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TURF BULLETIN

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BETTER TURF THROUGH RESEARCH AND EDUCATION

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The Massachusetts Turf and Lawn Grass Council Incorporated is chartered under the laws of the Commonwealth of Massachusetts as a non-profit corporation. The turf council seeks to foster "Better turf through research and education".

More detailed information on the subjects discussed here can be found in bulletins and circulars or may be had through correspondence with the editor.

The Effect Of Sawdust On The Germination And Seedling Growth Of Several Turfgrasses[1]

D. V. WADDINGTON, W. C. LINCOLN, JR.
and J. TROLL[2]

Studies conducted to determine the effect of sawdust on several turfgrass species indicated that germination and seedling growth may be suppressed by the use of some fresh sawdust materials. Grass was grown in soil-sawdust mixtures and germination tests were made using cold water extracts from sawdust. The most severe toxic effects were noted with sawdust from ash and red oak. Abnormal seedlings with stunted roots occurred when seed was germinated in extracts from these materials. Nitrogen fertilization of soil-sawdust mixtures did not overcome these toxic effects. 'Merion' Kentucky bluegrass seems to be more susceptible to the injurious effects than 'Pennlawn' creeping red fescue and 'Highland' and 'Seaside' bentgrasses. The adverse effects were not apparent in sawdust which had weathered for 2 and 7 months.

In the field of turfgrass management a popular practice is to physically modify soils which will be subjected to heavy use. Soil, organic matter, and sand, or other coarse aggregate materials are mixed in proportions which will provide a mixture that maintains desirable physical properties when compacted. Peat is the material most often mentioned as a source of organic matter for the mixtures; however, where supplies are adequate, sawdust is often used.

The value of sawdust as a soil amendment has been reported in various publications (1, 6, 8, 9, 10). Some of the favorable changes which can be expected when sawdust is used as an amendment are increases in humus, cation exchange capacity, aggregation, moisutre holding capacity, and aeration porosity. On the other hand the possibility of adverse effects from sawdust exists. Nitrogen deficiency often occurs when undecomposed sawdust is attacked by microorganisms. This condition can be corrected by additions of a nitrogen fertilizer. Sawdust from hardwoods decomposes more rapidly than that of soft woods; thus nitrogen tie-up and the need for supplemental nitrogen is greater with hardwood sawdust (3, 4, 5, 9, 12).

Some wood materials have a toxic effect on plants. Newton (11) reported that cedar sawdust depressed germination and subsequent seedling growth of peas, beans, and swet peas; but little or no depression occurred with sawdust from fir, hemlock, and balsam. All four materials reduced germination and growth of radishes. The depression in germination was attributed to a phytotoxic effect, and the depression in subsequent growth was attributed to tie-up of nutrients during decomposition of the sawdust. Allison et al. (2) found that California incense cedar wood and white pine bark were highly toxic to garden peas. Twenty-two of the 28 woods they studied were not toxic. Viljoen and Fred (14) concluded that the unfavorable action of birch, willow, alder, and poplar wood on red clover and oats was due to lack of nitrogen rather than a toxic effect of oils, resins, or tanins since the same effects came from wood-pulp cellulose. Bear and Prince (7) found pine shaving to be injurious to carrots but not to snap beans, while oak shavings were not injurious to either plant. Lunt (9), working with aspen, birch, hickory, oak, red pine, and white pine sawdust, attributed any and all injurious effects to nitrogen deficiency.

The objective of this study was to determine the effect of sawdust from different tree species on the germination and seedling growth of several turfgrass species.

MATERIALS AND METHODS

Experiment 1. Sawdust from the following 12 species was used: Pitch pine, *Pinus rigida;* White pine, *Pinus strobus;* White ash, *Fraxinus americana;* Red oak, *Quercus borealis;* Norway spruce, *Picea abies;* White oak, *Quercus alba;* American elm, *Ulmus americana;* White birch, *Betula papyrifera;* Eastern hemlock, *Tsuga canadensis;* American basswood, *Tilia americana;* Sugar maple, *Acer saccharum;* and Red maple, *Acer rubrum.* Fresh sawdust from each species was mixed with a sandy loam soil, 2 parts soil and 1 part sawdust. A sedge peat was also included in the experiment at the same mixing proportion. The prepared mixtures were put in 16-oz. waxed cottage cheese containers. 'Highland' colonial bentgrass (*Agrostis tennis* Sibth.), 'Seaside' creeping grass (*Agrostis palustris* Huds.), 'Pennlawn' creeping red fescue (*Festuca rubra* L.), and 'Merion' entucky bluegrass (*Poa pratensis* L.) were seeded in the various mixtures. The bents were seeded at a rate equivalent to 0.49 kg per 100 square meters, and the fescue and bluegrass at 2.44 and 0.98 kg, respectively.

Twenty days after seeding, observations were made on seedling height and number of seedings in each container. The stand of grass was expressed as the relative number of seedlings compared to the highest seeding count for each grass in each experiment. Containers having the highest number of seedlings were given a rating of 100. All treatments were evaluated in triplicate.

(Continued on Page 11)

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[1] Contribution of Massachusetts Agricultural Experiment Station, Amherst, Mass. Received July 18, 1966.

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The Leaf Is Life

DR. S. B. HENDRICKS
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Leaves are the photosynthetic centers on which plants depend for their lives. Leaves receive light from the sun and carbon dioxide from the air. Water and mineral nutrients, necessary for plants to function, come from the roots. Water is transferred across the leaf surface and products of photosynthesis move to the roots and the shoot. During light periods, oxygen is given off to the air, to be replaced by oxygen uptake and carbon dioxide output in darkness. Waste products are negligible. In their effectiveness and efficiency, leaves, in a microcosm, surpass even the most elaborate man-made factories.

Plant anatomists have traced the intricate pattern of tissues involved in flow and counterflow of air, water, plant products, and nutrients in the leaf. Biochemists and physicists have a reasonable understanding of the detailed way in which photosynthesis takes place in the green plastids of the cells. Physiologists seek to understand the operation of the stomatal openings controlling gas exchange between the leaf and the air. Others try to find the way in which light striking the leaf controls plant growth and fruiting.

Agronomists are concerned with the optimum functioning of crop plants. They fully appreciate that both carbon dioxide and light can be limiting to plant growth. It is not practical to increase the carbon dioxide content of the air except in greenhouses, but the amount of air reaching plants in a field can be enhanced by developing greater unevenness of the leaf canopy in order to catch the wind. Light is most limiting in the way it penetrates the canopy. Plants are being bred for leaf shapes and intercept more of the light and decrease shading of bottom leaves by top ones. Seeds are planted as early as possible to make the greatest use of early summer as the most favorable growth period.

The leaf permits evaporative cooling of the plant. Only a small percentage of the incoming light energy is used in photosynthesis. The remainder is heat, most of which has to be removed by evaporation of water. If the infrared part of sunlight could be removed, the water demand of a crop could be halved.

Some nutrients when sprayed on the leaves can penetrate the internal open and receptive structures. These same pathways are also open for entry of fungi and attack by pests, which require sprays or dusts for control. The leaf structures and tissues are delicate. Care must be used to prevent injuring them while assuring even spreading of added materials over the water-repellent surfaces.

Leaves, like people, have youth, productive life and death and, as with people, hormones have much to do with the life course of leaves. Some of the active compounds that govern plant growth are known — auxins, gibberellins, kinens, phytochrome, and abscissin — but others surely remain to be discovered and the known ones need to be better understood. Some of these insure the best seasonal growth of the plant and regulate leaf shape and stem length. Others are involved in maturity and senescence, or aging. Finally, when the days shorten, hormonal action cuts off the leaves, but not before the seed or new buds are set for the next season, and the leaf's work is done.

—Reprinted from Plant Food Review Vol. 13, No. 2, 1967

Color It Green

DR. R. S. LOOMIS, *Department of Agronomy, University of California*

LIFE ON EARTH is almost totally dependent upon photosynthesis of green plants. No color can equal green in portraying our planet in a mural of the universe. Nor, is there any color in plants more indicative of life and of photosynthesis, our planet's most extensive and important manufacturing process.

The importance of photosynthesis lies with the storage and release of energy from carbon compounds. A brief review of such events will reveal the significance of some of the principles involved in photosynthesis.

Carbon Is Life's Essence

Although carbon constitutes less than 0.1 per cent of the earth's crust, its compounds and their reactions are the essence of life. All of the complex organic substances in living things have a skeletal backbone of carbon atoms. Included are proteins which serve as enzymes, nucleic acids which carry genetic information, and carbohydrates of cell walls. The carbon backbone of these substances is fitted with hydrogen and oxygen ribs and, on occasion, with nutrient elements such as nitrogen and sulphur.

These organic compounds are rich in energy. Their chemical bonds contain more potential energy than those in carbon dioxide (CO_2). Chemists describe energy-rich organic carbon as being in a "reduced" state. Some of this energy may be released by burning with oxygen to form CO_2. Figure 1 illustrates relative amounts of energy released by several simple carbon compounds upon burning.

One should try to visualize that carbon substances in living organisms exist at very high energy levels relative to inorganic carbon and that living organisms control this potential for oxidation to their advantage. When energy is needed to lift a finger, to push a seedling through crusted soil, or to coil the tendril of a pea vine around a new-found support, the organism obtains the energy through respiration. In respiration, food materials such as simple sugars are oxidized. These have energy levels similar to methanol and formaldehyde in Figure 1. The energy thus released appears as heat, as motion or in the form of new chemical bonds.

The magnitude of the respiratory processes releasing energy of carbon bonds is awesome. For the world as a whole, one may estimate that perhaps 100 million tons of carbon are oxidized biologically each day (or about 70 pounds for each person on earth). Large amounts are also oxidized non-biologically.

Photosynthesis Essential

It is clear that continuation of life on earth depends upon the cyclic regeneration of energy-rich organic carbon compounds from CO_2. This regeneration is accomplished by the photosynthesis of green plants which is an even bigger daily business than respiration.

In photosynthesis, the carbon in CO_2, through the agency of hydrogen ions from water, is partially released from the tenacious grasp of the two oxygen atoms. Energy needed to generate the hydrogen ion, and which then appears in the bonds of the newly synthesized carbon compounds, comes from sunlight, as absorbed through green plant pigment, chlorophyll.

The over-all scheme can be expressed as follows:

$$CO_2 + 2H_2O \xrightarrow[\text{Green plant chlorophyll}]{\text{Light}} [CH_2O] + H_2O + O_2$$

This equation represents the net result of photosynthesis only in a very general way, and does not detail the steps of the process which are carried out in chloroplasts, small green bodies within plant cells.

Process Is Stepwise

Advances during the past 15 years in biochemistry and biophysics distinguish several specific steps in photosynthesis:

1. Capture of light energy by chloroplasts with the formation of an excited state of chlorophyll pigment.

2. Cleavage of water using the energy from the excited pigment and the release of oxygen gas.

3. Transport of hydrogen ions and electrons from the cleaved water through a series of agents to a hydrogen carrier ($NADH_2$) and to a phosphate compound with energy-rich bonds (ATP).

4. A complex carbon cycle in which hydrogen from the hydrogen carrier $NADH_2$, and energy carried by ATP, reduces CO_2 to form simple sugars.

Only the first step above requires light. The other steps are coupled together rather loosely and their exact natures may vary. Thus, the carbon cycle may produce several different kinds of sugars or amino acids, depending upon the kind of plant and on conditions such as the supply of carbon dioxide and the availability of nitrogen.

Researchers are excited presently by new information on the role of various forms of chlorophyll and other pigments, how membranes serve to separate the highly reactive hydrogen ion and its electron until they can be attached to carriers, and what proteins serve as intermediate carriers. Two new proteins called plastoquinone and ferrodoxin have recently been identified as carriers.

Plants Vary in Efficiency

As agriculturalists, we are primarily concerned with the rate and efficiency of photosynthesis under field conditions, particularly with how much carbon is fixed each day and how it adds to the plant weight.

Laboratory studies may explain some of the differences among species, e.g., why corn is more efficient than sugar beet, and may lead us to ways of improving the efficiency of plants. Laboratory work alone, however, will not advance the agricultural uses of photosynthesis, and I would like to illustrate some problems to which production specialists can profitably give attention.

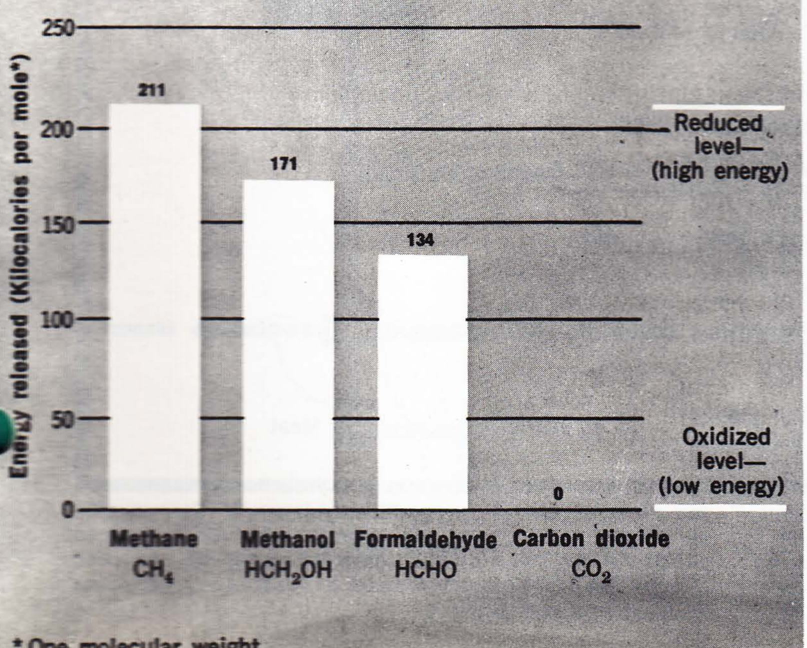
Figure 2 illustrates several of these problems. The hypothetical curves shown here were calculated using W. G. Duncan's model for simulating the photosynthesis of leaf canopies of corn and clover. A computer calculated the amount of light received by each leaf and, from this, the rate of photosynthesis. The rates for all leaves were summed to get the rate for the canopy.

One of the most striking features of the diagram is the large differences in amount of carbon fixed by corn and clover. These are due to the differences in efficiency of the individual leaves in strong sunlight.

Photosynthesis in corn plants increases with increasing illumination, even at full sunlight, while clover reaches its maximum rate at a much lower level with about one-third of full sunlight. Similar, but much smaller differences in photosynthesis may exist among varieties of a species. If so, selection for high photosynthetic rates should lead to superior varieties. Although some work has been done on this problem in the past, it needs additional careful study with modern techniques of photosynthesis measurement.

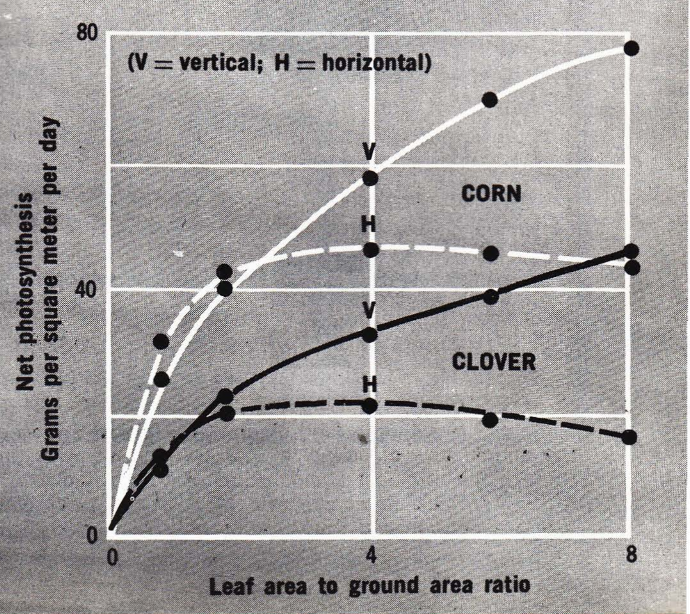
Also, researchers should think more

FIGURE 1.
Energy released by burning several carbon compounds.



* One molecular weight

FIGURE 2.
Net photosynthesis, as dry matter accumulated, by corn and clover at varying foliage density, with two orientations of leaves.



about how to get efficient plants like corn and sugar cane to synthesize more of the things we need, such as protein or scarce but essential amino acids, as well as how to get a protein source like alfalfa to be as productive as corn.

Leaf Arrangement Can Be Important

The importance of variations in foliage architecture also is revealed in Figure 2. With low amounts of leaf area, horizontal leaves are best, but large numbers of erect leaves will make much better use of the sunlight. The differences are due to the way light from the sun is distributed within the canopy.

It is interesting that most field crops achieve ratios of leaf area to ground area of only about four to one. At this ratio of four, leaf angle (vertical or horizontal) is not very important. Perhaps this explains why there are as yet only a few examples of yields being improved through changes in leaf angle.

Density of plants is a major factor influencing leaf area. Quite high densities are usually required to achieve ratios of eight or more. However, the yield or quality of the harvested portion, such as grain, may decline as density increases. Since increasing plant density seems to be one way to advance to new yield plateaus, we need to spend more effort in maintaining or increasing the proportion of total photosynthate going into the part of the plant we favor.

Efficiency Level Is Low

Agriculturalists also need to consider food chains more carefully since energy is lost through respiration at each step in such chains. For example, most of our parents were staunch devotees of butter for their bread. Vegetable oil spreads now appear on our tables without being transformed in a cow. By eliminating the cow as a step in the food chain, there is a considerable increase in efficiency of energy utilization.

To see how we might delay the time when T-bone steak will vanish from the table to be replaced by plant protein, let us examine the food chains shown in Figure 3. The examples represent good production sites in California with 10 tons of leafy alfalfa hay produced per irrigated acre during a 250-day growing season. Rose clover, introduced to California to raise production on dry foothill ranges, produced about one ton of forage per acre during the winter rainy season.

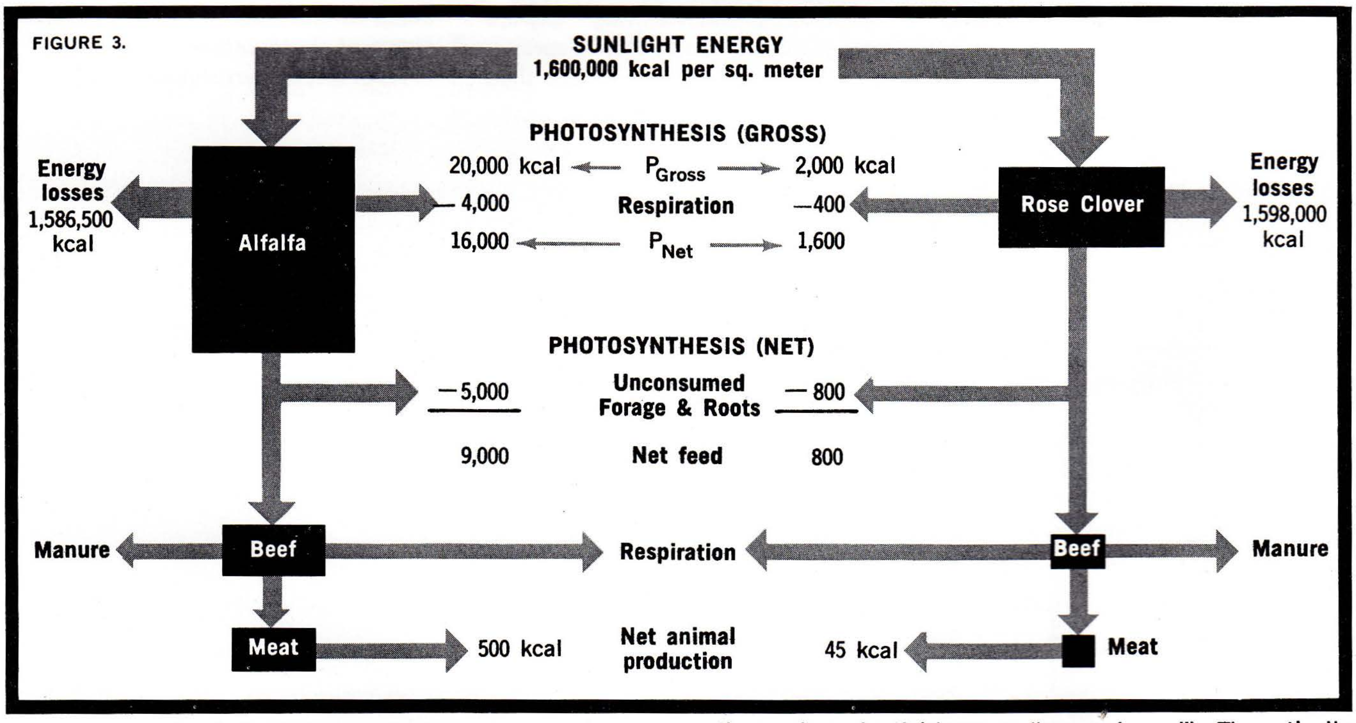
In Figure 3, these yields are shown in terms of the amounts of energy stored in organic carbon compounds. Alfalfa converted only a little over one per cent (20,000 kcal) of the incoming sunlight energy. Yet, it is possible that as much as FIVE per cent could have been stored in organic carbon compounds.

But, there is still another "low-efficiency" operation in the food chain shown. It is the conversion of plant substance to meat. Figure 3 shows that this process was only a little above five per cent. Unless we can improve forage yields, we may need to eliminate the beef animal, or substitute a more efficient animal, such as a pig or chicken, in order to increase the human food output of these lands.

Summary

The combination of land, forage plants, and beef constitutes a small ecosystem. Into this system the sun pours only a certain amount of energy each day, each year. When some of this fails to be intercepted by leaves, or is intercepted by a competing weed, we have a leak in the system. Insects, unpalatable or undigestible forage, and nutrient or moisture deficiencies represent additional leaks. These and other problems, such as inefficiencies in respiration and photosynthesis, will be plugged through research and improved management. □

Reprints of this article are available.



Models of two simple food chains. The **green** arrows denote the annual flow of energy in kcal, originating with the sun, through the producer communities of alfalfa and rose clover to beef animals as consumers. Most of the sun's energy is lost in reflection and transpiration or is converted to heat at the producer level (shown as "energy losses"). Theoretically, about 5 per cent of the sun's energy might be trapped in photosynthesis. The alfalfa converted about 1.2 per cent. Sizes of the boxes are proportional to the annual productions by the plants and animals.

Reasons Behind Rules Proposals

by JOSEPH C. DEY, JR.

Why is it proposed that the Rules of Golf prohibit certain unconventional styles of putting, as of January 1, 1968? Recommendations to this effect have been made to the United States Golf Association and the Royal and Ancient Golf Club of St. Andrews by their joint Negotiating Committees.

The basic reason is to keep golf as golf, and to prevent it from being modified into another kind of game. In recent years a straddle style of putting and clubs designed for that style have tended to modify the game. The Committees feel it is now advisable to correct the trend.

Historically, golf has always been played with the player standing to one side of the intended line of play (except for occasional strokes from awkward lies). This is a natural result of certain fundamentals, as follows:

1. That the shaft of the club be attached at the *heel* of the clubhead (except for putters), and that the clubhead length be greater than its breadth.
2. That the ball be advanced only by a stroke of the club resulting from a true swing.

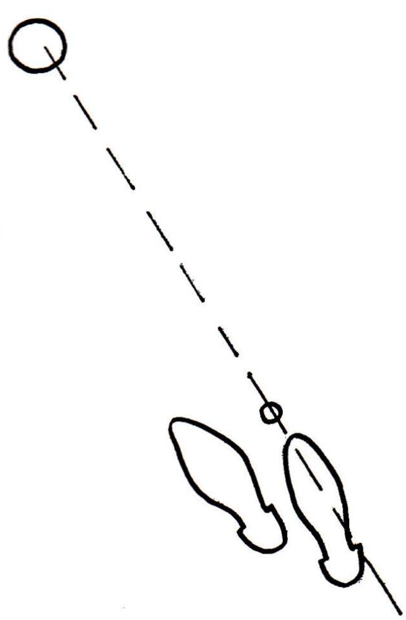
The USGA has never required that putter shafts be attached at the heel of the clubhead. In late years, however, this liberal policy has admitted aberrations from the normal type of golf club and the normal stance, resulting in methods akin to some of the styles of stroke used in croquet. Clearly, golf putting was heading down a road whose end could not be foreseen but which certainly would have further changed the nature of golf.

The impulse to correct the trend originated in the USGA Executive Committee. British authorities also must have had it in mind, for they welcomed the suggestion.

But how best to accomplish the aim with least disturbance?

First, consideration was given to limiting the types of putters. However, after months of study, it was realized that this alone would not solve the problem unless it were required that putter shafts be attached to the heel of the clubhead, as in other clubs. But such a solution was rejected because it would have been too radical in light of the long history of the rule allowing the shaft to be fixed at any point in the head.

Finally, it was concluded that the most effective method of dealing with the matter was to require a putting stance to the side of the line of play, as in other strokes. There was great reluctance to adopt such a proposal because it would run counter to the game's long tradition of allowing full play for individual style and method, as long as a fair stroke is



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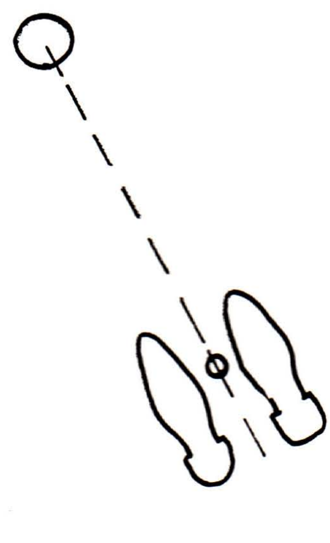

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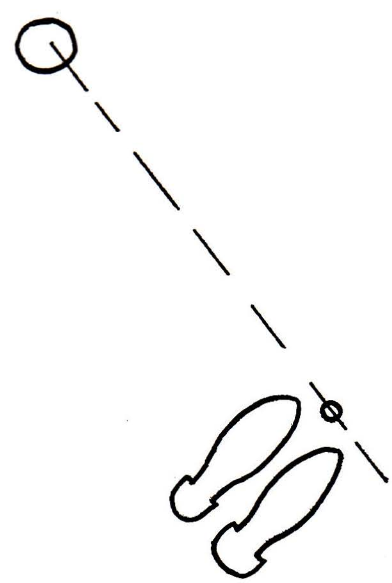

Approved.

made. However, it was ultimately decided that a prescription of stance would be, on balance, a lesser evil than increasing abnormalities in the nature of putting.

Thus the final proposals to prohibit certain unconventional styles of putting would require the following:

(a) On the putting green a player shall not make a stroke from astride, or with either foot touching, the line of the putt or an extension of that line behind the ball;

(b) Club shafts, including those for putters, must be substantially straight and plain in form and generally circular in cross-section;

(c) If a putter shaft is not attached to the head at the heel, the shaft must be at an angle by a certain number of degrees (the number to be determined later). This would have the effect of prohibiting a shaft at right angles to the head. However, it still would be permissible for a putter shaft to be attached to any point in the head.

The principle of assigning certain areas to players is common among many games—thus, the batter's box and the pitcher's mound in baseball, and the service baseline in tennis, as has been pointed out by Joe Novak, a former President of the Professional Golfers' Association of America.

In the first United States Amateur Championship in 1895 a contestant putted with a billiard cue. It was soon prohibited. Since then, hundreds of putting devices have been submitted to the USGA for approval as to conformity with the Rules. Most have been disapproved as contrary to golf principles. In recent years some two dozen types of shuffleboard putters have been submitted and have not been accepted.

In short, the nature of golf might have been radically altered long ago if there had been no guiding principles to preserve the best traditional interests of the game. The present recommendations for putting are a link in that chain, simply part of that ongoing policy.

Answers to Objections

Following are some questions and objections to the proposals which the USGA has received and the position of the USGA Negotiating Committee on those points:

1. Physical Problems

Q: Why keep players with the yips or the twitches and other physical problems from playing as they want to?

A: The Committee has full sympathy with persons who can enjoy the benefits of golf in spite of physical problems. However, Rules for the game should not be twisted to take such problems into account. If it were otherwise, the better player might well be penalized indirectly.

2. Individual Technique

Q: Why try to regiment or limit individual technique?

A: The Committee studiously tried to avoid just that. Limitation of the stance for putting is proposed only because it is considered the only effective way of preserving golf as golf. The Committee has rejected other proposals dealing with the manner of gripping the club. For example, one suggestion provided that the hands not be separated in gripping. It was turned down.

3. Innovation

Q: Why stifle innovation?

A: The record is clear that the USGA has been receptive to new ideas. The USGA has always been more concerned with results and their effect on the game than with manufacturing processes. Thus, with respect to the golf ball, the USGA specifies only size, weight and velocity; it has declined to specify what the ball shall be made of and how it shall be made, as is done in some sports. If a new idea has not seemed basically harmful to the game, the USGA has not stood in its way, as in the cases of sand wedges with wide sole flanges (although some golfers have long felt that such wedges should not have been admitted); shafts of steel, glass and aluminum; synthetics for clubheads, etc. Markings on the faces of iron clubs were limited only when widely slotted and grooved clubs tended to minimize skill.

4. History of Croquet Style Putter

Q: The croquet style putter has been in use for over a half century; why illegalize it at this late date?

A: The first recorded club of this general type was the Schenectady putter used by Walter Travis in winning the 1904 British Amateur Championship. But it was obviously not made or used for a croquet style stroke. It was not quite center-shafted, the shaft was not at right angles to the head, and Travis stood to one side of the line of putt in using it. The straddle method is comparatively recent.

5. Affecting Professional's Living

Q: Why do an injustice to professional players who make a living while using the straddle method?

A: The Committee has full sympathy with such players, but it regards the larger interests of the game as paramount.

6. Affecting Manufacturers and Professional Sales

Q: Why do something that will cause putter makers and professionals to lose money? What is the USGA's position about changing Rules which have heretofore authorized certain putters?

A: It is inherent that means will always be sought to overcome Rules prohibitions. The proposed new Rules still leave plenty of room for inventiveness in the conventional type of club. A preamble to Rule

2 provides: "The United States Golf Association reserves the right to change the Rules and the interpretations regulating clubs and balls at any time." The present situation is a good example of the need for such a reminder to inventors and manufacturers.

The Committee wishes to assure all players affected by the proposed Rules that their interests were thoroughly considered and had strong advocacy. Among croquet style putters are the President of the USGA Wm. Ward Foshay; a former President, ex-Senator Prescott Bush; and at least two former Captains of the Royal and Ancient Golf Club of St. Andrews.

—*Reprinted from The Golf Journal*
Vol. XX, No. 4

The tourists were incensed to see the Indian Chief riding a horse, while his heavily laden squaw trudged along on foot.

"Why," asked a tourist, "don't you let the squaw ride?"

"She got no horse," the Indian replied.

Lawns Fight Pollution

DR. ROBERT W. SCHERY, *Director*
The Lawn Institute

Humble bluegrass, fescue and bent lawns, so taken-for-granted, do more than beautify America. Hundreds of grass shoots to each square foot provide "zillions" of individual leaf "factories" that take care of Nature's most vital needs, all across our land.

A fundamental activity of green leaf is to absorb carbon dioxide, release oxygen. Oxygen in the air is, of course, necessary for breathing. Not only this, but mounting fuel burning is increasing carbon dioxide in the air. Some scientists fear that this creates a so-called "greenhouse effect", by which certain of the sun's rays are selectively absorbed changing the heat patterns and eventually climate. Your favorite lawngrasses, indeed, are working daily to prevent the next ice age, by their use of carbon dioxide!

The lawn, too, is a miniature world with its own balances. At home in the grass and soil are many kings of microbes which decompose old tissue and duff, releasing its elements once again for use by plant life. Nor do toxic substances and pesticides last long in a community of grasses flourishing on good soil. In short, the lawn is a first-rate air purifier, detoxication agent, and a buffer against pollution. And there is nothing better to protect and build the soil!

Lawn Renovation

by

DR. JOSEPH TROLL, *Assistant Professor*
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Renovation of a lawn means renewing or improving the turf surface. It implies that existing deficiencies should be corrected and that a proper maintenance program should follow.

Deficiencies can be traced to one or more poor maintenance practices, that is, failure to grub proof, improper watering practices, maintaining incorrect cutting height, and failure to maintain soil fertility. These are some of the reasons that can lead to thin, weedy, unhealthy turf.

In New England, late summer is the best time to renovate a lawn so that it will be ready for reseeding in early fall. During the fall there is less competition from weeds and drought, also the cooler weather favors the growth of permanent grasses.

If lawn renovation is to be undertaken, it should first be determined if it is worth improving. Often on an established lawn you may find that the soil was improperly contoured for adequate surface drainage or, perhaps, soil conditions are such that it may need subsurface drainage. Sometimes home builders or previous owners have seeded the lawn to undesirable, non-permanent grasses. If any of the above conditions exist, then you may have to reconstruct the lawn completely. However, if they do not exist and if your lawn consists of 50 per cent desirable basic grasses (Kentucky blue, fine leaf fescue, Merion bluegrass), then it should be worth improving.

The first step is to get rid of all the weeds and, if possible, all the undesirable grasses. Most broadleaf weeds such as plantain and dandelion can easily be destroyed by an application of 2,4-D. There are several forms on the market either as sprays or dust. When a spray is used, it is suggested that the amine forms be used on home lawns since they are less apt to drift and kill surrounding shrubs and plants. Sometimes a second application may be needed. It is imperative, however, that directions on the label be read and followed when using 2,4-D or any pesticide. If chickweed or clover is a problem, the use of 2,4,5-TP is recommended.

One of the most noxious weed grasses is crabgrass. The plants mature in late summer and are difficult to control at that time with post-emergence chemicals. However, crabgrass is an annual and develops from seed produced the previous year. To cut down reinfestations from seed, rake the lawn to bring the seed heads up so that the mower can remove them. Use a grass catcher or rake to remove the seed heads. If growth of the newly renovated lawn is vigorous in the fall and again early the following spring, one of the newer pre-emergence crabgrass killers can be applied to reduce crabgrass infestation.

The next step in renovating is to remove all the dead matted debris and to loosen the surface of the soil. If the lawn is small, a steel-toothed rake can be used. On larger areas a disk with its disks set straight may be needed. Whatever implement is used to loosen the soil, care should be taken so that the basic grasses are not uprooted. If the soil is compacted, it might be better to use aerifying equipment. This equipment should be available for rent from most reliable garden centers and/or landscape operators.

After a rough seedbed has been prepared, the areas should be limed and fertilized. If in doubt about the need of lime, have your local county agent test your soil. Prior to seeding, apply a complete fertilizer, one that contains nitrogen, phosphorus and potash. Apply the fertilizer at a rate that will provide 1½ to 2 pounds of nitrogen per 1000 square feet. Apply it over the entire lawn, making certain to wash it in, or apply it when the grass is dry, to prevent burning. In the bare areas, rake it thoroughly into the soil.

The next step is to seed. Make certain that you use a good grass seed, one that has a high germination and purity test. In New England, Kentucky bluegrass, Marion bluegrass and the fine leaf Fescues are recommended as permanent grass. For renovated lawns, apply 1 to 2 pounds of seed per 1000 square feet, cover the seed lightly by raking, and make firm the seedbed by rolling with a light roller. Unless an unusually dry fall is encountered, watering should not be necessary. It is wasteful to throw seed on top of a lawn that neds renovation without going through the above steps.

Once your lawn has been renovated, determine the cause of its deterioration and then follow a corrective program. If it is fertilized regularly, watered when needed, the corrective mowing height maintained, and every effort is made to keep out weeds, a good lawn should be ensured.

Roots Underground Space Frontiers

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Trees and flowers excite poets and painters, but no one serenades the humble root, the hidden half of plants. Scientists too are preoccupied with greenery, its cellulose and chlorophyll, and with that part of the genetic code which is manifest in above-ground displays.

Yet, the root system is deserving of more friends and it is a safe guess that such friendship will be rewarded. In the 1930's, men such as Hoagland and Lundegardh studied root physiology and metabolism and initiated the important modern theories of active ion transport.

If short root segments are immersed in Hoagland solution, the outer cell portions are bathed in a super-rich nutrient medium. Naturally, their rate of ion absorption is governed by what the inside root tissue can transport and metabolize.

In most soils the situation is totally different because the soil solution is notoriously low in concentrations of certain ions. Delivery of ions from the soil to the metabolic sites of the root is slow and may become the critical factor limiting ion uptake and hence crop growth. If that were not a general fact there would be no need for fertilizer.

Modern soil fertility research will try to find out how soil ions and molecules, including water, manage to get to the metabolic sites. This problem must be solved at the molecular level which involves sophisticated gadgetry and theories, particularly diffusion methodology.

Already the electron microscope is upsetting the ingrained notion that soils and roots are separate entities, one dead, the other alive. On the submicroscopic level it is no longer clear where the root ends and where the soil begins. In fact, soil colloidal particles appear to be chemically bonded to root macromolecules, creating a unified system. Likewise, soil microbes show little respect for scientific fence lines. They seem to enjoy the rich boundary zone and prosper near clay platelets and inside the root's mucilaginous layer. It is a promising world for soil-space explorers.

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THE EFFECT OF SAWDUST

(Continued from Page 3)

Experiment 2. Seaside creeping bentgrass was planted in soil and in six soil-sawdust mixtures. As in Experiment 1, waxed containers were used to grow the plants. A nitrogen variable was included in this experiment. Ammonium nitrate was incorporated in the mixtures at rates equivalent to 0, 0.49, 0.98, and 1.95 kg of nitrogen per 100 square meters. Data on stand, seedling height, and leaf color were collected 18 days after seeding. Treatments were triplicated.

Experiment 3. Cold water extracts were obtained from the six kinds of sawdust used in Experiment 2. Equal volumes of water and sawdust were mixed and allowed to stand overnight at room temperature, approximately 21C. The mixtures were filtered and the filtrates were used as moisture sources for seed germination tests on Seaside creeping bentgrass, Merion Kentucky bluegrass, and Pennlawn creeping red fescue. Four pieces of filter paper were used as substrata in 100 mm petri dishes. Each dish was first moistened with 5 cc of the various leachates and later moistened with leachate as necessary. The Merion bluegrass and Seaside bent were germinated in an alternating 15C-30C light germinator and the fescue in a 15C-25C light germinator. The colder temperature was used for 16 hours and the warmer temperature for 8 hours. Rules of the Association of Official Analysts were followed in setting up the tests and in making all seed counts.

At a later date similar tests were made using extracts from sawdust which had been weathered for 2 and 7 months.

Experiment 4. Portions of the 12 sawdusts were placed outside in wooden flats and allowed to weather for 7 months. The remaining materials were stored inside. The weathered (but not decomposed) and unweathered sawdusts were then mixed with soil, as in Experiment 1, and Seaside bentgrass was seeded in these mixtures. Stand and seedling height were determined 20 days after seeding. Treatments were triplicated.

Data were analyzed statistically and Duncan's multiple range test (13) was used to compare treatment means.

RESULTS AND DISCUSSION

The effects of the different kinds of sawdust on the stand and seedling growth of four grass species are shown in Table 1. The stands of both bents were significantly reduced by pitch pine, white pine, ash, and spruce sawdust. The effects of sawdust on fescue and bluegrass stands were more drastic. Each sawdust significantly reduced bluegrass stand. Seedling height was reduced by all sawdusts on each grass species. Peat additions did not influence seedling height or stand of the test grasses.

Experiment 2 was set up to determine how much of the reduction in stand and seedling height could be attributed to depletion of soil nitrogen by microorganisms which attacked the sawdust. Table 2 shows the average relative stand for each treatment. Only the 0.49 kg rate of nitrogen gave a significant increase over the check. It appears that fertilizer injury may have occurred at the higher rates. Although the 0.49 kg nitrogen treatment increased the stands of all sawdust treatments, the stands in the white pine, ash, and red oak treatments remained far below the stand in soil.

Seedling heights and color notations for Experiment 2 are shown in Table 3. All fertilized treatments showed significant increases over the check in seedling height. At the 0 level of N, seedling height for each sawdust treatment was significantly lower than for soil alone. At the other levels of N, only ash and red oak were significantly lower than the soil. As indicated in Table 2, these two materials also showed the greatest inhibition of germination and the resulting stand.

The underlined values in Table 3 indicate a good healthy green color for the particular treatment. Those values not underlined showed yellowing, which was taken as an indication of nitrogen deficiency.

The softwoods (white pine, spruce, and hemlock) which decay slowly, required less nitrogen to restore green color than did the more rapidly decaying hardwoods (ash, red oak, and red maple).

The reductions in stands in the first two experiments were obvious as early as three days after seeding when the plants first began to emerge. This early effect suggested that perhaps a soluble component of the fresh sawdust rather than a decomposition product was inhibiting germination. The effects of water extracts on germination were determined in Experiment 3. The actual counts in germination tests were transformed to relative values with the water control treatment receiving a value of 100. Values for both total seedlings and normal seedlings are shown in Table 4. Ash and red oak extracts significantly reduced normal germination of all three grass species. A large part of the reduction can be attributed to the presence of abnormal seedlings. Most of the abnormal seedlings had stunted root growth and dark, injured root tips were apparent. When normal plus abnormal seedlings are considered the sawdust extracts had no effect on Seaside bent, however a large amount of seedlings were abnormal in the ash and red oak treatments. The percentage of total seedlings which were abnormal for both fresh and weathered sawdust are shown in Table 5. The occurrence of absnormal seedlings in the ash and red oak treatments was greatly reduced when extracts from weathered sawdust were used. The increased percentage of abnormal seedlings in the 2- and 7-month treatments, as seen with other sawdusts and the control, was attributed to the loss of viability of the seed while in storage.

In Experiment 4, tests of soil-sawdust mixtures indicated that weathered ash and red oak sawdust did not adversely affect Seaside bent germination, but pitch pine had a depressing effect. The nonweathered ash, red oak, and pitch pine significantly reduced germination, giving relative stands of 18, 27, and 22 respectively.

Table 1. Relative stand and seedling height of Highland bentgrass, Seaside bentgrass, Pennlawn red fescue, and Merion bluegrass as affected by various kinds of sawdust.

Treatment	Highland bent		Seaside bent		Pennlawn fescue		Merion bluegrass	
	Stand	Height cm	Stand	Height cm	Stand	Height cm	Stand	Height cm
Pitch Pine	15 d*	1.4	55 d*	2.3	58 cd*	4.7	25 cdef*	1.8
White Pine	35 c	1.6	57 d	2.4	57 cd	4.4	17 ef	1.7
Ash	52 c	1.5	65 cd	2.0	47 d	3.8	6 f	1.5
Red Oak	73 b	1.5	82 abc	2.4	40 d	3.0	22 cdef	1.9
Spruce	75 b	2.2	78 bc	3.1	88 ab	4.7	32 bcde	2.0
White Oak	78 ab	2.1	88 ab	2.6	50 d	4.7	20 def	1.6
Elm	80 ab	2.5	98 ab	3.1	40 d	3.7	37 bcde	1.7
White Birch	82 ab	2.2	95 ab	2.6	52 d	4.1	13 f	1.4
Hemlock	85 ab	3.5	95 ab	4.0	73 bc	5.4	52 b	2.1
Basswood	85 ab	2.2	100 a	3.4	93 a	4.5	42 bcd	2.1
Sugar Maple	85 ab	2.4	100 a	3.0	88 ab	4.1	43 bc	1.9
Red Maple	90 ab	2.6	90 ab	2.8	87 ab	4.8	25 cdef	1.8
Peat	97 a	5.4	98 ab	6.4	97 a	9.3	87 a	4.4
Soil	95 a	5.1	98 ab	5.9	97 a	7.9	90 a	3.2

* Means followed by the same letter do not differ significantly at the .05 level.

Table 2. Relative stand of Seaside creeping bentgrass as affected by sawdust materials and nitrogen applications.

Treatment	Relative stand				
	Nitrogen application rate, kg/100 m²				
	0	0.49	0.98	1.95	Avg*
White Pine	42	60	57	52	52 c
Ash	35	53	45	42	44 cd
Red Oak	28	50	51	28	40 d
Spruce	62	82	87	80	78 b
Hemlock	88	95	78	80	85 ab
Red Maple	80	87	82	88	84 ab
Soil	98	93	92	93	94 a
Avg*	62 b	74 a	70 ab	66 ab	

* Means followed by the same letter do not differ significantly at the .05 level.

Table 3. Seedling height and color* of Seaside creeping bentgrass as affected by sawdust materials and nitrogen application.

Treatment	Height of seedlings, cm				
	Nitrogen application rate, kg/100 m²				
	0	0.49	0.98	1.95	Avg**
White Pine	1.6	3.3	3.3	3.2	2.8 c
Ash	1.8	2.4	2.6	2.4	2.3 d
Red Oak	1.6	2.4	2.8	2.6	2.3 d
Spruce	2.6	4.7	3.9	3.8	3.7 a
Hemlock	3.3	4.8	4.4	3.6	4.0 a
Red Maple	2.3	3.8	3.7	3.4	3.3 b
Soil	4.4	4.1	4.0	4.0	4.1 a
Avg**	2.5 c	3.6 a	3.5 ab	3.3 b	

* Height values which are underlined designate good color; others showed yellowing.
** Means followed by the same letter do not differ significantly at the .05 level.

Table 4. Relative germination of Seaside bentgrass, Pennlawn red fescue, and Merion bluegrass as affected by water extracts from different kinds of sawdust.

Treatment	Relative germination values for					
	Seaside bent		Pennlawn fescue		Merion bluegrass	
	Total count	Normal seedlings	Total count	Normal seedlings	Total count	Normal seedlings
White Pine	100 a*	105 a	98 a	98 a	95 a	94 a
Ash	95 a	7 c	78 c	41 c	41 c	9 c
Red Oak	97 a	17 b	90 b	87 b	66 b	27 b
Spruce	95 a	99 a	95 ab	96 a	95 a	89 a
Hemlock	99 a	103 a	98 a	98 a	88 a	89 a
Red Maple	99 a	106 a	95 ab	94 ab	94 a	100 a
Control (Water)	100 a	100 a	100 a	100 a	100 a	100 a

* Means within columns followed by the same letter do not differ significantly at the .05 level.

Table 5. Percentage of abnormal seedlings of Seaside bentgrass, Pennlawn red fescue, and Merion bluegrass as affected by water extracts from various kinds of fresh and weathered sawdust.

Sawdust treatment	Seaside bent			Pennlawn red fescue			Merion bluegrass		
Months of weathering:	0	2	7	0	2	7	0	2	7
White Pine	3.0	10.3	36.9	2.3	2.9	5.6	26.0	28.0	44.8
Ash	93.5	12.0	22.1	48.9	4.2	22.8	100.0	36.2	53.2
Red Oak	84.0	26.4	11.2	5.8	4.1	1.8	68.8	29.7	49.1
Spruce	4.6	29.1	27.9	1.7	3.0	2.9	29.5	30.6	40.2
Hemlock	4.4	7.3	25.5	1.8	2.3	4.1	23.8	29.7	33.8
Red Maple	1.9	17.2	26.0	3.2	3.5	5.3	20.6	29.1	35.5
Control (Water)	8.6	30.4	26.1	2.2	4.8	3.0	25.4	34.5	46.4

Several unexplained inconsistencies occurred in these experiments. A toxic effect of red oak sawdust on Seaside bent was not statistically present in Experiment 1, but a trend toward toxicity was apparent. The material was a more obvious suppressor of germination in all other tests using fresh or unweathered material. The depressing effects of white pine as seen in Experiments 1 and 2 were not shown with the water extracts or with the stored unweathered sawdust used in Experiment 4.

An examination of results obtained indicates that the fresh red oak and ash sawdust samples contain a phytotoxic substance that may be water soluble. Wise and Jahn (15) state that water soluble materials in wood include inorganic salts, sugars, cyclitols, and polysaccharidic substances such as gums, mucilages, starch, pectin-like materials, and galactans as well as a portion of the tannins and pigments. The extraction may also remove volatile oils event though they are not soluble in water. Whatever the toxic materials may be, they were leached out or were destroyed in some manner when the sawdust was exposed to natural weathering.

Although each grass species was not used in each experiment, it appears that a species difference occurs in the susceptibility to injury, with Merion bluegrass being most severely injured.

The most appropriate recommendation to be made from these preliminary studies is to avoid the use of fresh sawdust in turfgrass seedbeds. Those interested in using relatively fresh sawdust materials should prepare and pot a small portion of the mixture, seed to the desired grass, and compare germination to that in soil alone. Further research with these materials should be conducted.

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The cow who got her tail cut off while crossing a railroad track?

They had to wholesale her because they couldn't retail her.

Use Of Sweetcorn For Bank Stabilization

Sweetfern rhizomes or year-old seedling can be successfully plant for bank stabilization. Once established these plants form colonies which take over the entire bank. Sweetfern is generally found on dry sandy soils in the New England area. It is an attractive, sweet-scented, low, deciduous shrub valuable for ornamental purposes.

On May 1, 1963, two hundred and thirty-four rhizomes of sweetfern 1/8-1/4″ in diameter and 3-6″ long were planted in rows perpendicular to the slope on south- and north-facing backslopes in Amherst, Massachusetts. The soil was a gravelly subsoil covered with 3″ of woodchips. The spacing was 3′ x 4′ with two rhizomes planted per hill. The rhizomes were covered with 1″ of soil and about 1″ of woodchips. In addition, thirty-one one-year-old natural growing sweetfern plants were planted on 8′ centers on a slope in an adjacent slope.

Observations during the same summer showed 36% and 54% survival on the south- and north-facing slopes, respectively, for the rhizome plantings. There was better survival and establishment at the base of the slope than near the top, where soils dried out more quickly. Two years later the slopes were covered satisfactorily with sweetfern plants.

The thirty-one one-year-old transplants of sweetfern had 82% survival in July of the first year. Two years later the slope had excellent cover of sweetfern.

Year-old plants should be used in transplanting. Plantings made with older sweetfern plants of undetermined age were unsuccessful.

The above summary is condensed from an article in Establishment and Management of Roadside Vegetative Cover in Massachusetts, Research Report 6/Project R5/Roadside Development, Massachusetts Agricultural Experiment Station Bulletin No. 562, Final Report 1966, aJnuary 1, 1967. Prepared in cooperation with the U.S. Department of Commerce, Bureau of Public Roads, and the Commonwealth of Massachusetts, Department of Public Works. John M. Zak and Evangel J. Bredakis, Department of Plant and Soil Sciences, College of Agriculture, University of Massachusetts, Amherst.

Fertilization And Root Life

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ROOTS TOO OFTEN are the forgotten part of plants. Yet, root growth and their functions in most cases set the pace of development for the entire plant. Rapid crop establishment depends on corresponding root development, and may mean the difference between a successful, high-yielding crop or a failure.

High yields depend on root systems that effectively utilize soil fertility and moisture. Especially in seasons of drought, even a satisfactory yield may depend on a deep, extensive root system. Of course, a good root system, in turn, depends on proper soil fertility.

Winter survival and persistence of perennial forage stands can be increased considerably by proper liming and fertilization practices. Here again the important effects primarily are due to an expanded root system and to an increased food supply.

An understanding of how the soil chemical and physical environment affects plant roots and subsequent plant growth is essential to the development of lime and fertilizer practices for most profitable yields.

Fertilizer Banding Helpful

It has been demonstrated many times that roots increase in weight and volume as soil nutrient deficiencies are corrected. This beneficial effect of lime and fertilizer can be shown for both seedlings and older plants.

Drilling legume seeds above bands of fertilizer is an excellent example of how proper placement of fertilizer can be used to encourage root development. Figure 1 illustrates the difference in root development and top growth of alfalfa seedlings where fertilizer was banded below the seed. Although the soil was reasonably fertile, fertilizer increased the root system markedly, enabling plants to develop more rapidly than unfertilized plants. A better stand was the result.

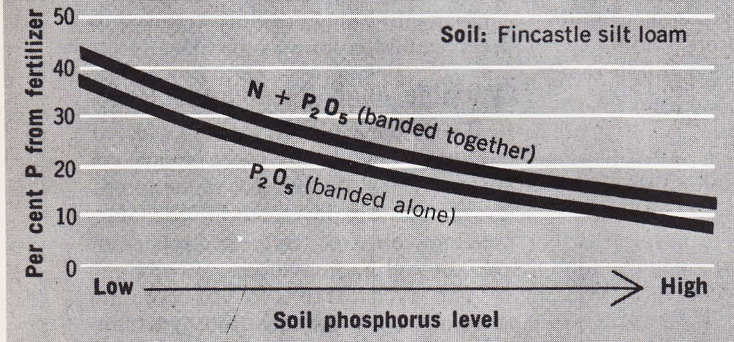
Band application of phosphorus is particularly important during periods of low soil temperature, when less efficient utilization of soil phosphorus occurs and phosphorus deficiency is more likely to occur. Band application also is important on soils low in available phosphorus, particularly if they have a high phosphorus-fixing capacity.

Nutrient Balance Essential

Studies of root growth in young corn show that banding nitrogen and phosphorus together usually increases root development, whereas either alone usually has little or no effect.

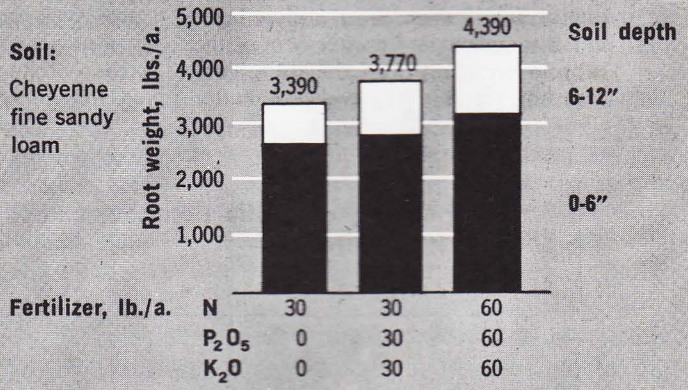
In addition to greater total root weight, roots that develop in the band of nitrogen and phosphate fertilizer are much finer and silkier in appear-

FIGURE 2
Influence of soil phosphorus level and nitrogen addition on corn uptake of phosphorus when applied in a band.



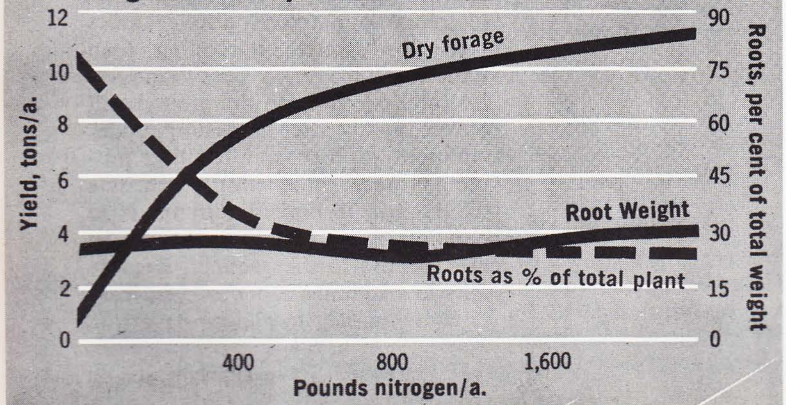
(M. H. Miller and A. J. Ohlrogge, Purdue University)

FIGURE 3
Increased dry root weight of smooth bromegrass resulting from fertilization.



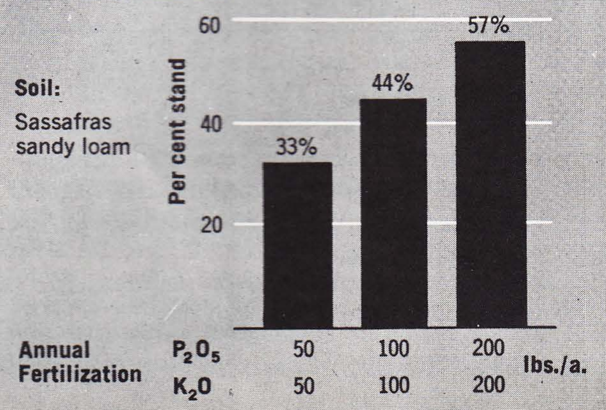
(H. J. Haas, ARS, USDA, Mandan, North Dakota)

FIGURE 4
Effects of nitrogen on irrigated coastal Bermuda forage and root production.



(E. C. Holt and F. L. Fisher, Texas A & M University)

FIGURE 5
Increased stand in 6-year-old alfalfa resulting from fertilization.



(H. D. Gross et al, New Jersey)

ance and of greater number. These conditions increase the total root surface available for nutrient uptake.

Another interesting effect of banding nitrogen along with phosphate fertilizer is the relative increase in the feeding power of the root system. This is illustrated in Figure 2, where absorption of phosphorus is seen to be greater when nitrogen was included with the phosphate fertilizer. It is interesting too that young corn plants derived about 10 per cent of their phosphorus from the fertilizer when the soil had a high level of phosphorus, but got up to 40 per cent from the fertilizer when the soil was low in phosphorus.

Effects such as these are manifested in "starter effects" farmers see in the field. As would be expected, these effects are most pronounced on infertile soils and in cool, wet seasons.

Liming Improves Alfalfa Rooting

Lime application long has been recognized as a necessary practice for growing legumes. Fibrous roots and nodules of legumes largely concentrate in limed areas.

Research in Nebraska showed that during the first season alfalfa roots penetrated more than five feet into a limed soil, but only three feet into an unlimed soil. This resulted in higher alfalfa yields on the limed soil.

Since lime applied on the surface of soils will move down relatively slowly, it is essential to lime regularly and to mix lime well in the plow layer to ensure adequate improvement of the subsoil. As the pH of the subsoil increases, alfalfa will develop a better root system. Forage yield and stand persistence thus will be improved.

Fertilization Improves Grass Roots

Total weight and proliferation of grass roots can be increased markedly by correcting soil nutrient deficiencies. Results of U.S. Department of Agriculture research with five-year-old smooth bromegrass in North Dakota illustrate this in Figure 3.

Similar results occurred with crested wheatgrass and Russian wild rye, with the wild rye having a larger yield of roots than either bromegrass or crested wheatgrass.

In a Texas study, nitrogen fertilization did not increase root weight of Coastal Bermudagrass nearly as much as it did above-ground forage yields. This suggests an enhanced efficiency of roots in absorbing water and nutrients, as nitrogen fertilization is increased. This is shown in Figure 4.

Under relatively dry soil conditions plants tend to develop a more extensive root system than under moist soil conditions. The extent of root development largely determines the amount of subsoil moisture utilized if drought conditions occur.

In a Nebraska study with wheat, root development was extensive for all moisture treatments on soils wet to two, four and six feet at seeding time. Roots were found as deep as 13 feet.

In the same study, nitrogen fertilization increased root weights at all moisture levels and at nearly all soil depths. It also permitted more complete utilization of subsoil moisture.

Under conditions of natural rainfall, drought can occur frequently. The utilization of subsoil moisture becomes important if maximum crop yields are to be obtained. Increasing soil fertility levels with proper use of lime results in deeper root penetration and provides increased utilization of soil moisture.

Thus, the increased crop yield, vigor, and improved drought tolerance, so frequently obtained by fertilization, often may be the indirect benefit of enhanced root development resulting from fertilization.

Fertilization Lengthens Stand Life

An important relationship of fertilization and root life is the increased longevity of perennials, particularly legumes. For example, potash fertilization is particularly important to winter survival and stand maintenance of alfalfa. Effects of 50, 100, and 200 pounds each of P_2O_5 and K_2O applied annually to alfalfa are shown in Figure 5. Note the marked improvement in stand of six-year-old alfalfa as fertilization increased.

A Wisconsin study demonstrated that cold resistance of alfalfa can be increased by both phosphate and potash. The per cent survival increased with increasing rate of applied phosphate up to 80 pounds per acre and with potash up to 200 pounds per acre. The optimum ratio between the two elements was two to five.

Since alfalfa is costly to reseed and is an important source of protein and high-quality roughage, farmers need to keep stands as long as possible.

Variable Food Reserves in Roots

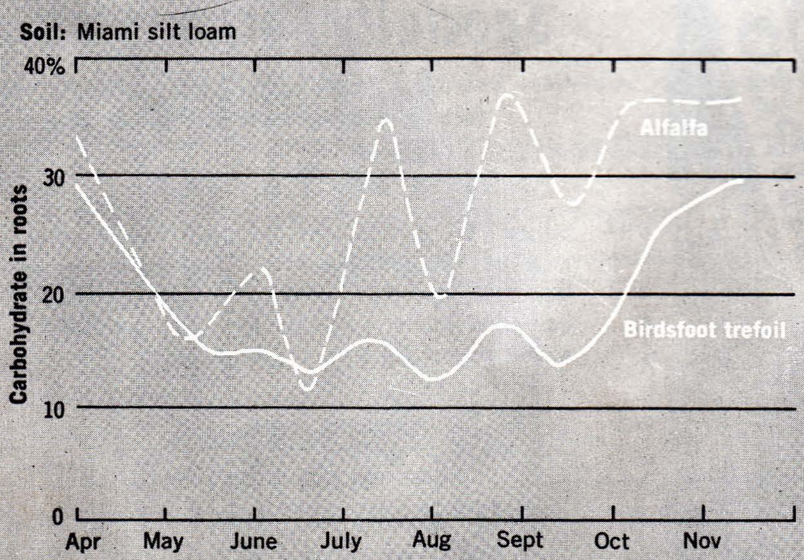
The vigor of stands and yields of forage crops depend very much on root reserves. In general, reduction of reserves results in reduced vigor. Harvesting too frequently reduces root weight and carbohydrate content.

The cyclic trends of storage and utilization of carbohydrate root reserves for two perennials are shown in Figure 6. Note that alfalfa reserves recover rapidly following cutting. Birdsfoot trefoil, on the other hand, maintains a low carbohydrate reserve level during the growing season until fall. Birdsfoot trefoil also recovers more slowly after harvesting than alfalfa.

Alfalfa cut close to the ground will recover rapidly after harvesting, under conditions of high soil fertility, providing a reasonable cutting schedule is followed. If birdsfoot trefoil is to be maintained, however, it must not be cut too close to the ground. Because of its low summer root reserves, leav-

FIGURE 6

Effect of cutting on cyclic trends of carbohydrates in alfalfa and birdsfoot trefoil.



(Dale Smith, University of Wisconsin)

ing appreciable photosynthetic area permits faster recovery and better stand survival.

Soluble Aluminum Harmful

Under some conditions, soil chemical environment can be harmful to root development. For example, poor root growth often is the result of toxic amounts of soluble aluminum in the soil.

In legumes, stunted, bumpy roots are symptoms of aluminum toxicity. Cotton roots are highly sensitive to soil concentrations as low as one ppm of aluminum.

Many soils of eastern U.S. are high in soluble aluminum, particularly the subsoil. Liming these soils reduces soluble aluminum to non-toxic levels. An example of increased root growth resulting from reduced aluminum toxicity by liming is shown in Figure 7, using results from North Carolina.

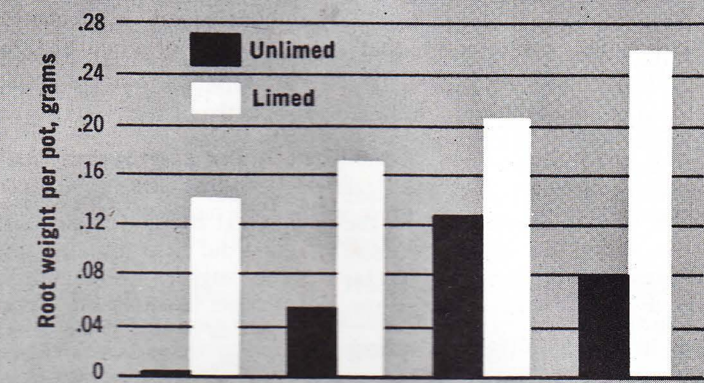
Again, a knowledge of the soil chemical environment is necessary to know what soil fertility practices must be followed for profitable crop production.

The chemical environment of soils markedly affects root growth and development. This, in turn, influences the growth and survival of the above-ground portion of the plant.

Profitable crop production depends on knowing what is limiting yields. Often these limitations originate in the soil and can be eliminated by following proper recommended lime and fertilizer practices. □

FIGURE 7

Liming increases root growth of sorghum by reducing soluble aluminum content of soil.



Soil		Portsmouth	Lynchburg	Norfolk	Goldsboro
pH:	Unlimed	4.4	4.8	5.0	4.8
	Limed	5.5	5.5	5.7	5.4
Al:	Unlimed, ppm	486.0	90.0	27.0	99.0
	Limed, ppm	.7	.2	.2	.2

(J. L. Ragland and N. T. Coleman, N. C. State University)

USE OF MALEIC HYDRAZIDE* FOR GROWTH SUPPRESSION OF HIGHWAY TURF

1963. Amherst:

By JOHN M. ZAK and EVANGEL J. BREDAKIS
University of Massachusetts

Materials and Methods

A Wethersfield sandy loam at Brown's Farm in Amherst was used for the MH-30 tests. This area had been seeded in the spring of 1962 with a mixture of 50% creeping red fescue, 15% Kentucky 31 tall fescue, 15% Kentucky bluegrass, 10% domestic ryegrass, 5% redtop, and 5% alsike clover. The sod was in excellent condition and contained all the grasses mentioned above. On May 2, 1963, the whole area was mowed to remove the previous year's accumulation of old grass.

Plots 15′ x 50′ were established in a randomized block design with two replications. One-half of each plot was fertilized with urea equivalent to 50 lbs. of nitrogen per acre on April 15, 1963. On May 16 of that year, MH-30 was applied at the recommended rate of 4 lbs. of actual material per acre and also at the two-lb. rate. On the day of application, the temperature was 70°F and three days later there was 0.6 inch precipitation.

The second series of plots, the same as above, were sprayed on May 31, 1963. On this day, the temperature was 86°F. There had been a light shower on the previous day; six days later there was 0.4 inch precipitation. Conditions, therefore, were ideal for both applications of MH-30. Grass height and estimated number of seedstalks of grass were used to evaluate the effectiveness of the MH-30 treatment.

*MH-30, a solution of maleic hydrazide as diethanolamine salt containing 30% MH acid equivalent by weight or 3 lbs. active MH per gallon, was used.

Results

There was very good suppression of grass growth on the plots which received the two rates of MH-30 application, as shown by the average length of clipped grass (Table 12). Both the two-and-four-lb. rates of MH-30, with the added nitrogen from urea, eliminated grass seedstalks from the plots on both dates of application. The average length of grass on July 18, 1963 was 10.6 and 11.2, respectively. This was more than 50% reduction in height when compared with the check plot that received urea. However, because there were no seedstalks present, the appearance of the grass was satisfactory for highway turf. The two- and four-lb. May 15 treatment without urea gave good control for some grasses, but the seedstalks of grasses not controlled gave the area a spotty appearance and would have required mowing, if present along a highway. The May 31 treatment with the two and four lbs. of MH-30, without the added nitrogen from urea, produced very good suppression of growth.

1964. Median Strip - Route 116:

Materials and Methods

A median strip on Route 116 in Amherst and Hadley was used to further evaluate the use of MH-30 with nitrogen fertilizers. This area had been seeded in 1959 with turfgrasses composed of red fescue, Kentucky 31 tall fescue, Kentucky bluegrass, orchardgrass, and some quackgrass. The soil was classified as a sandy loam.

Two large areas, 72,000 square feet each, divided into

(Continued on Page 19)

Table 12: Average percentage of estimated seedstalks and average height of 20 clipped plants[1] from MH-30 treatments (Brown's Farm). 1963. Amherst.

Treatment	Estimated percentage seedstalks September		Average plant growth in inches May 31 treatment	
	May 15 application	May 31 application	July 18 measurement	Sept. 30 measurement
1. 2 lbs./A MH-30 & Urea	0	0	10.6	13.8
2. 2 lbs./A MH-30	40	3	4.2[2]	5.1[2]
3. 4 lbs./A MH-30 & Urea	0	0	11.2	15.6
4. 4 lbs./A MH-30	30	3	4.1[2]	5.2[2]
5. Check - no nitrogen	100	100	12.3	12.2
6. Check - Urea	100	100	25.4	26.1

[1]Dominant species were red fescue and redtop; sparse species were Kentucky bluegrass, Kentucky 31 tall fescue, ryegrass, and alsike clover.

[2]Plants with seedstalk not measured.

Facts About Gasoline Additives

By Harold E. Gulvin
Agway Petroleum Product Engineer

What are the facts concerning additives in gasoline? Despite sales claims (many exaggerated) made for a seemingly endless list of additives, only five are usually needed, and all five are in Agway gasoline.

Listed here are the five common and useful additives . . . why they're used and what they accomplish.

(1) Lead Tetraethyl. Used in all regular and premium gasolines except American's Amoco in the East. By law, these leaded gasolines must be colored.

Lead raises the octane rating of gasoline, but the amount that can be added is limited by law. Most gasolines, whether regular or premium, contain about 2.5 to 3.0 ml of lead per gallon.

Lead cushions valve heads as they contact the valve seats, thus prolonging the life of the valves. Lack of lead is why valves burn when the gas used is white, marine, aviation, or propane. Thus lead has two worthwhile purposes: It raises the octane rating and it adds to the life of the valves.

On the negative side, lead does contribute to combustion space deposits. These appear as brown deposits on valve heads and plug electrodes. In normal accelerating-decelerating operation, the deposits are quite readily blown from the combustion chamber.

(2) Phosphorous. Its purpose is to sufficiently lower the temperature of deposits in the combustion chamber so that they do not glow and cause pre-ignition of the fuel charge.

It also improves the firing of the spark plugs by modifying plug deposits so they are less conductive.

(Continued on Page 26)

USE OF MALEIC HYDRAZIDE (Continued from Page 17)

Table 13: Average dry weight, and percent suppression of yields on nitrogen fertilized and on unfertilized plots treated with MH-30 May 4, 1964, and cut on June 3, 1964. Amherst & Hadley.

Plot number	Plot treatment	Yield in grams 16 sq. ft.[1]	Yields lb./A	Percent suppression in yield	Plot number	Plot treatment	Yield in grams 16 sq. ft.[1]	Yields lb./A	Percent suppression in yield
1	No fertilizer	75.8	431.1	55	7	No fertilizer	40.8	245.0	75
2	25 lbs. N/A 10-10-10	95.3	571.8	42	8	25 lbs. N/A 10-10-10	45.3	272.2	72
3	50 lbs. N/A 10-10-10	154.2	925.7	6	9	50 lbs. N/A 10-10-10	49.9	299.5	69
4	25 lbs. N/A Urea	96.0	576.2	41	10	25 lbs. N/A Urea	54.5	326.6	67
5	50 lbs. N/A Urea	77.1	462.7	53	11	50 lbs. N/A Urea	31.6	190.5	81
6	Check - no fertilizer, no MH-30	162.8	980.1		6	Check - no fertilizer, no MH-30	162.8	980.1	

[1]Average of 3 replications

eleven plots 40′ x 200′ (with the exception of the check plot which was one-half the size), received nitrogen fertilizer treatments (Table 13) at two rates, 25 and 50 lbs. of nitrogen per acre. One area received the two-lb. rate of actual MH-30 per acre on May 4, 1964, and the second area received four lbs. per acre of actual MH-30 on May 18, 1964.

A tractor - mounted three hundred gallon capacity sprayer*, throwing a fan-shaped spray a distance of twenty feet at a speed of 10 miles per hour from off-center nozzles, using 20 lb. pressure, was used to apply the MH-30 from each side of the median strip. Approximately eighty-five gallons of spray material were used per acre. Weight data samples of four, four-square-foot quadrates in each plot taken to determine the suppression of yields in order to evaluate the effectiveness of MH-30. Grass height was also measured.

*Chemicals were applied with company equipment by Mr. Paul Bohne, Naugatuck Chemical Division, U. S. Rubber Co.

Results

Data taken June 3, shown in Table 13, give the suppression in yields on grass for the May 4 application of the two rates of MH-30 treatment. For the two lb. rate treatment of MH-30, suppression in yield was about 50%, if plot 3 was eliminated, where yields were reduced only 6%. Even with this reduction in yield, the height of grass and the seedstalks gave an uneven, unsightly appearance. Mowing would have been necessary to maintain general attractiveness.

The four lb.-per-acre rate of MH-30 produced good suppression of grass growth, and the reduction in yields on all plots averaged 73%, as shown by the data taken June 3, 1964. Table 14 shows the low height of the grass

Table 14: Average height of grass (in inches), and seedstalk production on MH-30 plots treated May 18, and observed June 11, 1964. Amherst & Hadley.

	2 lbs./A MH-30			4 lbs./A MH-30			
Plot number	Plot treatment	Average height in inches	Amount of seedstalks	Plot number	Plot treatment	Average height in inches	Amount of seedstalks
1	No fertilizer	9	few	7	No fertilizer	4	very few
2	25 lbs. N/A 10-10-10	8	few	8	25 lbs. N/A 10-10-10	4	very few
3	50 lbs. N/A 10-10-10	9	many	9	50 lbs. N/A 10-10-10	4	very few
4	25 lbs. N/A Urea	10	few	10	25 lbs. N/A Urea	5	very few
5	50 lbs. N/A Urea	8	few	11	50 lbs. N/A Urea	6	very few
6	Check - no fertilizer, no MH-30	12	many	6	Check - no fertilizer, no MH-30	12	many

and the small number of seedstalks which gave the treated area a uniform appearance. No mowing was necessary. Plots 10 and 11, which were treated with urea, had seedstalks of red fescue, Kentucky 31 tall fescue, orchardgrass, and redtop, which were slightly taller than the seedstalks of grasses in the other plots. This was contrary to the results obtained the previous year at Brown's Farm, when no seedstalks were produced. Nitrogen, used with MH-30 to stimulate growth in order to aid the intake and the effectiveness of MH-30, reduced but did not eliminate the formation of seedstalks.

Table 15: Average dry weight, percent suppression, and height (in inches) of grasses in MH-30 plots treated in the fall of 1964 and the spring of 1965, as measured June 11, 1965. Amherst & Hadley.

Fall 1964	Yield - grams 12 sq. ft.[1]	lbs./A	Percent suppression	Average height in inches
4 lbs./A	98.8	791.0	41.6	15
6 lbs./A	69.9	559.6	58.6	12
8 lbs./A	45.2	361.8	73.3	4.5
Spring 1964				
4 lbs./A	64.4	515.6	61.9	10
6 lbs./A	68.6	549.2	59.4	9
8 lbs./A	44.0	352.3	74.0	4.5
Check	169.2	1354.6		22

[1]Average of 3 replications.

1964 and 1965. Median Strip - Route 116:

Materials and Methods

A fall and spring application of MH-30 were made on the same (above) median strip in Amherst and Hadley. Treatment dates were November 7, 1964, and May 5, 1965, with MH-30 used at the rates of four and six lbs. of actual material per acre, sprayed with the same equipment. Weather conditions were good for MH-30 treatment. Fertilizer was applied at the same rate as in the previous experiment. An eight lb. rate per acre of actual MH-30 was also applied on a fill slope in the same area of the median strip in the spring and fall, for evaluation purposes. Samples of three, four-square-foot quadrates, were taken at random to determine weight yields and height of grasses to evaluate the MH-30 results.

Results

Table 15 shows the percentage of suppression in yields and the average height of grasses for the various treatments. Fall and spring treatments of MH-30 indicated no differences between the various nitrogen-treated plots for the four and six lb. rates of MH-30 treatment, so the data used were for the unfertilized plots. Spring treatment was more effective than the fall treatment for both the four and six lb. rates of MH-30. However, the eight lb. rate gave excellent suppression of grass growth; average height of grass was 4.5 inches, which required no mowing, and this inhibition of growth was evident throughout the season in both spring and fall treated plots. There was some injury to the Kentucky 31 tall fescue in the fall treated plots, when observed during the spring of the next year, but the grass recovered in several weeks and appeared normal. The spring treatment of both the four and six lb. rates of MH-30 suppressed yields by 61.9 and 59.4%, respectively, and had an average grass height of 9-10 inches. It would have been necessary to mow these treated areas in order to maintain general attractiveness. To be effective in reducing grass growth to the point where mowing is eliminated, it appears that there must be a yield reduction of about 75%.

1966. Median Strip - Route 116:

Materials and Methods

The same median strip on Route 116 in Amherst and Hadley was used for MH-30 trials with no fertilizer applied to the area. Applications of MH-30 were made as before at the rates of four and six lbs. of actual material. The first application was made on May 11, 1966. Windy conditions were encountered when the material was applied.

On the second area, the grass was first cut to a height of 4-5" on May 18. MH-30 was applied at rates of four and six lbs. of actual material on May 24, 1966. Dry matter yields were taken to evaluate the results.

Results

Table 16 gives the yield data, per cent suppression, and height of grasses in plots treated with four and six lb. rates per acre of MH-30. The May 11, 1966 treatment results were poor because of the windy conditions which prevailed at the time of treatment. Thus, some areas had poor suppression of growth, and others had excellent control. Data were used from areas that appeared to have uniform reduction throughout the sprayed area. Yield reductions were 60% and 64.4% for the four and six lb. rates, respectively. This was not satisfactory, as shown by the height of seedstalks, 14 and 15 inches, which gave an uneven and tall appearance to the turf area.

The May 24, 1966 application of MH-30, which was applied to the area cut a week prior to the application (Table 16), gave good results. Dry matter yields were

(Continued on Page 25)

factors limiting photosynthesis

barriers to higher crop yields

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LIGHT is the most important environmental factor influencing photosynthesis. However, as yet, man has been able to exercise little control over the amount of light reaching his crops. Natural phenomena, such as the earth's rotation and atmospheric absorption determine this.

Man can, however, use practices to improve utilization of the limited light supply. The most important of these is to choose or to create crops photosynthetically responsive to intercepted light at all intensities. Better leaf distribution, increased leaf surface areas, and longer leaf life are ways of improving use of light by plants.

Efficiency Varies

One of the large differences between plants is their ability to utilize light energy in producing plant substance. Varieties of a species even can differ widely in this respect. Figure 1 shows this for two corn hybrids.

Hybrid B shows the type of photosynthetic response characteristic of most crops as light intensity is increased. Leaves become "light saturated" at less than one-half full sunlight and photosynthesis fails to increase further with increased light. This means that other factors are limiting in the upper half of the light range.

Photosynthesis in hybrid A, however, increases with increasing light intensity near to full sunlight. Differences in photosynthetic efficiency can account for much of the yield difference of these two hybrids.

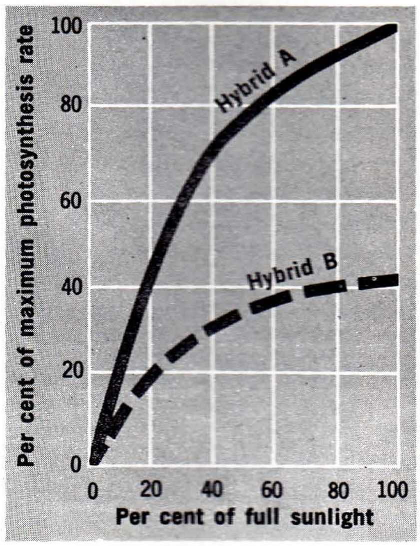


FIGURE 1.
Photosynthesis rates of two corn hybrids as influenced by light intensity.

High-yielding varieties of crops, such as sugar cane, sorghum and corn, can capitalize on the extra energy in full sunlight. Their leaves respond like hybrid A.

Light Limits Yield

In one way or another, however, light limits yields of all crops. Many leaves in a crop canopy are shaded and fail to receive adequate light. Clouds can reduce light intensity by more than 75 per cent. Light intensity reaching the crop also depends on the sun angle. It decreases from midday and from the first day of summer. Duration of the daily light period also is involved as, even with the longest day, photosynthesis is limited by day length.

The advantage for a crop responding to high light intensities is best evaluated by examining light absorption. A green leaf absorbs about 80 per cent of the light radiating to it regardless of intensity and capacity for photosynthesis. Most of the absorbed light energy is converted into heat which, in turn, is dissipated by transpiration (60 per cent), by convecting air currents (15 per cent), and dry thermal radiation (15 per cent).

Low Energy Utilization

Plants use only five to 15 per cent of the absorbed light energy in photosynthesis. Referring to Figure 1, hybrid A is seen to have more than a twofold superiority in photosynthetic efficiency. Both varieties absorb the same amount of light energy. Yet, B produces less than one-half the photosynthesis of A where B is light saturated.

Chlorophylls and other plant pigments are responsible for the high rate of light absorption by leaves. The superabundance of chlorophyll in healthy green leaves is such that its content could be reduced to one-fifth without reducing the rate of photosynthesis. Only in obviously chlorotic leaves is photosynthesis impaired by lack of chlorophyll. Chlorosis occurs when nutrients and oxygen are deficient or when the leaves have been subjected to extreme drought, heat or cold. Diseases and improperly used chemical sprays also may cause chlorosis.

Leaf Area Important

Efficient crop production provides the greatest conversion of available light energy into usable produce. It includes those practices that generate and maintain a "leafage" which intercepts the highest possible portion of light. Common terms to describe leafage are leaf area index, leaf area duration, leaf distribution, and leaf angle.

Leaf area index (LAI) is the ratio of green leaf surface of a crop to the ground surface. Only the upper surface of the leaf is considered in this index. An LAI which results in a 95 per cent interception of the light is considered essential for maximum photosynthesis. To obtain this, LAI values range from three to 10 or more, depending on leaf angle distribution, and other factors.

Vertical leaves require a much higher LAI than horizontal leaves for the same degree of light interception. This results from light intensity being highest during midday when vertical leaves are poorly displayed.

Leaf Life Also Important

Part of the greater productivity of corn compared to wheat is due to the longer leaf area duration (LAD) of corn. Wheat leaves die soon after the plant flowers. while corn leaves remain green and active for about two months after flowering (silking). This difference of LAD of corn and wheat is even more significant in view of the fact that most of the photosynthate deposited in grain is produced after flowering. Very little is translocated from other plant parts where deposits were made before flowering.

Superior varieties sometimes have longer LAD's. However, breeding for this factor is difficult because extending the LAD for the reproductive stage usually extends the vegetative stage also. Maturity of the variety thus may be undesirably late. Benefits from balanced fertilization, irrigation, cutting management and disease con-

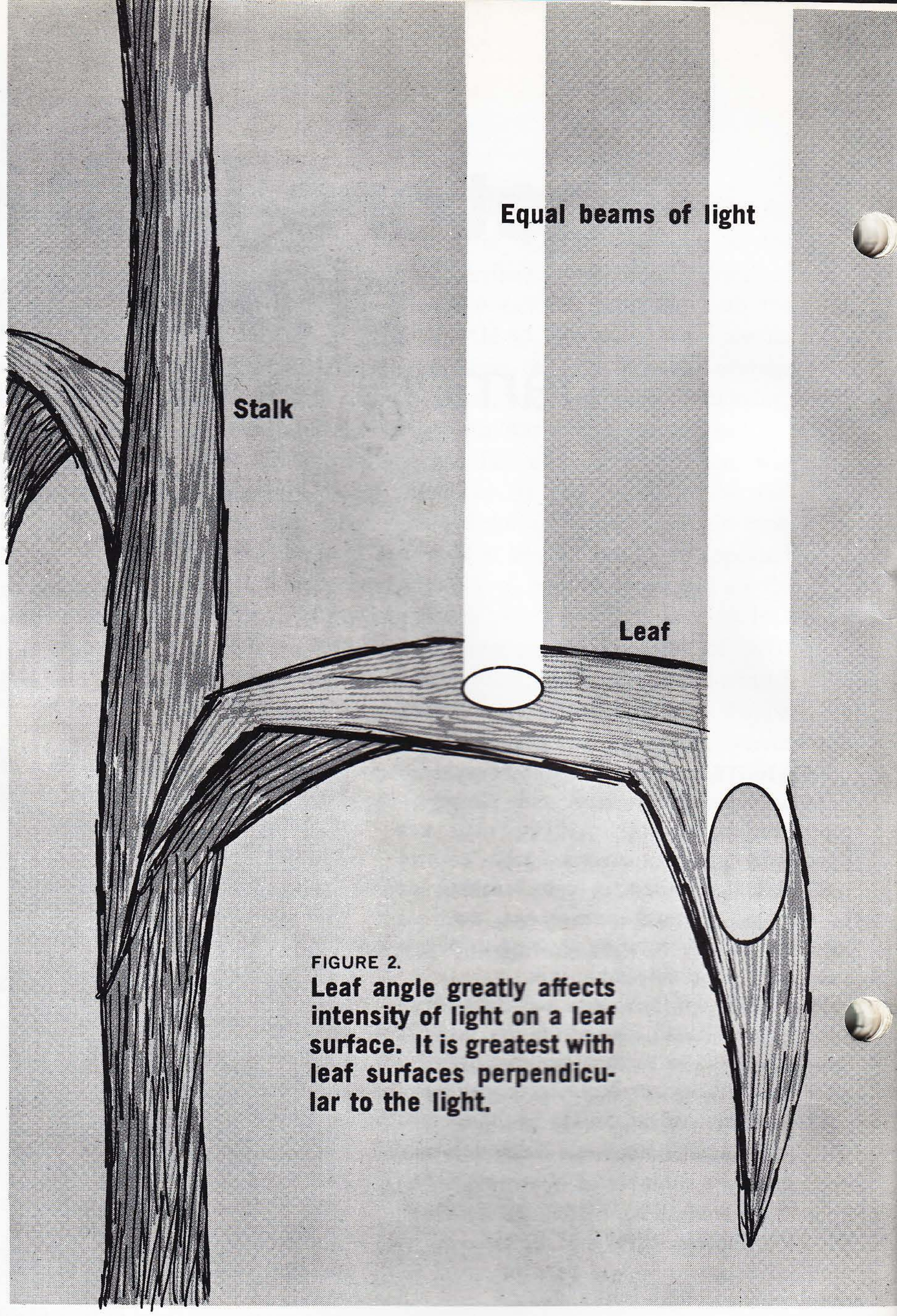
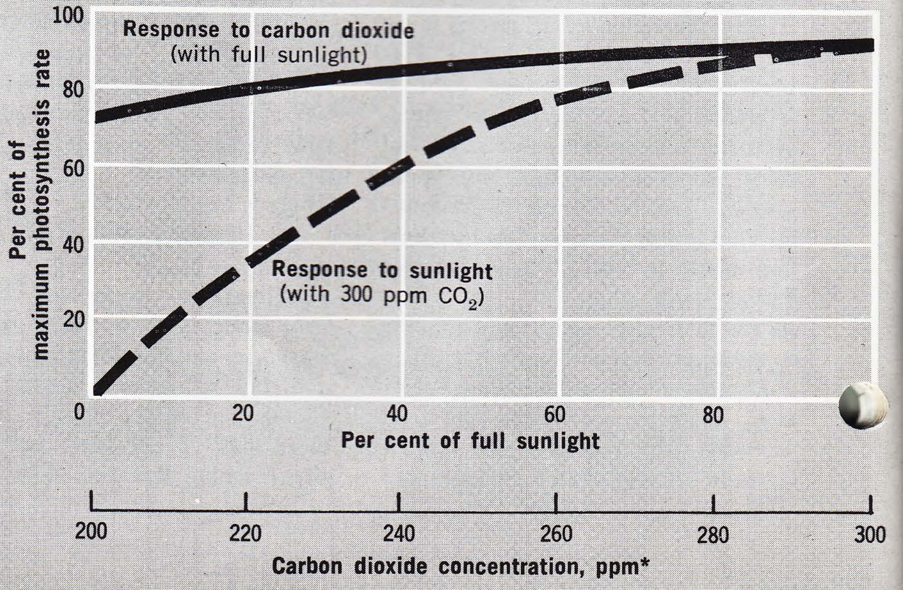


FIGURE 2.
Leaf angle greatly affects intensity of light on a leaf surface. It is greatest with leaf surfaces perpendicular to the light.

FIGURE 3.
Relative influence of carbon dioxide and light on photosynthesis in corn



* 200 ppm CO_2 is the lowest concentration expected in the field

trol often are the result of improved LAD.

To absorb light most efficiently, leaves should be evenly distributed above the soil surface. This means even plant distribution and minimum row widths. Row direction, except where rows are wide, has little influence on photosynthesis during the late period of growth when grain and other useful parts are produced.

A beam of light has maximum illumination when it strikes a perpendicular surface. As the angle departs from the perpendicular, intensity of illumination decreases.

This relationship is shown in Figure 2 for two light beams of equal size and energy. The light energy per unit of leaf area on the oblique surface is seen to be about half that on perpendicular surface.

Amount of Carbon Dioxide Varies

The amount of carbon dioxide required for optimum photosynthesis is difficult to maintain under field conditions. The normal concentration of carbon dioxide in air is 0.03 per cent (same as 300 ppm). But, normal levels for the air enmeshed in a dense crop canopy is only about 270 ppm during the daytime. At night, in the absence of photosynthesis, but with respiration in plant and soil, the concentration may be much above 300 ppm, especially during periods of calm.

Concentrations of carbon dioxide usually are highest at the soil surface and lowest in the zone of leaves absorbing the most light. Under clear skies and little wind the average carbon dioxide concentration in this zone may decrease to 250 ppm around midday. However, concentrations at or very near the leaf surfaces in this zone are often 25 to 50 ppm less than the average.

The low carbon dioxide concentration near leaf surfaces is the result of photosynthesis. Inside the leaf where photosynthesis occurs, the carbon dioxide concentration is nearly zero. Thus, a concentration gradient of zero to approximately 250 ppm is generated. Such a gradient is sufficient to diffuse carbon dioxide into the leaf at a rate sufficient to support photosynthesis.

The extent to which carbon dioxide concentration may limit photosynthesis in corn leaves in the field is illustrated in Figure 3. The plants were maintained under optimum conditions while the leaves were enclosed, one at a time, in experimental chambers for testing.

The upper curve resulted when photosynthesis was measured with full sunlight at carbon dioxide concentrations between 200 and 300 ppm, the naturally occurring range in a corn field. The lower curve was obtained with carbon dioxide at 300 ppm, and with light intensity ranging from darkness to full sunlight. These curves show that the maximum depression in photosynthesis from reduced carbon dioxide levels was only one-fourth that from reduced light.

Stomata Regulate Passage

Carbon dioxide enters leaves through very small openings in the leaf surface called stomata. These open and close in response to stimulation from changes in light, leaf water and carbon dioxide content.

If the carbon dioxide content of the cells around the stomatal openings becomes high because of reduced photosynthesis, resulting from insufficient light, the stomata close. Moisture stress also can close the stomata, thereby increasing resistance of carbon dioxide diffusion into leaves.

The larger the carbon dioxide gradient and the smaller the diffusion resistance between the leaf surface and the chloroplasts the greater is the potential for photosynthesis. Wind helps to keep the gradient large by rapidly replacing canopy air with air of higher carbon dioxide content from above.

An insufficient supply of carbon dioxide often is blamed for the "light saturation" condition mentioned in reference to Figure 1. Light and water may control the permeability of a leaf to carbon dioxide, yet the latter is also involved in the control mechanism. These examples of the intricate interplay between environmental factors and photosynthesis emphasize the complexities hindering a more complete understanding of the carbon dioxide factor.

Water a Limiting Factor

In most agricultural areas, water stress in plants remains a serious limiting factor, at least for parts of the growing season. Photosynthesis is generally reduced in proportion to the degree of moisture stress in the leaves. Stress resulting in severe wilting may completely stop photosynthesis.

Just how leaf moisture stress reduces photosynthesis is not fully understood. However, stomatal closure, and increased internal resistance to carbon dioxide diffusion, work to reduce carbon dioxide supply to the chloroplasts. Loss of chlorophyll accompanies extreme stress.

Temperature extremes reduce photosynthesis rates, too. At high temperatures, increased respiration consumes a larger portion of the products of photosynthesis. Thus, there is less net accumulation. Chlorophyll may be destroyed at high temperature and its rate of formation is very slow at low temperature.

Within the range of normal summer temperatures found in the major crop-producing regions, however, temperature has a minor effect on photosynthesis per unit of leaf area. Low temperatures in the spring and early summer can inhibit leaf development and thereby prolong the time where there is adequate leaf area for light interception.

Summary

A vast amount of knowledge is rapidly accumulating on the influence of external and internal factors of photosynthesis. Such knowledge is of primary importance in discovering ways to increase crop production.

As yield potentials of varieties are pushed higher through improved germ plasm and elimination of growth limiting factors, such as soil fertility, more attention will be paid to the ultimate determining limits of plant production. These will include factors affecting photosynthesis efficiency. Observations of higher yields by border rows and lower yields of crops in cloudy seasons point to photosynthesis as being a determining factor in yields. Direct cause-and-effect evidence for the assumed photosynthesis-yield relationship is sorely needed. With it the practical significance of factors limiting in photosynthesis would be unquestioned. □

—Reprinted from Plant Review Vol. 13, No. 2, 1967

(Continued from Page 20)

59% and 63%, respectively, for the four and the six lb. rates of application. In both instances, the grass height was 11-12 inches, yet there was uniformity of appearance. The few seedstalks that were found were poorly developed, and could not be seen unless observed closely. The six lb. treatment, which was slightly better, could have been accepted as roadside cover where a groomed highway cover is not essential.

Even though results with MH-30 as a turf - growth inhibitor are sometimes erratic, in that the treatment does not entirely eliminate mowing, yet it does reduce the yields of dry matter substantially. This reduction in yields necessitates less subsequent mowing. Very heavy grass cut along highways has to be raked and disposed of because of its unsightly appearance. This is in agreement with the findings of the Maryland State Road Commission (2) which has used MH-30 in areas where it is too costly and/or inaccessible for mowing, on inner interloops of interchanges, and on mowed roadside areas. Medians that are costly to maintain may also be treated with MH-30 under good absorption conditions to reduce the frequency of mowing. MH-30 treated turf generally had a lasting effect of growth inhibition throughout the summer. However, drought conditions during the past summers may also have contributed to lack of regrowth. Grass areas in Amherst, which had received treatments during the past three years, showed no detrimental effects to the turf.

Table 16: Average dry weight, percent suppression, and height (in inches) of grasses on MH-30 plots treated May 11 and May 24, 1966, as measured June 11, 1966. Amherst & Hadley.

Date of application	Rate MH-30/A	Dry matter yield 4 sq. ft.[1]	Percent suppression	Average height in inches
May 11, 1966	4 lbs.	222 g	60.0	14.3
	6 lbs.	200 g	64.4	15.1
May 24, 1966	4 lbs.	176 g	59.3	11.2
	6 lbs.	192 g	62.7	12.7
Check		472 g		33.1

[1]Average of 3 replications

She was Honey Chile in New Orleans,
The cutest babe in the bunch;
But on the old expense account,
She was gas, cigars, and lunch.

A motorist who was bogged down in the sticky clay of an old deserted Georgia road, and paid a passing farmer $10 to pull him out with a team of mules. After he was on the road again he remarked to the farmer, I should think that at that price you'd be pulling people out of this stuff day and night."

"Nope," drawled the farmer, "at night's when I tote the water for the holes."

NUTRIENT DEFICIENCIES REDUCE PHOTOSYNTHESIS

NUTRIENT DEFICIENCIES, expressing themselves through a variety of physiological mechanisms, often markedly reduce crop yields. A particular mechanism will depend not only on the nutrient involved, but also on the particular plant part, such as fruit, grain, tuber, or above-ground portion.

Not all yield-reducing mechanisms are related to reduced photosynthesis, thus a nutrient deficiency can affect yield without directly affecting this basic process. For example, a deficiency can interfere with flowering, fruit set, or tuber initiation. In such cases, photosynthesis in the leaf may be normal while yield is reduced because mechanisms other than photosynthesis are impaired.

Of course, if a nutrient deficiency reduces photosynthesis, it will, in all probability, also reduce yields of fruit, grain, or tuber, by decreasing the internal carbohydrate supply of these organs.

Nutrient Effects Vary

Despite the essentiality of photosynthesis to plant life and development, knowledge of effects of nutrition on the over-all process is incomplete. It is known, however, that nutrient deficiencies affect photosynthesis by several different mechanisms.

First, deficiencies which influence fruit or grain formation can have indirect effects on photosynthesis. Potassium deficiency in corn at flowering time, for instance, results in barren or poorly fertilized ears. The ear is a storage site for carbohydrates, and if no ear, or if only a small ear is formed, sugars build up in the leaves and photosynthesis is suppressed. Thus, a temporary potassium deficiency at tasseling can impair flowering and development of a storage site for photosynthate from leaves.

An easier process to visualize is the control of photosynthesis through the control of plant size. Deficiencies of many elements, especially in young plants, mean smaller plants and fewer and smaller leaves. Although photosynthesis per unit leaf area may not be adversely affected, such deficient plants have less leaf area and a lower photosynthetic capacity than larger plants and will produce less dry matter.

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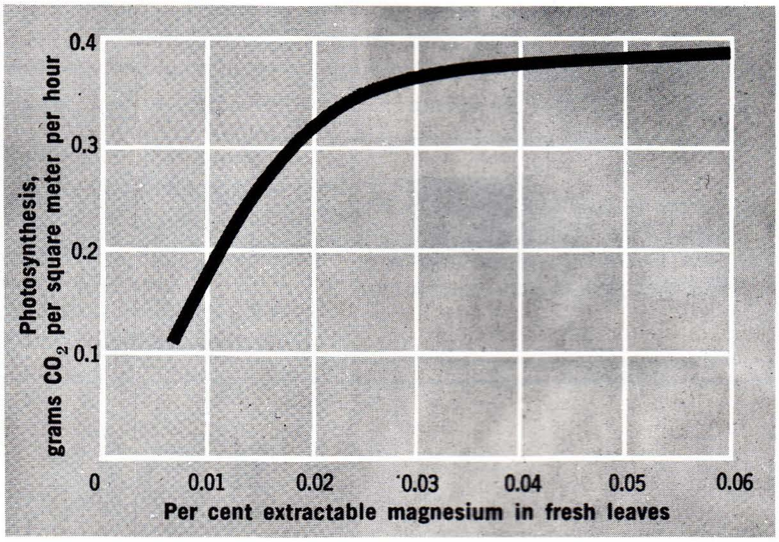


FIGURE 1.
Relationship of extractable magnesium in fresh corn leaves and photosynthesis.

Another mechanism by which lack of nutrients reduces photosynthesis is by shortening the duration of active food production by leaves. Nutrient deficiencies shorten this period by hastening maturity of plants and the aging of leaves.

In some cases, soil nutrient supplies are sufficient for maximum plant growth only up to a certain point in the growing season. As soil nutrient levels are reduced, nutrient deficiencies develop. Under such conditions the older leaves characteristically show "burning" with the active photosynthetic surface decreasing rapidly. The entire plant ages quickly.

Other Nutrient Effects

Stunted plants and early leaf aging are well-known symptoms of nutrient deficiencies. The effects may be indirect, such as reduced leaf area of a plant, or they may directly suppress leaf photosynthetic efficiency.

Since leaves must contain chlorophyll in order to perform photosynthesis, nutrient elements necessary for chlorophyll formation and stability, such as nitrogen and magnesium, are essential.

An illustration of how magnesium deficiency can decrease photosynthesis is shown in Figure 1. Photosynthesis in this case is expressed in terms of grams of carbon dioxide (CO_2) fixed per square meter of leaf area in one hour.

This decrease in photosynthesis is correlated with the concentration of chlorophyll in the leaf as can be seen in Figure 2. A magnesium-deficient corn leaf typically has yellow stripes between the veins and visual estimates of the degree of yellowing often can accurately predict the decrease in photosynthesis. Loss of chlorophyll in leaves is called chlorosis and yellow or light green areas are called chlorotic areas.

Deficiencies of other nutrients, such as iron, manganese, nitrogen, potassium, and copper, also produce yellow leaves. Chlorosis is often followed closely by death of the leaf, but under some conditions chlorosis may persist or even be followed by recovery if the deficient nutrient becomes available. Thus, small plants and chlorotic or aged leaves are widely recognized as means by which nutrient deficiencies decrease photosynthesis.

Some Deficiences Non-Visible

Some deficiencies are subtle and reduce photosynthesis without producing visual symptoms. Potassium deficiency in corn is an example.

Effects of such a non-visible deficiency on photosynthesis of corn are illustrated in Figure 3. Although all leaves in this experiment appeared normal, their photosynthetic rates dropped sharply when potassium concentration in leaves went below 0.2 per cent (fresh weight). Unlike the magnesium deficiencies which depleted chlorophyll, potassium deficiency sometimes stopped photosynthesis without changing the chlorophyll content.

A search for the invisible mechanism by which potassium deficiency decreased photosynthesis revealed that the potassium-deficient leaves lost much less water than normal ones. Since water escapes from leaves into the atmosphere through the tiny stomatal pores in the leaf surface, a likely effect of potassium deficiency is closure of the stomata. Closing of stomata suppresses carbon dioxide passing into the leaf to reach the photosynthetic factory inside. Hence, photosynthesis is reduced.

That potassium deficiency closes stomata is observed in Figures 4(a) and 4(b) showing the open and closed stomata of well-fertilized and potassium deficient leaves. This is one example of how a nutrient deficiency may reduce yield with no visual symptoms apparent to the naked eye.

Lack of phosphorus and nitrogen also decreases photosynthesis in leaves before symptoms of the deficiency are visible. The mechanisms by which these nutrients act on photosynthesis in the early stages of deficiency are still unknown. Nitrogen and phosphorus are components of numerous vital compounds within leaf cells and it is not surprising that they have roles in photosynthesis that are more sensitive to deficiency than chlorophyll concentration.

Critical Concentration Important

Relationships of photosynthesis to magnesium and potassium concentration, shown in Figures 1 and 3, resemble those between yield of dry matter and nutrient concentrations in plants. Increasing a nutrient concentration, when the concentration is low, increases photosynthesis but at a decreasing rate.

In the field, the point where yield ceases to rise as concentration of the nutrient increases is called the critical concentration. For example, the critical concentration for potassium in corn is about 1.3 per cent on a dry weight basis. When the concentrations of Figure 3 are converted to dry weight rather than fresh weight, the critical concentration for photosynthesis is also between 1.1 and 1.5 per cent.

This close agreement is encouraging. Unfortunately, little information is available on the relation of tissue concentration of nutrients to photosynthesis despite the fundamental importance of photosynthesis to yield.

Summary

As broader knowledge is obtained, soil fertility and crop production programs may be designed more rationally. Indeed, scientists may be able to use foliar analysis to reveal exact nutrient requirements for the next crop, thus assuring maximum photosynthesis throughout the life of the crop.

Be that as it may, the probability of optimal crop management will certainly increase as more is learned about numerous mechanisms limiting crop yields. For that purpose, an understanding of the relation of proper nutrition to photosynthesis is of fundamental importance. □

FIGURE 2.

An illustration of how magnesium levels affect photosynthesis in corn by influencing chlorophyll content.

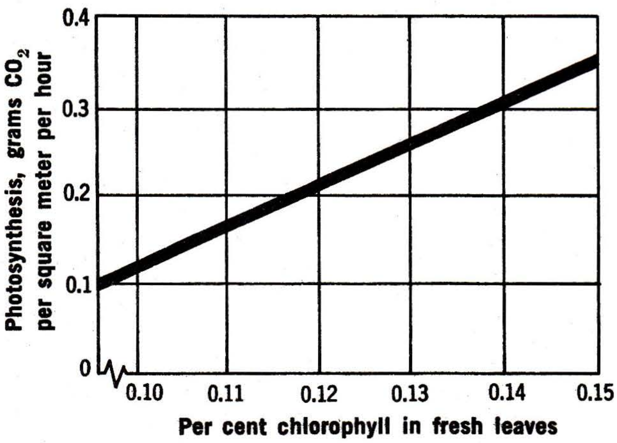
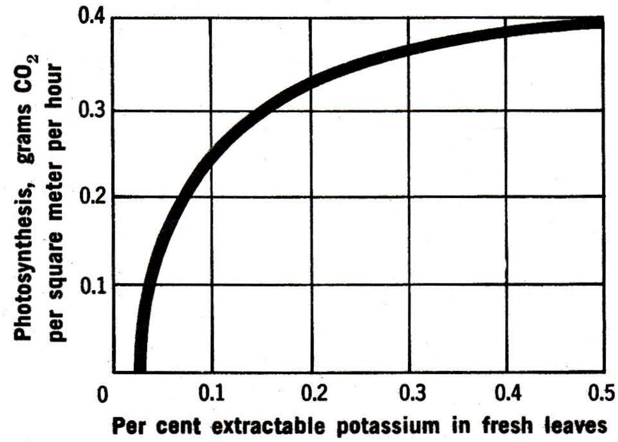


FIGURE 3.

Relationship of extractable potassium in fresh corn leaves and photosynthesis.



FROM

MASSACHUSETTS TURF AND LAWN GRASS COUNCIL INCORPORATED

RFD #2, HADLEY, MASS. 01035

TURF BULLETIN

TROLLING

FACTS ABOUT GASOLINE

(Continued from Page 18)

Result: Fewer shorted out plugs.

(3) Detergents. They keep the entire fuel system clean and free of gum formations, particularly in the carburetor needle and jet areas. Detergents also pick up some water in the gasoline and permit it to pass through the system and out the engine exhaust.

A third function of detergents is to keep the venturi-butterfly valve area clean, so that ice formed there on cold-humid days doesn't cling. This prevents stalls on such days. In this category, the detergent serves as a common de-icer.

(4) Metal Deactivator. Prevents metal surfaces from rusting and the formation of gum in the gasoline. Gum causes sticky rings and valves.

Agway adds one-half pound of this material to each 1,000 barrels of regular and premium gas.

(5) Anti-Oxidant. This additive reduces gum formation which causes rings and valves to stick. Agway gasolines contain five pounds of this additive in each 1,000 barrels.

Two other additives for special situations and problems may be useful. These are not incorporated in Agway gasolines, but are added by the operator of the vehicle.

For constant damp cold-day stalls, alcohol known as "dry gas" works. It's available in 12-ounce cans at Agway stores and petroleum plants. Put into the tank, it also will prevent freeze-ups.

For suspected heavy combustion chamber deposits, use of special solvents in the fuel or via the carburetor throat is helpful.

The highly advertised "platformate" which is claimed to give extra mileage to gasoline is really just a "reformate" — a gasoline molecule which has been reformed into a different kind of molecule. Reformate is in *all* gasolines, including Agway's.

—Reprinted from Agway Cooperator August 1967

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Membership is not restricted to Massachusetts residents or turf professionals alone, all are welcome to take part. Write today.