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THE SELECTION AND MANAGEMENT OF TURF FOR SHADED AREAS*

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Figure 1. Poor bermudagrass growth under a Southern live oak *(Quercus virginiana).*

Many landscape problems arise when turfgrasses are established, utilized or maintained in shade environments. Most shade related to turfgrasses is a direct result from low, full tree canopies, large buildings, bleachers or other structures which block out the direct sunlight. Turfgrasses in association with other plant material and appropriate structures, create an aesthetically pleasing landscape; an inseparable ecology; a total composition.

Extensive acreage of shade-turf exists in the United States. Estimates of twenty to twenty-five percent of existing turf areas are maintained under some degree of shade.' Nearly all parks, golf courses, cemeteries, schools and lawns, either commercial or residential, have unique areas where turf is difficult to grow under shade attributed to reduced sunlight.

Shade not only imposes severe limitations on the selection of adapted turfgrass species but also restricts the size, shape, type and use of plant material associated with these turfgrasses.

SOME COMMON TURF-SHADE PROBLEMS

Turf-shade interrelationships involve many intricate management problems. Although by no means complete, the following are some of the most common experiences by turf grass managers :

1) Establishment of trees and turf together in a new planting. Initially, the young trees create very little permanent shade; however, as the tree matures the direct sunlight reaching the turf decreases and the shade area increases.

2) Establishment of turfgrasses after the trees are planted. The tree canopy introduces a shade prob-

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learn from the outset requiring consideration of shade adapted turf species.

3) Establishment of trees after the turf has been installed. Trees exhibting shallow root systems and thick, low canopies will not coincide with turfgrasses originally selected for open sunny areas.

4) Establishment of turfgrasses under shade trees with dense canopies This is particularly true when the tree also has shallow surface feeder roots and when the foot and/or vehicular traffic is heavy.

5) Establishment of turfgrass cover on the north side of a building or structure. This situation is particularly a problem in the northern hemisphere. In addition, a planting of trees would further enhance the shade problem on a north exposure.

HOW DOES SHADE INFLUENCE THE TURFGRASS ENVIRONMENT?

The turfgrass microenvironment is severaly altered when shade is introduced into the turfgrass community. The reduction in light intensity is perhaps the greatest overall effect of shade.[8] Potentially, a canopy of trees can screen out as much as ninety-eight percent of the incoming solar radiation. Furthermore, the quality of light under a shade environment is considerably reduced. Wavelengths of blue and red light, vitally necessary for photosynthesis, are also screened out under a shade environment, particularly beneath deciduous trees. In contrast to deciduous trees, evergreens act more like a neutral filter in that they minimally alter the light quality, despite low light intensity."

A number of other important environmental factors influencing the shade ecology are evident and these include:

1) Competition between tree roots and turfgrass roots for water, nutrients and space;
2) The interception of moisture (rainfall) by the tree canopy;
3) A reduction in atmospheric carbon dioxide;
4) Increased relative humidity;'
5) Moderation of air and soil temperatures;*
6) Restriction in air and wind movement;*
7) Prolonged wetness after rainfall or irrigation;*
8) Prolonged duration of dew or guttation fluid.*

TURFGRASS RESPONSE TO SHADE

Under shade conditions low light intensity limits the quantity of carbohydrates a turfgrass plant can synthesize. Hence, this reduction in carbohydrates reserves results in a decrease in rhizome, stolon, root and topgrowth. In addition, the root system of plants growing in the shade is shorter, thinner, wiry and less branched.[2]

Morphologically turfgrass plants respond to shade in the following manner:[4]

1) Tinner leaves	6) Reduced shoot density
2) Larger leaf area	7) More upright growth
3) Thinner stems	8) Increased leaf length
4) Longer internodes	9) Reduced shoot and root growth
5) Reduced tillering	10) Reduced rate of new leaf appearance

*Environmental factors four (4) through eight (8) in combination may enhance, contribute to or increase disease incidence of susceptible turfgrass species under shade.

Physiologically turfgrass plants respond to shade in the following manner:[3]

1) Higher chlorophyll content
2) Reduced respiration rate
3) Lower photosynthesis rate
4) Higher tissue moisture content

The above characteristics which result in thinner, softer, more succulent leaf tissue will ultimately cause an overall deterioration in the plant's vigor. The resultant effect lowers the plant's resistance thereby increasing disease susceptibility and decreasing its tolerance to drought. heat, cold and wear.

TURFGRASS MANAGEMENT IN SHADE

No turfgrass will tolerate dense shade. Even the most shade tolerant grasses require some direct sunlight each day for healthy growth and survival. Many times a combination of environmental factors and poor management limits turf growth under shade conditions. One should not assume that shade alone caused the poor turf cover.

Turfgrass Cultural Practices

Grasses growing in shade have a tendency to grow more erect than their counterparts found in sunny areas. A higher mowing height is recommended for grasses managed under shade conditions. Mowing a turf in shade environments too low will tend to reduce the food manufacturing leaves and eventually cause the plant to decline in health and recuperative potential. To maintain an adequate stand under shade, one should raise the mowing height one-half to one inch above the normal mowing height.

Fertilization of grasses in shade should be reduced so as to not over-stimulate the plant with nitrogen. Turf should be fertilized three to four times per year wtih a complete fertilizer (N, P, K) in order to fertilize both turf and trees.' Under deciduous trees the turf should be fertilized in the spring prior to emergence of tree leaves, and again in the fall after the leaves have fallen to promote vigorous growth. In order to prevent shallow rooted trees from depriving the turf of all essential nutrients, vertical mulching and deep, infrequent irrigations are recommended.

Disease incidence in shade is considered to be one of the primary predisposing factors for turf decline. The ever-present pathogens, combined with succulent tissue, soil moisture, poor air movement, increased humidity, irregular management and selection or use of non-adapted turf species, many times contribute to disease problems under shade environments. Good cultural practices combined with a preventative fungicide program may be necessary under shade. The cultural practices should take precedence over fungicides whenever possible. Keen ob servation and common sense are far better than compensation through use of pesticides to cover up errors in judgment or cultural practices. Turf management in shade necessitates using disease resistant turf cultivars, mowing turf higher, removing grass clippings, avoiding over-stimulation with nitrogen, avoiding excessive soil moisture, and reducing traffic whenever possible.

Examples of some of the major destructive fungi which may cause potential disease problems on turfgrass species in shade, along with the common name of a few fungicides which are frequently used in their control, are included in Table 1.[10]

TABLE 1. Major destructive disease fungi which commonly attack turfgrass species in shade and the common name of a few fungicides used in their control.

Disease Fungi	Fungicides
Brown Patch (Rhizoctonia solani)	thiophanates, analazine, benomyl, PCNB, TBZ, maneb + zinc ion, thiram, mercury compounds, chlorothalonil, cycloheximide
Fusarium Blight (Fusarium roseum)	benomyl, TBZ, thiophanates
Leaf Spot (Helminthosporium spp.)	anilazine, captan, chlorothalonil, cycloheximide, folpet, maneb, maneb and zink ion, thiram
Powdery Mildew (Erysiphe graminis)	benomyl, cycloheximide, karathane, thiram
Pythium (Pythium spp.)	cadmium compounds, chloroneb, terrazole
Rust (Puccinia spp.)	anilazine, chlorothalanil, cycloheximide, maneb, maneb + zinc ion, oxycarboxin, thiram, zineb
Stripe Smut (Ustilago striiformis)	benomyl, thiophanate

Tree Selection and Care

Many times if new landscape plantings are considered carefully, particularly when turf and tree selection are involved, many shade-turf related problems could be avoided. Selection of trees possessing shallow roots and low, thick canopies should be avoided. Trees possessing deep roots, open canopies and structures, and ones that can be adequately pruned to increase sunlight exposure to the turf are recommended.

Trees normally should be pruned vigorously each year to remove lower limbs to a height of six to ten feet above the ground. Crowns should also be thinned to increase sunlight penetration to the underlying turf. The thinning of shrubs and underbrush is helpful to allow more light to the turf surface and to increase air circulation. Furthermore, fallen branches and leaves from deciduous trees should be removed to prevent accumulation and smothering of the grass plants. Shallow feeder and surface roots may be pruned to make maintenance easier and to reduce the turf-tree-root competition without harming the tree. Unnecessary trees should be removed to enhance the landscape planting and prevent deleterious effects.

The following trees should be avoided for turf areas due to shallow roots and dense canopies:

White Alder	***Alnus rhombifolia***
Camphor	***Cinnamomum camphora***
Sweet Gum	***Liquidamber styraciflua***
Moreton Bay Fig	***Fiscus macrophylla***
Indian Laura1 Fig	***Fiscus nitida***
Fruitless Mulberry	***Morus alba "Striblingi"***
Evergreen Ash (Shammel)	***Fraxinus uhdei***
Silver Maple	***Acer saccharinum***
Brazilian Pepper	***Schinus terebinthefolia***

The following deep rooted trees ***could be*** considered even though they possess somewhat dense canopies providing a moderate thinning is practiced yearly:

Tulip Tree	***Liriodendron tulipifera***
Carob	***Cerantonia siliqua***
California Live Oak	***Quercus agrifolia***
European sycamore	***PIa tinus acerf olia***

The following trees can be recommended since they are deep rooted and have a canopy which allows some sunlight to reach the turf (selective limbs should be pruned yearly):

Crepe Myrtle	***Lugerstroemia indica***
Carrotwood	***Cupana anacardiodes***
Golden Rain Tree	***Koelreuteria paniculata***
Silk Floss Tree	***Chorisia speciosa***
Jacaranda	***Jacaranda acutifolia***
Evergreen Pear	***Pyrus kawakamii***
Fern Pine	***Podocarpus elongatus***
Madenhair Tree	***Gingko biloba***
Olive	***Olea europa***

Palm trees and selected conifers may be utilized in a landscape planting in southern California where turf is planned. Several pines, provided selective pruning is practiced, grow well in association with turf and include a few selected types such as:

Canary Island Pine	***Pinus canariensis***
Aleppo Pine	***Pinus halepensis***
Italian Stone Pine	***Pinus pinea***
Monterey Pine	***Pinus radiata***

Palm trees, being monocotyledonous, possess very few extensive feeder roots and do not appreciably compete with turfgrass plants for nutrients and moisture. Such trees enhance landscape plantings and contribute a certain unique quality to turfgrass communities but do not cause extreme turfshade problems due to their structure and canopies. Three palm trees can be widely recommended for southern California turfgrass areas and these include, but are not limited to:

Queen Palm	***Cocos plumosa***
Mexican Fan Palm	***Washington robusta***
Windmill Palm	***Chamaerops excelsa***

THE SELECTION OF TURFGRASSES FOR SHADE

Although much has been written and discussed concerning the difficulty of establishing, growing and maintaining turfgrasses under shade environments, a suitable turfgrass stand is possible providing two important. conditions are instituted. First, proper management practices, as previously mentioned, must be judiciously and faithfully implemented and maintained. Secondly, shade adapted species should be incorporated into the landscape plans which best meet the needs of the area, its overall use, and the specific ecological microenvironment present.

Several cool season grasses are sold either separately or in combination as “shade-adaptable” species throughout the United States. Many seed companies package what are known as typical “shot gun” mixtures for retail outlets. These mixtures contain several grasses adaptable to large areas of differing shade exposures, soils, drainage situations and management level. Most “shade mixtures” contain varying percentages of creeping red fescue *(Festuca rubru L.),* chewings fesca *(Festuca rubra commutata),* roughstalk bluegrass *(Pou trivialis),* tall fescue *(Festucu arundinacea)* meadow fescue *(Festuca elatior),* colonial bentgrass *(Agrostis tenuis),* or certain of the “improved” cultivars of Kentucky bluegrass *(Poa prutensis).*[6,7] Manv of these so-called “cure all” mixtures may be adequatk for the average homeowner who merely strives for some type of turf cover. However, when the homeowner overwaters or underwaters his lawn, or applies too much fertilizer or other improper techniques, especially under shade conditions, the results mav be disatrous. Many times these pre-packaged shade mixtures, depending upon the maintenance practiced, segregate into specific locations in the law where they are best adapted. For instance, the fine fescues prefer a dry shade; roughstalk bluegrass, a moist shade under minimal traffic; the Kentucky bluegrasses, a moist sunny location; the colonial bentgrasses, a moist sunny or semi-shaded area; and the coarse fescues and “improved” perennial ryegrasses, a moderately moist, semi-shaded environment. Table 2 illustrates some of the common retail shade mixtures available to homeowners in southern California.

TABLE 2. Examples of retail shadegrass mixtures available in southern California.

Percent	Turfgrass in Mixture
58.23	Poa trivialis
24.24	Creeping Red Fescue
14.50	Highlight Chewings Fescue
39.20	Pennlawn Red Fescue
29.10	C-l Kentucky Bluegrass
19.60	Chewings Fescus
9.70	Newport Kentucky Bluegrass
50.23	Victa Kentucky Bluegrass
48.26	C-26 Hard Fescue
29.10	Pennlawn Creeping Red Fescue
26.70	Poa trivialis
14.62	Newport Kentucky Bluegrass
33.25	Chewings Fescue
23.75	Red Fescue
38.80	Annual Ryegrass

The professional turf manager today has many types of cool season grasses to choose from for shade conditions provided he is acquainted with the local conditions, the growth habit of the particular grass, and has a willingness to intensively manage the turf under shade.

The fine textured fescues appear to have moderate shade tolerance in southern California providing they are grown on well-drained soils, receive limited irrigations, and are mowed at two to three inches in height. Fair results are achieved when red fescue or chewings fescue are seeded in the shade and the area left natural with no mowing.

Spreading fine fescues *(Festucu rubru* sub-species *rubru)* differ from the chewings fescues *(Festuca rubru,* sub-species *commututu),* and the creeping types of red fescues *(Festucu rubru,* sub-species *trichophylla)* since they have fifty-six chromosomes, long spreading rhizomes and wider leaves.[9] The spreading fine fescues do not tolerate close mowing, but have better shade adaptation and more rapid establishment rates. The cultivars “Ruby” and “Fortress” are representatives of the spreading types.

An additional fine fescue classified as hard fescue — *Festucu longifolia (Festucu ovina var. durisculu)* originally introduced as C-26, but now known as “Biljart,” possesses better disease resistance, tolerance of poor soils, and tolerance to *Helminthosporium spp.*

Poa trivialis (roughtstalk bluegrass) is another cool-season perennial accepted for its shade tolerance.[12] Moreover, *Poa annua* (annual bluegrass) is considered quite shade tolerant and is able to survive and produce viable seed under lower light intensities than any other turfgrass grown in the northwestern United States.[5]

Shade studies initiated at California State Polytechnic University-Pomona (Cal Poly) in 1971, and continuing through 1974, indicate the following cool season grasses to have satisfactory shade tolerance: Alta tall fescue, Manhattan perennial ryegrass, C-26 (Biljart) hard fescue, and A-34 Kentucky bluegrass. The new “improved” Kentucky bluegrass cultivars, namely Nugget and Glade (P-29) are reported to possess shade tolerance due to their resistance to powdery mildew and moderate tolerance to *Helminthosporium spp.*

In southern California the warm season grasses best adapted to shade are somewhat limited. The bermudagrasses are not tolerant to shade, although a selection from the University of California, Riverside, known as “Hilo” and another selection from Florida “Floraturf” (no-mow) have shown some promise in moderate shade. St. Augustinegrass *(Stenotaphrum secundutum)* is the best adapted warm season grass in southern California. Manilagrass *(Zoysia matrella),* Korean velvetgrass *(Zoysiu tenuifolia)* and Emerald zoysia *(Zoysia japonica x Z. tenuifolia)* exhibit good shade adaptability in southern California. Table 3 indicates a general list of turfgrasses adapted to shade.

TABLE 3. Tolerance of Specific Turfgrasses to Shade

	Good	Satisfactory	Fair	Poor
Cool Season Grasses	Hard fescue	Roughstalk Bluegrass Tall fescue Red fescue Chewings fescue Cultivars of Kentucky Bluegrass 'Nugget,' 'A34' 'Glade'	Colonial Bentgtass Perennial Ryegrass Meadow fescue Annual Bluegrass	Kentucky Bluegrass
Warm Season Grasses	St. Augustine Manilagrass	Korean Velvetgrass Emerald Zoysia	Centipedegrass Carpetgrass Bahiagrass	Bermudagrass

In conclusion, if shade conditions are such that no modifications in the shade environment are possible or adapted species will not survive under good management practices, several shade tolerant ground covers may be recommended in non-traffic areas. These shade tolerant ground covers include:

Periwinkle	***Vinca minor***
Big-leaf Periwinkle	***Vinca major***
Bugleweed	***Ajuga reptans***
English Ivy	***Hedera*** helix
Baltic Ivy	***Hedera baltica***
Algerian Ivy	***Hedera canariensis***
Japanese Spurge	***Pachysandra terminalis***
Star Jasmine	***Trazhelospermum jasminoides***
Blue Fescue	***Festuca ovina glauca***

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WHAT'S NEW IN GROUND COVER HERBICIDES?

W. A. Humphrey and C. L. Elmore*

Evaluation of additional herbicides with potential use on groundcovers has continued, both looking at chemicals for preemergent and postemergent weed control. Information on both recently registered and some experimental herbicides will be discussed. Registration of new herbicides for use in ground covers is somewhat limited but there are indications additional ones may be available soon.

Usually the chemicals that are being evaluated for preemergent weed control have been applied within ten days after planting of some of the more common groundcovers, including large-leafed iceplant, *Carpobrotus edulis*, African trailing daisy, *Osteospermum fruticosum*, Algerian ivy, *Hedera canariensis*, and *Vinca minor*. Two factors are evaluated with these groundcover plantings. Tolerance of the groundcovers to the chemicals is determined as well as their effectiveness in controlling weeds. Similar information is determined with the herbicides potentially useful for postemergent weed control. Established plantings of the groundcovers are used when evaluating these chemicals. The preemergent herbicides are incorporated with sprinkling.

Nitrofen (Tok®) is one of the newer preemergent herbicides that has shown good weed control in groundcover areas with a reasonable margin of safety on the groundcovers mentioned above. Several groundcovers have been evaluated and are listed on the Tok® label for groundcovers. When Tok® was applied to groundcovers within a few days of planting, little adverse effect has been noted. A good level of weed control has usually resulted, though as with most of the herbicides there are some weeds tolerant of Tok® particularly those in the mustard family.

Napropamide (Devrinol® is another material that groundcovers have shown good tolerance at the rate of 4 pounds of actual chemical per acre. Good weed control has generally resulted. This chemical has recently been registered in California for use on groundcovers and some other ornamental plants. Dichondra, particularly has shown a high tolerance to this chemical. Its effectiveness in controlling a number of annual grasses and some broadleaf weeds can make it useful in groundcover plantings.

Another new herbicide is Amex® 820. It again has shown little adverse effect when used at rates of 4 or 8 pounds actual chemical per acre in reducing growth of the above mentioned groundcovers. It controls several annual weeds, but has a somewhat shorter residual life than materials such as trifluralin (Treflan®). A label for use on groundcovers may be soon forthcoming.

There are others being evaluated including alachlor (Lasso®), oxadiazon (Ronstar®) and oryzalin (Surflan®). Experience has shown Surflan® to be a potentially useful chemical for weed control in ground covers. Groundcovers evaluated have shown tolerance at rates of 2 to 4 pounds of actual chemical per acre. Reasonable weed control including a broader spectrum of weeds than Treflan® has resulted at these rates. With Ronstar® the formulation used is important. Experience has shown that greater groundcover safety is provided with Ronstar® when using either the granular or flowable formulations over the emulsifiable concentrate. Rates of 2 to 4 pounds can provide a high level of weed control. Lasso® has given adequate control of many weeds and with reasonable safety to several groundcovers at rates up to 4 pounds per acre of the chemical.

Herbicides for postemergent weed control (control of weeds that have emerged from the soil) discussed will include 3 chemicals. There is considerable difference in the stage of weed growth they will affect. These are either registered or show promise for use in established groundcovers. Others have been evaluated but are considered more experimental.

Tok® will control weeds in the very early stages after

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emergence. This provides somewhat more latitude in applying the chemical in that even though weeds may have emerged, still many of them will be controlled. It has been most effective on weeds younger than the 2 to 3 leaf stage. It is not effective on established weeds. With the groundcovers that have been evaluated there is a good margin of safety with this type of application. RonstarÒ shows more safety with established groundcovers with either the granular or flowable formulations. It is effective on young emerged weeds primarily. Incorporation with sprinklers will activate it.

Glyphosate (Roundup®) has been evaluated for use on groundcovers because of its effectiveness in controlling some of the perennial weeds such as bermudagrass or bindweed. In early tests rates of 2 or 4 pounds active chemical on a per-acre-basis indicated that a higher margin of safety is provided on established *Carpobrutus edulis,* the large-leaf iceplant, for example, with a summer application than with similar rates with a fall application. *Hedera canariensis,* Algerian ivy, appears to have tolerance at these rates. It is more effective, however, on perennial weeds with a fall application. Observations to date on the iceplant show reduced growth at the 4-pound rate. Additional tests have given injury on established or recently planted iceplant, Algerian ivy or *Osteospermum* fruticousus, trailing daisy, at rates as low as 1 lb/A. It is not labeled for this type of use but could provide a useful tool if proper rates and timing can be determined. Further work will be continued in or around ornamentals with this compound.

Summary: Tok® is registered for use in several groundcovers. It has both preemergent and postemergent weed control use and is a newer chemical for application in ground covers. Devrinol® has recently been registered in California for use in groundcovers for preemergent weed control. Amex® 820 may gain registration in the near future for preemergent weed control in some groundcovers. Lasso® and Ronsta® show promise for this use. Roundup® would provide a useful tool for controlling some perennial weeds which occur in groundcovers if tolerance and effectiveness can be determined. Additional evaluations are being made with it.

AN EVALUATION OF SOME SOLUBLE IRON SOURCES FOR TURF FERTILIZATION

Victor A. Gibeault and Kenneth Mueller*

Fertility management of turf is frequently likened to a 16 link chain with each link representing a needed element for plant growth and development; weaken one of the links and the entire chain breaks. Likewise, if the availablility of one of the 16 elements is reduced, plant growth and/or appearance is impaired. The aesthetics and use of a turfgrass sward is then affected. Iron is one link of that hypothetical chain and it is iron that often causes a management problem in California.

Iron is important in the oxidation-reduction systems in plants and in the synthesis of chlorophyll. It is the lack of chlorophyll synthesis that first signals a nutritional problem. With iron chlorosis, the normally green leaves turn an unthrifty light green proceeding to yellow in the interveinal area of the leaf blade. Veins usually remain green. This response is first observed on new leaves of the turf plant. Growth is not decreased at this stage as would be the case with limited nitrogen. If the deficiency is not corrected new leaves will appear stunted in size and yellow in color. Advanced stages are characterized by an obviously weakened plant that is ivory or white.

There are a number of agronomic situations that can cause iron chlorosis. Generally, iron is in plentiful supply but is unavailable to the plant because of 1) chemical tieup/imbalance or 2) the physical properties of the soil.

Chemically, high levels of soil phosphorus can result in insoluble iron as a phosphate; a high pH can foster the formation of insoluble iron hydroxides (best pH for iron availability is around 7.0 to avoid lime induced chlorosis) ; high bicarbonate in the irrigation water increases the availability of phosphorus which in turn interfers with iron activity in the plant (note that effluent water is often high in bicarbonates which could account for frequently observed iron chlorosis where effluent is used for irrigation) ; also, an imbalance of metallic ions such as copper and manganese can cause chlorosis.

Physically, overwatering or heavy rainfall with resulting saturated soils of poor aeration can lead to iron chlorosis. Under this condition root growth is restricted and nutrient adsorption is limited. Similarly, "cold" soil can limit iron uptake by roots as is the case with iron chlorosis of zoysiagrass in the spring. In summary, iron is most often deficient in agronomic situations of high phosphorus, high lime content, high pH, high levels of certain heavy metals, low soil temperatures, poor aeration and limited root growth.

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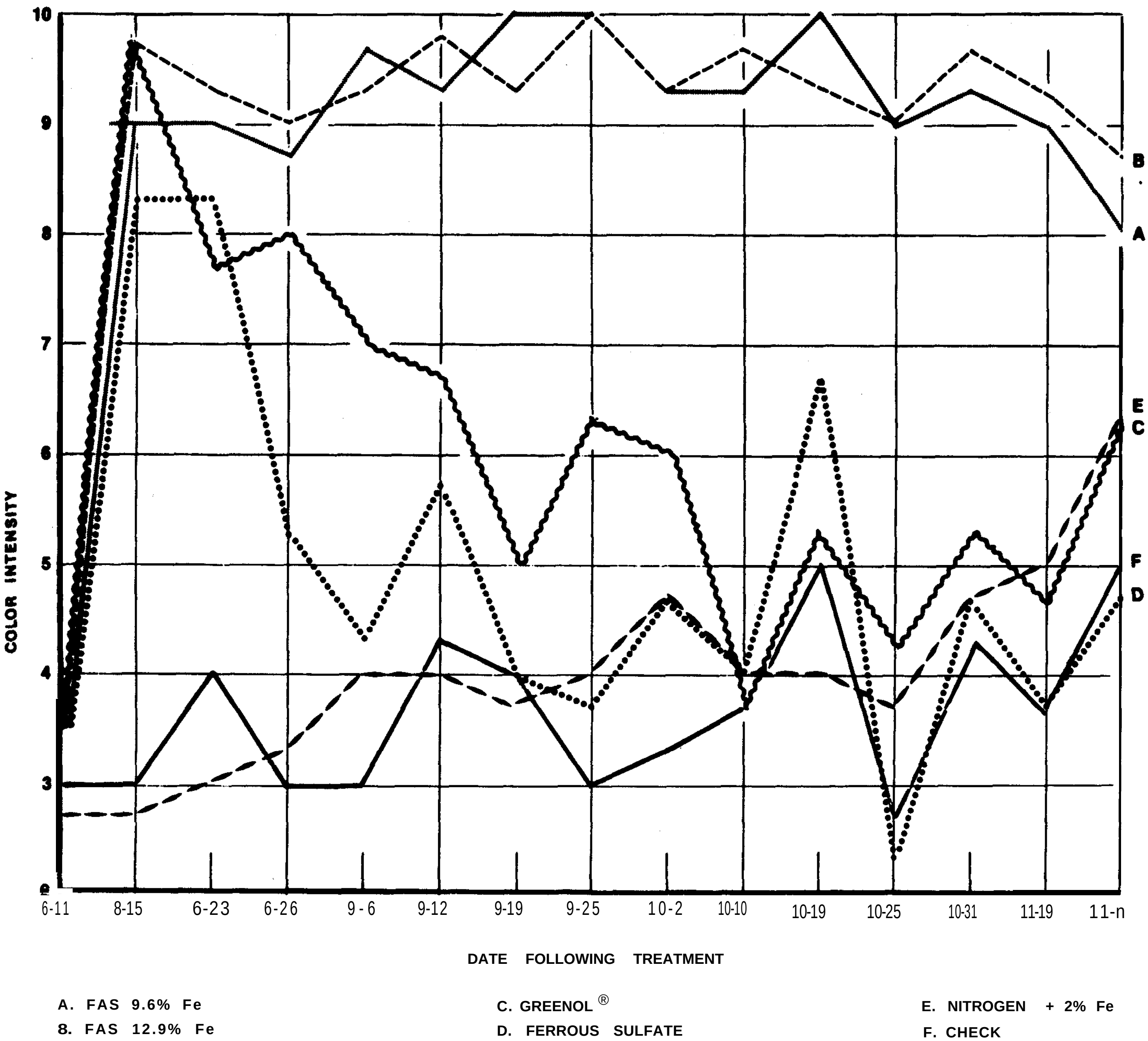
There are several fertilizers used to overcome iron chlorosis in turf. These include soluble sources, chelated carriers and natural chelated iron from sewage sludge. To evaluate the effectiveness and longevity of several soluble iron materials, a trial was conducted on chlorotic Kentucky bluegrass in 1972. It was a specific objective of this trial to examine two experimental formulations of ferrous ammonium sulfate in comparison to some commercially available soluble iron sources.

The test site was located in a rough area on the Leisure World Golf Course, Laguna Hills, California. Grass cover was predominantly chlorotic Kentucky bluegrass with some non-chlorotic common bermudagrass present. The sward was irrigated with effluent water but otherwise received typical management for Kentucky bluegrass. The iron chlorosis became obvious in July, 1972, and the experimental area was treated with the following materials on August 1: ferrous ammonium sulfate (9.6% Fe, 14.7% N, 21.3% S); ferrous ammonium sulfate (12.9% Fe, 15.8% N, 21.4% S); a 3% ferrous sulfate spray (100 GPA); a commercially available soluble iron source (Greenol®) consisting of 5.3% iron, 3.1% sulfur, 0.13% copper and 0.07% zinc; a standard nitrogen treatment with 2% iron; and a check. All treatments with nitrogen were applied at the 1 lb. N per 1000 sq. ft. rate. The two soluble iron treatments were applied at recommended rates for the respective products. All treatments were applied to 50 sq. ft. plots and were replicated three times in a completely randomized block design.

Response to the treatments was recorded as color scores with 0 representing a completely bleached appearance and 10 representing a deep green color. Observations were taken on approximately weekly intervals and the data subjected to an analysis of variance with significance determined by a Duncan's Multiple Range Test. The results are graphed and presented in Figure 1.



Both formulations of ferrous ammonium sultfate, ferrous sulfate and Greenol® gave an immediate and suitable corrective action for the iron deficiency. There was no significant difference among these materials for three weeks following application. In comparison, the 2% iron source on a nitrogen fertilizer did not show a color improvement initially nor for the duration of the trial.

The 3% ferrous sulfate treatment was effective for a three week period; thereafter plots treated with the 3% solution lost color and, by four weeks following treatment, were statistically the same as the untreated check plots.

Greenol® improved the color of chlorotic Kentucky bluegrass for a five week period. Thereafter it decreased in effectiveness until ten weeks following treatment when it was statistically the same as the untreated check.

The two experimental formulations of ferrous ammonium sulfate gave the most consistent iron response and had the greatest longevity of action. Desirable Kentucky bluegrass color was noted up to 16 weeks following treatment. Thereafter, temperatures had cooled and normal color returned to all bluegrass in the test area. At no time was there a statistical difference between the two experimental ferrous ammonium sulfate formulations, as Figure 1 indicates.

In summary, iron chlorosis can be caused by numerous agronomic factors. The several fertilizers that can be used to overcome iron .deficiency can be classified as soluble, chelated and natural chelated types. A test of some soluble types showed a response from ferrous sulfate, Greenol® and two experimental ferrous ammonium sulfate materials. The experimental products had the greatest longevity.

Appreciation is extended to Chevron Chemical Co., Ortho Division and to Jerry Woffinden, manager of grounds maintenance, Leisure World.

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