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SOME FUNDAMENTAL ASPECTS OF GRASS MANAGEMENT

J. R. Watson, Jr.[1]

Growth, or the absence of growth, is the summation of all physiological processes occuring within the plant, and since turfgrass management is directly concerned with the growth of turfgrasses, it follows that there is a fundamental relationship between physiological processes and turfgrass management. Plant physiology may be defined as the study of the growth processes and functions of the various organs and parts of the living plant. Environment -- both soil and climatic -- exerts a marked influence on physiological processes, such as photosynthesis, transpiration, respiration, absorption of water, uptake of nutrients, and growth. Likewise, environment -- both soil and climatic -- influences to a large extent management practices. In fact, turfgrass management may be partially defined as the practices required to adjust, compensate or manipulate environment to assure adequate growth of turfgrass in spite of adverse soil and climatic conditions.

This discussion will deal primarily with the influence environment exerts on the physiological functions of the roots and shoots of turfgrasses, and the relationship these bear to turfgrass management practices.

Environmental soil factors which exert a major influence on the physiological processes within the plant are aeration, moisture and temperature. Each of these factors influences the other, and alone, in combination, and collectively they govern and control growth processes; hence, are of utmost consideration from the standpoint of turfgrass management.

Aeration

Aeration, as spoken of in connection with soils, is an interchange between atmosphere and soil air. This is necessary to supply the oxygen needed by plant roots and soil organisms, and to remove carbon dioxide from soil air. It is generally accepted that changes in such physical properties as pore size distribution, bulk density and aggregate stability result in changes in soil aeration.

Factors which influence or affect an interchange of soil and atmospheric air are (1) Diffusion - the spreading of gases. Diffusion is less in compacted soils than in non-compacted ones. (2) Changes in pressure and temperature. These produce almost a complete change of air in the surface few inches of soil each week. (3) Removal of water -- drainage -- as the water moves out of large pores air moves in. Removal of water by roots produces the same effect, only more slowly and to a lesser extent. (4) Except insofar as they affect biological activity in the soil, tillage practices have not shown any clearly defined affect on the composition of soil air.

Composition of soil air. Soil air contains more carbon dioxide and less oxygen than atmospheric air. Atmospheric air is made of approximately 78 percent nitrogen, 20 to 21 percent oxygen, 0.03 percent carbon dioxide, and small (less than 1 percent) amounts of hydrogen, argon and other rare gases. In a well aerated soil, the air generally contains approximately .65 to 1

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percent carbon dioxide and 19 to 20 percent oxygen, the only two gases of primary concern in this discussion. It may be of interest to note that the sum of carbon dioxide and oxygen in a well aerated soil at a six inch depth is only slightly less than the sum of the two in the atmosphere, although the percentages vary.

Variations in Soil Air. Soil air fluctuates more than atmospheric air. Oxygen content is decreased when nitrates are high. Oxygen content is decreased to a greater extent when soils are water logged. Marked reductions have been shown to occur following irrigation and rainfall, although if a soil is well drained, this is only a temporary phenomenon. Carbon dioxide may go up as high as five or six percent under water logged conditions, and if a large supply of readily decomposable organic matter is present along with adequate nutrients, the carbon dioxide content may go up as high as ten percent.

Seasonal Variations. The composition of soil air exhibits marked seasonal variations, the intensity of which is affected by the texture of the soil and the position of the water table. The oxygen content in heavy soils is generally low in the early spring, and increases as the season advances. Less variation is reported in sandy soils or in soils of light texture. Carbon dioxide content fluctuates over a narrower range, but normally reaches a maximum in the summer when soil temperature and moisture conditions are favorable for biological activity. An increase or decrease in the percentage content of oxygen does not necessarily follow in a direct proportion to a decrease or increase in the percentage content of carbon dioxide or vice versa; there is, however, a relationship.

Effect of Aeration on growth and function. Roots growing in well aerated (adequate oxygen) soils are long, light colored and well supplied with root hairs. These roots have a longer portion of the root covered with root hairs; hence, a longer portion over which absorption of water and nutrients may occur. Roots growing in poorly aerated (low oxygen) soils are short, thick, dark and have less than the normal number of root hairs.

Absorption of ions by roots is one of the most important physiological functions of living plants. It represents the connecting link between soil conditions and plant growth. Failure to obtain normal plant development in poorly aerated soils is related to restricted ion uptake by roots.

Inadequate aeration decreases the intake of water by plants directly through its effect on absorption and indirectly by reducing root growth. Reduction of water uptake occurs only at relatively high carbon dioxide concentrations and even then its effect is reduced by presence of oxygen; hence carbon dioxide is of minor significance in water economy, except in those cases where roots are growing in water logged soils in the presence of large amounts of readily decomposable organic matter.

In the absence of adequate oxygen, anaerobic reactions predominate and large amounts of reduced soil constituents are built up. Among reactions most strongly influenced by changes in aeration are those involving manganese and iron.

Germination of seed is strongly affected by the concentration of oxygen and carbon dioxide. Faulty aeration conditions are one of the primary causes of poor germination and often occurs in soils having poor structure or excessive water content.

Aeration and Temperature on Root Growth and Function. Root growth at various levels of oxygen is strongly influenced by temperature. Experiments have shown that at an oxygen concentration of three (3) percent and at temperatures of 64 and 86 degrees, root growth is inhibited; whereas, at an oxygen concentration of 10 percent, root growth is normal at 64 but reduced at 86 degrees. This indicates that at the higher temperature, 10 percent oxygen is deficient. Further work has shown that (1) at oxygen concentrations of less than one percent, roots lose weight; (2) concentrations from to 10 percent are necessary for the growth of existing root tips; and (3) oxygen concentrations greater than 12 percent are required for root initiation.

Within the temperature limits for root growth, the greater the temperature of the soil, the higher must be the concentration of oxygen in the soil atmosphere for normal root growth. Cannon attributes this relationship to decreasing solubility of oxygen in the soil solution with increased temperature. Although this may be a factor, the effect of increasing temperature on respirational demands of the roots for oxygen certainly plays an important part.

Soil Temperature

Growth is a complicated summation of a number of individual and essential processes, each of which is influenced in varying degree by atmospheric and soil temperatures. The activity of soil micro flora likewise have an important bearing on growth of higher plants, and are dependent entirely on soil temperature. Maintenance of an adequate carbohydrate supply and the absorption of water and nutrients, all essential for growth, and all affected by temperature are of interest in this discussion.

Direct Effect. It is generally agreed that roots must constantly extend (grow) to obtain a continuing supply of water and nutrients. For each plant there is a definite range of temperature within which it will grow. Within these limits, increasing temperatures speed cell division and elongation while decreasing temperatures retard root elongation; hence, temperature affects the role of growth processes *per se*.

Effect on Carbohydrates. Carbohydrates required at the growing points must be translocated from storage tissue in the roots or shoots or from leaves where they are produced by photosynthesis. The rate of photosynthesis is relatively unaffected by temperature; high temperatures favor more rapid translocation and accelerated respiratory activity, while low temperatures retard translocation and depress respiratory activity. Hence, low temperature favors an accumulation of photosynthetic products (carbohydrates), while high ones may cause a serious depletion of carbohydrate materials and may, therefore, restrict growth.

Effect on Absorption. Within limits, the rate at which water and nutrients are absorbed increases as temperatures rise and decreases as temperatures decline. The viscosity of water is twice as great at 32 degrees as at 77 degrees, and the viscosity of protoplasm is several times as great at 32 as at 77 degrees. An increase in the viscosity of water results in a slower movement from the soil to the root, as well as in the root. Likewise, an increase in the viscosity of protoplasm retards water movement within the root. Temperature is only one of several factors which influence transpiration. The effect of temperature on transpiration is direct; i.e., when temperatures increase, transpiration increases, and when temperatures decline, transpiration is reduced. Low soil temperatures reduce water absorption, while high atmospheric temperatures increase transpiration. Under such conditions, wilting becomes a possibility. Wilting always occurs whenever transpiration exceeds water absorption.

Effect of Soil Texture. Summer growth is largely dependent on photosynthesis, whereas early spring growth comes largely at the expense of stored food. Thus, soil temperatures exert a greater influence on early season growth, particularly in well drained soils. Such soils (well drained) show faster temperature changes than the same soil with higher moisture. In general, light textured soils (sands and sandy loams) warm up faster than heavier textured soils (clays).

Effect on Species. Rate of absorption by plants appears to increase with increasing root temperature up to a point above which absorption is depressed by a further rise in temperature. There is also a marked difference in the response of different grasses to temperature. For example, Brown has shown that water absorption by Bermudagrass was sufficiently retarded at 50 degrees to cause wilting, but that Kentucky bluegrass was unaffected at this temperature. This indicates a basic difference in the reaction of protoplasm to low temperature. Quite possibly permeability of protoplasm is reduced by low temperature in some plants more so than in others. It appears that soil temperatures of approximately 59 - 68 degrees are optimum for growth of Kentucky bluegrass, and that temperatures above 80 degrees are unfavorable. Bermudagrass, on the other hand, continues to grow with rising temperatures up to 100 degrees (the highest temperature studied). From this study it appears that maximum growth of Bermuda occurs at soil temperatures around 95 degrees.

The slow down in growth of cool season grasses may be a result of restricted carbohydrate supply to roots, rather than the high temperature. This could result from an increase in air temperature, which causes a low rate of foliar growth. At least it has been indicated that high temperatures adversely affect ryegrass by causing a rapid dissipation of reserve carbohydrates and retarded production of new leaf growth.

Factors Affecting Changes. Irrigation is quite effective in reducing soil temperatures. In Arizona it has been shown that soil temperature was lowered four (4) to ten (10) degrees at one (1) inch, one (1) to four (4) degrees at three (3) inches following irrigation. Other factors which affect temperature changes, and which are of significance from the standpoint of turfgrass management are:

(1) Evaporation --- the cooling effects brought about by evaporation from irrigated areas (such as greens) adjacent to non-irrigated areas are well known. This is sometimes referred to as the "Oasis" effect;

(2) Shade --- Cooler temperatures under shade trees scarcely requires mention. Brown (Missouri) in a study comparing summer temperatures at a depth of one-half inch under a bare soil and a Kentucky bluegrass sod found that the semi-monthly mean values of the daily maxima were as much as 10 degrees higher and minima were as much as 5 degrees lower for the bare soil than for bluegrass sod. Similar effects (though probably not as great) would be expected under thin stands in contrast to dense stands of turf;

(3) Mulch --- an organic mulch will absorb heat and insulate the soil;

(4) Dark materials absorb heat --- the use of dark, amorphus materials such as lamp black, sewage sludge and topdressing to speed the melting of ice on greens takes advantage of the heat absorbing properties of these materials. This is also one reason why bentgrass greens should not be topdressed during summer months.

(5) Location and position --- When choosing a site, it is well to remember that, in general, southwest slopes are the warmest. Whenever possible, turf areas (such as greens) should be faced toward the sun (southward) in the colder climes and away from the sun (northward) in the warmer latitudes to take advantage of this difference in temperature. Other topographic features to keep in mind when selecting a site is the fact that cool air settles in valleys during the night, and that high wind-swept hills are more subject to excessive transpiration. Exposure to wind and provisions for adequate air drainage are of importance from turfgrass management and temperature standpoints. Nearness to buildings likewise affects these factors because of the influence of radiant heat.

Soil Water

Plant growth cannot take place without moisture. The fact that plants require water for their existance and development, and that most plants require it in considerable quantities, is common-place knowledge. It is not generally realized that a very large proportion of the water absorbed from the soil is lost by the plant into the atmosphere and plays no permanent part in its development or in its metabolic processes. Water is supplied to and absorbed by the plant in a liquid form, while the greater part of the water lost by plants is in the invisible form of water vapor. This probably accounts for the failure to recognize the tremendous quantities of water needed for plant growth. The loss of water vapor from any part of a plant exposed to air is known as transpiration. Because this physiological process is influenced directly and indirectly by aeration, temperature and water, further discussion seems in order.

Transpiration. The importance of transpiration and its effect on soil moisture is apparent when we consider that the 60 to 90 percent of the plant body which is water actually represents only a very small proportion of the water used by the plant. There is a constant stream of water passing in through the roots and being transpired by the leaves. From 300 to 500 pounds of water are required for every one pound of dry matter produced by the plant. Many plants transpire an amount of water equal to their weight every twenty-four hours.

The actual amount of water required by plants is, therefore, far in excess of the amount used by the plant in its growth and development processes and is dependent upon the amount transpired. The amount of water transpired by a given plant is governed by several factors such as:

(1) Temperature - High temperature increases and low temperature retards transpiration.

(2) Air Movement - Air movement increases transpiration from the plant. The movement of the plant itself aids in circulation of water within the plant and so increases transpiration.

(3) Humidity - Low humidity increases transpiration.

(4) Soil fertility - More transpiration takes place on poor soil than on a fertile one.

(5) Light intensity - Transpiration is greater in bright sunshine.

(6) Soil Moisture - The more moisture contained in a soil, the greater is the transpiration rate.

In this discussion we are not concerned with the fundamental controversy of whether the transpiration phenomenon is beneficial or just a necessary evil. Rather our interest is simply to point up the fact that very large quantities of water are transpired by plants and, hence, it behooves us to adjust our management practices so as to alleviate excessive transpiration whenever possible.

Water practices that are based directly on transpiration phenomena are "syringing" of golf greens during hot, windy summer days, and the watering of turf areas during winter or early spring when atmospheric temperatures are considerably higher than soil temperatures. In both cases, transpiration is likely to exceed water absorption. This results in wilting or dessication. On high areas not covered by snow and exposed to drying winds during winter and spring months, winterkill is often observed. The plant roots are relatively inactive and cannot take up sufficient water to offset transpiration; hence, wilting -- and often death -- occurs.

Other effects of soil moisture on physiological processes have been mentioned in the discussions of aeration and soil temperature. Although an effort has been made to separate the individual effects of each of these factors, it should be pointed out that from a practical standpoint, all are inter-related, and each affects the other, as well as exerting an influence on physiological processes.

Photosynthesis

Photosynthesis (photo-light; synthesis - putting together) is the process of converting, in the presence of sunlight, carbon dioxide and water into simple sugar (glucose). This process is carried on in the leaves of green plants and is without question the most important process on earth. The simple sugars produced by photosynthesis are the basis of all organic compounds which all living organisms (plants and animals) depend upon for their life activities.

Trapping sunlight necessary for photosynthesis is only one of the functions of grass leaves, and carbon dioxide and water are only two of the elements or materials necessary for proper growth. Nitrogen is an integral part of proteins, iron an essential in chlorophyll production, phosphorus is involved in the transfer of energy, and potassium is necessary for translocation of sugar and other physiological processes. The role of these and other essential elements, as well as other leaf functions, should not be minimized; however, this discussion will be confined to the relationship of photosynthesis and mowing --- the management practice most directly related to this physiological process.

Growth and Anatomy of Grasses. The grass leaf is remarkably adapted for intercepting a maximum of the sun's rays. The long flattened grass blades provide a maximum of exposure, with a minimum amount of protoplasm, thus making efficient use of living tissue. Reduction in the area of the plant leaf exposed to light reduces the plant's capacity to carry on photosynthetic activity. This is a vital and basic consideration in determining cutting heights and frequencies of turfgrasses.

The ability of grasses to withstand frequent and "close" cutting is related to other peculiarities of the grass family. Grasses exhibit "basal" growth as opposed to "terminal" growth found in most other plants. Basal growth means simply that growth initiates at the base rather than the tip of the blade, the stem, the buds and the crown. From a practical standpoint, this means that normal and frequent mowing does not cut off the growing areas of the grass leaf. Removal of too much leaf surface (probably not over one-third of the leaf area) at any one cutting is harmful because some of the growing tips may be destroyed.

From the standpoint of type of growth (manner in which new plants grow from basal buds), grasses may be classified as:

(1) Bunch --- new shoots grow inside the sheaths of the previous stem growth; example - ryegrass.

(2) Stoloniferous -- spread by stolons or runners (creepers) -- new shoots push through the sheath and run along the surface of the ground and root at the nodes (joints); example - bentgrass.

(3) Rhizomatous -- spread by rhizomes (underground stems) -- new shoots push through the sheath and grow under the surface of the ground, followed by repeated shoot and root formation underground at the nodes; example -- Kentucky bluegrass.

There are intermediate types with decumbent stems which root at the nodes, such as crabgrass, nimblewill and some fescues. Some grasses spread by both rhizomes and stolons. The most notable example of this habit of growth is Bermudagrass. This, incidentally, is one reason Bermuda is such a vigorous grower and is so difficult to control or keep out of places such as flower and shrub beds, bentgrass greens, etc.

Leaf area and height of cut. The height to which a given grass (perennial) can be cut and still survive for extended periods is directly related to its ability to produce sufficient leaf surface for the photosynthetic activity required for its growth. Basically this ability is related to the inherent type and habit of growth found in the grass. Factors such as the length of internodes (distance between nodes), the number of stolons or rhizomes, and the number of basal buds all contribute to the leaf mass produced by a given grass; hence, its ability to withstand low heights of cut.

If bunch type grasses are cut close and infrequently, too much leaf surface is removed and the plant can no longer carry on sufficient photosynthetic activity to support growth. The fact that ryegrass can be cut at greens height (3/16 to 1/4 inch) for a few months and still survive, is related to the lower temperatures prevailing during the growing period. This reduces metabolic (growth) activity to a level which can be supported by the photosynthetic activity of the existing leaf mass. When temperatures rise and a greater demand for carbohydrates (products of photosynthesis) is created, the reduced leaf area is not able to meet the requirements and the plant dies. Frequency of mowing (how often the grass is cut) may also be of importance in this case.

Creeping type plants such as bentgrass and Bermuda are able to produce adequate leaf surface at very low heights of cut. For this reason, they are normally used on golf greens. Buffalograss, although a creeper -- produces stolons, cannot produce sufficient leaf mass at very low heights because too few basal buds exist; hence, it cannot withstand the low cuts to which bent and Bermuda can be subjected. For this same reason, Kentucky bluegrass and fescue must be cut higher -- 1 to 1 1/2 inches.

Obviously, environment -- soil physical and chemical properties, temperature, humidity, moisture, wind movement, etc., as well as <u>usage</u> -- are of importance in determining the height which a given grass should be cut to produce satisfactory growth; nevertheless, leaf area, as governed by type and habit of growth, is probably basic to determining minimum heights of cut.

THE DEVELOPMENT AND CHARACTERISTICS OF TURFGRASS STRAINS

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Agricultural Experiment Station

It has been a number of years since we have had a discussion of strain or variety development. I do not propose to give you a detailed discussion of plant improvement procedures. Rather, I hope to be able to present a few facts that may help you in better understanding the material you work with.

Plant improvement is based on variability or variation in the population being worked with. Thus, this variability is good from the breeder's standpoint, but not necessarily from the consumer or user's standpoint. Thus the breeder's job is to pick out of the population the desirable types and stabilize them through various selection procedures. The usual procedure is to grow a population of plants, select the desirable ones, collect seed and plant out a population from which desirable plants are again selected and the same procedure repeated until the entire population is of the type desired.

A number of factors affect the procedures to be used. One of the most important of these with us is vegetative propagation. Where vegetative propagation can be or is practiced, selection to stabilize the population is not necessary. Thus desirable types can be selected and propagated vegetatively. Turf from a strain maintained in this way will be uniform as long as no seed are produced. This is an advantage because it is often difficult to obtain the dedired uniformity from seed.

The above procedure sounds quite simple, but even this procedure presents some problems. It may be difficult to find in a single plant all the desired characteristics, such as texture, density, color, disease resistance, drouth tolerance, etc. Since, in effect, such plants are hybrids, and since seed from such plants will segregate for the above characteristics, it is necessary to prevent seeding in propagation nurseries. These two problems will be discussed in more detail.

In much of the work in the South to date, we have settled for as many of the desired characteristics as we could find in a single plant. Many of the Bermuda strains as we know them today and also the creeping bent strains came about through simple selection of desirable plants existing in nature. You are familiar with the collection program in Texas from which Texturf IF and Texturf 10 have been released. Gene Tift, U-3 and L-2 were developed in a similar manner. Each of these strains has some desirable characteristics, but each could be further improved in some characteristics. Their general characteristics will be given later.

When Dr. Glenn W. Burton was here on the program a few years ago, he showed how desired combinations were made if they were not found in existing populations. Such a hybridization program is tedious and is generally undertaken after existing variation has been exploited. In a simplified form it consists of selecting two plants each having some of the desired characteristics, emasculating (removing the anthers) the flowers of the one chosen to be the female parent and introducing pollen on to the emasculated flowers from the second plant. Each seed developed from this procedure will give rise to a distinct plant and not all the plants will combine the desired characteristics. In fact, it is necessary to make many such hybrids to obtain the desired type. It may be necessary to carry such a program through several generations to obtain the desired end product.

A number of varieties have come from Dr. Burton's hybridization program including Tiflawn, Tiffine, Tifgreen and the pasture Bermuda, Coastal. With all of the vegetative strains, whether resulting from natural selection or artificial hybridization, vegetative propagation is necessary.

Since vegetative propagation is necessary in order to maintain the desired characteristics, it is necessary then to avoid excessive seed maturation in the nursery. If seed are allowed to mature, off types may become established in the nursery, or more likely in new turf established from the nursery. Seedlings are not likely to be able to compete with a mature sod, but when sod is removed it will give seedlings an opportunity to become established. Also, if mature seed are deposited in the sod, where the sod is shreded for establishing new areas, it gives the seed a chance to become established. Proper care of the nursery is one of the main thoughts I would like to leave with you today.

Fortunately, most of the fine-leafed types probably are not fertile. Sunturf, which we did not list earlier, and Tifgreen are hybrids between 20 chromosome African Bermuda and 40 chromosome regular Bermuda. Thus they are 30 chromosome triploids and do not produce viable seed. We think that Texturf IF is of this same parentage but it has not been checked. Most of the intermediate and coarse-textured types are selections of Common Bermuda and will produce viable seed. They are the most difficult to maintain in pure form because of viable seed and soil contamination with Common Bermuda.

I would like to show a few pictures to demonstrate the reason why vegetative propagation is necessary with existing strains and why care must be exercised in maintaining vegetative nurseries. The first slides show seedling progenies from various creeping bent strains. Each row came from one original plant and shows the many types that may be obtained. Similar but somewhat less striking differences are shown in Bermuda seedlings. Turf established from U-3 Bermuda sod shows variation in color, density and texture.

Finally, along the line of strain development, I do not know whether there is any interest in seed-propagated types. There are none in Bermuda at present and not likely to be in the near future. In the fine-leafed types, the fine texture comes from the African parent and the hybrid is sterile. Until this sterility is overcome through chromosome doubling or other means, fertile types will not be available. In the Common Bermuda types, several generations of selection would be necessary to fix in a strain the desired uniformity. Thus you can see there is little prospect of a seed type and especially since the plant is so easily propagated vegetatively.

Other characteristics of several Bermuda strains,
College Station, 1956

Strain	No. Stems Per 3/4" Plug	Weight of Thatch Per 2" Plug
Uganda	27.1	6.21
Texturf IF	14.7	4.94
T-11	14.5	5.04
Sunturf	12.7	4.16
Gene Tift		5.56
Tiffine		7.18
Tifgreen		4.95
Common		5.92
African		6.06

Observational ratings 1/ of turfgrass strains,
College Station, 1956

Strain	Color	Seed Heads	Disease	Spring Recovery	Texture
Texturf IF	2.7	4.0	1.5	3.0	3.0
Sunturf	5.0	3.2	2.5	3.5	3.2
L-2	3.3	2.9	3.5	3.0	2.5
Gene Tift	2.3	2.2	3.5	2.5	2.7
Tiffine	2.5	1.0	5.0	4.0	4.0
Tifgreen	4.5	5.0	5.0	3.2	3.7
Common	3.5	2.0	3.0	1.2	1.2

1/ All ratings on a scale of 1 to 5 with 5 being best, except for color where 5 is dark green.

SOME FUNDAMENTALS OF LANDSCAPE PLANNING

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Four fundamental considerations in any landscape design will be discussed in this paper. These fundamentals are:

(1) Circulation

(2) Finish grade

(3) Planting

(4) Maintenance

Circulation:

A plan should be prepared on paper at reduced scale which affords opportunity to study the circulation patterns and needs in more detail. Both pedestrian and vehicular circulation must be considered in the plan. Walks on school grounds, parks and other public places should be wide enough to serve the needs. Many 8, 10 and 12-foot walks are now being constructed where 4 and 6-foot walks have been used previously. The walk should be direct, taking the traffic from and to the place desired, else the walk will not serve its maximum use. The walk should have proper pitch and slope for drainage purposes. Pitch might be considered as cross-sectional giving drainage from the center to each side or from one side to the other. Slope is longitudinal and provision should be made for drainage even if sump construction is necessary.

Vehicular circulation is also becoming more important and must be provided for. Provision should be made for limiting the circulation to desired areas. To do this streets and particularly parking areas must be defined, preferably with curbs and gutters. Other less desirable methods are posts, fences, etc.

For two-side parking in a parking lot, a 60-foot width is considered necessary. In this type of lot, where perpendicular parking is used, 240 sq. ft. are necessary for each vehicle. This is less space than would be necessary for angle parking.

Finish grade:

Finished grading is vital in tying landscape plan into the circulation plan and providing drainage for plant maintenance. Only one main point will be discussed in this to present the general idea. Where a walk is to be built, either at the top or bottom of a slope, at least a 3 ft. berm should be provided between walk and the beginning of the slope. This is important from the standpoint of preventing the slope from encroaching on the walk where walk is placed at the base of a slope, or to prevent the slope from gradually working from under the walk where walk is placed at the top of a slope.

Where a slope is to be turfed, in general it is desirable that the slope not exceed a 1:3 ratio.

Planting:

Plantings may be used as ground cover to prevent erosion or blowing. Turf is an example of this type of planting. Woody vines are also useful for this type of planting. The woody vines present fewer maintenance problems than turf. However, a considerable amount of maintenance is necessary in establishing a woody vine ground cover. This is especially true where Bermudagrass is common and competes with the woody vine cover in the establishment phase. A number of woody vines are suitable for this area, including Hall's honeysuckle, Chinese or Texas honeysuckle, Vinka, particularly Vinka major in the southern part and perhaps Vinka minor in the northern part, English ivy, Japanese jasmine and Carolina jasmine. Plants may also serve for enclosure and canopy purposes. It is important to consider usefulness as well as beauty in selecting plants for a particular purpose. Contribution must go beyond the aesthetic. Some examples of this would be plants to serve in guiding players and providing shade on a golf course. An example in the home planning design would be the use of desiduous trees on the south side of the residence so that sunlight would have free access to the house during the winter months.

Maintenance:

The landscape planned should include maintenance considerations in the initial phases. Too many plants are often used in landscaping and frequently used without regard to growth habit. For example, large plants planted too close to the foundations of buildings result in heavy pruning being necessary to maintain the plants. If the individual plant in the design is not allowed to express itself, all plants tend to be pruned into the same shape, thus losing much of their value. Turf should have some type of permanent border so that the original form and shape of the design may be maintained and also to reduce the amount of maintenance necessary in maintaining the original design.

ROSE GROWING SUGGESTIONS

By Texas Rose Research Foundation, Inc.
Dr. E. W. Lyle, Plant Pathologist

Location for Planting:

Select a place where there is sun at least half of the day, not under trees nor next to hedges.

Time for Planting:

Plant during the winter months unless the ground is frozen. Late fall or early spring planting is best in cold climates.

Preparation of Beds:

(1) Remove grass, weeds or other plants for a width of 4 feet if for single row; 6 feet if for a double row. For convenience in caring for plants and cutting of blooms, it is best not to have more than 2 rows together. For further planting, allow a walkway of about 5 feet to the next row of roses.

(2) Dig a trench 12 to 15 inches deep and about 2 feet wide for each row.

(3) Place 3 to 5 inches of rotted manure (cattle preferred) or compost in the bottom of the trench.

(4) Add 2 or 3 inches of soil on top of the manure or enough so the lowest branches and union with the understock will be just above the soil level when the planting is completed.

Care of Bushes on Arrival:

Unpack and soak the roots in water for about an hour. If the bushes cannot be planted immediately, dig a trench and bury plants roots-down in soil except for top inch or two of the canes. Wet down if the soil is dry. Plant bushes as soon as possible.

Setting out the Bushes:

(1) Trim the roots to not more than 12 inches long.

(2) Prune the tops back to about 8 inches from the union (where the branching originates).

(3) Bushes may be spaced as close as 18 inches apart in a row.

(4) Place a mound of soil under the base of each bush so the roots slant downward into the trench. Cover the roots with good top soil and pack slightly by tamping or tramping. Water if the soil is dry.

(5) Mound the soil over the union and around the canes for the winter, but rake away the mound just before new growth starts.

Pruning Established Bushes:

General pruning should be done in late winter or just before the buds start swelling. Prune out all the dead wood. Remove enough top growth to keep the bushes in size and shape. Make the pruning cuts close to joints or just above buds (this is superior to using paints or pastes over cuts). The climbing roses which bloom just in the spring should be pruned only right after the bloom period.

Fertilizing:

Apply in the spring about the time growth starts and repeat every 6 or 8 weeks as the growth requires. Fall applications are not advised. Well rotted cattle manure is one of the best fertilizers for roses. Apply about 1 or 2 inches deep around each bush but not touching the canes. Commercial fertilizers are satisfactory. Complete fertilizers, 5:10:5 or similar formulas are good but should be used at not more than 1 or 2 pounds per 100 square feet of bed space. This is approximately 1 pound for 20 bushes each application. Soluble type fertilizers of high analysis are excellent but should be used in lesser amount. These can be applied as liquids if desired.

Winter Protection:

Where freeze damage is anticipated, cover the crowns and canes by mounding with soil to 8 or 10 inches deep but remove as soon as growth starts in the spring.

Extra Precautions:

(1) Plant so the finished bed will be high if the soil is not well drained, or level with the surrounding area otherwise.

(2) Plant shallow enough so the soil comes no higher than the base of the union or crown and does not touch the branches during the growing season.

(3) For black spot disease of leaves a sulphur-copper rose dust fungicide is very effective if used properly. Dust lightly within 24 hours after each rain or once a week during continuous rains; a sufficient amount of fungicide is not unsightly; treat when the air is still. Begin using a fungicide before black spot appears. (Black spot spreads only during rains or when the leaves are wet from watering). Captan or Maneb sprays give better control than the dust fungicide but are more laborious. Spray once a week, making sure to cover the lower as well as the upper side of the leaves. Ten pounds of dust fungicide or one pound of wettable spray material will care for about 50 bushes a year. For powdery mildew disease spray with Karathane fungicide, using only when needed.

(4) Principal insects are aphids (plant lice). Use Malathion or benezene hexachloride (BHC or Lindane) when needed. For red-spider mite (tiny insects yellowing and finally webbeing the leaves, spray with "Aramite." For beetles, caterpillars, and other leaf chewing insects use lead arsenate or DDT (not household DDT).

(5) Avoid sprays containing oils which might burn.

(6) Avoid wetting the foliage when watering if black spot disease is present.

(7) Cut blooms short until bushes become good size. Snap off old blooms to help build the plants as well as to improve the appearance. Usually when cutting flowers it is best to leave 2 or 3 leaves of each flower stem on the bush, making each cut close as possible above the leaf joint (axil). Do not leave stubs after any cutting or pruning. Remove dead wood any time of year.

(8) Cultivate shallow or just enough to kill weeds.

(9) Keep fertilizers off leaves and canes except the specially diluted foliage nutrients.

(10) Mulch with 1 to 2 inch layer of pine needles, leaves, sawdust, cotton burrs or other suitable materials to conserve moisture and help control weeds.

SUGGESTED VARIETIES OF ROSES
*(Patented Varieties)

ROSES FOR FRAGRANCE

Crimson Glory	(red)
Rouge Mallerin	(red)
Mirandy*	(red)
Nocturne*	(red)
Etoile de Hollande	(red)
Briarcliff	(pink)
Dainty Bess	(pink)
Pink Frost*	(pink)
Rubaiyat*	(pink)
Golden Charm	(yellow)
Golden Ophelia	(yellow)
Caledonia	(white)
Talisman	(pink-yellow)

ROSES FOR BORDERS (Floribundas, Grandifloras, Polyanthas, Climbers)

World's Fair	(red Fl.)
Donald Prior	(red Fl.)
Red Pinocchio*	(red Fl.)
Permanent Wave*	(red Fl.)
Independence*	(red Fl.)
Geranium Red*	(red Fl.)
Crimson Rosette*	(red Fl.)
Red Cap*	(red Fl.)
Red Ripples	(red Fl.)
Baby Chateau	(red Fl.)
Improved Lafayette	(red Fl.)
Roundelay*	(red Gr.)
Valentine*	(red Fl.)
Queen Elizabeth*	(pink Gr.)
Else Poulsen	(pink Fl.)
Pink Rosette*	(pink Fl.)
Ma Perkins*	(pink Fl.)
Frolic*	(pink Fl.)
Pinnocchio*	(pink Fl.)
Goldilocks*	(yellow Fl.)
Circus*	(yellow pink)
Jiminy Cricket*	(orange-red Fl.)
Fashion*	(coral-peach Fl.)
Vogue*	(cherry-coral Fl.)
Spartan*	(salmon-pink Fl.)
Floradora	(salmon-orange Fl.)
Ideal	(red Poly.)
Pinkie*	(pink Poly.)
Cecile Brunner	(pink Poly.)
Mrs. R. M. Finch	(lt. pink Poly.)
Summer Snow	(white Poly.)
Katharina Zeimet	(white Poly.)
Golden Salmon	(orange Poly.)

ROSES FOR EASY GROWING

Red Radiance	(red)
Etoile de Hollande	(red)
Poinsettia	(red)
Ami Quinard	(red)
Radiance	(pink)
Editor McFarland	(pink)
Mrs. Charles Bell	(light pink)
Betty Uprichard	(2-tone pink)
Edith Nellie Perkins	(2-tone pink)
K. A. Viktoria	(white)
Buccaneer*	(yellow)
Golden Charm	(yellow)
Talisman	(pink-yellow)

ROSES FOR SHOW BLOOMS

Red
- Nocturne*
- Mirandy*
- New Yorker*
- Etoile de Hollande
- Crimson Glory
- Better Times
- Grande Duchesse Charlotte*
- Texas Centennial
- Bravo*
- Chrysler Imperial*

Pink
- Rubaiyat*
- Katherine T. Marshall*
- Charlotte Armstrong*
- Tiffany*
- Helen Traubel*
- The Doctor
- Show Girl*
- Briarcliff
- Picture

Yellow
- Golden Masterpiece*
- Eclipse
- Lowell Thomas*
- Buccaneer*
- Fred Howard*
- Golden Scepter*
- McGredy's Sunset

White
- Caledonia

ROSES FOR BORDERS, cont.

Paul's Scarlet	(red Cl.)
Dr. Huey	(red Cl.)
Improved Blaze	(red Cl.)
New Dawn	(pink Cl.)
Golden Showers*	(yellow Cl.)
Dream Girl	(pink Cl.)
Climbing Hybrid Teas	(many varieties)

1958 ALL-AMERICA WINNERS

White Knight*	(white H. T.)
Fusilier*	(red Fl.)
Gold Cup*	(yellow Fl.)

ROSES FOR SHOW BLOOMS, cont.

White, cont.
Blanche Mallerin*

Apricot
Mme. Joseph Perraud
Duquesa de Penaranda

Blends

Peace*	(yellow pink)
Contesse Vandal	(pink)
Mojave*	(orange-red)
Forty-Niner*	(red-yellow)
Pres. Herb. Hoover	(red-yellow)
Hinrich Gaede	(orange)
Montezuma*	(salmon-pink)

ADDITIONAL INFORMATION OR REFERENCES ON ROSES

AMERICAN ROSE ANNUAL---Published each year since 1916 by the American Rose Society, Columbus, Ohio. Newest reports on roses. $5.50 a year.

MODERN ROSES IV. (1952) $7.50. By Horace McFarland Co., Lists over 6000 kinds of roses.

ROSES FOR EVERY GARDEN (1956) $4.50. By Dr. R. C. Allen. General information on roses and their care.

ANYONE CAN GROW ROSES (1954) $3.00. By Dr. Cynthia Westcott. A guide for home growing of roses.

HOW TO GROW ROSES (1955) $1.50. By J. P. Edwards. A Handy, brief, yet complete guidebook.

(These books are all available from the American Rose Society, Columbus, Ohio.)

PROBLEMS AND DISCUSSIONS

Is it necessary to add 2,4-D to disodium methyl arsonate to control Dallisgrass and goosegrass?

Some research results have indicated that at light rates of DSMA, its effectiveness may be increased through the addition of small amounts of 2,4-D. However, DSMA alone, properly applied, will give satisfactory results. There are State laws regulating the use of 2,4-D and these would have to be considered when mixing 2,4-D with disodium methyl arsonate. The same studies mentioned above also indicate that ammonium nitrate in the amount of 4 lbs. per 1000 sq. ft., mixed with the disodium methyl arsonate, may also increase its effectiveness at lighter rates of disodium methyl arsonate.

Will Crag I control goosegrass?

Crag I is a preemergence herbicide and for control it would have to be applied before the goosegrass emerged and should be applied every 14 days. Rates of $2\frac{1}{4}$ ozs. per 1000 sq. ft. should be effective and there is little residual effect of the material.

Is it worthwhile to use a sticker with disodium methyl arsonate?

Yes. Studies at Texas A & M indicate that one of the most important considerations in the use of DSMA is in having a wetting agent with the material.

Will DSMA work on sedge and nutgrass?

It is not effective on nutgrass but seems to give some control of the sedges.

Is soil moisture important in using DSMA?

Yes. Grass and weeds should be growing actively if the material is to be the most effective. In periods of extreme moisture stress, a burning of the foliage could be expected, but probably not as good control as under better growing conditions. However, some studies have indicated that the material is most effective under slight moisture stress.

Is amount of moisture (gallonage) of spray important in using disodium methyl arsonate?

Yes. Grass blades can hold only about 5 gallons of water per 1000 sq. ft. before run-off occurs. At minimum rates of DSMA, the percentage control is reduced if this run-off becomes excessive. On the other hand, if the gallonage of water is too low, the concentration of the material may be such that burning will occur and again the optimum amount of killing not be obtained.

Do fungicides and insecticides harm beneficial soil microorganisms?

Yes. However, soil life tends to reactivate itself rapidly in nature.

Do fungicides and insecticides work differently on fine-leaf Bermuda?

Yes. In fact, different strains of Bermuda may react differently to fungicides and insecticides. For example, chlorodane and other chlorinated hydrocarbon insecticides tend to bleach Texturf 10 temporarily.

Why does one hear of good and poor Bermuda control with Vapam?

Bermuda that is rooted in the soil is killed by Vapam. Stolons on top of the soil that are not connected or only loosely connected to the soil may escape damage. These then will root later and become established in the soil. For better control, it is suggested that the surface be raked and treated with sodium arsenite or diesel fuel and topdressed heavily before using Vapam.

Does all methyl bromide contain teargas?

No. Dow's formulation, M.C.2, stands for methyl bromide, chloropicrin 2%. One superintendent in Austin was injured severely by methyl bromide recently. Thus, one should use precautions when applying the material.

Will DMAS control goosegrass?

Yes. Application should be started before germination of the goosegrass seed and used regularly.

What are the advantages and disadvantages of DSMA vs. sodium arsenite in controlling St. Augustine?

Sodium arsenite required more applications, usually 3 or more, will burn desired vegetation but the cost of material is cheaper. DSMA is safer to use, one application will give control but the cost of material is higher.

How does one set up worthwhile specification for purchasing peat?

Large orders should be purchased in bulk, with maximum and minimum moisture content and PH specified. Also, it is important to specify whether reed or sedge peat is desired.

THE USE OF PLASTIC PIPE IN IRRIGATION SYSTEMS

Robert L. Frazer
Parks and Recreation Department
City of San Antonio, Texas

Born of war-time necessity, the development of plastics for pipe has varied by country and appears to be due to the availability of the raw materilas, know-how and demand. England has been a leader in polyethylene pipe development while Germany has specialized in polyvinyl chloride pipe. The United States has achieved sizeable production in six plastics, namely; polyvinyl chloride, polyethylene, vinylidene chloride, cellulose acetate butryate, polyesters, and styrene copolymers.

Vinylidene chloride pipe was introduced as a replacement for metal pipe in 1942. By 1950 only vinylidene chloride and cellulose acetate butyrate had established market uses, while polyethylene and reinforced polyester pipe had just completed their final stages of development and were being made ready for the commerical market.

Although thermoplastic pipe is fabricated by the simplest form of extrusion known, and almost any extrudable resin can be used, this use for plastics has lagged behind other applications. Meanwhile, the growth of thermosetting pipe has also been retarded due to more complex processing operations.

In general, plastic pipe has an advantage over metal pipe because of its resistance to rust, corrosion, chemical and electrolytic attack, ease and economy of installation, long lengths and flexibility which eliminate some fittings, minimal solid deposit collection, low frictional losses and turbulance, and low capital investment in equipment to produce pipe.

Our program regarding the use of high impact rigid Polyvinyl Chloride plastic pipe stemmed from the critical situation facing us - the extreme need of adequate water in our parks and the need for a piping material which would hold up against electrolysis and scale build-up.

Since the bulk of our water program involved the use of quick-coupling valves, we were able to slant our program towards standardization, not only in valves and sprinklers but also in pipe and pipe sizes.

Regarding plastic pipe, we use only 1½" high impact P.V.C., which costs us approximately $.30 per foot in quantities of 10,000 feet (bid basis). By doing so, we cut down our over-all costs in three ways.

(1) In designing and engineering
(2) Fewer pipe sizes and fittings to carry in stock
(3) Easier field installation

There are two types of plastic pipe which are adaptable to irrigation systems, these are polyethylene and high impact polyvinyl chloride.

Polyethylene is used to a good extent in pop-up or dissipating systems; however, we would not recommend its use in the quick-coupling system, where pressure will remain in the line constantly. For constant pressure systems, we feel that the high-impact polyvinyl chloride pipe is the only practical plastic pipe to use.

To-date we are using a plastic pipe with a wall thickness slightly heavier than a schedule "A" and less than schedule 25. We call it a custom size pipe. We have had this pipe in the ground in two, 4 acre parks, for 14 months. Static pressure has been approximately 65 to 70 pounds. This pipe passed the "Acetone Immersion Test" indicated in our specifications and to-date has performed as expected without a single pipe failure (longitudinal rupture).

Recently, we removed sections of this pipe from these two installations and sent them to B.F. Goodrich Chemical Company for analysis and testing, and the report returned to us was very favorable.

The following information regarding cost comparisons of current bid prices of standard galvanized pipe versus custom size P.V.C. plastic pipe will prove interesting.

COMPARISON OF CURRENT BID PRICES
OF P.V.C. vs GAL. PIPE IN 7,000' - 10,000' QUANTITIES

SIZE	BID PRICES PER FOOT	
	STANDARD GAL. PIPE	CUSTOM SIZE P.V.C.
½"	.14	.10
3/4"	.18	.14
1"	.26	.18
1¼"	.34	.24
1½"	.40	.31
2"	.51	.47

ADVANTAGES AND DISADVANTAGES OF HIGH IMPACT
RIGID POLYVINYL CHLORIDE PLASTIC PIPE

Advantages:

(1) Low cost - (in our custom size)

(2) Chemically inert - solutions carried will remain chemically pure

(3) Age, weather resistant - will not deteriorate, age, rust or rot due to weather or moisture. Will not become brittle if stored in sunlight.

(4) Corrosion resistant - P.V.C. pipe is uneffected by most acids and alkalies, as well as oil, water, alcohol, and salt solutions.

(5) Self-insulating - Poor conductor of heat

(6) Smooth bore - same flow factor, as copper pipe. Flow rates are as

much as 25 % greater than are possible with steel pipe of the same size. It is almost impossible for materials to stick to the glossy walls. Because there is little, if any, build-up of deposits, P.V.C. plastic maintains its original effeciency and capacity in use.

(7) Light weight - makes for ease of handling and rapid installation in the field.

(8) Larger I.D. (1,720) - permits a greater volume of water to flow through pipe than galvanized pipe of the same size.

Disadvantages:

(1) Should not be used in irrigation systems where surge will increase the static pressure beyond 80 lbs.

(2) Unless it is deeply buried it is unwise to use it in areas immediately close to buildings where follow-up construction work will be done at a later date.

(3) Difficult to reclaim since it is subject to damage by digging equipment such as a pick or mechanical digger.

(4) Requires responsible people to install plastic pipe. Can not afford careless installation procedures.

SPECIFICATIONS FOR RIGID PLASTIC SPRINKLER PIPE
CITY OF SAN ANTONIO, TEXAS
DEPARTMENT OF PARKS AND RECREATION

I. SCOPE:

This specification describes the properties and performances required from High-Impact Rigid Polyvinyl Chloride plastic pipe, extruded from B.F. Goodrich's "Geon 8700-A" virgin resin.

II. RAW MATERIALS:

The rigid plastic sprinkler pipe shall be extruded from B.F. Goodrich's "Geon 8700-A" virgin resin. The material must be non-toxic, free from taste and odor, possess good elongation and impact characteristics, and conform to the following minimum physical standards:

Specific gravity	1.35
Tensile strength (p.s.i. at 77°F)	5,600
Tensile strenght (p.s.i. at 150°F)	2500
Compressive strength (p.s.i.)	7900
Flexural strength (p.s.i.)	11,000
Coefficient of linear expansion (inches/inch/°Cx10)	14

Izod impact strength (lbs/inch of notch)	15
Burning rate	Will not support combustion
Water absorption (% wt. 24 hrs.)	.07

III. FINISHED PIPE:

Pipe shall be furnished in 20 feet lenghts plain ends (not coupled). Pipe shall be produced so as to maintain a manufacturing tolerance of plus or minus .005" on the O.D. of 3/8", 1/2", and 3/4" pipe, and a manufacturing tolerance of plus or minus .008" on the O.D. of 1", 1 1/4", 1 1/2" and 2" pipe. Working pressure shall be calculated from the Barlow Formula, with a safety factor of five to one.

IV. MINIMUM QUALITY CONTROL TESTS FOR GEON RIGID POLYVINYL CHLORIDE PIPE:

A. Visual Inspections:

Pipe shall be homogeneous through out and free from visible cracks, holes, or foreign materials. Pipe shall be free from blisters, wrinkles and dents. This inspection shall be made on each length of pipe shipped by the extruder.

B. Dimensional and Tolerance Specifications

1. Outside Diameter Measurements

Measurements shall be made using a suitable micrometer or caliper capable of measuring to the nearest 0.001". A series of sets of two measurements of the outside diameter, approximately 90° apart, shall be made at each end of the pipe. One measurement shall be reported as the maximum and the other measurement shall be reported as the minimum outside diameter. Both readings at each end of the pipe should conform to the requirements. The requirements are listed under No. VI.

2. Wall Thickness

Measurements shall be made using a suitable micrometer or caliper having rounded anvils and capable of measuring to the nearest 0.001". A series of sets of two measurements 180° apart shall be made on each end of the pipe. One measurement shall be the maximum and the other the minimum. The maximum and minimum readings determined at each end of the pipe and shall be in accordance with the requirements, as listed below under No. VI.

C. Determination of the Quality of Extrusion:

1. A sample of extruded pipe shall be immersed in 99.5% Pure Anhydrous Acetone for one hour. This test should be conducted frequently enough to serve as a check on the quality of pipe being extruded before shipment. Any pipe not passing this test after delivery may be rejected as pipe that does not meet specifications.

2. Flattening

A test specimen of pipe 2" long shall be cut from each end of the pipe sample. Each test specimen shall be flattened between press plates of a press or hammer until the distance between the plates in inches is equal to the flattening factor in Table #3 below, multiplied by the measured wall thickness of the pipe size. There shall be no evidence of cracking, splitting, or breaking when any diameter pipe specimen is subjected to flat bending.

TABLE #3

Nominal Pipe Size in Inches	Flattening Factor
1/4	3
3/8	3
1/2	3
3/4	4
1	4
1 1/4	5
1 1/2	6
2	6
2 1/2	6
3	6
3 1/2	6
4	6
5	6
6	6

V. MANUFACTURING GUARANTEE:

All pipe must be guaranteed by the manufacturer to be free of manufacturing defects in material or workmanship. Manufacturer's liability may be limited to replacement or credit for defective pipe if the use has been within the limits of pressures and temperatures recommended. The manufacturer must guarantee that all pipe has, or will pass, the Anhydrous Acetone Immersion Test, as specified above.

VI. PHYSICAL REQUIREMENTS:

P.V.C.
I.P.S. - O.D.
20' LENGTHS-PLAIN END

NOM. SIZE	O.D.	I.D.	WALL THICKNESS	WT/FT	RECOM. W.P.* @77°F
3/8"	.675	.545	.065	.073	216 lbs.
1/2"	.840	.710	.065	.093	162 lbs.
3/4"	1.050	.920	.065	.118	139 lbs.
1"	1.315	1.185	.065	.150	111 lbs.
1 1/4"	1.660	1.500	.080	.232	108 lbs.
1 1/2"	1.900	1.720	.090	.300	106 lbs.
2"	2.375	2.155	.110	.458	104 lbs.

* Working pressure p.s.i. calculated at 77°F using Barlow's Formula with tensile strength of 5,600 p.s.i.
Working pressure equal to 20% (or 1/5) of Burst Pressure.

SPECIFICATIONS FOR FITTINGS AND SOLVENT
FOR USE WITH P.V.C. RIGID PLASTIC PIPE

FITTINGS:

All plastic fittings shall be "Sloane," or E. and A., moulded fittings with the exception of 2" and larger couplings, which shall be "swage" type couplings. All fittings must be compatible with rigid polyvinyl chloride pipe. All fittings will be medium wall unless otherwise specified.

SOLVENT:

All solvent must be I.P.S. #710F P.V.C. solvent unless otherwise specified.

BERMUDA GRASS (CYNODON DACTYLON (L.) PERS.) DISEASES REPORTED ON THE NORTH AMERICAN CONTINENT.

Frank L. Howard, Head, Department of Pathology
and Entomology,
University of Rhode Island.

A. Fungus pathogens of stems, leaves and inflorescenses.

1. Ascochyta graminea "Leaf Mold", "Spot"
2. Cercospora seminalis (Ell. and Ev.) Sacc. "False Smut", "Spot" Texas
3. Colletotrichum graminicola (Ces.) G. W. Wils. "Anthracnose"
4. Diplodina graminea Sacc. So. C.
5. Erysiphe graminis DC. "Powdery Mildew" California
6. Fusarium nivale (Fre) Ces., or Calonectria nivale "Fusarium Patch", "Snow Mold" Wash.
7. Helminthosporium cynodontis Marig. "Leaf Blotch" Fla., Ga., N. C., Va.
8. Helminthosporium giganteum Heald and Wolf. "Zonate Eye Spot" Fla., Md., N.C., Texas
9. Macrophoma sp. So. C.
10. Papularia arundinis (Fr.) Cda., or Coniosporium gramineum (Ell. and Ev.) Sacc., or C. rhiqophilum (Pruess.) Sacc. La., Miss.
11. Papularia sphaerosperma "Mold"
12. Piricularia grisea "Gray Spot", "Blast"
13. Puccinia cynodontis Lacroix ex Desm. "Rust" Gulf States to Calif.
14. Puccinia graminis Pers. "Stem Rust"
15. Sclerospora farlowii Griff. "Downy Mildew" Okla.
16. Septoria cynodontis Fckl. "Lead Spot" Texas
17. Sorosporium syntherismae (Ph.) Farl. "Flower Smut" Calif., Texas
18. Ustilago cynodontis P. Henn. "Loose Smut" Ariz., Calif., Mo., Okla., Texas.

B. Fungi and nematodes injuring roots, sometimes stems and crowns.

1. Gloeosporium bolleyi Sprague. "Root Necrosis"

2. Heterodera marioni (Cornu) Goodey "Rootknot" nematode. Calif., Ga.

3. Leptostromella cynodontis Sacc. "Decline"

4. Pratylenchus pratensis (DeMan) Filip. "Field" nematode. Calif.

5. Pyrenochaete terrestris "Pink Root"

6. Pythium debaryanum "Blight"

7. Rhizoctonia grisea (Stevenson) Matz., or Corticium sasakii (Shirai) T. Matsu. "Banded scleratial disease" Ala., La., Miss.

8. Rhizoctonia solani Kuhn, or Pellicularia filamentosa "Brown patch" La., Okla., Texas

9. Sclerotium rolfsii Sacc., or Pellicularia rolfsii "Southern Blight", Stalk Rot". Fla.

C. Fungi associated with dead plant parts, presumably non-parasitic.

1. Apiospora montagnei Sacc. "Leaf Mold" Ga.

2. Dimerosporium erysipheoides Ell. and Ev. "Leaf Mold" La.

3. Marasmius graminis "Fairy Ring" "Mushroom"

4. Phymatotrichum omnivorum (Shear) Dug. "Root Rot" Ariz.

5. Physarum cinereum (Batsch.) Pers. "Slime Mold" Fla., Okla., Texas

GRASS IDENTIFICATION

By
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School of Agriculture
Texas A. & M. College

There are over 1200 species of grasses in the United States, with some 600 of them found growing in Texas. This includes those commonly cultivated and native or natural species. Most of the grasses used for turf are from the cultivated species; however some of the weedy and a few of the good ones are native to Texas. There are at present many different strains of Bermuda and bent grasses which are very difficult to distinguish within a specie. The most critical determination of grasses is based on the vegetative and the flowering parts. There are no complete keys based on vegetative parts alone. However, it is sometimes expedient to identify grasses when they are in the vegetative stage prior to the time that they have flowered.

In order to identify grasses, one must learn a few technical terms and be willing to do some thinking on his own. Botanical or technical names are given to the parts of the plant for the same reason that names are given to the parts of an automobile. Who would think of saying "the bright metal part of an automobile on the front end between the two eye-like projections sunken into a rounded, metal-like affair." Why not say the grill? All understand this word because it is in common usage. It is just as easy to say ligule as to say "a paper-like projection at the juncture of the leaf blade and sheath." It is essential to know the names of the different parts of the grass plant in order to understand how these parts are alike or are different among the species. The roots, stem, and leaves form the vegetative parts; and from the flowers the seed are produced. Where close mowing is practiced it is often difficult to find flowers. Therefore, in order to identify grasses in the vegetative state one must have a clear understanding of the various vegetative parts.

The leaf blade, which is the expanded portion of the leaf, is made up of the collar, ligule, and auricle. The sheath is that portion of the leaf that encloses the stem and is attached to the stem at a node. At the juncture of the leaf blade and sheath is the collar. The collar is often lighter in green color than the rest of the leaf. On the inner face of the leaf blade at the collar is located the ligule which may take the form of a thin, paper-like projection, or it may be a ring of hairs, or it may be absent.

In some species there are claw-like appendages or projections at the collar opposite to where the leaf blade joins the collar. The stem of the grass plant is called the culm. The joints of the stem are nodes, and that part between the nodes is the internode. The culms in grasses may be flat or rounded, hollow or pithy, but in all cases the nodes are solid. The culm of the grass plant may be upright or prostrate. When the culms are prostrate, running along the ground, they are called stolons. In some cases stems arise just below the ground surface and develop underneath the ground, and these are called rhizomes or root stocks. The rhizomes have short internodes and reduced leaves; however when they appear above the ground they develop normal leaves with normal appearance. Roots arise from the nodes that are just below or at the ground surface. At each node is a vegetative bud. These may develop or remain dormant. When they develop they either grow parallel to the parent culm until they emerge from the leaf sheath or the young branch splits the sheath and grows outward. Leaves are always born at the nodes and are two ranked--in other words they develop on opposite sides of a stem. The cells that divide and cause the leaf to grow longer are found at the base of the leaf blade. Whenever a young blade is cut it will continue to grow until mature. Thus, in mowing, the ends of a grass leaf may be cut several times. In most other plants leaf growth takes place at the outer edge or tip of the leaf. Mowing may also stimulate the development of the dormant buds at the nodes. Thus, turf grasses will endure closer and more frequent mowing than most other plants.

Grasses may be annual, germinating, producing seeds and dying within a single season like ryegrass or crabgrass; or they may be perennials, living from year to year, such as Bermuda or bentgrass. The perennial grasses are of two basic types: bunch and sod formers. In the bunch grasses the new shoots form at the base of the nodes and grow up inside the sheath, and as a result there is little lateral spread from the original seedling. Examples of the bunch grasses are ryegrass and bluestems. When new shoots burst through the sheath and run along the ground and develop roots at the nodes the result is a sod. Bermuda, creeping bent, and buffalograss are good sod grasses. In the case of Kentucky bluegrass a sod is formed by the development of rhizomes under the ground, which in turn produces new above-ground shoots. The density of the sod is basically a matter of the length of internodes in the stolons or rhizomes, and the number of vegetative buds that develop. In all cases the density may be influenced by the micro-climate which includes mowing, fertilizing and watering practices.

GRASSES ASSOCIATED WITH TURF IN TEXAS

Latin Name	Common Name
Grasses Used For Turf	
Agrostis alba	redtop
Agrostis palustris	creeping bent, seaside bent
Agrostis tenuis	colonial bent, Rhode Island bent
Axonopus affinis	carpet
Buchloe dactyloides	buffalo
Cynodon dactylon	(named Bermuda strains) Texturf 10, Texturf F1, Tiffine, Tifgreen, Genetift, Sunturf
Cynodon transvaalensis	African, Uganda
Eremochloa ophiuroides	centipede
Lolium spp	common rye
Paspalum notatum	Bahia
Stenotaphrum secundatum	St. Augustine

Grasses Considered Weeds in Turf

Bromus catharticus	.rescue
Bromus secalinus	.cheat
Bromus tectorum	downy brome
Cenchrus pauciflorus	.grass bur
Chloris latisquamea	windmill
Chloris verticillata	.windmill
Dactyloctenium aegyptium	.silver crabgrass
Digitaria sanguinalis	crabgrass
Distichlis stricta	.saltgrass
Echinochloa colonum	jungle rice
Eleusine indica	goosegrass
Eragrostis spp	.lovegrass
Brachiaria ciliatissima	fringed signalgrass
Brachiaria extensa	broadleaf signalgrass
Festuca octoflora	six weeks fescue
Hordeum pusillum	.little barley
Paspalum dilatatum.	dallis
Paspalum dissectum	.mudbank paspalum
Paspalum acuminatum	brook paspalum
Paspalum distichum	.knotgrass
Paspalum vaginatum	.seashore paspalum
Poa annua	annual bluegrass
Schedonnardus paniculatus	tumblegrass
Sporobolus poiretii	smutgrass
Setaria geniculata	.foxtail.

NITROGEN MANAGEMENT STUDIES FOR BERMUDA PUTTING GREEN TURF

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Much has been written and said about turf fertilization in recent years. It has been stated that between 1949 and 1955, 33 major talks had been given on the subject at 12 state and national turf conferences. During the same time 25 articles were published in popular magazines such as the Golf Course Reporter and over 50 technical papers touching on the subject had been published in The Agronomy Journal and other technical journals. It has also been stated that nitrogen is the most critical of the fertilizer elements used in turf management, and its proper use is second only to water in importance.

Work at Texas A. & M. from 1951 to 1953 showed that Bermudagrass responded readily to 12 pounds of ammoniacal and nitrate nitrogen per 1000 sq. ft. Where the nitrogen was applied in 4 applications, peaks of rapid growth and succulence resulted. Smaller amounts of nitrogen per application gave better results immediately following treatment but the same or longer periods of starvation occurred before the next application. These results indicated that 12 pounds or less of actual nitrogen were adequate to maintain turf in good condition. The data also suggested the need for more frequent small applications where ammoniacal and nitrate nitrogen sources are being used.

Actually, some golf courses are following the practice on greens of applying nitrogen as frequently as every 5 - 7 days, in mid-summer, in amounts of 1/4 lb. or less per 1000 square feet. This results in uniform growth and avoids heavy build-ups of nitrogen in the soil, thus avoiding super-abundance of nutrient elements at any time in case weather conditions favor disease attacks. This is one of the serious problems that may be encountered with single, heavy applications of nitrogen.

Applications of the frequency indicated above introduce a cost factor unless soluble forms are used and applications combined with fungicidal treatments or other maintenance operations. Of course, cost is often of secondary importance when a practice is necessary to maintain desired conditions.

In recent years the urea-form products, which have been known for some time, have become available in commercial quantities. These materials, in theory, release nitrogen over a period of several months. The rate of this release is dependent on soil and climatic conditions. Also, grasses differ in their feeding habits and nitrogen requirements. Thus it is necessary to study the materials under specific conditions and for specific grasses to establish desired management practices.

Lunt and Younger reported in 1956 that 30 pounds per 1000 square feet of nitrogen from 38% methylene urea maintained adequate nitrogen levels for periods of 6 months and longer whereas applications of 8 pounds did not maintain adequate nitrogen levels for periods longer than about 3 to 4 months.

Studies were started at Texas A. & M. in 1956, supported in part by du Pont, to determine desirable management practices using Uramite on both lawn turf (Bermuda) and a fine-leafed Bermuda, cut at putting green height. Because of a change of location of the turf nursery in late 1956, the tests have not conducted for a full season in either year.

Plots were 5' x 10', replicated 4 times. Three sources of nitrogen were used; (uramite), 38% N, milorganite and ammonium nitrate. Nitrogen was applied at various rates and in 1, 2, and 4 applications per season as indicated on the slides to follow. All plots received adequate phosphorus and potash. The soil is a fine sandy loam, Ph 5.5 to 6.0, about 10 to 18 inches deep overlaying an impervious clay subsoil. The plots were sprinkler irrigated in 1956 and both sprinkler and flood irrigated in 1957. More rainfall was received in 1957 than in 1956, but irrigation was necessary frequently.

Data were obtained on yield of clippings, accumulated dried and weighed for weekly periods; color, rated biweekly; density, rated biweekly and to be measured quantatively at the end of the season; soil nitrates and tissue nitrogen. The later laboratory measurements were obtained on selected treatments to aid in establishing periods of both excessive and deficient nitrogen supply.

The results are presented as a series of bar-graph slides and are limited to those studies conducted at putting green height of cut.

Slide 1: Average biweekly yield of clippings are shown for 4 rates of uramite in 1956. These yields show growth stimulation for some 14 weeks from single 4, 8 and 12-pound applications of uramite and a somewhat more unifrom growth for about the same period from two 6-pound applications.

Slide 2: Monthly color ratings from 6 treatments in 1956. Monthly color ratings show that 4 pounds of uramite never did produce good color. Eight and 12-pound single applications gave good color for about 6 weeks and improved color for another two months. The nitrogen was applied about two weeks before the first ratings were made. Split applications of uramite gave more uniform color readings but with lowered readings when the applications wer too far apart (note the 6-6 and 3-3-3-3 patterns). The same was true for milorganite.

Slide 3: The plots were overseeded with bent in mid-November and clipping yields were obtained during the winter. Very little residual effect of spring applications is apparent. October applications indicate a slower release and a longer period of response, with some response in both color and yield being apparent at the end of 6 months.

Slide 4: In 1957, with two exceptions, all plots received 12 pounds of nitrogen regardless of the source. A check plot received no nitrogen and one uramite treatment received 24 pounds of nitrogen. Yield data in the chart indicate some response, erratic in nature, for about 16 weeks following a single application of 12 pounds of nitrogen from uramite. The length of response was about the same whether the material was applied in 1, 2 or 4 applications. Growth was most uniform when 4 applications were used. A 4-8 split resulted in some shift of growth to late summer which we think is desirable. October growth was poor with all treatments. Based on 1956 and earlier work, we think spring growth is often excessive while fall growth is slow, thus there is some need for shifting the growth to later in the season.

Slide 5: Growth behavior patterns were about the same for milorganite and ammonium nitrate. Eight applications gave more uniform growth (milorganite) than 4 applications.

Slide 6: Two of the previously shown treatments, the check and the 24-pound rate, are shown in this slide. More growth and better fall growth resulted with 24 pounds of nitrogen as might be expected. However, the 24-pound rate in 4 applications also gave a more erratic growth pattern.

Slide 7: Color ratings are perhaps more important than yield since we are obviously not interested in maximum yield. Of course, we are interested in uniform growth which color would not indicate adequately. The data in this slide indicate a more uniform color rating for the split 4-8 treatment than any other. Color ratings were higher at times for some of the other treatments. You may note that the average rating is 4 to 4.5, with the October ratings dropping to about 4.

Slide 8: Color ratings are satisfactory for all milorganite and ammonium nitrate plots. The ratings hold up better in the fall and also are somewhat higher than for uramite, averaging 4.5 to 5.

Slide 9: The data in this slide show that better color response is obtained with 24 pounds of nitrogen from uramite than from 12 pounds. Better fall color is obtained than from 12 pounds of milorganite in 8 applications.

Slide 10: The previous data have indicated the treatments that give us maximum growth or color and the most uniform growth or color. They have not indicated whether the rates were excessive since we cannot establish a definite desired growth rate. Nitrogen accumulation in the plant tissue and soil nitrates under actively growing plants may give us some indication of adequacy of nitrogen. Nitrogen in the tissue was maintained at a high level at all times for the 3 treatments shown. All of these were applied in 4 applications. While it is again not possible to establish definite desired levels of soil nitrates, it is obvious that 20 to 40 ppm measurable, available nitrate under actively growing grass is excessive and would result in over-succulence or be subject to leaching. Based on other work at College Station, 5-8 ppm appears to be fairly adequate. Thus, ammonium nitrate as applied in this study was often excessive. High amounts of nitrates occurred occasionally with the other treatments. The single 12-pound application of uramite, which is not shown, maintained levels above 16 ppm for 6 weeks.

In summary, the results of this study indicate that a single 12-pound nitrogen application of urea-formaldehyde material is not adequate to maintain good growth and color for more than 3 to 4 months and the rate of nitrogen release may be in excess of actual needs in the early part of that period. Two applications gave the most uniform growth and color pattern but more than 12 pounds of nitrogen may be needed since both early and late response were lower than desired from the split 4-8 application. Slightly better color was maintained from the readily available ammonium nitrate nitrogen especially in late summer and early fall, indicating a possible need for supplementary feeding at times where urea-formaldehyde materials are used.

These results are for a period of 150 days while the summer growing season at College Station is in excess of 210 days, thus the study will have to be conducted a full season before definite conclusions can be reached.

THE TURF RESEARCH PROGRAM AT TEXAS A & M

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The turf research program at Texas A & M dates back officially about eight years. During this period of time a great deal of information has been accumulated on such subject areas as turf nutrition, weed control, strain evaluation for the selection of improved turf grasses, methods of establishment of turf grasses and soil mixtures for special turf sites.

The question we might ask is what has been done with this information or what is being done with this information at the present time? We know of course that information obtained from previous nutritional studies has served as the basis for answering many requests on amounts and kinds of fertilizer for many different turf applications. A recent extension publication on home lawns utalized such information as a basis for fertilizer recommendations. Recent research in turf weed control from which the selective control of Dallisgrass was obtained emphasizes what is being done with information developed in the research program at Texas A & M. Since the information was released to the public about 1 year ago, we learn from you and other sources that the material DSMA is being used widely not only in Texas but other areas across the south in all types of turf use situations. In considering just these two areas of research, it is difficult to measure the benefit to the general public in terms of income, pleasure received, etc. We could mention other services and benefits received by the people of Texas from information developed in other phases of the turf research program.

Before considering the results of some of the research conducted within recent years in turf we might look at the financial status of the research program. Dr. Patterson pointed out problems relative to obtaining funds for turf research because of the impression many people have on the relationship of turf culture and production to agriculture. Funds for the support of the turf research this fiscal year total approximately $7,000.00 of which 50 percent came from state appropiated funds and 50 percent from association and industry grant-in-aid funds. We should point out the importance of some of the grant-in-aid funds to the turf research program. For example the annual grant of $500.00 from the Texas Turf Association alone would not support too much research, but by combining it with other funds makes it possible to support fairly extensive studies such as the Dallisgrass control work. Grant-in-aid funds from the Texas Turf Association for 1957 were used to support continued research on Dallisgrass control and establishment studies on Zoysia grasses.

The results of some of the research conducted during 1956 and 1957 will follow:

Experiments were continued during 1957 to try and obtain more information on factors influencing the action DSMA for the control of Dallisgrass. Applications of DSMA were made in May, June, August and September to Bermudagrass fairway turf uniformly covered with Dallisgrass. Results of the May treatments showed 3 oz. and 4 oz. of actual DSMA per 1000 square feet or 24 and 33 pounds of the commercial (31.5 percent) DSMA per acre gave very good control of Dallisgrass. A wetting agent at 1 teaspoon per gallon of spray mix was used. The next series of slides show the results of some of these treatments. Results of DSMA applications made during June showed the 3 oz. and 4 oz. rates per 1000 square feet to be somewhat less effective than the same rates made in May. Results of the June study also indicated that 2 gallons of water per 1000 square feet as a carrier was as good as higher volumes. This would be equivalent to 87 gallons of water per acre. Studies conducted in August using the same rates as in May and June showed almost no control obtained when a wetting agent was not used. Rains occurred immediately after treatments were applied in September. Results showed not reduction in stand of Dallisgrass in these studies. The next slide show these plots several weeks after treatment.

The results of studies with DSMA during 1957 indicated that considerable variation in control of Dallisgrass could be expected with comparable rates of different commercial formulations of DSMA. Best kills of Dallisgrass were obtained when a wetting agent was used in the spray mixture. Rainfall occurring shortly after treatment greatly reduces the effectiveness of the DSMA.

Several previous speakers have emphasized the importance of clipping height and frequency on turf grasses. The results of a clipping height study conducted on Sunturf, Texturf 10 and St. Augustine grass during 1957 are summarized in the next two slides. The first slide gives comparable densities of the three grasses for clipping height of 3/4, 1, 1 1/2 and 2 inches. Highest density for St. Augustine grass, Texturf 10 and Sunturf was at 1 1/2, 1 and 1 1/2 inches respectively. The next slide showing color ratings for St. Augustine grass, Texturf 10 and Sunturf shows the best color at 1 1/2, 1 1/2 and 1 inch respectively.

The results of a fertilizer factorial experiment conducted on St. Augustine grass with different rates and ratios and frequencies of application of fertilizers NP&K are summarized in the next slide. First considering nitrogen we note the more uniform growth rate occurring on plots that received 6 pounds of nitrogen per 1000 square feet in 8 applications. From the standpoint of maintenance this would be important since about the same amount of clippings would be removed at each clipping date. Peaks of growth occurring in the plots receiving the nitrogen in different frequencies other than 8 would suggest problems arising in mowing maintenance. Yield data for the phosphorus potassium treatments indicated that 2 pounds of P_2O_5 and 2 pounds of K 20 per 1000 square feet was adequate and that little or no increase in growth was obtained by increasing amounts of either of the above.

Several different chemicals were tested in relation to cultivation to determine their effectiveness for killing nutgrass. This study was conducted on the basis of complete renovation of nutgrass infested turf sites followed by re-establishment of the turf grass. The next slide shows the results of some of the treatments. Plots that were rototilled three times previous to being treated with 300 pounds of Mylone per acre and 840 pounds of Vapam per acre showed the highest stand reduction of nutgrass. Plots that were rototilled once before treating with 840 pounds of methyl bromide per acre showed high stand reductions. One series of plots treated with a new experimental chemical EPTC at a rate of 30 pounds per acre showed complete kill of nutgrass. The counts made on these plots were taken about 2 months after treatment. A final evaluation will be made on these plots next spring to determine if some of the better treatments will hold up.

Considerable interest by the general public in the possible use of Zoysia grasses for lawns has indicated a need for information on proper establishment practices. An experiment was conducted during 1957 with two strains of Zoysia grass (Emerald & Meyer). Row spacing of 6, 9 and 12 inches was used. Vegetative plugs and vegetative stolons were planted at the different row spacings. Two levels of nitrogen were imposed on the above variables of row spacing and vegetative material. A third treatment which included different concentrations of gibberellic acid plus nitrogen was evaluated. The results at the end of the first season indicated that a more uniform turf could be obtained from the use of vegetative stolons planted in continuous rows over the vegetative plugs. Complete coverage was not obtained at the end of 7 months even in plots planted at the six inch row spacing. No significant differences were apparent between 6# of nitrogen per 1000 square feet and 12 # of nitrogen per 1000 square feet treatments on the rate of establishment of either strain of Zoysia grass. The gibberellic acid plus 6 # of nitrogen per 1000 square feet did not show any visable increase in growth rate and coverage.

The last experiment to be discussed in this presentation was conducted to evaluate the effectiveness of different chemicals for the control of burclover in Bermudagrass turf. The next slide shows chemicals, rates employed and percent stand reduction of clover. You will note the percent control for the various chemicals and rates; 93% and 100% for 2,4,5-T-A at 3/4 # and 1 1/4 # per acre, 83% and 99% for 2,4,5-T-P at 3/4 # and 1 1/4 # per acre, 100% for 2,4-D at both the 3/4 # and 1 1/4 # per acre rates, 100% and 99% for TCB at 1 # and 2 # per acre, 90% for NH_4NO_3 at 5 # per 1000 square feet in 5 gallons of water per 1000 square feet, 96% and 100% for endothal at 2 # and 4 # per acre. The next few kodachrome slides show what some of these treatments looked like.

STRUCTURAL CHARACTERISTICS OF THE GRASS PLANT AS RELATED TO ADAPTATION

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Grasses are among the most widely distributed of the economic plants. Some species of grass are found on almost every part of the earth. Some grow under very cold conditions; some under very hot conditions; some grow where it is very wet; and some where it is very dry. The types of grass that are adapted to the conditions they encounter will survive, while those that are poorly adapted will die.

How Does a Plant Adapt to Its Environment?

Some changes can be made by a plant in any one generation to aid in the matter of adjustment to environment. For example, roots will become shortened in a water-logged soil. Leaves will curl or fold on the grass plant and the loss of moisture may be retarded. However, these changes are not heritable; they will not be passed on to the next generation.

More important changes are those which come about over a period of several generations by the process of natural selection. This concept of natural selection is sometimes spoken of as the "survival of the fittest." We may understand this process a little better by considering the example of bentgrass. When bentgrass is grown in the Pacific Northwest, it grows in an area which is admirably suited to the needs of bent. Therefore, this species has no difficulty in surviving and even the weak types may thrive. However, when we move bentgrass to the Desert Southwest, it finds itself rather poorly adapted to its environment and only those plants which are equipped with mechanisms which allow them to cope with drouth and the other unusual environmental conditions may survive. The adaptive mechanisms which permit one type to live in an area where another cannot grow may be of various natures. These are primarily biochemical and biophysical factors and there are also certain structural characteristics that are involved in a plant's ability to thrive under a given set of conditions.

Mechanisms for Adaptive Ability

Dormancy is one factor - and perhaps the most important factor - in a plant's ability to thrive in its environment. We may contrast bluegrass, bent, and fescue to bermudagrass or Zoysia. Bermuda and Zoysia must undergo dormancy in order to survive periods of cold weather, whereas bluegrass, bent, and the other cool season grasses, seem to thrive under conditions of low temperature. Some plants shed leaves in order to protect themselves against severe weather or drouth. This is true in the case of deciduous trees and shrubs. This ability to shed leaves is not found so much among the grasses but we find such species as buffalograss, in which the leaves dry up during seasons of drouth. In these cases the plant depends upon its reserves of stored food for survival and for the support of new growth when favorable conditions again occur. There are other grasses like bluegrass which are not equipped with this mechanism of dormancy which would permit escape from drouth. Bluegrass, therefore, would die under comparable conditions.

We may also consider the difference in perennials and annuals as this characteristic of longevity relates to adaptation. Perennials survive because of an ability to store food and to maintain life in protected parts. Annuals do not have this ability, but we sometimes find annuals growing more than one season and thus behaving as perennials when favorable situations exist. Poa annua sometimes lives for several years in cool areas. The annual habit of some plants enables them to reproduce themselves year after year by seeds, even where there are some seasons extremely unfavorable to their growth.

Seed modification is a very important factor in the plant's adaptive ability. Some plants produce seeds which may lay dormant for a certain period before they will germinate. Other plants produce seeds with hard seed coats so that the seeds will not germinate all at once. Such mechanisms which prevent the seed from all germinating at one time serve to insure the plant against complete destruction by any one period of unfavorable weather during the time the plants are in the seedling stage.

Temporary protective mechanisms may be illustrated by the fact that the leaves of the grass plant will roll or fold during periods when transpiration rates are extremely high. The plant is able to protect itself against excessive water loss by the rolling of leaves which closes the stomata, leaving exposed only the heavily cutinized lower surface of the leaf.

Physical Modifications

It has been mentioned that some of the structural characteristics of grass plants are important in the plant's relation to its environment. One of the highly variable physical characteristics is that of root length. It is known that bermudagrass roots will enter a good soil to a depth of six feet or more, whereas such grasses as red fescue and bluegrass in similar soil will produce roots to a depth of only about three and one-half feet. Bermudagrass roots are coarse and deep, whereas Zoysia roots are finely divided and relatively shallow. However Zoysia root systems are so extensive that the upper portions of a soil are explored thoroughly for moisture and nutrients. Another example which may be visualized is the contrast between goosegrass which is an annual grass and Poa annua which is also an annual grass. Goosegrass produces a prolific root system which is almost impossible to pull up when the grass is firmly established, whereas Poa annua may be very easily pulled out of the soil. Such characteristics are extremely important in the ability of plants to compete and to maintain themselves under various conditions.

There are many modifications of grass stems which affect the plant's ability to grow in a given environment. In speaking of stems we think not only of the upright stem but also of the stolons and rhizomes, which are modified stems. Stems serve as storage organs for food material, and in the case of stolons and rhizomes, they are one of the means of enlargement and spread of the plant. The position and form of the stem has a marked influence upon the plant's ability to compete with other plants for ground space. Zoysia and bermudagrass have vigorous rhizomes and stolons which spread through and under other grasses. Bentgrass is not so competitive; it spreads primarily by stolons. The fescues and bluegrass are characterized primarily by stems which grow upright though they do have short rhizomes which permit some degree of spreading.

Bermudagrass stems are mostly prostrate or underground. This characteristic permits bermudagrass to be mowed very closely without the removal of a large amount of storage tissue. On the other hand, bluegrass stems are mostly upright; therefore, continual mowing removes much of the storage tissue and the grass tends to die out. Thus we may see that the physical modification in a grass stem determines to some extent the ability of the grass to thrive under certain types of management.

Perhaps some of the most extensive anatomical modifications among grass plants are those existing in the leaves. Much of the literature on this subject may be traced back to the work of an Englishman named Lewton-Brain. This gentleman published a paper about grass leaves in 1898. Relatively little additional information has been published since that time. Lewton-Brain attempted to devise a taxonomic key based on leaf anatomy. He failed in this attempt because temporary modifications caused by environment were greater than differences between species.

There are a great many ways in which leaf anatomy may vary. The epidermis, or skin, of the grass leaf is made up of numerous cells of different size and shape. The arrangement of these cells is important. Most grasses have a rather heavily cutinized lower leaf surface. This layer of cutin affects moisture loss in the leaf and it varies greatly in its thickness. One type of cell which is found in the epidermis is large and thin-walled. These are characterized as motor cells. These usually occur in rows and they lose water rapidly under conditions of moisture stress. When these large cells collapse, the leaf tends to fold or curl, depending upon the number and arrangement of the motor cells. As folding or curling takes place, water loss is retarded. The amount of pubescence, or hairiness, of leaves affects the rate of water loss, and the number and arrangement of stomata is also important in this respect.

There is also variation in the structural elements for support of the weight of grass leaves. These leaf components consist of fibers and thick-walled cells which make up the conducting tissue. Another type of cell which is sometimes important as a structural element is the thin-walled parenchyma cells. These cells when filled with water are turgid and hold the leaf upright. When the plant is under a severe moisture stress these thin-walled cells may lose much of their moisture and become flaccid. When this occurs, we see wilting and the grass is sometimes damaged severely when subjected to traffic during such periods of stress.

There are many other ways wherein the plant may relate to its environment through structural, chemical, and physical modifications. The ones mentioned in this discussion are merely examples of the great variation that exists in plants.

Plant Structure Affects Management Needs

The examples of structural differences which have been discussed indicate that even grass plants vary greatly in their ability to fit into a given environment. These examples will serve also to demonstrate the fact that a type of management must be provided which will take into account the tolerances of the particular grass being grown. Some grasses must be watered often because their structural makeup does not allow them to resist drouth. Some grasses may not withstand close mowing because their food storage organs are removed by such treatment.

Most of the accepted management techniques employed in growing turf have come about as a result of trial and error through the years. However, when one looks closely at the individual plant and considers the effect of any particular treatment upon the ability of that plant to tolerate the treatment, he finds good fundamental reasons for following the practices that he does. It is equally important that we be able to predict the effects of management treatments by understanding the requirements and tolerances of individual plants imposed by their structural attributes.