TURF BULLETIN

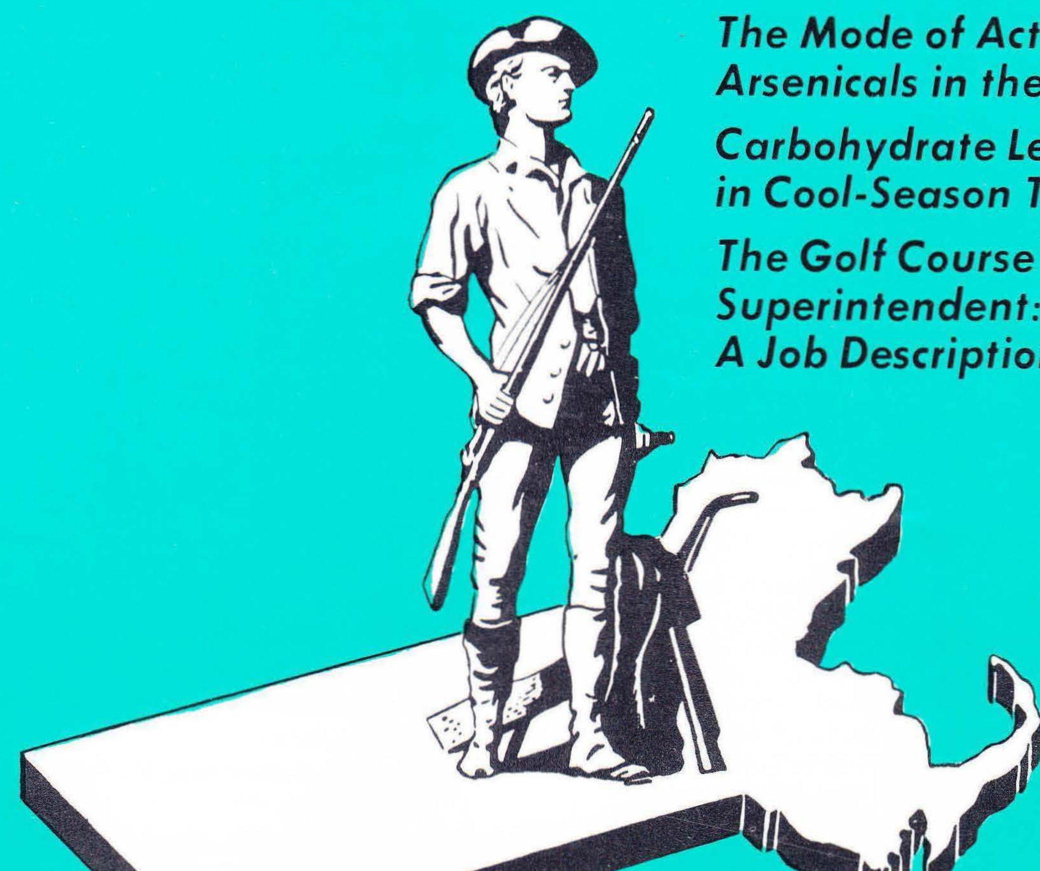
MASSACHUSETTS TURF AND LAWN GRASS COUNCIL INCORPORATED

Featured in this Issue:

The Mode of Action of Arsenicals in the Soil

Carbohydrate Levels in Cool-Season Turfgrasses

The Golf Course Superintendent: A Job Description



WINTER 1972

BETTER TURF THROUGH RESEARCH AND EDUCATION

Editor
Frederick Guy Cheney
Apt. 5B North Village
Amherst, Mass.

Secretary-Treasurer & Advisor
Dr. Joseph Troll
RFD No. 2 Hadley, Mass.

Vol. 8, No. 2 **Winter 1971**

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.

Table of Contents

The Mode of Action of Arsenicals in the Soil

By: Cecil F. Kerr
Chipco Turf Products Manager

ABSTRACT

Arsenicals are widely distributed in nature. Soils contain naturally arsenic values from 0.2 to 40 ppm.

Arsenic is very similar to phosphorus. Factors which affect the behavior of phosphate in the soil will also affect the behavior of arsenate. Phosphates and arsenates are either fixed or absorbed by plants. Fixation is greater in a fine silty clay colloidal soil. Chelated iron and zinc increase fixation of arsenic.

The addition of iron and zinc to the soil will decrease available arsenical by increased arsenic fixation and should insure a more gradual removal of Poa annua.

Liming the soil increases the displacement of phosphate by arsenate. The availability of arsenates and P_2O_5 is increased as the pH increases to pH of 7.

Some crops are injured by concentrations of arsenicals, especially on light sandy soils, however, most plants thrive on accumulations of arsenicals. The yields of peas, radishes, wheat, potatoes, turnips, sorghum, soybeans and cotton are increased on heavy soils, such as Davidson clay loam, even with applications of 1000 pounds calcium arsenate per acre.

High levels of phosphate will overcome arsenate by antagonistic action. Increasing phosphate levels caused less arsenic to accumulate in the plant. Both phosphorus and arsenic accumulate in surface soils. Neither phosphorus or arsenic appreciably leach in the soil. They do not contribute to pollution of lakes and streams.

Bent, bluegrass, zoysia, bermuda and fescue grasses are extremely tolerant to arsenical formulations. Most researchers recommend tri-calcium arsenate for Poa annua, crabgrass and soil insect control.

There is no acceptable substitute for tri-calcium arsenate for effectively controlling Poa annua. All other materials seriously injure bent. Overseeding is not possible with most other chemicals.

Professional golf course superintendents have a thorough knowledge of their soil type, pH, phosphate level, zinc and iron requirements and are now able to compute the approximate arsenic needed to control Poa annua in their soil by atomic absorption spectrometry.

With repeated applications of tri-calcium arsenate, small amounts of arsenicals become available to the plants, gradually removing Poa annua over a period of years. Control is maintained with light annual applications (2 to 3 lbs. 48% tri-calcium arsenate per 1000 sq. ft.)

Golf course superintendents throughout the United States have, for years, safely used tri-calcium arsenate on an individual prescribed basis to control Poa annua, crabgrass, chickweed and harmful soil insects. They manage turfgrass as an anti-pollutant, as a basic oxygen producer and as a prime erosion control agent.

The prescribed usage of arsenicals eliminates unsightly weeds and harmful insects on golf courses creating a beautiful environment, enabling our population to enjoy both nature and recreation.

Arsenic is widely distributed in nature as oxygenated compounds or as sulfides. Deposits of arsenic trioxide are known as ores such as realgar, As_4S_4 and orpiment, As_4S_6 which are mined. Arsenic appears in almost all soil, sea water, spring water and volcanic gas. The average arsenic content of soils for various parts of the world is approximately 5 ppm (17). Williams and Whetstone (27) reported soil arsenic values from 0.2 to 40 ppm.

Arsenic is very similar to phosphorous in the compounds formed and the way they are formed. Arsenic forms tetrahedral compounds, exhibits the same valences, and has nearly the same molecular properties as phosphorous (28).

Factors which affect the behavior of phosphates in soil will also affect the behavior of arsenate. Phosphates and arsenates are either fixed or absorbed by plants. The texture of a soil influences arsenic fixation. Boischot and Hebert (4) stated that fixation increased as the fineness of the soil increased.

Several researchers, Deb and Datta (9) and many others, indicated a direct proportionality between iron content in the soil and the ability of that soil to fix arsenate. Albert (1) demonstrated fixation reaction between a salt and the hydrous oxide. Arsenic from sodium arsenate was removed from a solution by freshly prepared ferric hydroxide in a few hours.

Aluminum, like iron, may fix arsenate according to Wiklander and Alvelid (26).

(Continued on Page 4)

(Continued from Page 3)

Arsenical residues are not generally harmful to plants because iron and aluminum cations in the soil chemically adsorb (tightly bind) and thus detoxify the inorganic arsenate. Arsenic and phosphorous are both fixed in the surface soils if sufficient iron, aluminum and/or calcium are available for reaction (27).

Calcium arsenate is either fixed or taken up by the plant. Vandecaveye (24) reported that alfalfa and grasses grown on a soil having less than 2.5 ppm soluble arsenic contained 20-30 ppm arsenic on a dry weight basis.

Clements and Munson (5) treated sudan grass, tomato and bean plants with sodium arsenite. It was found that as time elapsed, more and more of the arsenic was fixed by the soil, a fact indicated by a reduction in the amount of arsenic found in the plant tops.

Batjer and Benson (3) reported experiments in Washington soils showing that zinc and iron chelates are helpful in overcoming arsenic content of the foliage. Soil treatments appreciably reduced absorption of this element.

Quastel and Scholefield (19) reported a constant amount of sodium arsenite being adsorbed by soil. The arsenite apparently was bound irreversibly to the soil. A portion of the arsenite, however, was oxidized in the soil to form an arsenate.

Arsenic and phosphorous are in the same periodic family. They have similar chemical and physical properties and act as antagonists towards each other. High levels of phosphate will overcome the arsenate toxicity in nutrient solution by antagonistic action. Hurd-Karrer (14) using a nutrient solution culture technique, noted that phosphorous does overcome the effects of arsenate.

Increasing phosphate levels in the plant nutrient solutions, caused less arsenic to accumulate in the plant.

Schollenberger (22) found a general similarity of phosphates and arsenates with respect to molecular structures and solubilities. He found that as the pH is increased from 4.4 to 7.0, several factors occurred: A maximum cation exchange, a maximum displacement of phosphate by arsenate and also a maximum release of phosphate anions. Liming increases the availability of arsenates and also increases the availability of P_2O_5.

There is a marked difference between soil types with respect to the quantity of calcium arsenate required to produce injury to the growth of plants.

On Davidson clay loam soil, the addition of 500 lbs. per acre of actual calcium arsenate stimulated the yield of cotton and cowpeas.

Average dry weights of two plants of cotton and cowpeas grown on Davidson clay loam with addition of calcium arsenate.

Pounds of Calcium Arsenate per Acre	Cotton Grams	Cowpeas Grams
0	17.60	23.85
250	20.70	24.10
500	23.85	25.00

On a Durham coarse sandy loam, the above crops were injured by applications of calcium arsenate (18).

Some plants are injured by concentrations of arsenicals, however, soils with a high percentage of soil colloid and with adequate available iron may contain 2,112 lbs. of As_2O_3 per acre and not damage sensitive crops (13). Most plants thrive on accumulations of arsenicals. Stewart and Smith (23) found that concentration of 25 ppm As in the soil was beneficial to the growth of peas, radishes, wheat and potatoes. MacPhee et al, (15) also found an increase in turnip yields from 150 ppm total arsenic in the soil.

Cooper et al, (6) also noted a beneficial effect on several crops when fields were treated with calcium arsenate. The yields of wheat and rye from soils treated with 1200 ppm As were greater than the yields from the same soil with no arsenic added. In a separate experiment on a Davidson clay loam, corn, sorghum, soybeans and cotton, showed yield increases when 1000 lbs. calcium arsenate was added per acre.

Agricultural scientists who have investigated the affect of arsenic on soils and crops have found that when added to the soil in the amount usually present in sprays, that arsenic tends to stimulate plant growth and increase yields rather than to injure plant growth (25).

J. E. Greaves (Journal Agric. Research vol. 6, P389) found that arsenic stimulated the activity of the bacteria in the soil that produces ammonia and nitrogen and also affected soil organisms that tended to render the phosphorous of the soil more available. Both Greaves and Andersen, (1915) reported actual stimulation of soil flora by soluble arsenic in soil at 10 ppm.

Funabiki et al, (12) studied phosphorous distribution and reported more than half the phosphorous remained in the top 5 cm. Arsenic also accumulates in surface soils. Using leaching columns, Arnott and Leaf (2) could find no concentrations of arsenic beneath 7.5 cm.

Many other researchers found that arsenic not only occurs in the soil, but because of methods

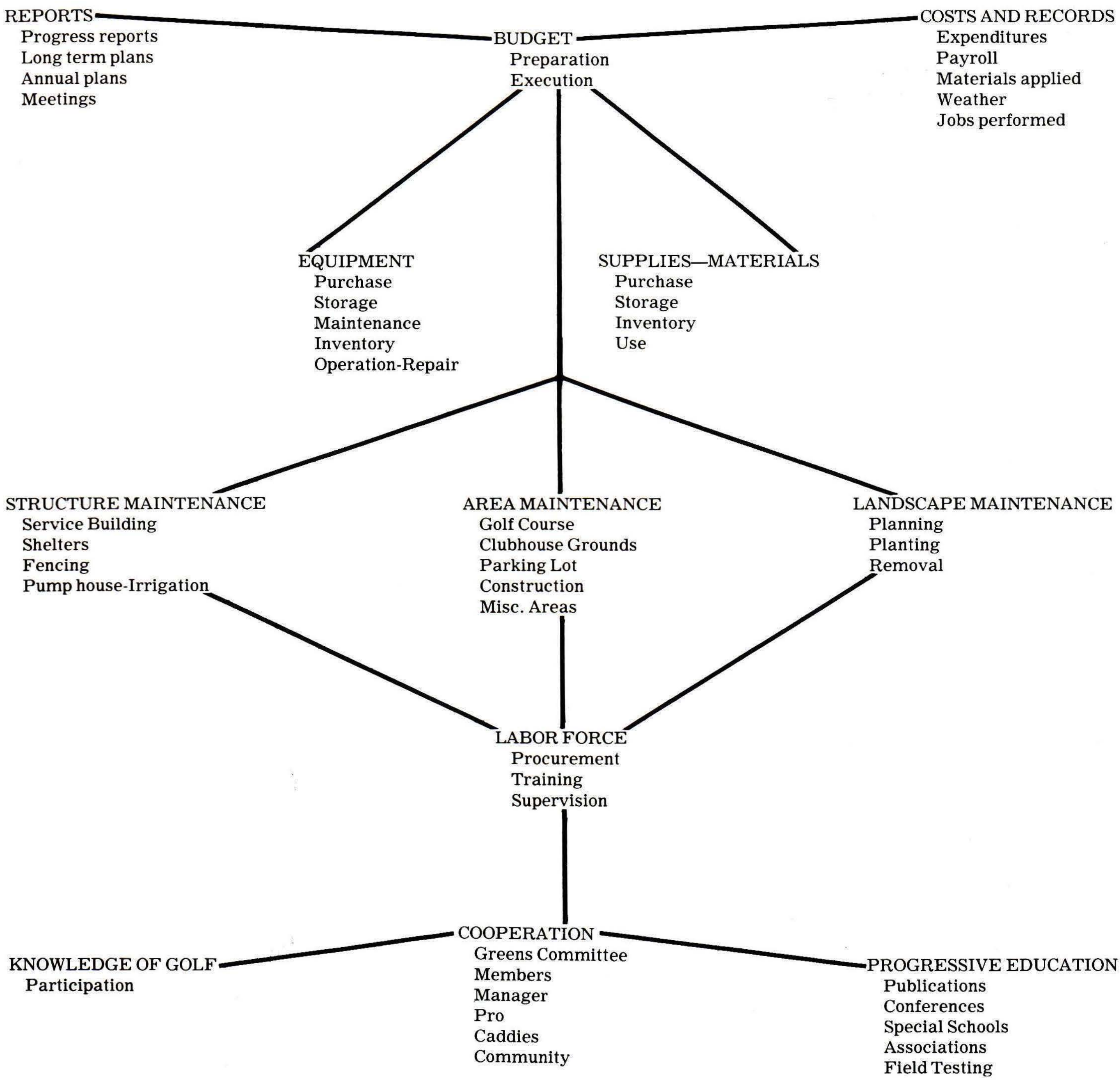
(Continued on Page 20)

THE GOLF COURSE SUPERINTENDENT: A JOB DESCRIPTION

The Job Description diagram illustrates the many different areas a superintendent has to deal with.

Although all these duties are necessary, the superintendents' job centers around two main points:

1. His ability to devise a plausible, efficient, workable budget.
2. His ability to develop a maintenance crew that will help him achieve these ends.



— *Reprinted from Agronomy Journal Vol. 61, March-April 1969, p. 195-198*

Factors Affecting Carbohydrate Reserves of Cool Season Turfgrasses[1]

L. J. Zanoni, L. F. Michelson, W. G. Colby, and M. Drake[2]

ABSTRACT

Changes in levels of soluble carbohydrate reserves were determined for four turfgrass species under two levels of nitrogen and two levels of potassium fertilization under standard golf course management practices. Soil temperatures and the level of nitrogen fertilization were the most important factors in producing seasonal fluctuations in soluble carbohydrate levels. The main soluble carbohydrate reserves were localized in the stem tissue. The percent total soluble carbohydrates were found to be proportionally higher than the percent total fructose for all species and at all sampling periods.

Additional index words: **Nitrogen fertilization, Soil temperature.**

WITH golf course maintenance practices, turfgrasses are subjected to intense management and highly unnatural conditions. For example, both high nitrogen and water levels are maintained throughout the growing season to keep the grasses in the active

[1] Contribution of the University of Massachusetts College of Agriculture, Experiment Station, Amherst, Massachusetts 01002. Received Aug. 7, 1968.

[2] Graduate Assistant, University of Massachusetts (now Graduate Assistant, Department of Plant Pathology, University of Rhode Island); Associate Professor, Professor, and Professor, Department of Plant and Soil Sciences, University of Massachusetts, respectively.

vegetative stage of growth. Also very frequent close clipping of the turf is a requirement of the game. Under such artificial conditions, turf managers teeter on a narrow threshold between success and failure. Characteristically, turf managers follow rather definite routines as to fertilizer application, disease control practices, and other managerial factors, with little regard for seasonal climate changes. It is the purpose of this study to examine the following: (*1*) the seasonal fluctuation of carbohydrate levels of four turfgrasses, (*2*) the effect of fertilization and soil temperature on the levels of carbohydrate reserves. There have been few, if any, studies on seasonal changes in carbohydrate levels of turfgrasses grown under field conditions. Recently Schmidt and Blazer (8) have reported on growth chamber studies of the factors affecting carbohydrate reserves of 'Cohansey' bentgrass. The environmental factors studied were temperature, light, and nitrogen levels.

Many studies have been reported on the carbohydrate regimes of various cool season forage grasses as affected by climatic conditions, fertility levels and other management factors[3] (1, 2, 3, 7, 9, 10, 11).

MATERIALS AND METHODS

In April, 1966, the following three varieties of grass were sodded: Kentucky bluegrass (*Poa pratensis* L.) var. Merion, creeping bentgrass (*Agrostis palustris* Huds.) var. 'Penncross' and velvet bentgrass (*Agrostis canina* L.) var. 'Kingstown.' Colonial bent (*Agrostis tenuis* Sibth.) var. 'Astoria' was seeded. The 1.52 × 4.57-m (5 × 15 ft) plots were established on the University of Massachusetts farm, on a Merrimac fine sandy loam, pH of 7.

Four fertilization treatments were applied at biweekly intervals in a series of 10 applications throughout the growing season. The treatments are given in Table 1.

The high nitrogen and potassium rates represent the ranges used and recommended for the particular varieties in question in golf course maintenance practices. Unfertilized plots provided the low levels of available nitrogen and potassium. With most Massachusetts soils there is relatively little residual nitrogen or potassium carried over from year to year regardless of fertilization rates. The fertilization treatments were replicated three times. The soil temperatures were recorded each day at a 5-cm (2-inch) depth for each variety and on bare soil. The Kentucky bluegrass was cut twice weekly at a 3.8-cm (1½-inch) cutting height. The bentgrasses were cut twice weekly at a 0.6 to 1.2-cm (¼ to ½-inch) cutting height. The plots received a minimum of 2.5-cm (1 inch) of water each week either as rainfall or rainfall plus supplemental irrigation. Diurnal carbohydrate reserve level variations were determined and a standardized sampling time of day between 6 and 7 a.m. was indicated. Analysis was made of total fructose using the resorcinal method of McRary and Slattery (5) and for total carbohydrates the anthrone method of Dreywood, as modified by Morris (6) was used. Preliminary studies of carbohydrate localization in several plant tissue areas revealed that the carbohydrate reserves were maximum in the basal portion of the stem and leaf tissue. Samples were taken at approximately 2-week intervals to include periods of relatively uniform weather conditions. Three random plant samples were collected per treatment with a 10-cm (4-inch) sod plug sampler. Representative plants were selected from each of the three plugs and the stems were cleaned of debris and dead plant tissue. The vegetative material was clipped at soil level. The samples were dried in a force-draft oven at 90 C for 1 hour and transferred to an alternate oven at a temperature of 70 C for 2 days to complete the drying.

[3] Blaser, R. E., R. H. Brown, and H. T. Bryant. 1966. The relationship between carbohydrate accumulation and growth of grasses under different microclimates. Paper presented at Univ. of Mass. Turf Conf.

Table 1. Fertilizer treatments used.

Treatment	Merion N-K	Creeping N-K	Velvet N-K	Colonial N-K
1 N-K	2.7-2.7	3.6-3.6	1.8-1.8	1.8-1.8
2 N-0	2.7-0	3.6-0	1.8-0	1.8-0
3 0-K	0-2.7	0-3.6	0-1.8	0-1.8
4 0-0	0-0	0-0	0-0	0-0

Data in actual kilograms of nitrogen and potassium per 93 m² (1,000 ft²) per season.

RESULTS

The results of these studies are displayed in Figures 1 through 5. The percent total soluble carbohydrates was found to be proportionally higher than the percent total fructose in the following interactions examined: (Sampling Dates - Varieties); (Sampling Dates-Fertilization); (Fertilization - Varieties) and (Sampling Dates, Varieties and Fertilization). A comparison of both methods is shown in Fig. 1 which indicates that either method is satisfactory for obtaining an index of the carbohydrate reserve status of these plants. This paper reports only total soluble carbohydrate analysis. Figure 1 also shows significant differences in carbohydrate levels among the four turfgrasses studied. In all species the carbohydrate levels are lower at the higher level of nitrogen. No real differences in carbohydrate levels resulted from potassium fertilization.

Figure 2 shows that the bentgrasses follow a similar pattern in the seasonal fluctuation of carbohydrates and that Merion Kentucky bluegrass recorded the highest percent carbohydrates throughout the growing season. All of the grasses demonstrated an increase in carbohydrates in the fall.

Figures 3 and 4 show that the seasonal fluctuation of carbohydrates is related to soil temperature at a 5-cm (2-inch) depth. Figure 5 shows the difference

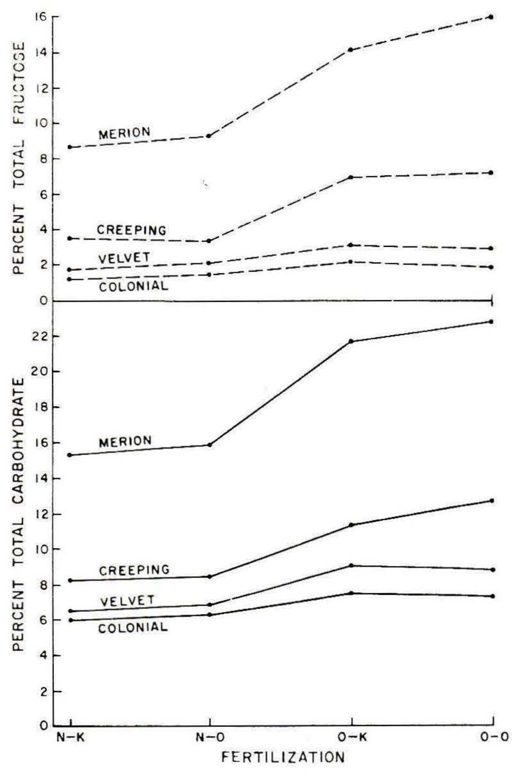


Fig. 1. Effect of fertilization on total soluble carbohydrate and total fructose within the varieties (Values used are seasonal averages).

(Continued on Page 8)

(Continued from Page 7)

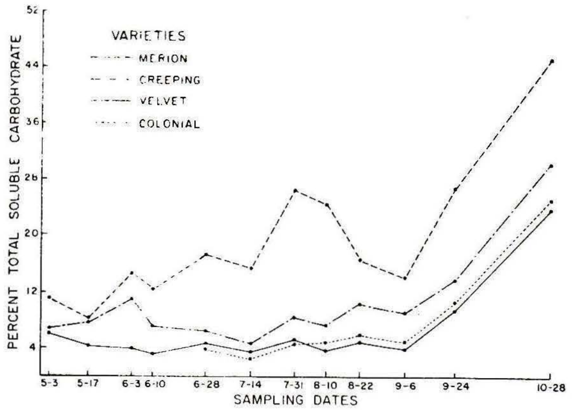


Fig. 2. Seasonal effect of total carbohydrates fluctuation within the varieties.

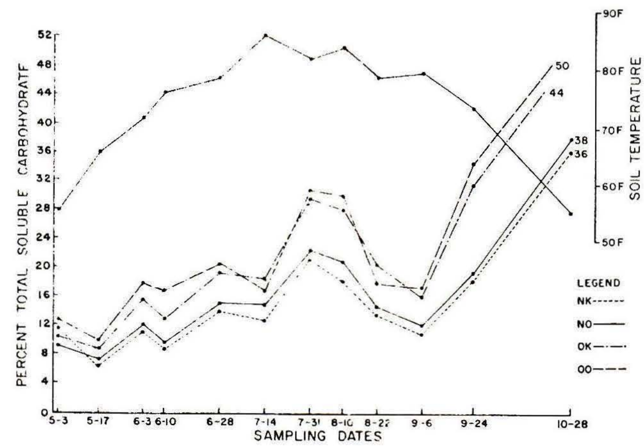


Fig. 4. Effect of harvest time and fertilization on total soluble carbohydrate content in Merion bluegrass.

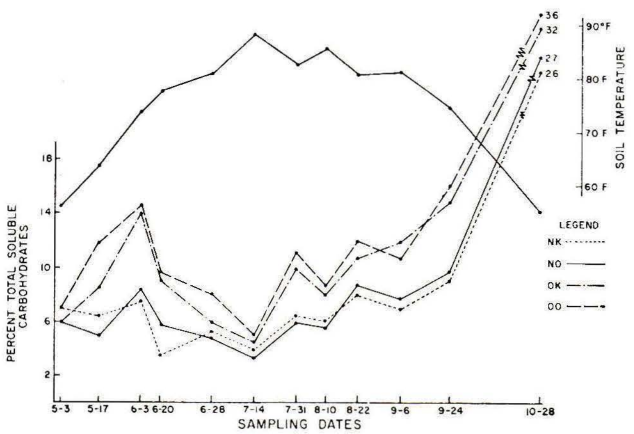


Fig. 3. Effect of harvest time and fertilization on total carbohydrate content in creeping bentgrass as related to soil temperature.

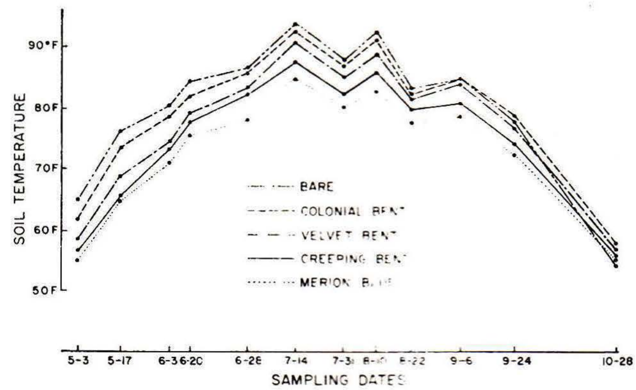


Fig. 5. Seasonal fluctuation of soil temperature.

in the soil temperature recorded under the four turf species and bare soil at the 5-cm soil depth.

DISCUSSION

The results show that the seasonal fluctuation of carbohydrate appears to be directly related to soil temperature and that the magnitude of the carbohydrate level was highly influenced by the presence or absence of high nitrogen in the fertilization treatment. This soil temperature - nitrogen interaction follows a most consistent pattern in the bentgrass as illustrated in Fig. 3 for the creeping bent.

The insulating effect of vegetative cover upon the soil temperature recorded at a 5-cm soil depth can be readily observed by comparing the lower soil temperatures recorded under the Merion Kentucky bluegrass in comparison to higher soil temperatures recorded under the bentgrasses in Fig. 5.

In general, all the three bentgrasses resemble each other in pattern of fluctuation of carbohydrate throughout the entire growing season but at slightly different levels. To explain the seasonal high carbohydrate content of creeping bentgrass it is important to note the vegetative characteristics and growth habits of the grasses. Creeping bentgrass, in comparison to velvet and Colonial bentgrass, produces more stem and leaf tissue. Also its reclining growth habit provides for greater leaf surface area even after mowing and results in higher carbohydrate synthesis. Figure 2 shows that the creeping bentgrass displayed the largest carbohydrate level change at all sampling periods throughout the growing season, whereas Colonial bentgrass recorded the least.

Merion Kentucky bluegrass showed a gradual increase in carbohydrate reserves from spring to midsummer followed by a prominent depression in carbohydrate level in late summer and a subsequent rise in the fall (See Fig. 4). This late summer depression in carbohydrate content corresponds to the characteristic "summer dormancy period" of bluegrasses. In forage studies Kentucky bluegrass has been found to exhibit this depression in growth as shown by a decrease in clipping yields; these low yields were found to parallel the low carbohydrate period observed in the turfgrass examined.

In all bentgrasses examined, the entire late spring to late summer period in the growing season displayed a seasonal depression in carbohydrate level that followed the extended U-shaped curve of Fig. 2. This depression was especially prominent in both velvet and Colonial bentgrasses which obtained the lowest carbohydrate values recorded among the four grasses and also displayed the least variation in the degree of carbohydrate fluctuation. The prominence of the extended U-shaped curve, appears to be a response to the high soil temperatures recorded in the summer in comparison to the lower soil temperatures recorded in the spring and fall.

The carbohydrate reserves in grasses represent an accumulation or surplus of materials in excess of the immediate needs of the plant for growth and maintenance. Synthesized carbohydrates are dissipated when the demands for growth (respiration) exceed photosynthesis and in turn, synthesized carbohydrates are stored when growth demands are low. If the carbohydrate reserves are depleted to low levels in response to higher soil temperatures and these levels are further lowered by increased nitrogen levels, it would appear that the grasses are placed in a more vulnerable position as to disease susceptibility and to delayed dormancy recovery and direct injury to plants in extreme situations due to metabolic breakdown.

Since it is reported (4) that the establishment of an adequate carbohydrate reserve is essential for producing good verdue during this critical growth period, those factors which can be controlled should be adjusted to favor the accumulation or to prevent the further depletion of the carbohydrate reserves.

LITERATURE CITED

1. Baker, H. K., and Garwood, E. A. 1961. Studies in the root development of herbage plants. V. Seasonal changes in fructosans and soluble sugar contents of cocksfoot herbage, stubble root under two cutting treatments. J. Br. Grassld. Soc. 16:262-267.
2. Colby, K. G., Drake, M., Field, D. L., and Kreowski, G. 1965. Seasonal patterns of fructosans in orchardgrass stubble as influenced by nitrogen and harvest management. Agron. J. 57:169-173.
3. DeCugnac, A. 1931. Recherches sur les glucides des gramiecs. Ann. Sci. Naturelles (Bot.) 13:1-129. (Review in Weinmann 1948, J. Br. Grassld. Soc.).
4. Madison, J. H. 1962. Effect of mowing, irrigation, and nitrogen treatments of *Agrostis palustris* Huds., 'Seaside' and *Agrostis tennuis* Sibth., 'Highland' on population, yield, rooting, and cover. Agron. J. 54:407-412.
5. McRary, W. L., and Slattery, M. G. 1945. The colorimetric determination of fructose in plant materials. J. Biochem. 157:161-167.
6. Morris, D. L. 1948. Quantitative determination of carbohydrates with Dreywood's anthrone reagent. Sci. 107:254-255.
7. Schulback, H. H. 1957. On the carbohydrate metabolism of grass (English Transl.) Biokhimiia 22:96-101.
8. Schmidt, R. E., and Blazer, R. E. 1967. Effect of temperature, light, and nitrogen on growth and metabolism of Cohansey bentgrass (*Agrostis palustris* Huds.). Crop Sci. 7 (5):447-451.
9. Sprague, V. G., and Sullivan, J. T. 1950. Reserve carbohydrates in orchardgrass clipped periodically. Plt. Phys. 25:92-102.
10. Waite, R., and Boyd, J. 1953. The water soluble carbohydrates of grasses. I. Changes occurring during the normal life cycle. J. Sci. Fd. Agr. 4:197-204.
11. Waite, R., and Boyd, J. 1958. The water soluble carbohydrates of grasses. The effect of different levels of fertilization treatments. J. Sci. Fd. Agr. 9:39-43.

Attention to all Readers

The purpose of the Massachusetts Turf Bulletin is to inform you on present problems and research in the turf-related field. Articles that may help a Golf Course Superintendent and topics of interest are also included in the Turf Bulletin. Criticisms, suggestions, items of interest, and articles would be greatly appreciated to make the Turf Bulletin a better magazine.

Address all mail to:
MASS. TURF and LAWN GRASS COUNCIL
RFD No. 2
HADLEY, MASS. 01035

—The Editor

Turf Bulletin's Photo Quiz

CAN YOU IDENTIFY THIS PROBLEM?

Area: Golf green

Description: Jagged scars extending out from flagstick and cup.

Answer on Page 22.

— Reprinted from Agricultural Research, U.S. Department of Agriculture, October, 1971

A Close Look at TCDD

A highly toxic substance that may occur as a contaminant in a few pesticides synthesized from chlorophenols is under intensive study by ARS scientists to learn its chemical and environmental significance.

The contaminant, 2,4,7,8-tetrachlorodibenzo-p-dioxin (TCDD), is formed during the manufacture of some chlorinated phenols when temperatures exceed known safe limits. The substance has been a contaminant in some commercial formulations of herbicides and an important consideration in the recent review of uses of the herbicide 2,4,5-T.

TCDD causes chloracne, a condition characterized by skin eruptions and irritations on the face, arms, and shoulders. Chloracne was first described in Germany in 1899, but not until the late 1950's was TCDD pinpointed as a causative agent. Chloracne occurred in 1964 in a 2,4,5,-T manufacturing plant.

Synthetic TCDD is highly toxic to mammals and a powerful teratogen (fetus-deforming agent). Tests in mammals reported in 1970 indicated that some commercial samples of 2,4,5-T contaminated with high levels of TCDD were potentially teratogenic. As a result of the concern that arose from these biological tests, ARS initiated a high-priority research program to assess the significance of TCDD in 2,4,5-T and similar chlorophenol-based pesticides in the environment.

The ARS studies on TCDD in the chlorinated compounds, with particular emphasis on 2,4,5-T, were started in February 1970 at Beltsville, Md., by a research team led by biochemist Philip C. Kearney.

"Our research," said Dr. Kearney, "shows that TCDD is immobile in soil, it is relatively persistent but not readily taken up by the plants nor translocated to other plant parts, and it can be washed off plants."

Dr. Kearney also said, "We are certain that TCDD is not produced biosynthetically from 2,4,5-T in soils, nor in any other manner except in the manufacturing process. Therefore, current regulations and careful quality control during manufacturing can assure that the environment is protected from ill effects of TCDD-contaminated 2,4,5-T."

To detect and measure accurately the TCDD contamination in chlorophenol-based pesticides, chemist Edwin A. Woolson and former ARS chemist Ronald F. Thomas devised extraction, cleanup, and electron-capture gas-chromatographic procedures capable of detecting about 0.1 ppm TCDD. Identification in selected samples was further confirmed by several techniques including mass spectrometry.

Using these procedures, the chemists, assisted by technician Peter D. J. Ensor, analyzed 42 commercial samples of 2,4,5-T. Results showed that 2,4,5-T produced after April 1970 contained less than 0.5 ppm TCDD — although higher levels were found in certain older samples.

Chemist Jack R. Plimmer, who examined the photochemical stability of TCDD, found that, in a methanol solution in a closed system, approximately one-half of the TCDD had been changed in 3.5 hours when exposed under a sunlamp. TCDD in methanol in a closed system also rapidly decomposed under natural sunlight. On a soil surface, preliminary data on the photochemical degradation of TCDD indicated that the process would be slow.

The movement of 2,4,5-T and TCDD in five soils of widely differing characteristics was studied by soil scientist Charles S. Helling. Using soil thin-layer chromatography (AGR. RES., June, 1968), Dr. Helling verified that 2,4,5-T moved extensively in sandy soils, moderately in clay soils, and only slightly in muck. He found, however, that TCDD was immobile in all soils studied and remained on the surface where it was applied.

There is virtually no chance of TCDD entering the food chain as a result of normal agricultural uses of 2,4,5-T. Plant physiologist Allen R. Isensee determined that plants do not absorb nor translocate TCDD from the soil except at extremely high levels of treatment, nor do they translocate the material after foliar applications.

Dr. Isensee grew oats and soybeans in the TCDD-treated soil. He harvested part of each crop at 6-, 10-, 15-, 20-, and 40-day intervals and at maturity, then analyzed the plants for TCDD. Labeling TCDD with a radioactive material permitted measurement of quantities as low as 1 part per billion. No detectable TCDD was found in any mature plant tissue or the grain. This was encouraging as the concentration of TCDD in the soil in these experiments was approximately 40,000 times greater than the amount that would be deposited in soil from a 2-pound-per-acre application of 2,4,5,-T contaminated with 1 ppm of TCDD incorporated in the top 1/3-inch of the soil surface. The scientist did detect small amounts in young plants.

Also, unlike 2,4,5-T which is known to move into plants after foliar applications, TCDD remained on leaf surfaces. However, Dr. Isensee found that about half the original TCDD applied in a carrier could be washed off the plants by simulated rainfall occurring 2 hours after application. Subsequent washings failed to remove any additional significant amounts.

ENVIRONMENTAL NEWS

ENVIRONMENTAL PROTECTION AGENCY CANCELS REGISTRATION OF HERBICIDE AMITROLE

Administrator William D. Ruckelshaus of the Environmental Protection Agency has issued a final notice cancelling the registration of the herbicide amitrole for use on croplands because of evidence that it may cause tumors in experimental animals.

Amitrole is produced by the American Cyanamid Company and Amchem, Inc. It has been used since 1948 on non-croplands and in the production of crops such as: apples, pears, grainfields, corn, alfalfa, clover, legumes, pastures, peas, soybeans and grapes.

Studies by American Cyanamid indicated the appearance of thyroid tumors in rats fed 100 parts per million of amitrole for 68 weeks. A "no-effect" level was not established. Nonetheless, no clinical effects have been discovered in man or animals resulting from the use of amitrole in accordance with directions, EPA said.

The Department of Agriculture issued a notice of cancellation in 1968 regarding the registration of amitrole. The EPA took responsibility for pesticides registration following its organization in December, 1970. In accordance with a request from the producers of amitrole, a committee nominated by the National Academy of Sciences reviewed the case pursuant to law and, in March, 1971, also recommended cancellation.

American Cyanamid and Amchem then agreed to take steps to stop sale of amitrole for these purposes, foregoing their right to a public hearing, and the cancellation order was issued.

Ruckelshaus praised the two companies for agreeing to abide by the judgment of the committee of the National Academy of Sciences, rather than resorting to further appeals in the administrative process, which might make the case take another year.

—Reprinted from Weeds/Today, Vol. 1 No. 1, June 1970

For the Homeowner

Crabgrass In Perspective

by R. A. Peters
Department of Plant Science
University of Connecticut
Storrs, Connecticut

To many home owners, crabgrass is synonymous with weed. Crabgrass is certainly the most common weed problem of suburbia. It is a very conspicuous weed in lawns. Because of its broad leaves and lighter color, it does not blend into the fine-leaved perennial sod species. Since crabgrass is killed by the first heavy frost, it is particularly evident in the autumn. The brown foliage stands out in strong contrast to the still green, active foliage of the perennial sod grasses. Bare spots become evident where the crabgrass grew, resulting in a thin sod a good part of the year. While crabgrass may be found in lawns well into Canada, it is most serious in the mid-Atlantic states, the southern limit for bluegrass lawns. Relatively marginal climatic conditions for bluegrass tip the scale in favor of crabgrass in this region.

Crabgrass is a truly versatile weed, since it is frequently found in cultivated gardens and farm fields as well as in undisturbed sod. In any crop grown on a seedbed prepared by plowing and disking each year, crabgrass can be expected. The seriousness of the weed will depend upon competitive ability of the crop and the time of year the crop is grown. In general, crabgrass is most serious in crops which are planted in rows since the ground between the rows remains exposed to the sun longer, providing favorable conditions for crabgrass growth.

To understand the wide prevalence of crabgrass and some of the problems relating to its control, it is necessary to know something of its biology and life history. It is necessary to study each species individually because of wide differences between weed species in growth habits and environmental adaptation.

Crabgrass belongs to the genus "Digitaria, a genus containing many species, all of them adapted to warm, humid climates. The only two species found to any extent in the United States are both called by the common name crabgrass. These species are "Digitaris sanguinalis," large crabgrass and "Digitaria ischaemum," small crabgrass. While both can be found over a wide range of conditions, small crabgrass is the most common species in turf while large crabgrass is most common in gardens and fields.

DISTINGUISHING CHARACTERISTICS

The difference between the two species is evident soon after germination. Large crabgrass is dark green in color as compared to the apple green color of small crabgrass and has a leaf twice as wide as the small crabgrass. Older plants of large crabgrass usually are quite pubescent or hairy, especially on the sheath, while small crabgrass always has smooth foliage. Because of this difference, the name hairy crabgrass frequently is used for large crabgrass and the name smooth crabgrass for small crabgrass. If you inspect a number of large crabgrass plants, however, you will find a wide variation in hairiness with some having virtually no hairs. Only at the juncture of the leaf blade and sheath is hairiness found consistently. Consequently, large and small crabgrass are preferred common names.

Both species have a similar crab-like branching habit, thus the name crabgrass. Crabgrass stems, especially in small crabgrass, tend to be prostrate in habit. Each tiller branches repeatedly to result in a multiple-stemmed, sprawling plant. The prostrate stems root readily at the nodes which makes control by hoeing or cultivating very difficult. Up to 800 tillers per plant for small crabgrass and 690 for large crabgrass actually have been counted on plants in the field. Individual plants of small crabgrass will spread over 50 inches and large crabgrass over 75 inches in diameter when uncrowded by adjacent plants. When crowded by other plants, as in a lawn, the lateral spread is much less, but the crab-like growth pattern is still evident. Because of the prolific branching habit of crabgrass, there is little relationship between the number of plants germinating per square foot and the total ground area covered by mature plants. If only a few plants are present, they spread until the gaps are filled in.

SEED PRODUCTION IS HEAVY

Since each branch of a crabgrass plant may produce a seed head, the seed producing potential of crabgrass is prodigious. Uncrowded plants can produce over 150,000 seed per plant. Abundant seed production combined with long life in the soil explains why crabgrass appears so consistently. Crabgrass seed have a built-in mechanism which insures that the seed produced in 1 year will not germinate sooner than the following spring. If seed were to germinate in August and September when it first falls to the soil, there would not be sufficient time before frost for the plants to complete their life cycle by reproducing again.

CRABGRASS REQUIRES WARM CONDITIONS

Crabgrass has quite a different growth schedule than most lawn species. It is a strict annual which will not germinate until about the time of the last frost, which in the Northeast is about the time the lilacs bloom. At Storrs, Connecticut, emergence on bare soil occurred May 11, May 12, and May 23 in 1964, 65, 66, respectively. Germination in a thick, perennial sod is retarded and even prevented because of the cooler soil temperatures in the shade of the sward. Rate of vegetative growth is closely related to temperatures with maximum growth occurring in mid-summer. Daylength has a marked influence on crabgrass. Long days promote vegetative growth while short days promote flowering. In growth chamber studies, plants grown in 14 hours of light and 10 hours of dark daily over an 8-week period were still in a vegetative stage at the end of the experiment, while those grown in 10 hours of light and 14 hours of dark had produced flowers. Once flowering starts in mid-summer (early August in Connecticut), new flowers continue to form until the plant is killed by frost.

Increase in plant size by formation of new shoots is greatly retarded once flowering starts. Thus, plants which start growing early in the season produce much larger plants than those starting growth later. A May-germinating plant may spread over a 3-foot circle, while a plant germinating in late August will be only a few inches across.

HOW CAN CRABGRASS BE CONTROLLED?

Since crabgrass is an annual which must start all over again each year from seed, it is weakest and most easily controlled as it germinates. In the lawn, good management including use of adapted turf species, adequate lime and fertilizer applications, and proper cutting height (no less than 1½ inch for bluegrass) will go a long way to preventing the establishment of crabgrass. A dense sod prevents the development of seedlings.

Herbicides are available which will kill crabgrass without injury to sod grasses, vegetable, or field crops. In general, preemergence treatments, i.e., applications made before the crabgrass germinates, are much more effective than postemergence treatments applied after the crabgrass is growing.

In established bluegrass, red fescue, and bentgrass lawns, selective control can be obtained from the commercially-available herbicides DCPA, benefin, bensuide, bandane, and siduron. In new lawn seedings, only siduron can be used at the time the grass seed are planted. It is necessary to wait 3 to 4 months after seeding when using the other materials to prevent injury to the seedling turf grasses. Numerous commercial formulations of these preemergence herbicides are available, including fertilizer and weed control with one application. With all materials, application early in the spring before crabgrass germinates is the important consideration. If crabgrass does show up in the lawn and only postemergence control is possible, DSMA or PMA can be used. Two or more applications may be required. The DSMA frequently gives some turf discoloration.

In many ornamentals and vegetables, selective control can be obtained from preemergence applications of DCPA, benefin, dephenamid, and treflan. It is imperative to check on the label of

(Continued on Page 14)

(Continued from Page 13)

each product used to determine for which plant species a particular chemical can be used and at what dosage.

Among field crops, crabgrass is most frequently a problem in corn. Corn and crabgrass start growth at about the same time in the spring and crabgrass is fully exposed to the sun between the corn rows until the corn canopy closes in early summer. Crabgrass actually has increased in corn in the past 10 years, especially in the Northeast. This problem can be associated with the continuous use of the herbicide, atrazine, in corn. When atrazine was first introduced, it gave nearly complete weed control of both annual broadleaf and annual weed grasses. Crabgrass was an exception. Because of an inherent resistance to atrazine, it was poorly controlled. Released from competition from the other weeds, crabgrass increased each year especially where atrazine was used on continuous corn. Other annual grasses increasing in frequency in corn fields are fall panicum and witchgrass.

Herbicides which are more effective in controlling crabgrass and other weedy grasses are now used in addition to atrazine. Atrazine continues to be used, although at a reduced rate, because of its effectiveness on annual broadleaf weeds. Effective grass killers with good selectivity on corn include sutan, butylate, and alachlor. The sutan must be applied and incorporated in the soil before corn planting. The other two materials are applied after corn planting but before germination of the weedy grasses.

Crabgrass must be considered a successful weed as judged by an ability to perpetuate itself. An understanding of its life habits combined with good management practices, including the judicious use of herbicides, provides the means of keeping this pest under control.

MERION TEES — MAINTENANCE SUGGESTIONS

- Height of Cut - no less than ¾ of an inch
- Catch all clippings
- Do not over water
- Aerate frequently
- Top dress as necessary
- Thatch at least twice a year
- Maintain high ph (6.5-7.0)
- Apply 5 lbs. N per 1,000 sq. ft. per year.
- Move tee markers at least once a day

—*Reprinted from Fertilizer Solutions, Vol. 15, No. 5, Sept.-Oct., 1971*

USE OF AMMONIUM SULFATE IN FLUID FERTILIZERS

By
Frank P. Achorn
Head, Process and Product Improvement Section,
and
W. C. Scott, Jr.,
Assistant to the Chief
Process Engineering Branch
Tennessee Valley Authority

For several years approximately two and a half million tons of ammonium sulfate have been produced annually in the United States. Ammonium sulfate is an excellent agronomic source of sulfur and has frequently been a very economical source of both nitrogen and sulfur.

It is a byproduct of the steel and plastic industries and probably will become a byproduct of the petroleum industry when sulfuric acid is used as a drying agent. Also, there is a possibility that ammonium sulfate may be a byproduct of pollution control processes employed in the electrical utility industry.

Ammonium Sulfate in Clear Liquid Fertilizers

Small-scale tests were made to determine how much ammonium sulfate can be dissolved in 10-34-0 solution. The 10-34-0 for the tests was produced from electric-furnace superphosphoric acid, and 50 percent of the phosphate in the product was in the polyphosphate form. A 10-24-0-4S solution with a salt-out temperature of 32° F was produced from the 10-34-0 and ammonium sulfate (1).

Tests were not made with commercial 10-34-0 from wet-process superphosphoric acid nor from 11-37-0 (75 to 80 percent polyphosphate).

These liquids usually contain 50 percent or more of their P_2O_5 in the polyphosphate form, and it is assumed that a 10-24-0-4S produced from them would have a salt-out temperature below 32° F.

With potash in the mixture the solubility of the ammonium sulfate is greatly decreased. When ammonium sulfate, 10-34-0, and potash are

(Continued on Page 16)

Table 1

Small-Scale Tests of the Production of Suspensions With Ammonium Sulfate, 13-41-0[a], and Potash

Formula number	OT-78-1	OT-83-2	L-1	OT-83-7	L-3	L-4
Grade	12-12-12-9.3S	12-12-12-9.3S	11-11-11-8.6S	14-7-7-13.5S	16-8-4-15.4S	16-8-4-13.1S
Formulation, Lbs./ton of product						
Ammonium sulfate[b] (60.2% +20 mesh; 40.8% −20 mesh)	781	—	—	—	—	—
Ammonium sulfate[b] (98% −20 mesh)	—	781	715	1,122	1,281	1,091
Urea-ammonium nitrate solution (32-0-0)	—	—	—	—	—	125
TVA 13-41-0 suspension	586	586	537	342	391	391
Potash (62% K_2O)	388	388	355	226	129	129
Clay	9	9	11	13	12	12
Water	236	236	382	297	187	252
Clay content of product, %	1.0	1.0	1.1	1.0	1.0	1.0
Settling, percent of clear liquid at top of sample, 30 days[c]						
Stored at 80°F	11	Too	—	7.0	Too	10.5
Stored at 32°F	7.5	thick	—	0.0	thick	6.2
Viscosity, centipoises[d]						
Initial (80°F)	410	to	850	887	to	850
Product stored 30 days (80°F)	507	apply[e]	—	855	apply[e]	—
Plus 20-mesh crystal after 30 days of storage	0	—	0	0	—	0

a TVA 13-41-0 ammonium polyphosphate suspension contains 2 percent clay.
b Ammonium sulfate contained 21 percent N and 24 percent S. One source had larger particle size than other.
c Amount of clear supernatant liquid, percent of total volume.
d Brookfield Synchro-lectric viscometer, No. 3 spindle at 100 rpm.
e In excess of 1,000 centipoises at 80°F.

(Continued from Page 15)
combined in a 1:1:1 solution with a salt-out temperature of about 32° F, the grade is 7-7-7-0.56S (2). This depression of sulfate solubility by potash suggests advantages for suspension made from ammonium sulfate, ammonium polyphosphate fluids, and potash.

Other data show that only one percent of sulfate as ammonium sulfate can be dissolved in a 28-0-0 urea-ammonium nitrate solution if the liquid is to have a salt-out temperature of less than 32°F.

Ammonium Sulfate Suspensions— Small Scale Tests

Suspensions were made by a coldmix process[1] from TVA 13-41-0 (ammonium polyphosphate base suspension), ammonium sulfate, urea-ammonium nitrate solution, potash, and clay. Formulations and some of the results of the tests are shown in Table 1. In test OT-78-1, the sulfate was relatively coarse (60.2 percent plus 20-mesh). Suspension containing this sulfate stored fairly well although there was some separation and settling of solids during storage.

About 11 percent of the total volume was clear liquid at the top of the sample after storage for 30 days at 80°F. The settling was less at 32°F. When the samples were shaken the settled material was easily dispersed and it is likely that the product could have been applied easily. The viscosity of the product with coarse sulfate was not excessive.

Availability of a large quantity of fine ammonium sulfate (98 percent minus 35 mesh) prompted a test with this material in the production of 12-12-12-9.3S suspension (test OT-83-2). The product was too thick for the satisfactory application. Test data indicate the 12-12-12-9.3S would have satisfactory storage and handling characteristics if the clay content were reduced to 0.16 percent.

Ammonium sulfate of the same particle size was used to produce 11-11-11-8.6S (test L-1). This product appeared to be excellent. Although there was slight settling during storage, it was easy to disperse the solids with very little agitation. The initial viscosity was not excessive for satisfactory application. Probably this suspension could be applied easily with conventional equipment.

In another test the fine sulfate was used to make a 14-7-7-13.5S suspension (test OT-83-7). There was a slight settling of solids during storage for 30 days; however, the solids were easily dispersed with slight agitation. The initial viscosity was not excessive and did not increase during storage.

In test L-3 a 16-8-4-15.4S grade was produced with all the supplemental nitrogen supplied as fine ammonium sulfate. The product became too thick for satisfactory application.

Table 2

Plant Tests for Production of Ammonium Sulfate Suspensions

Grade	12-6-6-11.5S	11-11-11-8.6S
Formulation, pounds per ton of product		
Ammonium sulfate[a]	962	715
TVA 13-41-0[b]	293	537
Potash	193	355
Clay	15	9
Water	537	384
Clay content of product, %	1	1
Chemical analysis, % of total		
Total N	11.5	11.2
Total P_2O_5	6.5	11.7
Total K_2O	5.8	12.4
S	10.6	8.7
Viscosity, centipoises at 75°F	135	1,440
Specific gravity, pounds per gallon	11.8	12.7
Settling, percent of clear liquid at top of sample[c]	15	5

a. Chemical analysis of ammonium sulfate: 21 percent N and 24 percent S. Screen analysis (percent cumulative): +6M, nil; +10M, 0.5; +14M, 6.3; +20M, 59.3; and −20M, 40.7.
b. TVA 13-41-0 base suspension, about 50 percent polyphosphate and 2 percent clay.
c. Amount of clear liquid on top of sample after 2 weeks of storage at 70°F.

In test L-4 the same grade was made with two units of the nitrogen supplied by urea-ammonium nitrate solution (32-0-0), and 11.5 units of nitrogen supplied by fine sulfate. The product had good physical characteristics. Settling after a few days of storage was not severe and the solids were easily dispersed.

A screen analysis of the solids in stored samples shows that there was essentially no crystal growth larger than plus 20-mesh during 30 days. When urea-ammonium nitrate solution is used to apply all the supplemental nitrogen[2] for the foregoing grades, there is considerable growth of plus 20-mesh crystals in the sample.

Plant data show that it is not advisable to store high-nitrogen grades having N:P ratios greater than 0.5 if all the supplemental nitrogen is supplied by urea-ammonium nitrate solution.

The potassium chloride of the suspension reacts with the ammonium nitrate in the UAN solution to form long needle-like potassium nitrate crystals. In test L-4 the quantity of urea-ammonium nitrate solution used was not sufficient to cause difficulty with the formation of an excessive amount of large potassium nitrate crystals.

At the 8th TVA Demonstration of Fertilizer Technology (3), a sample of a suspension produced from urea and ammonium sulfate was shown. The suspension contained 30 percent nitrogen and 33.4 percent sulfur with 50 percent of the total weight as urea, 33.4 percent as ammonium sulfate, and 1 percent as clay.

The initial viscosity was satisfactorily low and did not increase during several months of storage. A slight settling was easily dispersed.

---

[1] A cold-mix process is one in which essentially no heat is generated during the mixing of the materials used in the formulation.

[2] Supplemental nitrogen is that quantity of nitrogen supplied by sources other than ammonia.

Ammonium Sulfate Suspensions—Plant Tests

Tests were made in a cold-mix plant similar to the one shown in Figure 1. In the first test a 14-7-7-13.5S product was made using the same formula as OT-83-7 in Table 1 except for a clay content of 2 percent. More clay was used because of the relative coarseness of the ammonium sulfate. The product became too thick during mixing and had to be diluted to a 12-6-6-11.5S grade.

The diluted product was applied without difficulty. Results were similar in the production of 12-12-12-9.3S with 2 percent clay. The product became very viscous during mixing and had to be diluted to an 11-11-11-8.6S grade which was applied without difficulty.

Additional plant-scale tests were made in which the 11-11-11-8.6S and 12-6-6-11.5S suspensions were produced by the formulations shown in Table 2. The 12-6-6-11.5S had an initial viscosity of only 135 centipoises and settled somewhat during 2 weeks of storage. The solids were easily dispersed.

Similar results were obtained in production of the 11-11-11-8.6S. The initial viscosity was somewhat higher than desired (1,440 centipoises at 75°F) but the product could be applied without difficulty.

Both suspensions were applied with a pull-type applicator similar to the one shown in Figure 2. The applicator has a mechanical sweep-type agitator and is equipped with three KSS60 flooding nozzles. The suspension is pumped to the nozzles by a ground-driven piston-type pump that discharges into a cross-type manifold. All the lines to and from the pump and the manifold are 1 inch in diameter. The fluids were applied without difficulty at a rate of about 850 pounds per acre.

One fluid fertilizer manufacturer in the Midwest is using commercial 10-34-0 (produced from wet-process superphosphoric acid and ammonia) as a base for the production of ammonium sulfate N:P:K suspensions.

The grades most frequently produced are 20-8-4-3S and 4-12-12-5S; they usually contain 2 to 3 percent clay. The products are not stored but are immediately applied by broadcasting from an applicator truck equipped with a recirculation system and flooding nozzles.

These small-scale and plant data show the practicality of producing nonpotash clear liquid N:P:S grades from ammonium sulfate and ammonium polyphosphate solutions. Potash grades or fluids with high sulfur content should be made as suspensions. The suspensions produced from ammonium sulfate and ammonium polyphosphate fluids usually handle satisfactorily.

Literature Cited

1. **TVA.** Developments in Technology of Fertilizer Production. **Fourth Demonstration. August 7-8, 1962.**
2. **Striplin, M. M., Jr., J. M. Stinson, and J. A. Wilbanks. High-Analysis Liquid Fertilizer from Superphosphoric Acid.** Agricultural and Food Chemistry, September 1959.
3. **TVA.** New Developments in Fertilizer Technology. **Eighth Demonstration, October 6-7, 1970.**

River Ecology and the Impact on Man

An International Symposium on "River Ecology and the Impact on Man" was held June 20-23 and sponsored by the Northeast Division of the American Fisheries Society. The symposium has been highly praised by leading environmentalists and has been called "the environmental event of the year!"

Mr. Robert Jones from Connecticut Fish and Game was the General Symposium Chairman. Dr. Roger Reed and Dr. James McCann, Fisheries Professors from the UMASS Department of Forestry and Wildlife Management, served as Arrangements Chairman and Program Committee Co-Chairman, respectively.

The first session of the symposium was concerned with the question, "WHAT IS A RIVER?" and was answered by a panel of experts. A series of river case histories were presented for the next session which considered the "USES OF A RIVER: PAST AND PRESENT." The second day of the symposium was devoted entirely to an in-depth consideration of various "EFFECTS OF RIVER USES." The effects explored were discharge, morphometric changes, sedimentation, radionuclides and nutrients. The final day was devoted to the extremely important social question of "RATIONALIZATION OF MULTIPLE USE OF RIVERS." This subject area was subdivided into three main parts: environmental considerations, economic considerations, and political considerations.

A noteworthy banquet address was given by Ron Bonn, Associate Producer, CBS News, and producer of the CBS Evening News segment, "CAN THE WORLD BE SAVED?" Mr. Bonn presented film clips from the series and spoke from his experience in reporting on environmental issues.

UMASS and Continuing Education are proud to have been a part of this outstanding symposium so pertinent to one of the world's most important considerations — the saving of our natural resources.

From across the Atlantic —

Reprinted from — the British Sports Turf Bulletin

To Roll or Not to Roll

There is a story (well known but probably apocryphal like many of the best stories) that an Oxford gardener when asked by an American tourist how he produced such good college lawns said "Well, we cuts 'em and rolls 'em and cuts 'em for hundreds and hundreds of years." A suitably deflating reply although not quite correct — one can make a good lawn in less than two years and to roll a lawn regularly year in and year out is far more likely to result in a bad lawn than a good one.

Damage to Soil Structure

The roller, in fact, by applying pressure to the soil squashes the soil crumbs together and destroys them so that air is excluded and the free downward passage of water from the surface is disturbed. Drainage becomes poor and the grass plant suffers because the roots can not get enough oxygen to grow and develop properly.

Rolling a wet soil does more damage than rolling when the soil is relatively dry, and generally speaking the heavier the roller the greater the damage to the soil structure, although one must take into account the weight of the roller, its width and diameter when assessing the actual pressure imposed.

Lawns are not rolled much

A good lawn then is usually a lawn which is not rolled at all. This fact seems to be more widely accepted by home owners these days, to judge by the relative scarcity of garden rollers, or is it just that the attractions of "Grandstand" or a family trip in the motor car have outmoded that fine old British pastime of rolling the lawn on a Saturday afternoon?

Rolling is needed for some sports

Where turf is used for sport and is not purely ornamental a smooth and in some cases hard suface must be maintained if games are to be played successfully. To obtain these conditions the roller must be used with discretion, and in order to overcome the bad effects of rolling on the soil plenty of spiking and/or forking must take place.

Let us examine the various sports in relation to the type and amount of rolling required:

Cricket squares

True fast wickets are needed and they can not be obtained without rolling (although many other factors are also involved in producing good wickets). On County grounds at least two rollers ("light" and "heavy") are needed but the average cricket club can make do quite well with a single roller of a weight somewhere between 10 cwt. and a ton. When the weight can be varied by adjusting the ballast this is ideal. Rollerpushing is not popular on cricket squares either these days and therefore the roller must be powered by an engine. Roll the square well but not too well; roll to get the wickets; don't roll because you like to ride on the roller, or to make the players happy! And spike and fork whenever you have the chance. The best system of rolling is to roll down the whole square in the early spring before the start of the cricket season, timing the rolling so that it is done when the moisture content of the soil is just right; then during the season roll the actual wicket strips only as you prepare them for play.

Tennis courts

Here also a modicum of rolling is needed if good playing conditions are to be achieved. Rolling on the average club court need not be as heavy as on the cricket square. Quite often if one of the large motor mowers (30 in. — 36 in.) is used to mow the court an occasional run-over with a roller not exceeding 10 cwt. is all that is required.

Bowling greens

A hard surface is not needed here and heavy rolling would be most undesirable. Rolling just to settle back the surface after the winter's frosts is usually needed in March or April and then an occasional light rolling during the season as necessary. No roller used on a bowling green should exceed 5 cwt. and special bowling green rollers mounted on a wide frame which spread the weight over a relatively large area are to be preferred.

If a bowling green is too soft the answer does not lie with extra rolling. Very often it is a question of extra scarifying to reduce the amount of soft fibre at the surface and/or possibly a change in the top dressing material (more gritty sand being included for instance).

Golf greens

Correct top dressing is the real agency by which smooth resilient (though not too soft) putting surfaces are built up. Rolling is rarely necessary especially nowadays when motorized mowers weighing round about 1 cwt. have taken the place of the old light hand mowers. The first cut with the mower in the spring is usually enough to put back the surface after the winter.

Winter playing pitches

Maintenance of a smooth surface throughout the season is essential and this is not easy in the later stages when the turf may have been cut up and parts of the pitch have become grassless and muddy. After each game the surface must be smoothed out again otherwise there is a risk that it will freeze in the rough post-match condition, and then if the temperature remains below zero the pitch will not be fit for the next game. A wide roller of wood or cast iron weighing just 1 or 2 cwt. and pulled by hand is often adequate for smoothing back the surface. Motorised light rollers like the Aeromain roller are also useful. Heavy rollers should never be employed on soccer pitches under any circumstances. Sometimes in certain conditions light flat harrows or fairly strong rakes can be used instead of light rollers for smoothing out the surface after a game.

A smooth surface is essential on hockey pitches and sometimes a roller may prove necessary if the surface becomes badly cut up by play. Often, however, an annual roll in the spring with a wide tractor-drawn or tractor-mounted roller will be plenty, especially if supplemented by the pressure which one of the bigger motor mowers exerts. Hockey is often played on cricket outfields which may get a rolling in the spring in any case with the tractor-drawn or mounted roller. Do not use the cricket square roller on the outfield, by the way, except of course where it has to travel over the outfield to get to the square.

(Continued from Page 4)

of application and fixation by bases, tends to accumulate in the surface soil (16, 20, 29).

Clements and Munson (5) report that no matter how large or how small the annual increments to the soil may be, substantially all of the arsenic remains in the tilled layer.

Freeborg, of Purdue University, collected analytical data for his thesis for partial fulfillment of the requirements for the degree of Doctor of Philosophy. Mr. Freeborg's thesis is not yet published. Soil samples were collected with a 4" x 8" plugger. Two test areas were sampled with a "Noer" soil sampler ½" x 3" x 6". Soil samples were taken from golf courses where arsenic had been used as a pre-emergent Poa annua control. Samples were collected from golf courses in Kentucky, Indiana, Illinois and Michigan.

Soil cores were dried in the greenhouse and then divided into sections. They are: Thatch, thatch - 2", 2 to 4" and 4 to 6" depth. The extract used was Bray P-1 extractant (0.03 NNH_4F + 0.025 NHCl).

The phosphate was analyzed using the molybdenum blue colorimetric phosphate test. The remainder of the filtrate was analyzed for arsenic concentrations with atomic absorption spectrometry.

ANALYTICAL DATA

Sample Identification	Depth of Sample	Texture	pH	Lbs./1000 As Applied	Ppm As Avg. of 2
Beverly Country Club-Chicago, Ill. #9 Fairway	Thatch	Silt Loam	--	85% (TCA) 15.5	35
	T - 2"	" "	--	---	10
	2 - 4"	" "	6.7	---	0
	4 - 6"	" "	--	---	0
#4 Fairway	Thatch	Silty clay loam	--	85% (TCA) 15.5	33
	T - 2"	" "	--	---	8
	2 - 4"	" "	6.4	---	0
	4 - 6"	" "	--	---	No Sample
#8 Fairway	Thatch	Loam	--	85% (TCA) 15.5	35
	T - 2"	"	--	---	13
	2 - 4"	"	6.9	---	8
	4 - 6"	"	--	---	No Sample

This golf course's first application of 85% tri-calcium was made August 19, 1966. This course sprayed two applications of 4 pounds of 85% tri-calcium arsenate per 1000 sq. ft. two weeks apart. The total of 15.5 pounds has been applied at annual increments since 1966. Drainage has been improved. Excellent control of Poa annua has been achieved.

Sample Identification	Depth of Sample	Texture	pH	Lbs./1000 As Applied	Ppm As Avg. of 2
Country Club of Indianapolis, Indiana. #14 Fairway	Thatch	Loam	--	48% (TCA) 32	70
	T - 2"	"	--	---	45
	2 - 4"	"	6.0	---	25
	4 - 6"	"	--	---	13

The Country Club of Indianapolis started applying 48% tri-calcium arsenate granular in 1961. 9 pounds per 1000 sq. ft. were applied each year until a total application of 32 pounds per 1000 sq. ft. had been applied. Poa annua has been controlled.

Point O'Wood Country Club Benton Harbor, Michigan #15 Fairway	Thatch	Loam	--	85% (TCA) 21	25
	T - 2"	"	--	---	10
	2 - 4"	"	6.5	---	0
	4 - 6"	"	--	---	0
#16 Fairway	0 - 2"	Loamy fine sand	--	85% (TCA) 21	10
	2 - 4"	" "	6.2	---	0
	4 - 6"	" "	--	---	0

Point O'Wood started a complete program on all fairways in 1964. Drainage has been improved. Crabgrass, chickweed and insect problems are completely controlled. The total of 21 pounds tri-calcium arsenate powder has been applied since 1964.

Sample Identification	Depth of Sample	Texture	pH	Lbs./ 1000 As Applied	Ppm As Avg. of 2
Louisville	0 - 2"	Silt Loam	--	48% (TCA)	18
Country Club				16	
Kentucky	2 - 4"	" "	5.9	---	0
#2 Fairway	4 - 6"	" "	--	---	0
#3 Fairway	Thatch	Silt Loam	--	48% (TCA)	68
				26	
	T - 2"	" "	--	---	30
	2 - 4"	" "	5.9	---	0
	4 - 6"	" "	--	---	0

This course started a program in 1966. Both crabgrass and Poa annua have been controlled. 200 pounds of 48% tri-calcium arsenate have been applied spring and fall. Drainage has been improved. This course has applied an average of 26 pounds of tri-calcium arsenate per 1000 sq. ft. since 1966.

Lafayette	Thatch	Silt Loam	--	85% (TCA)	45
Country Club				14	
Lafayette, Ind.	T - 2"	" "	--	48% (TCA)	38
#1 Fairway				41	
	2 - 4"	" "	6.7	---	10
	4 - 6"	" "	--	---	0

This course began a program in 1960. An average of 41 pounds of tri-calcium arsenate per 1000 sq. ft. has been applied on this course since 1960.

Meridian Hills	Thatch	Silt Loam	--	N. D.	38
Country Club	T - 2"	" "	--	---	20
Indianapolis, In.	2 - 4"	" "	6.6	---	0
#9 Fairway	4 - 6"	" "	--	---	0

This course has had two superintendents and records of application rates were not available.

Explanatory Notes:

85% tri-calcium arsenate — powder.

48% tri-calcium arsenate — granular. Sold as Chip-Cal.

N.D. — Some clubs either had no data or data has not been supplied. Last application date on all sites was 1968.

The data collected by R. P. Freeborg demonstrates that arsenicals tend to accumulate primarily in the upper 4 inches of the soil. Mr. Freeborg is able to compute the approximate total arsenical needed to achieve Poa annua control by classification of soil type and analysis of available arsenic by atomic absorption spectrometry.

Dr. Paul Rieke, Soil Scientist of Michigan State University is also collecting soil samples from golf courses which have treated their greens and fairways with lead and calcium arsenate. He is studying arsenical accumulation and grass tolerance.

Gull Lake Country Club in Kalamazoo, Michigan has applied lead arsenate to greens for 40 years. The bentgrass is healthy. The greens are free from Poa annua.

Arsenicals and phosphates are very similar in their mode of action. Dr. Paul Rieke contended that the use of phosphate fertilizers on Michigan lawns does not contribute significantly, to pollution of lakes and streams. Research at Michigan State University and elsewhere, has shown that phosphates are almost insoluble in soil and there is no phosphate leaching (21).

Daniel (7,8), of Purdue University reports that accumulated arsenicals in the surface soil are beneficial to golf courses. After seventeen years of experience with arsenicals, Dr. Daniel has reported continuous control of Poa annua, crabgrass and soil insects without injuring desirable turfgrass. Bent, bluegrass, fescue, bermuda and zoysia grass are extremely tolerant to arsenicals.

Engel, Morrison and Ilnicki (10) have reported arsenical research on pre-emergence chemical effects on Poa annua. Eight materials were included in the test. Treatments with calcium arsenate gave the only effective control of Poa annua after 16 months. The estimated control ranged from 64 to 95% for their three test locations.

There is no acceptable substitute for tri-calcium arsenate for the effective control of Poa annua. All other Poa annua control chemicals seriously injure bentgrass. It is impossible to overseed with most other suggested Poa annua control herbicides (10).

Most leading golf courses in the United States have used tri-calcium arsenate as an essential practice in maintaining beautiful fine turf. Some of the courses in the East are: Baltusrol Golf Course, Canoe Brook Country Club, Winged Foot Golf Club, Garden City Golf Club, Piping Rock Club, Woodway Country Club, Mt. Pleasant Country Club and Merion Golf Club. In the South, clubs such as: Sparrow Point Country Club and the Greenbrier at White Sulphur Springs, West Virginia. In the Midwest, Detroit Golf Club, Country Club of Indianapolis, Olympia Fields Country Club, Playboy Club, Beverly Country Club, Louisville Country Club and Norwood Hills Country Club. There are over two hundred tri-calcium arsenate programs in California, applied on bent greens. These programs are on outstanding golf courses such as El Caballero Country Club.

Golf course superintendents, because of their expertise, knowledge and clear-cut sense of agronomic responsibility, have been leaders in the development of plant protectants. They intensely manage over 750,000 acres of fine turfgrass on over 10,000 golf courses in the country today, serving over 12 million golfers annually. Poa annua is rapidly becoming a menace to these fine courses. Approximately 25% of these courses are being treated with tri-calcium arsenate. Poa annua fails under stress. Most courses will have to follow a prescribed program with tri-calcium arsenate to gradually remove Poa annua.

(Continued on Page 22)

(Continued from Page 21)

BIBLIOGRAPHY

1. Albert, W. B. 1932. Arsenic toxicity in soils. S. Car. Agr. Exp. Sta. 45th. Ann. Rept. pp. 44-46.
2. Arnott, J. T., and A. L. Leaf. 1967. The determination and distribution of toxic levels of arsenic in a silt loam soil. Weeds. 15: 121-124.
3. Batjer, L. P., and N. J. Benson. 1958. Effect of metal chelates in overcoming arsenicals poisoning to peach trees. Amer. Soc. Hort. Sci. Proc. 72: 74-78.
4. Boischot, P., and J. Hebert. 1948. Fixation of arsenates by soil. Ann. Agron. 18: 425-448.
5. Clements, H. F., and J. Munson. 1947. Arsenic toxicity studies in soil and in culture solution. Pac. Sci. 1: 151-170.
6. Cooper, H. P., W. R. Paden. E. E. Hall, W. B. Albert, W. B. Rogers, and J. A. Riley. 1931. Effect of calcium arsenate on the productivity of certain soil types. S. Car. Agr. Exp. Sta. 44th. Ann. Rept. pp. 28-36.
7. Daniel, W. H. 1962. Preventing crabgrass in 1962. Proc. Midwest Reg. Turf Conf. Purdue Univ. p. 74.
8. Daniel, W. H. 1966. I'm tired of Poa annua. Purdue Univ. Midwest Turf Newsletter. 3: 1-3.
9. Deb, D.L.; and N. P. Datta. 1967. Effect of associating anions on phosphorous retention in soil. II. Under variable anion concentration. Plant Soil. 26: 432-444.
10. Engle, R. E., J. H. Dunn, and R. D. Ilnicki. 1967. Pre-emergence crabgrass herbicide performance as influenced by dry vs. spray treatment and variation of application date of spring treatment on lawn turf. Rutgers Ann. Rept. on Turfgrass Res. Bull. 818. pp. 112-115.
11. Engle, R. E. and R. D. Ilnicki. 1968. Turf weeds and their control. pp. 267-268. In Hanson, A. A. and F. V. Juska. 1969. Turfgrass Science, Am. Soc. of Agr. Inc. Madison, Wis.
12. Funabiki, S., N. Yoshinaga, and C. Kamimura. 1967. A six-year lysimeter experiment with satsuma orange trees (Citris unshiu). V. Form and movement of phosphorous in soils. Nippon Dojo Hiryogaku Zasshi. 38: 388-393.
13. Gile, P. L. 1936. The effect of different colloidal soil materials on the toxicity of calcium arsenate to millet. J. of Agr. Res. Washington, D. C. 52(8): 477-490.
14. Hurd-Karrer, A. M. 1939. Antagonism of certain elements essential to plants toward chemically related toxic elements. Plant Phys. 14: 9-29.
15. MacPhee, A. W., D. Chisholm, and C. R. MacEachern. 1960. The persistence of certain pesticides in the soil and their effect on crop yields. Can. J. Soil Sci. 40: 59-62.
16. McGeorge, W. T. 1915. Fate and effect of arsenic applied as a spray for weeds. J. Agr. Res. 5: 459-463.
17. Olson, O. E., L. L. Sisson, and A. L. Moxon. 1940. Absorption of selenium and arsenic by plants from soils under natural conditions. Soil Sci. 50: 115-118.
18. Paden, W. R. 1933. Differential response of certain soil types to applications of calcium arsenate. J. Am. Soc. Agr. 24: 363-366.
19. Quastel, J. H., and P. G. Scholefield. 1952. Arsenite oxidation in soil. Res. Inst. Montreal Gen. Hosp. Montreal. pp. 279-285.
20. Reichert, F., and R. A. Trelles. 1921. Presence of arsenic as a normal constituent of cultivated soils. An. Assoc. Quim. Argentina 9: 89-95. (Exp. Sta. Rec. 46: 814).
21. Rieke, P. April-1971. Benomyl for Fusarium blight, says, Michigan State University. Weeds Trees and Turf. p. 49.
22. Schollenberger, C. J. 1947. Arsenate — displaceable phosphate in long-fertilized and unfertilized plot soils. Soil Sci. 64: 371.
23. Stewart, J., and E. S. Smith. 1922. Some relations of arsenic to plant growth. II. Soil Sci. 14: 119-136.
24. Vandecaveye, S. C. 1943. Growth and composition of crops in relation to arsenical spray residues in the soil. Proc. Pacific Sci. Congr. Pacific Sci. Assoc. 6: 217-223.
25. Whittle, C. A. 1923. Will calcium arsenate injure the soil? Am. Fert. 58: P. 74.
26. Wiklander, L., and S. Alvelid. 1951. Solubility of arsenate in synthetic systems and soils. Kgl. Lantbruks Hogskol. Ann. 17: 342-354.
27. Williams, K. T., and R. R. Whetstone. 1940. Arsenic distribution in soils and its presence in certain plants. U. S. Dept. Agr. Tech. Bull. 732.
28. Woolson, E. A. 1969. The chemistry and toxicity of arsenic in soil. Ph.D. Thesis. Univ. of Maryland (L. C. Card No. Mic. 70-11, 650) P. 98. Univ. Microfilms, Inc., Ann Arbor, Mich.
29. Zuccari, Gino. 1913. Sulla prizenza dell' arsenico come elemento normale nelle terre. Gaz. Chim. Ital. 43: 398-403.

Answer to Photo Quiz

Metal in Flagstick and cup attracted a bolt of lightning which resulted in injury to nearby turfgrass.

MERRY CHRISTMAS!

HAPPY NEW YEAR

FROM

Massachusetts Turf and Lawn Grass Council Incorporated

RFD #2, Hadley, Mass. 01035

TALKIN'TURFIE

The Turf Bulletin has received the latest word on the couple who is eating D.D.T. daily: The wife is doing fine, but the husband, when putting on his pants, discovered that his fly died. For a more serious note on the latest pesticide research findings, consult the article on TCDD in this issue.

After attending the Jacobsen Product Training School in Racine, Wisconsin, I gained a very beneficial insight into equipment and maintenance from a manufacturer's point of view. This school is highly recommended for anyone concerned with the equipment, repair, and maintenance operations on the golf course. It is a worthwhile investment for a golf course Superintendent or his mechanic. The men at the School are doing a great job and deserve to be commended for their outstanding program.

The University has approached Golf Courses in Massachusetts requesting contributions in order to initiate much needed research programs. Superintendents and Greens Chairmen of the following Golf Courses have already sent in generous donations:

Juniper Hills G.C., Northboro
Pine Meadow C.C., Arlington
Pleasant Valley C.C., Sutton
Quaboag C.C., Munson

Presently the University is working under the auspices of the N.E.G.C.S.A. on the control of Grey Snow Mold without the use of Mercury. In addition to chemical control, Paul Harder, an M.S. candidate is beginning research on the biological control of this turf problem.

Paul, incidentally, will assume the position of Editor of the Turf Bulletin after this issue.

As for myself, I will be leaving UMass to assume the position of Grounds Superintendent at Wentworth By the Sea Hotel and Fairways, Newcastle. N.H. I hope to meet most of you at the Mass. Turf Conference this March. Until then, have a nice winter.

Frederick Guy Cheney