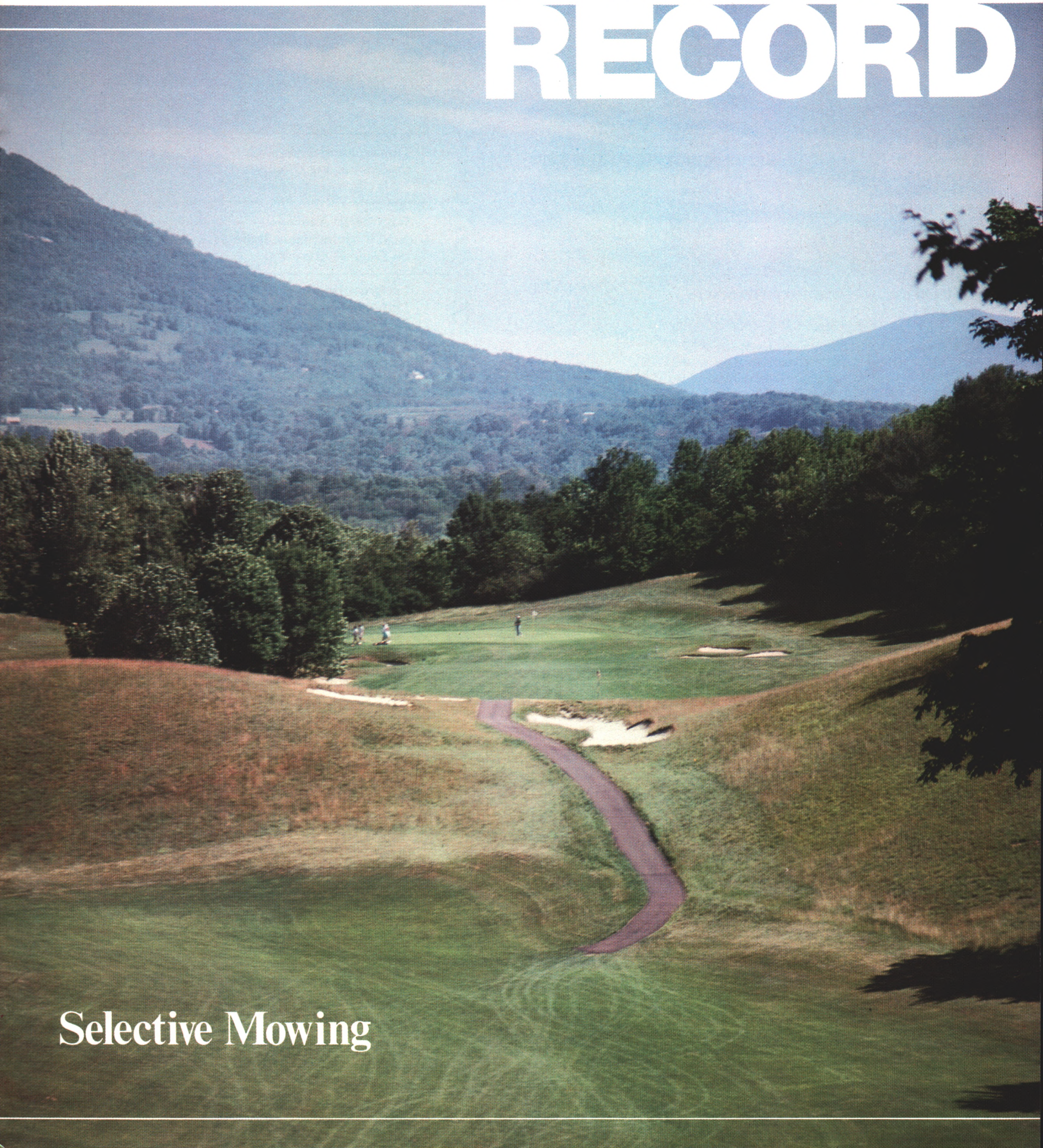

Selective Mowing

USGA

UNITED STATES GOLF ASSOCIATION ★ ORGANIZED 1894 ★

Green Section RECORD

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Cover Photo:

Seventh hole, Ekwanok Country Club, Vermont, from the tee. Unmowed hill adds to the challenge of the tee shot and saves on equipment and labor.

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A low degree of maintenance is placed on difficult to mow, out of the way places. The 15th hole, Brandermill Country Club, Virginia.

The Economy and Course Playing Quality

by WILLIAM G. BUCHANAN
Director, Mid-Atlantic Region, USGA Green Section

THE PINCH OF inflation and the talk of recession always have an adverse effect on golf clubs. The budget and course economy then become of more concern to members and to the people who earn their living with golf, such as the golf course superintendent, the golf professional, and the club manager. Because of member demands, those who are employed by golf clubs must be involved in decisions concerning budget tightening. These decisions are not easily made, but each department head can certainly find areas that can be streamlined to effect savings in the overall budget. Changes may be minor because saving a little in several areas may be more palatable to the membership than trying to make a sizeable saving in one specific area.

Cutbacks are painful. Members grow accustomed to certain standards and expect those standards to be maintained. Although inflation has affected the member's home life, it seems inconceivable to him that "the club" could suffer in the same way. If "the club" needs more money or needs to cut back, surely it is because it is mismanaged, and not because of an inflation rate of 18 percent.

Food quality, service, and attractive interior furnishings are the main attractions of the clubhouse. The old furnishings, carpeting, and china can be kept attractive and clean without having to be replaced whenever some influential house committee member decides it should be replaced. A somewhat similar situation occurs in the golf course maintenance operation. Machines break down, parts become worn and need repair. That is a job for a specialist, a trained mechanic who can repair a broken item. A person who calls himself a mechanic will simply replace the broken item. He is a parts changer, not a mechanic, and the cost differential is substantial. Clubhouse repairs usually work the same way. A good mechanic

Contour mowing of fairways can reduce acreage requiring frequent mowing while adding character to the hole. The first hole, Mountain Ridge Country Club, New Jersey.

or repairman is essential to club economy.

When *club* cutbacks are dictated, the golf course maintenance budget is the first to be examined. This is puzzling if one takes the time to note that the golf course maintenance budget comprises 10 to 15 percent of the entire club operation. The golf course, at the majority of the clubs, is the prime attraction for the members. People can join dinner and social clubs for dining and socializing, they can join any number of swim or racquet clubs if they want to swim or play tennis, but there are only a few places they can join to play golf. How many situations do you know of where the dining facilities were built before the golf course? How many swim or tennis clubs do you know of that have added a golf course to their facilities because of membership demands? I would guess very few, if any. The point is, plenty of areas in a club's operation can be streamlined before cuts are made on the golf course. The course maintenance budget should be the last to be examined — not the first.

Although the golf course operation requires a significant amount of money to maintain a good playing surface, some clubs could definitely economize if they would place more emphasis on maintaining a quality playing surface as opposed to a vast expanse of manicured acreage that is better to look at than to play over.

TO PUT GOLF course maintenance in proper perspective, one need not look very thoroughly into records of the past 60 years to realize that maintenance of the playing surface has greatly intensified. Imagine playing today on areas maintained with a sickle bar mower, equipment drawn by horses, and playing on courses without the improved strains of grasses. Going even further back, in July, 1776, when each club wrote its own Rules, Rule 12 at the Royal Burgess Golfing Society, in Edinburgh, Scotland, reads as follows: "When your ball comes within four or five club lengths from the hole to which you are playing, you must not mark, or cause to be marked, the direction of the hole, nor must any person whatever stand at the hole to point it out or to do any other thing to assist you in playing." If you couldn't see the hole when you were within five club-lengths of it, playing conditions must have been tough!

Golf course management, with the help of the USGA Green Section agronomists and the USGA's sponsorship of golf course oriented research projects, has made tremendous strides in improving technical knowledge of the playing surface. These efforts must be continued, and more effort needs to be made on *conditioning* a golf playing surface rather than *manicuring* an area loosely defined as a golf course. Money can be saved when this distinction is drawn.

Maintaining a quality playing surface requires a substantial expenditure. Certain procedures must be followed. The greens, tees, fairways and roughs have to be mowed frequently. Basic maintenance procedures have to be followed. Greens, tees, and fairways should be aerated each year, some areas more frequently than others. Equipment must be maintained and repaired, for the golf course cannot be maintained in even the crudest form without equipment. There are no shortcuts!

THE MOST CRITICAL of all the playing areas is the putting surface. No matter how much the economic situation dictates cutbacks or control, the putting surfaces are not the places to save money. In a regulation round, the putting surfaces will provide the area for about half of a player's strokes. The putting surface actually participates more since it is the target area for approach shots and therefore comes into play for approximately 75 percent of the strokes played in a regulation round of golf. Therefore, since approximately 50 percent of the strokes are used for putting and approximately 25 percent of the shots are approach shots, it is essential that the green be conditioned as a putting surface, not merely as a landing area for approach shots.

Putting surfaces generally occupy two to four acres of area on an 18-hole golf course. When they are well conditioned to provide a quality playing surface, greens can be largely responsible for the reputation of any course. A putting surface that is firm and provides a keen, close-cropped sward of grass and a free, true ball roll can justify a reasonable amount of money being spent.

To achieve quality putting surfaces, some of the procedures are:

1. **A close height of cut.** To ensure a close height of cut, championship or thin bedknives are necessary on greens mowers. These bedknives do not last as long as the thicker, regular bedknives. Because more frequent replacement is necessary, the use of thin bedknives is costlier than regular bedknives.
2. **Frequent mowing is necessary.** Fortunately, because of the relatively small area involved, mowing is not expensive. Roughly three gallons of fuel and six man-hours are involved with each mowing. This time varies with the use of single or triplex mowing units. Daily mowing will provide the best playing surfaces. Although more expensive, alternating between walking single units and triplex units can be done. Many times walkers are used on weekdays while triplex mowers are used on weekends and, especially, in spring and fall when labor is in short supply.
3. **Vertical mowing** is essential in controlling grain and thatch accumulation on the putting surfaces. Light, frequent vertical mowings are advised. The triplex greens mower is an example of a multi-purpose machine when it is converted to a vertical mower. It reduces substantially the time required to vertical mow. Most courses can verti-cut greens in approximately the same time the greens can be mowed. If the triplex machine is used exclusively to mow the greens, then the light vertical mowing should be done at least biweekly.
4. **Topdressing** costs money! Buying the material or mixing your own and stockpiling it to age, or using a sand material with no topsoil or organic matter additive is expensive. The availability and cost of these materials will vary with location, supply and demand, and shipping costs.

   Topdressing is a critical operation in making a quality putting surface. A program of light, frequent topdressings can improve an already good putting surface. Many course superintendents use a program of applying a light dusting of material on greens every three weeks during the spring and fall, with great success. Some extend the program well into the summer, if weather permits.

   This program is not expensive, because the same amount of material can be used lightly five to six times or twice a year applied more heavily. The real expense comes in labor — having the proper equipment to apply the material, buying extra bedknives which wear rather quickly when frequent topdressings are applied, and the time spent by the mechanic in backlapping the mowing units to keep them sharp. A program of this nature can only be carried out if the topdressing material can be kept dry. This may require a new shelter for storing the topdressing material. The shed need not be extravagant; just good enough to protect the material from the weather.
5. **Aeration.** The main expense in aeration is time and labor. This is a necessary expenditure. The only time aeration becomes extremely expensive is when it is *not* done. By neglecting to aerate on certain soils, conditions could deteriorate to the

Mowing and spraying greens simultaneously. Regular spray equipment used with extra-long hose. Pine Needles Country Club, North Carolina.

point where it is impossible to grow a healthy plant. When plants are not healthy and strong, more chemicals and more labor are required to maintain the grasses.

6. **Chemicals are necessary** for healthy plant grass growth, but their overuse can be expensive and detrimental to a good playing surface. In my opinion, many golf courses depend too much on chemicals. Some turf managers have begun to believe in them as cure-alls for their problems, and they overlook the basic operations listed above. Preemergent crabgrass control programs are a case in point. People become so concerned with the potential problem that they forget that the main objective is to provide a quality playing surface. Because they fear crabgrass, they neglect aeration. Long before preemergent weed controls were available, turfgrass specialists knew that the best approach to weed control is to grow healthy turf.

   The preemergent dilemma has become worse because some of these materials also control *Poa annua*. Therefore, when late summer preemerge applications are made to stop *Poa annua* germination in the fall, the fall aeration and overseeding is cancelled and two more important basic operations are omitted. The overuse of chemicals is wasteful and costly. Pre-emerge herbicides reportedly shorten the root system of permanent grasses, thereby making the area more susceptible to weed invasion. Preemergence weed control chemicals may cost clubs more than the prices indicate.

   Fungicides are necessary on putting surfaces, and the cost of a sound, efficient fungicide program is well worth the investment. This item should not be cut to the point where only a curative program can be followed.

7. **Fertilizer and water.** These items have been placed together for a very important reason. They are both essential to planned plant growth. For a quality putting surface, apply only enough fertilizer to provide a growth rate of the grass to keep apace of the traffic imposed upon it. Only enough water is necessary to keep the grass alive — any more is a waste of money.

   Improper use of water and fertilizer is mostly responsible for the decline of playing surfaces in the past 20 years. Clubs that believe in the philosophies that "dark green is good" or "the greens must be soft enough to hold a shot upon impact" are the clubs that could quite possibly realize a substantial saving in greens maintenance by reevaluating their priorities. Should greens be beautiful in color but mediocre in playing quality or merely good-looking and of very good playing quality? If cutbacks are necessary, costs can be cut on portions of the golf course other than the putting surface. The areas "through the green" and "hazards," as the Rules of Golf define them, bear close examination. The area of the course that is second to the putting surface on the priority list would be the fairway. Fairway grasses should be closely mowed, lightly fed, and sparingly watered.

SOME CLUBS, in an economy move, are greatly reducing the fungicide program on fairways. They apply curative rather than preventive fungicides, the rationale being that it is less expensive in the long run to overseed severely damaged areas in the fall than to treat regularly with fungicides during the year. One club dropped a $25,000 fungicide program in favor of a $6,000 seed bill. This, however, is not recommended. Studied fungicide applications are necessary in a well-rounded management program.

Mowing large expanses of fairways can be very costly over a season. It is possible that savings can be made by checking with widths of your fairways. In my view, a landing area over 40 yards wide is generous, but there is little reason for the entire fairway to be this wide. The landing areas for the high-handicap players could be this wide, but fairways in the 225- to 275-yard range could be narrowed so the low-handicap golfers have to work to better control their shots. Fairways may also be narrowed at the greens, and the rough can be brought in tighter around the greens. By eliminating areas presently mowed as fairway, savings can be realized in fuel, labor, seed, fertilizer, irrigation, and equipment. The fairway acreage reduction can be significant and the mowing requirement reduced when areas are mowed as rough once a week or less as opposed to being mowed three to five times a week, if they are maintained as fairways.

In some cases, roughs can be maintained at a slightly higher height of cut and mowed as needed. Several clubs report savings when out-of-play areas and areas that rarely come into play have been completely removed from the maintenance schedule.

TEES ARE THE next priority item. They should be firm, level, and closely mowed. Other than that, they can be treated much the same as fairways. The frequency of mowing and height of cut will be the most noticed items on the teeing area. Fungicides and herbicides are good programs if budget is adequate, but overseeding and moderate amounts of fertilizer and water should be budgeted annually.

Bunker manicuring is a tremendous expense at some courses. This is a development in the last two decades that came along at the same time as the "grass must be a dark, lush green to be good" philosophy. Many man-hours have reportedly been saved on bunker management by allowing the grass around the bunker to grow to rough height, by creating and maintaining a lip as a result of moving sand down and away from the bunker edge as opposed to frequent mechanical edging. Reducing the raking schedule of bunkers to once a week can help save money. Consider placing the burden of maintaining the bunkers on the players. By reducing required maintenance in bunkers, savings could be significant. Complaints about not having a perfect lie in the sand should not carry much weight if the club is pressed into cutting maintenance costs.

Off the playing surface, a tremendous saving can be realized by purchasing good, reliable, multi-purpose equipment that can save labor. Good equipment requires good care. A well-paid, well-trained mechanic who operates with a good repair parts inventory can help save money for the maintenance budget.

GOLF COURSES are notorious for using part-time or seasonal help. This is false economy because the golf course superintendent is forced to hire and retrain new workers annually. It takes several months to train a worker. Worker pride can save the club a considerable amount of money. Pride stems from permanent employment.

The economy no doubt has had its effect on golf course budgets. All phases of the club's operations are being scrutinized very carefully. For the sake of the game of golf, we can only hope that the flowers and extra manicuring will go before the playing conditions are sacrificed.

A view of the new maintenance building. Tall trees screen maintenance area from golfer's view.

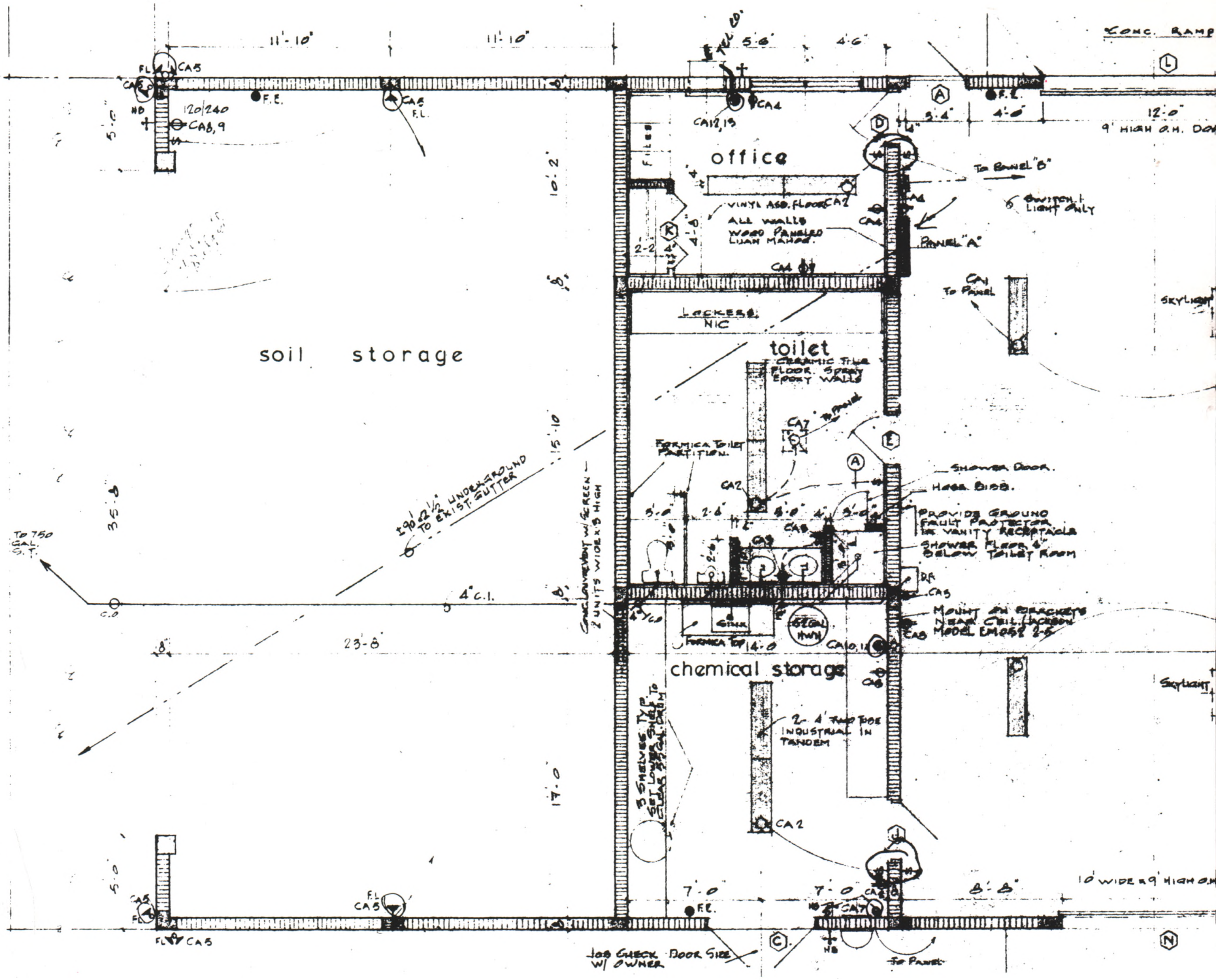
With Perseverance - A New Maintenance Building

by LOUIS F. OXENVAD, Certified Golf Course Superintendent,
High Ridge Country Club, Boynton Beach, Florida

TREMENDOUS STRIDES have been made in the golf course superintendent's profession since the days when the old tin building called "the barn" was stuck back in the woods, out of sight, so as not to mar the rest of the club theme and beauty. With sand greens as my first experience with golf course care, what else could one expect! As a point of interest, some of the first golf courses were built on farmland with barns to shelter and accommodate horses and dairy animals. These were converted to golf course maintenance use, but they were still called barns long after the golf course replaced the farm.

At the Riviera Country Club, in Coral Gables, Florida, we worked out of a building which had four additions attached to it. The first addition was made in 1926. One section of the building still had a dirt floor. The old building was long and narrow, and it was arranged in such a way that we could not house all the equipment. In fact, we always kept over $100,000 worth of precision machinery out in the weather. When it rained, we could go canoeing in the old barn. Definitely, we needed a *maintenance* building.

At different times, the club manager and I persuaded members of the board to inspect the old building. Prints were made of pictures taken through the years showing equipment parked outside the barn. These prints and copies

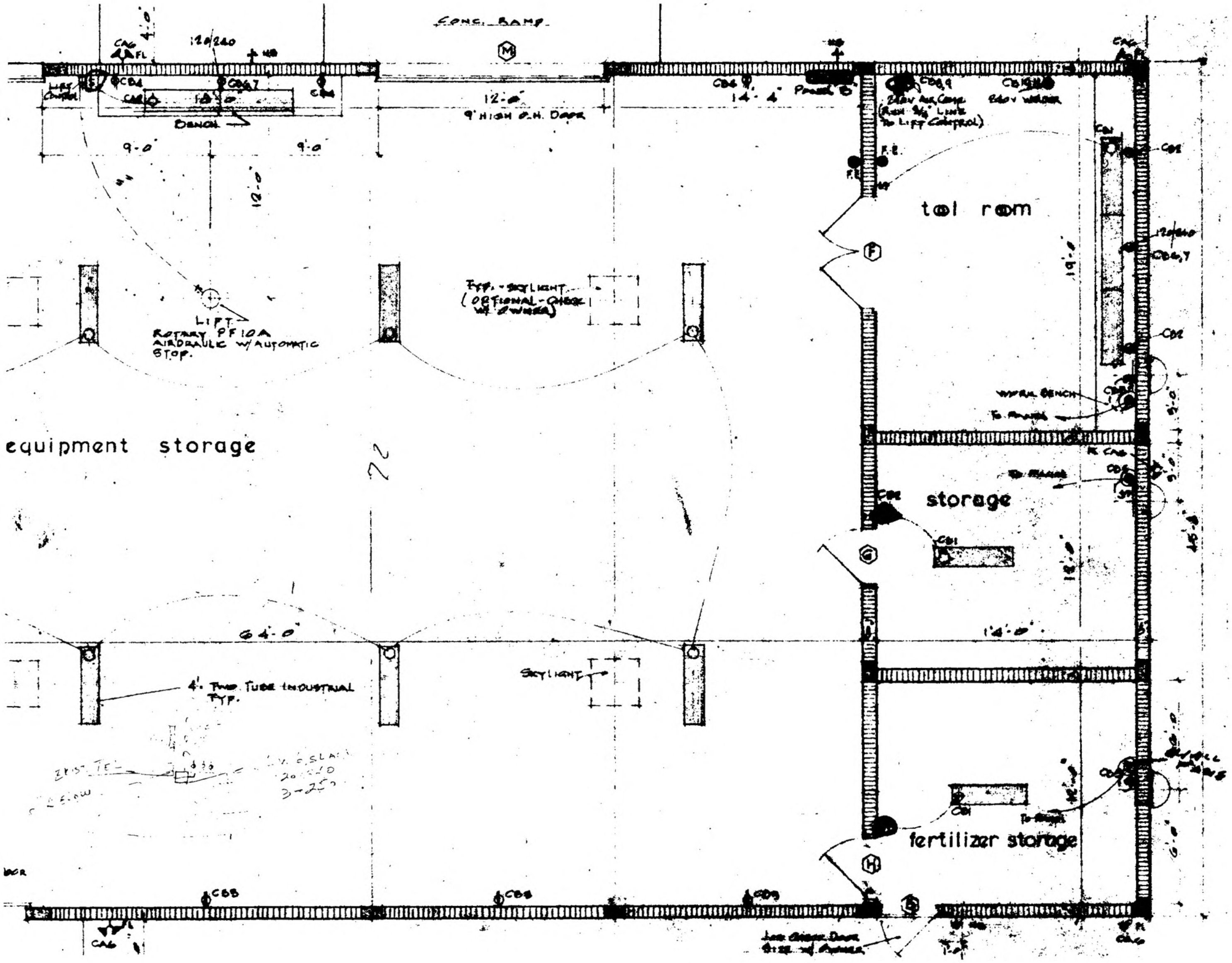


of all literature that we could find on life expectancy of golf course equipment, especially that which pertained to South Florida, were given to the board members. We also stressed that depreciation costs increased eight percent on equipment exposed to weathering all year long. Finally convinced of the need, the board of governors approved an expenditure of $137,000 for the construction of a new maintenance building in the spring of 1979.

Having served five years on the city planning and zoning board, I knew the next hurdle we faced was to acquire a building permit. One of the club's founding members, an architect, made up the drawings and blueprints from sketches I provided for him. After all the red tape was done with, an unexpected obstacle surfaced. One board member argued that the building as planned would be too small to house all our equipment. To convince him that

Floor plan for the maintenance and storage building, Riviera Country Club, Coral Gables, Florida.

The equipment storage area . . . of adequate size.



we planned well, we used rope to stake out the new building exactly as it was proposed on one fairway. We then moved all our equipment into the roped area to demonstrate that it fit, with room to spare.

Construction was begun in September, 1979, and the building was ready for use in December. The prime features are: a hydraulic lift for equipment repair, sufficient storage area to keep topsoil and sand dry, a room that accommodates 30 tons of bag fertilizer, a well-ventilated chemical room equipped with a sink and a storage area for the required safety equipment.

The hub of the golf course operation is the superintendent's office. It is spacious enough for file cabinets, records and reference material, a desk and chairs to accommodate small meetings with my foreman and members of my crew. My office is well-lighted; it is heated and air-conditioned. It is a very comfortable work room.

Working out of the new maintenance building also improved the work attitude and morale of our employees. They are more comfortable now that they have facilities that allow them to eat, wash, shower and dress as they would at home. Their efficiency improved because of this and the better organized work building that makes it easier to move the equipment out each morning. Having the equipment housed indoors gives them a feeling that the machinery is being cared for and they take better care of it as a result. Yes, the new maintenance building benefited the club in more ways than one.

Planning Checklist

1. Select centrally located site for maintenance building, with easy access for trailer and truck delivery.
2. Screen building and maintenance grounds from golfer's view with trees and shrubbery.
3. Comply with OSHA regulations for safety in storage of pesticides, petroleum products, etc.
4. Arrange for proper security such as fencing, burglar alarms and lighting.
5. Install irrigation controls in the building, if possible.
6. Arrange for dumpster units and rack to be located in an area large enough for trash removal vehicles.

Editor's note: Mr. Oxenvad recently resigned from Riviera Country Club and accepted the superintendent's position at the High Ridge Country Club, where the members thought so highly of the Riviera maintenance building plans that they built an identical facility there. In his long career he has been with five different courses at the time that each club was in the process of building a maintenance building.

Turfgrass Improvement Through Cell Culture

by DR. JEFFREY V. KRANS
Assistant Professor, Mississippi State University

CULTURE OF a turfgrass species and/or cultivar is tied directly to genetic makeup of that species/cultivar which, in turn, dictates its performance in the environment. Development and introduction of new and improved turfgrass varieties is the ultimate goal of the plant breeder and others who strive to produce improved turfgrasses. The availability of improved turfgrass varieties is growing and has resulted in grasses which show improved resistance to pest and environmental stresses as well as more desirable turf-type features (prostrate growth, fine texture, etc.). The majority of the new and improved turfgrass varieties that are available now originated from field selections of naturally occurring variants. These variants were recognized in their natural habitats by exhibiting outstanding characteristics noticeable to the observer.

Future progress in improving the desirability of turfgrass species will undoubtedly involve other techniques in the discovery and screening of improved turfgrasses. Plant breeding techniques including planned cross- and/or self-fertilization schemes, induced mutations and plant cell and tissue culture will all play a role in the continued improvement of turfgrasses.

Plant cell and tissue culture techniques are a recently employed tool to improve the genetic desirability of a plant species. Although cell and tissue culture technology has been used in various plant species, turfgrass species have received only limited attention. The Carolinas Golf Association, through the USGA Green Section Research and Education Fund, is supporting research at Mississippi State University to investigate the use of plant cell and tissue culture in creeping bentgrass (*Agrostis palustris* Huds.). This research is designed to improve the genetic desirability of creeping bentgrass for all but especially southern golf greens by generating and screening improved varieties.

CELL AND TISSUE CULTURE TECHNOLOGY

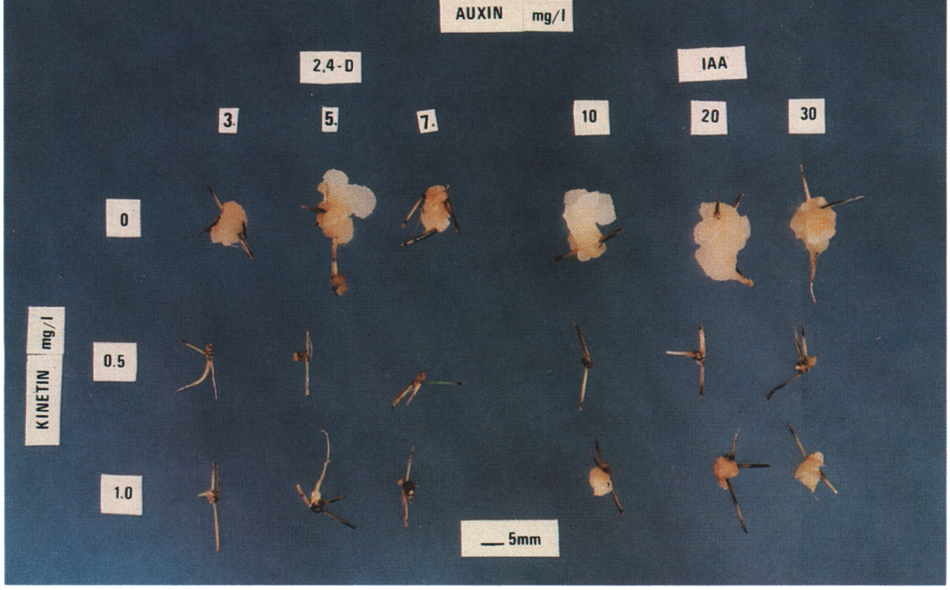
Plant cell and tissue culture deals with the culture of aggregates or individual plant cells in a vessel containing a substrate (media) which supplies nutritional elements and support for cell or tissue growth, replication and/or differentiation (Figure 1). The composition of the media used to culture plant cells consists of a variety of components, including inorganic salts, sucrose, vitamins and plant hormones (Table 1). The change in component or concentration of a constituent in the media dictates the growth and/or differentiation of the given tissue or cell culture. Throughout

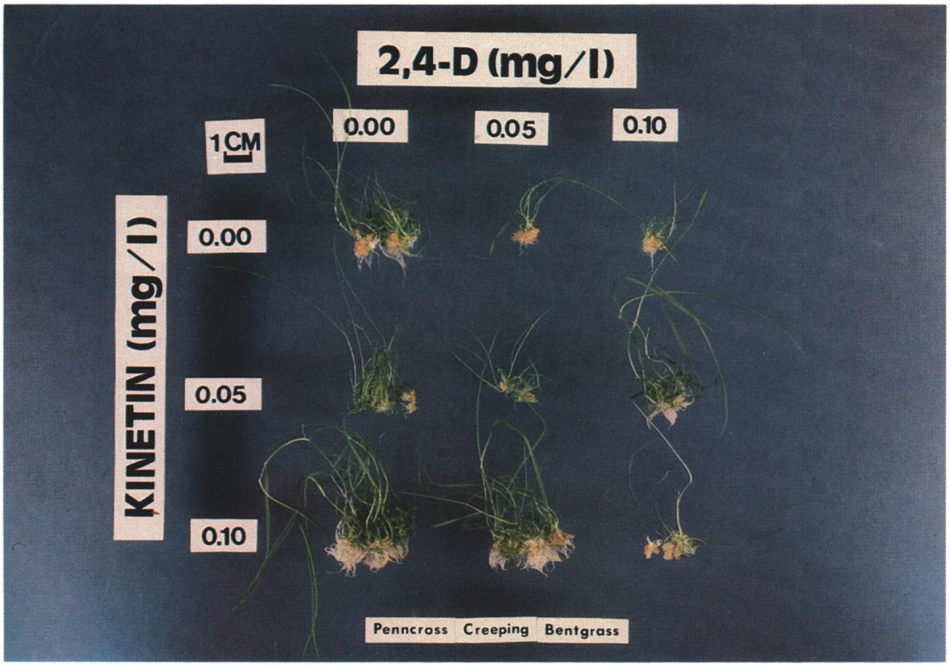
Figure 1: Callus (unorganized aggregate of cells) of Kentucky bluegrass growing in a sterile vessel on defined media of inorganic salts, sucrose, vitamins and plant hormones.

TABLE 1
Components of Media including Inorganic Salts, Sucrose, Vitamins and Hormones used for Callus Induction and Maintenance and Plantlet Regeneration of Creeping Bentgrass[1]

Media Constituents and Concentrations							
Inorganic Salts		**Vitamins**		**Hormones**		**Others**	
	—mg/l—		—mg/l—		—mg/l—		—g/l—
NH_4NO_3	1650	Thiamine•HCl	0.1	2,4-D	0-10	Sucrose	10-30
KNO_3	1900	Myo-inositol	100	Kinetin	0-1	Agar	6-10
$CaCl_2 \cdot H_2O$	440	Nicotinic acid	0.5				
$MgSO_4 \cdot 7H_2O$	370	Pyrodoxine•HCl	0.5				
KH_2PO_4	170						
Na_2EDTA	37.3						
$FeSO_4 \cdot 7H_2O$	27.8						
H_3BO_3	6.2						
$MnSO_4 \cdot 4H_2O$	22.3						
$ZnSO_4 \cdot 7H_2O$	8.6						
KI	0.83						
$Na_2MoO_4 \cdot 2H_2O$	0.25						
$CuSO_4 \cdot 5H_2O$	0.025						
$CoCl_2 \cdot 6H_2O$	0.025						

[1]Murashige, T., and F. Skoog. 1962. A revised medium for rapid growth and bio-assay with tobacco tissue cultures. Physiologia Plantarum 15:473-497.



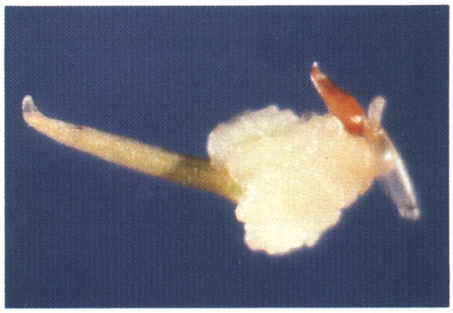


(Top, left) Figure 2: Callus which formed from the nodes of excised stolon segments of "Tifgreen" bermudagrass. Degree of callus formation is dictated by the addition of the plant hormones (2,4-D, IAA, and kinetin) in combination with defined media composed of inorganic salts, sucrose, and vitamins.

(Below) Figure 3: Callus which has formed from the embryo region of the seed and along the coleoptile (shoot) of a 4-week-old creeping bentgrass seedling. Callus was induced to form by the addition of 5 milligrams of 2,4-D in combination with defined media composed of inorganic salts, sucrose, and vitamins.

(Center, left) Figure 4: Plantlets regenerated from callus of creeping bentgrass. Degree of shoot and root formation is determined by the relative composition of plant hormones (2,4-D and kinetin) in combination with defined media composed of inorganic salts, sucrose, and vitamins.

(Below, left) Figure 5: Twelve-week-old creeping bentgrass plants which originated from callus cultures previously incubated and induced to form root and shoot structures on defined media composed of inorganic salts, sucrose, vitamins and plant hormones.



all phases of this research, techniques to destroy (sterilize) and exclude (asepsis) contaminating microorganisms are critical. Although elaborate facilities are not necessary to conduct cell and tissue culture research, controlled techniques and specialized equipment are required.

In order for tissue culture to be used in a given plant species, that species must be capable of manipulation such that callus (unorganized aggregate of cells) can be induced from an excised part of that plant (explant), callus growth after the explant has been excised can be continued and regeneration of whole plants (plantlets) from the callus is readily obtainable. Plant parts commonly used for callus induction include shoot or root tips from seedlings or mature plants, mature or immature embryos, leaf sections, etc. (Figure 2).

In creeping bentgrass, callus has been initiated from mature embryos (whole seeds). Callus forms from the embryo region and along the coleoptile up to the first node (Figure 3). Callus growth in creeping bentgrass following separation from the explant can increase in size six to 10 times over a six-week period. These callus cultures are subcultured or split into smaller pieces at four- to six-week intervals and placed on fresh media. Subculturing is required to maintain vigorous and healthy callus as well as a means to propagate additional callus. Plantlet regeneration in creeping bentgrass is accomplished by transferring callus to a media containing a specified hormone balance [auxin (2,4-D) to cytokinin (kinetin) ratio] (Figure 4). The resulting plantlets generally show 95 percent normally developed root and shoot structures. These plantlets can readily be transferred to soil and grown to full maturity (Figure 5).

Once the media requirements for callus induction, maintenance and plantlet formation are known for a given plant species, additional cell culture technology can be applied to improve the desirability of that species. However, it should be noted that not all plant species/cultivars are adapted to manipulation in cell or tissue culture. Table 2 lists those turfgrass species which have been shown to produce callus and/or plantlets.

UTILIZATION OF CELL AND TISSUE CULTURE TECHNOLOGY

Avenues of use of cell or tissue culture vary depending on the objectives desired. Tissue culture is currently most widely used to propagate plant varieties rapidly. Although not used in turfgrass species, numerous horticultural crops depend on tissue culture as the principal means of propagation.

Currently, a major application of cell and tissue culture technology in addition to rapid clonal propagation involves the improvement of the genetic desirability of plant species. This can be achieved in several ways. The most widely used method involves induction and screening of mutants at the cellular level. This system involves the exposure of aggregates or single cells to chemical [i.e., ethyl metlanesulfonate (EMS)] or radioactive (i.e., cobalt 60) mutagens or maintenance of cultures over a period of time which inherently results in random mutations. This use of chemical or radioactive mutagenic agents to generate mutations in plants is not unique to tissue culture. The generation of mutations using these external mutagens has been used in various crop species, including turfgrasses. However, mutant induction in tissue culture provides the opportunity to mutate large numbers of cells as well as screen for desirable mutants rapidly. This screening process involves the application of a selection pressure (chemical or environmental condition) on the mutant cells in order to separate non-mutants or undesirable mutants from desirable mutants. The actual method of this selection process generally involves the incorporation of a substance into the media or location of the holding vessels in a specific environment not usually conducive to normal (non-mutant) cell growth. Those cells showing resistance grow in the presence of the selection pressure and are later isolated. These isolates are induced to form plantlets which are usually representative of the resistant cells and retain the desirable characteristic originally selected for at the cellular level. This system of generating and screening for resistance in cell culture has been demonstrated in various crop species and is currently under way in creeping bentgrass. Items used in this screening process which have been utilized for developing resistance in other plant species include fungal diseases (most fungi are associated with a chemical toxin which is used to select for resistance), salt concentrations, antibodies, chemical toxins, drugs, and environmental stresses. Although this screening process may appear straightforward, various complications arise which limit widespread application to all plant species.

In addition, cell and tissue culture can be applied in other ways to improve the desirability of plant species. Perhaps the most popular and attractive of these tissue culture techniques is somatic (vegetative or non-germ origin) hybridizations. Somatic hybridization has generated widespread popular attention to tissue culture. This technology involves the fusion of plant cells in culture and bypassing normal cross-fertilization as the means of producing a hybrid. Although somatic hybrids of several plant species have been reported in tissue culture, this technology will undoubtedly require additional investigation to play a significant role in crop improvement. Other uses of plant cell and tissue culture include induction of haploid (one-half the normal chromosome number) plants and freeze-preservation of plant cells (cryogenic storage) at the temperature of liquid nitrogen (-196C°).

Plant cell and tissue culture technology is not a substitute for other techniques used to propagate or improve the desirability of a plant species. It will, however, be a part of the future development and discovery of more desirable plant species, including turfgrasses. Current research efforts in creeping bentgrass have established the necessary prerequisites, which enables the use of tissue culture techniques for improving its genetic desirability. Continued research efforts will determine the extent to which plant cell and tissue culture technology will play in the improvement of various economically important plant species.

TABLE 2
Turfgrass Species which have been shown to produce Callus and/or Plantlets using Plant Cell and Tissue Culture Techniques

Turfgrass Species	Callus Induction	Plantlet Formation	Reference
Annual Ryegrass	yes	yes	1,3
Tall Fescue	yes	yes	4
Creeping Bentgrass	yes	yes	3
Kentucky Bluegrass	yes	no	3
Common Bermudagrass	yes	no	3
St. Augustinegrass	yes	no	5
Rough Bluegrass	yes	no	2
Red Fescue	yes	no	2
Chewings Fescue	yes	no	3
Meadow Fescue	yes	no	2
Perennial Ryegrass	yes	no	2,3
Colonial Bentgrass	yes	no	2

ACKNOWLEDGMENT

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Alcohol Fuel – For Golf Course Use

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DWINDLING FUEL supplies are now a reality. No longer can we order fuel and expect it to be delivered upon request, and the future holds no promise of an easy solution to this dilemma. The only sure fact is that in order to survive we must develop economical fuel sources or cease to exist at our present level. Personally, we enjoy our present status and wish to maintain the existence we have come to know.

In 1979, we went without fuel several times and our golf course operations suffered. We decided that the best way to overcome this problem was to manufacture our own fuel. While there is nothing new about this idea, it was new to us, and we began investigating the prospect of producing fuel for golf course use. Our objective is to develop a renewable and economical source of fuel for our golf course maintenance vehicles. Gasoline is no longer cheap or plentiful, and worst of all, future supplies cannot be guaranteed. There is, however, a clean, efficient fuel which can be used in existing gasoline engines. This fuel is ethanol, or grain alcohol. Unlike gasoline, we need never run short of ethanol because we can manufacture it from corn, potatoes, beets, apples, or most any vegetable or small grain crop that we can grow on our own land.

Ethanol has other advantages over gasoline, too. While both fuels are similar in horsepower ratings and mileage tests, ethyl alcohol burns cleaner than gas because it contains no nitrogen, sulphur, or lead to pollute our atmosphere. The only emissions from ethanol-fired engines are water and carbon dioxide, and both are required for growth by living plants. Basically then, ethanol emissions return to the atmosphere to help grow the plants that make it possible to produce this fuel.

Another advantage of ethanol over gasoline is that while oil refineries have to find ways to dispose of toxic by-

Co-author Rob Coulter displays the equipment designed by the authors. The apparatus: left — cooling coil, center — still, and right — mash cooker. The still is a freon tank, the cooling coil is a section of 8″ pipe and the mash cooker is a kitchen steam cooker.

products, the spent mash from ethanol production is a superior livestock feed for which there is a ready market. Due to the growth of yeasts which convert starches and sugars to alcohol fuel, the distillers dried grain solids (DDGS) which remain after the used mash is dried are much higher in protein and vitamins than the original feed grains. Livestock fed on DDGS gain 10 percent to 20 percent more weight than those fed on conventional grains.

Another advantage of ethanol fuel is its chemical stability. Unlike gasoline, ethyl alcohol does not break down, become gummy, or mix with lubricating oils, causing residues to build up in an engine. Nor will it explode like gasoline when ignited by a hot spark or flame.

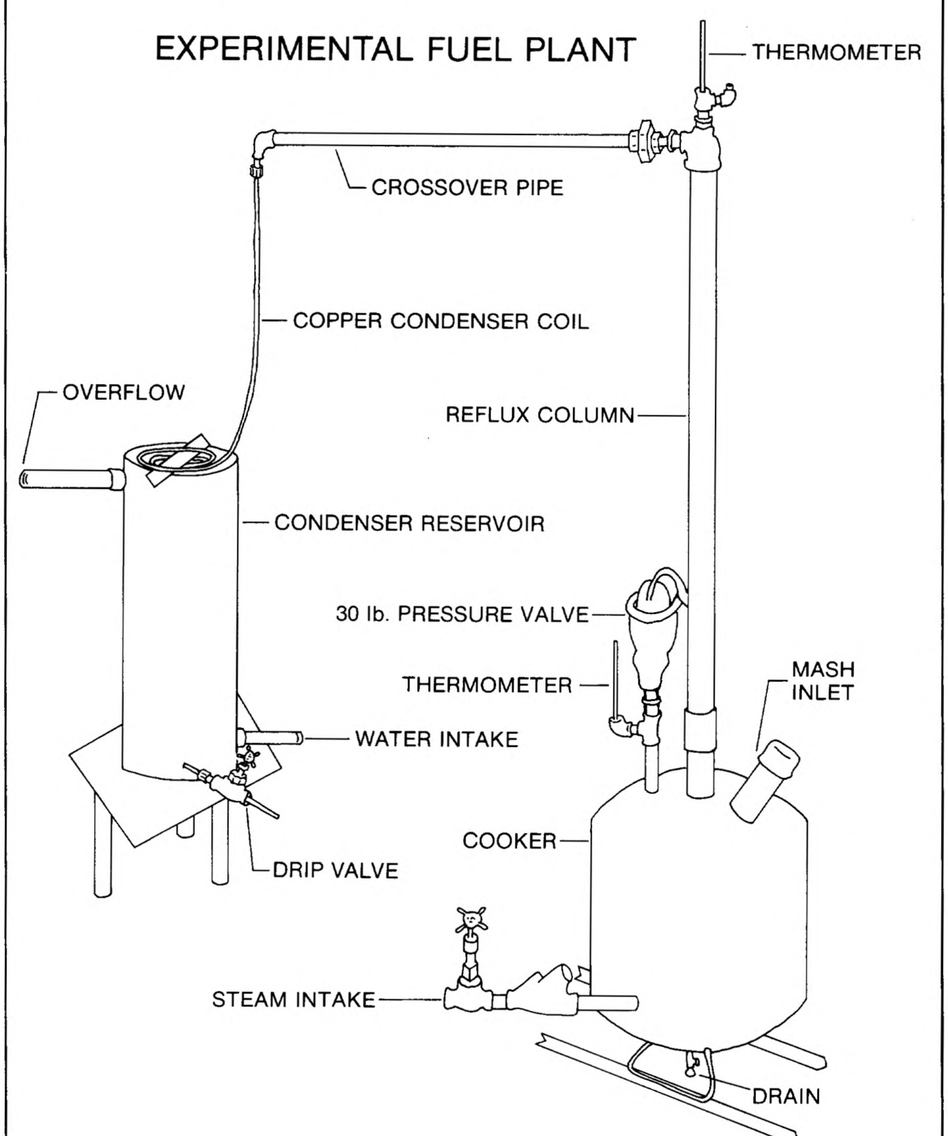
AT THIS POINT it is logical to ask, "If ethanol from farm crops is such a desirable, inexhaustible source of fuel, why has it not been developed more fully?" The answer lies in the economic trends of the past century. In the 1880s, Henry Ford designed the quadricycle, one of his first horseless carriages, to run on pure grain alcohol. A longtime proponent of farm-produced fuel, Ford even featured an adjustable carburetor in his Model T which could be converted to run on either gasoline or alcohol. During those early years of the automotive age, however, alcohol fuels were never commercially developed because of intense competition from gasoline, which was then refined from inexpensive domestic crude oil. Over the years, improved technology in gasoline refining and newly discovered oil reserves kept the price of gasoline relatively low, while very little was being done to improve on commercial alcohol fuel production. Ethanol as a fuel has been virtually ignored in the United States, with exception of the Depression years, the Second World War, and the race cars at the Indianapolis 500.

Although the technology of a modern ethanol plant can become rather complex, the process of converting food grains to fuel is well understood and consists of three basic steps: cooking the mash, fermenting the mash, and distilling the ethanol product.

Cooking the enzymes changes the plant starches to sugars. Fermentation is the process in which yeast microorganisms change protein residues in the spent mash. Distillation is the act of separating the 10 percent or so of alcohol in the mash to obtain a fuel alcohol that is 160 to 190 proof. We will discuss each of these steps and how we can perform them, using corn as an example.

The initial step, cooking the mash, serves the purpose of preparing the corn so that it may be utilized as food in the yeast phase. Yeasts multiply rapidly in a suitable medium, giving off ethanol as a toxic waste product which eventually kills them after the liquid reaches around 10 percent alcohol concentration. However, yeasts are able to feed only on simple sugars and cannot utilize the complex starch molecules of the corn grain unless they are broken down into their sugar components. This chemical breakdown is accomplished by cracking the corn kernels, cooking them in boiling water, and as the water cools, stirring in enzymes which convert the long starch chains to one- or two-molecule sugars. A pH adjustment is usually required for proper enzyme action. The early ethanol producers (moonshiners) obtained their enzymes naturally by malting or sprouting grain and then drying it before milling. This method was tedious and time-consuming. Today's enzymes cooking time for a batch of mash can be two hours or less.

ONCE THE MASH is cooked, and therefore all the corn starch is converted to sugar, the fermentation process begins. Fermentation is the process in which yeast feeds on sugars in the mash, giving off ethanol and carbon dioxide gas as end products of digestion, and leaving a high-protein residue in the mash. For the yeast to grow best, the



mash should be in an anaerobic environment at a temperature of 80° to 90° Fahrenheit and should contain no more than 20 percent sugar (over 20 percent sugar will kill the yeast). Baker's or brewer's yeast is used for ethanol production. Under ideal conditions, 80° to 90° F. with agitation, the yeast will work its magic in two and a half days. As long as a week may be required for the yeasts to use up all the sugar in the mash in a less than ideal environment.

If the batch was properly proportioned and fermentation is complete, a hydrometer reading will indicate that the mash contains at least 8 percent to 10 percent alcohol. The mash at this stage is ready for the final step in becoming ethanol fuel, which is distillation. Some day a superior method for refining alcohol fuel may be discovered, but at present, distillation remains the most effective technique for concentrating the alcohol in the mash to obtain a useful fuel product.

Basically, the distillation process takes advantage of the difference in the boiling point of ethanol (173° F. at sea level) and that of water (212° F. at sea level). Heating the mash by fermentation to a temperature between these boiling points vaporizes most of the alcohol along with some of the water. If this vapor is caught and condensed, the resulting liquid will contain a much higher concentration of ethanol than did the original mash. By re-distilling this product, an even more concentrated alcohol solution can be obtained, up to about 195 proof. However, because of a quirk in the chemistry of an alcohol-water mixture, completely pure 200 proof alcohol can never be obtained by simple distillation.

After study of the known technology of alcohol fuel plants, we constructed an experimental model for ethanol fuel production on a small scale. The batch-type apparatus we designed is capable of reducing no more than three gallons of mash to alcohol and water in one run. Even so, we are able to produce a quart or more of high-proof ethanol from each batch. The batching and cooking of the mash can be performed in ordinary cooking pots, and the fermentation vessels are simply five-gallon plastic pails with airtight lids which have been fitted with air locks for escape of carbon dioxide gas. One rather unusual feature of the distillation plant is the use of steam heat (5-10 pounds steam at about 300° F.) to vaporize the alcohol from the mash.

(Left to right, clockwise, starting at top) Enzyme, beaker, yeast, fermentation vessel, acid for pH adjustment, hydrometer, alcohol fuel, and temperature gauge.

WE HAVE PRODUCED alcohol from our experimental plant and have realized 160-proof alcohol. We are now testing this product in an old F 8 tractor. It works, but as yet we don't have it refined to the point of using it every day.

We have found that the cost of producing alcohol from corn is about $1.23 per gallon. As the price of gasoline has stabilized recently and supply now is no problem, I do not remmend manufacturing alcohol at this time. If we are faced with another round of increasing prices in gasoline and the price rises to above $1.40 per gallon, then the production of alcohol for golf course use will become attractive. We are continuing our experiments and will be ready to produce our fuel if economics or supply so dictate.

One word of caution: You must have a permit from the U.S. Department of The Treasury, Bureau of Alcohol, Tobacco, and Firearms and your state department of agriculture, before you produce alcohol. The reason — alcohol for fuel is also alcohol for consumption, and without a permit, that is moonshining — and moonshiners tend to get harrassed.

If, in light of the preceding information, you feel the urge to experiment on your own with alky fuel systems, there are a number of informed research organizations and publications available to help you. One of the largest and best organized groups is the National Alcohol Fuel Producers Association, an information exchange network between educators, researchers, fabricators, and alcohol fuel producers. The mailing address is NAFPA Headquarters, 1700 S. 24th Street, P.O. Box 2756, Lincoln, Nebraska 68502. Membership is $75 per annum, but is well worth the price to someone who is seriously interested in alcohol fuel production. Another information clearinghouse in the National Gasohol Commission, Suite 5, 521 S. 14th Street, Lincoln, Nebraska 68508. Several states, including Virginia, are full members of the Commission, and on request, you may obtain a list of members from your particular areas serving on the Board of Directors. The Commission also answers inquiries to specific questions and will send the price list for a fairly complete selection of the published literature on fuel alcohol production.

A NUMBER OF other groups have become involved in fuel alcohol research, notably *The Mother Earth News*, Hendersonville, North Carolina. Starting with a series of magazine articles, *The Mother Earth News* staff has gone on to develop an alky-fueled road show which conducts a series of one-day seminars all over the eastern U.S. There are many other good journals, books, and institutes, too numerous to mention here, which have sprung up that may be more appropriate to your particular needs. The point is, information and the technology to make alcohol fuel a reality are already available. The technology on which we now depend so heavily for golf course maintenance requires a dependable, economical liquid fuel. Perhaps for some in the golf industry, alcohol fuel will eventually become an appropriate alternative to gasoline for meeting our liquid fuel needs.

TURF TWISTERS

GOING AROUND IN CIRCLES

Question: We have a new member of our golf committee who insists that fairways should be mowed in circles in order to force the grain of the grass to lie away from the tee toward the green so the ball rolls farther. I have been a golf course superintendent for 25 years and this is the first time that I have heard this . . . . I'd appreciate your expert opinion. (Ohio)

Answer: Fairways are mowed in various directions — but never in circles. Fairways are mowed lengthwise, diagonally and sometimes they are cross-cut. The only circular movement on fairways occurs at the beginning and ends of fairways where the operator must turn to pick up his next line of cut. If fairways were always cut in circles, there would be a pronounced bruising all over fairways caused by the abrasion of turning wheels, similar to that which occurs at the beginning of fairways and at the turn-around point near the green.

MAY NOT BE SAFE

Question: Can oxadiazon (Ronstar) be used as a preemergent for *Poa annua* control on Tifgreen (328) greens and tees? (Texas)

Answer: No, at least two such cases we observed last spring indicated that fall applications of oxadiazon may not be safe on close-cut turf. Evidence also points to trouble on bermudagrass greens when oxadiazon is applied in spring for goosegrass control. The present label does not recommend oxadiazon for use on tees and greens.

IN PURSUIT OF A MATE

Question: Last fall we had a serious problem with coyotes digging holes on the putting greens. Insecticides had been applied regularly through the summer, and no substantial insect or grub problems were found. What can we do this year to prevent a recurrence of the problem? (California)

Answer: That's a tough one! If grubs and other insects had been controlled, the coyotes obviously were not after food. A check with conservation officials indicates that the most likely reason for the coyotes' presence at that time of the year was probably male coyotes in pursuit of a mate. The scent of females was probably found on the putting green, and the male coyotes dug on the green to try to reestablish the scent. If your state, county or local government has an animal control office, you might contact it about trapping and relocating the coyotes in areas away from the golf course.